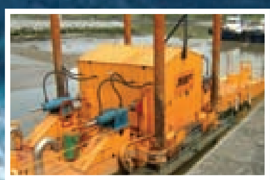
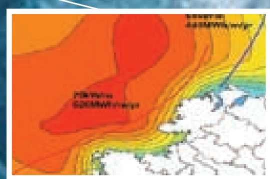
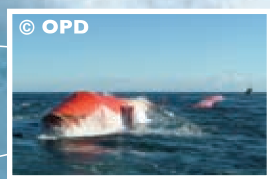
Ocean energy

Analysis of the Potential Economic Benefits of Developing Ocean Energy in Ireland

Summary Report

December 2005

Marine Foresight Series
No. 3

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Marine Institute Act 1991.

Development of an Ocean Energy Strategy

The Marine Institute and Sustainable Energy Ireland commissioned Peter Bacon and Associates and ESB International to complete a study entitled: "Analysis of the Potential Economic Benefits of Developing Ocean Energy in Ireland". The study outlines the potential economic benefits of supporting the development of an Ocean Energy Industry in Ireland and includes a roadmap for development of the sector.

This report aims to summarise the main findings of the Bacon / ESBI study, with the overall aim of contributing to the development of an Ocean Energy Strategy due to be launched in 2006.

A copy of the full report can be downloaded from www.marine.ie.

ISSN: 1649-590X

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Analysis of the Potential Economic Benefits of Developing Ocean Energy in Ireland

Summary

This report examines the potential for harnessing Ireland's ocean energy resources (wave and marine tidal currents) to produce electricity and the associated opportunity to develop an ocean energy industry in Ireland. Existing work, both in Ireland and internationally, suggests that there are opportunities to develop a competitive industrial sector around ocean energy in Ireland. Internationally, the technology is at an advanced experimental stage and there are prospects of commercial production being possible in the near future. However, the key question is whether the potential is sufficient to warrant Ireland engaging in a long-term programme of development. A consultation process undertaken by *Sustainable Energy Ireland (SEI)* and the *Marine Institute* indicated the potential. It also indicated that there are considerable risks. The aims of this study are to identify the potential economic contribution of ocean energy for Ireland and to devise a rational, viable, and economically feasible strategy to promote the development of the sector.

Ireland's ability to develop an ocean energy industry can be summarised in a SWOT analysis:

Strengths

- The Irish wave resource is extremely rich relative to the energy needs of the country.
- The technology to build functional wave converters is developing rapidly but the opportunity to gain a lead remains.
- Ireland is, academically, well-represented at the cutting edge of wave and tidal technology due to the technical competence of several universities and their participation in projects with other international participants.
- There is a manufacturing and construction industry available capable of the manufacture of components, systems and converters and their installation.
- A unified embryonic licensing exists that can facilitate development.

Weaknesses

- There is, as yet, no proven 'winning' wave converter design available.
- There is little commercial investor confidence because the technology is at an early stage and the economic and performance risks associated with technologies at pre-commercial stage are very large.
- There is a lack of publicly available data on the characteristics and extent of the Irish resource, due to incomplete measurement and lack of dissemination.
- Research funding has been sparse and intermittent. This has slowed the rate of progress that could otherwise have been possible.
- The existing supply chain relevant to ocean energy is weaker in Ireland than in countries that would have had a significant industrial base to build on, particularly in the offshore oil and gas sector.
- The technical industries relevant to ocean energy, electronics, control systems and communications, have had low R&D spend in Ireland and are in strong demand from other applications thus are not readily available to the ocean energy sector.
- While Ireland currently has strong research capabilities in the ocean energy sector, these capabilities are working at the limits of capacity currently and will need to expand to meet the needs of an extensive development programme.
- The structure of the Irish economy is moving away from traditional manufacturing and metal working, the sectors most closely concerned with the development of ocean energy beyond the initial experimental stage, and towards higher value-added activities, thus the economy could be too high cost to take advantage of the benefits offered by development of the sector.
- There is an unrealistic demand for industry to provide counterpart funding for research projects.
- There is a lack of integrated understanding at utility level as to the merits of wave and tidal relative to wind energy.


Figure 1 The 'Pelamis' device

- £7.5 million invested to date,
- Venture capital and Carbon Trust Funding
- Currently installed at European Marine Energy Test Centre in Scotland
- First grid connected offshore wave energy device

Opportunities

- The fact that there is, as yet, no proven 'winning' wave converter design available provides a significant opportunity to place Ireland in a frontline position in the sector.
- There is a very significant resource globally and a potentially large market in a number of key countries, in addition to niche markets elsewhere.
- There is a growing level of investment in R, D&D internationally, an increasing level of confidence that viable technologies will emerge and evidence that effective development consortia are being formed, e.g. the Pelamis system of the UK company, Ocean Power Delivery. (See Figure 1)
- Ireland has still the prospect of establishing commercially viable designs and exploiting these locally, or in collaboration with overseas players, in terms of supply and services, although this opportunity will not last for much longer.
- Direct synergies exist with offshore wind, which should accelerate the development of wave and tidal service capabilities.
- Wave and tidal resources can provide sustainable energy to meet Ireland's growing demand for electricity in the medium to long term.

Threats

- Designs developed elsewhere will become the norm and 'capture' the market.
- Better pre-commercial support, e.g. capital grants, power-purchase terms, etc., being provided elsewhere, may delay or stultify Ireland's development in the field. Table 1 overleaf summarises some of the more significant activity internationally.
- Greater market size and the development of standard designs abroad, coupled with economies of scale in production and rising costs in Ireland, may lead to manufacturing being carried out elsewhere.
- The research resource could easily disappear, as it is primarily led by a small number of key individuals who face uncertainty in securing regular funding.

The analysis undertaken in preparing this report, includes:

- the examination of the situation in other countries
- the examination of the strategies that have been used to develop successful renewable energy sectors
- the analysis of the potential of the ocean energy sector in Ireland including investigation of challenges facing the sector and requirements to achieve this potential
- the analysis of the potential economic contribution of an ocean energy industry to Ireland.

This analysis leads to the conclusion that Ireland has an important opportunity to develop an industry, based on ocean energy.

Table 1: Selected international ocean energy activity

	Government support measures	Private funding	Facilities	Devices under development
UK	• DTI new and renewable energy programme: £15 million to date on wave and tidal • Carbon Trust: £5 million, Marine Energy Challenge + other initiatives • £2.6 million for Supergen consortium • £50 million available in marine research development fund • Renewables obligation in place	Scottish and Southern Electricity and Weir Group: £10 million investment fund for marine renewables	• European Marine Energy Centre (EMEC) established • New and renewable energy centre (NaReC) largely focused on marine renewables • Supergen 3rd level consortium • "Wave-Hub" proposed for southwest	• Pelamis, 750 kW wave device • Limpet fixed 500 kW • MRC 1000 floating 1 MW, • Sperbuoy • Edinburgh Duck
Portugal	• 23c/KWh available for first 20 MW of wave energy installed equates to €45 million per year • This is to be extended to first 50 MW		Wave Energy Centre (WEC) established comprised of 10 partners including utility companies, industry and academia	• Archimedes wave swing 2 MW grid connected bottom sited device • Pico, Azores Wave Energy Plant
Others	USA : Electric Power Research Institute has initiated an ambitious four phase offshore wave power feasibility demonstration project as of January 2004 with a projected duration of 5-7 years and a budget of $2.5 - 4 million. Dept of Energy and several state energy agencies are making contributions at different phases of the project	Denmark: Danish electrical system operator has an R+D Fund USA: Electric Power Research Institute (EPRI) has initiated and is providing partial funding for demonstration project outlined above	Denmark: Danish Wave Energy Test Centre	Denmark: • Wave Dragon: 1:4.5 scale prototype 20 kW (4 MW full scale) USA: • Aqua Energy : AquaBuoy system • Ocean Power Technology : Power Buoy

This would have the potential to lead to the creation of valuable intellectual capital, economic wealth and employment opportunities. Furthermore, it would have a desirable regional spread, in the sense that much of the development would take place in areas of the country that are lagging economically.

In advance of implementing a development program, there is a need to develop a vision of ocean energy and of its place in the renewables portfolio available in Ireland. Ireland must decide if it will wait for technology development to occur in a more industrialised country and then access and apply this knowledge to the natural resource to produce energy, or alternatively seek to become a technology maker in the sector and maximize the potential economic gains available. Within that vision wave and tidal energy conversion should be seen as distinct concepts having different potentials and characteristics.

In the case of wave energy, the analysis indicates that Ireland has a significant development opportunity. All indications are that the resource is a good one, in which promising converter systems should be expected to excel, and which would serve as a good marketing tool in dealing with potential clients from other parts of the world. The UK resource is the only one in Europe that is more attractive.

The study considered four scenarios for deployment that correspond with differing strategic objectives for the development of an ocean wave energy industry in Ireland as illustrated in Table 2 below.

On the basis of the projections developed in this report, it is estimated that an industry in Ireland with a total employment impact of 1,125 in 2020 is feasible, assuming an installed capacity of 200MW in that year. The export potential of technology developed would also be important providing a further 760 jobs in 2020. Total employment creation in the region of 1,900 jobs appears feasible on reasonable assumptions.

The economic value of the output of the industry has been assessed under a number of headings including the electricity produced, the atmospheric emissions avoided, the contribution to improving the security of energy supply, the positive impact on regional development and the value of the knowledge created. Table 3 overleaf details the breakdown of the value provided under each heading. Together, these effects indicated a value of €97.5 per MWh. If it is assumed that the installations have a capacity utilisation of 35% during this period then total energy output will amount to 2.32 TWh. The total value of this output when all impacts are included is €227 million in current values. If this is discounted to 2004 at a public sector real discount rate of 2.5% then it has a present value of €158 million (€170 million if discounted to 2007 when the first prototype deployment is projected).

It is recommended that policy should aim to foster both home-developed converters and shared ventures with

Table 2: Scenarios for development

Scenario	Description	2010 (Total)	2020
A	Development and adoption of an Irish sourced floating wave power converter but overall policy stance is cautious	Prototype(s) 1.5MW (Total)	80MW
B	Application of floating converter systems developed both in Ireland and overseas with support for Irish participants with target to develop competitive supporting industry	Prototypes 5MW (Total)	200MW
C	Adoption of floating converters developed exclusively by external interests utilising maps of the Irish resource	1.5MW (Total)	200MW
D	As in (c) above without mapping of Irish resource.	1.5MW (Total)	60MW

These scenarios were based on an assumed wave climate of 50kW/m and an initial rate for 2010 of 8-10€cents/kWh, decreased to 5-6€cents/kWh by 2020.

Table 3: Estimated value of ocean energy produced in development period	
	Value per MWh (€)
Electricity	47
Emissions avoided	7
Security of supply	1.5
Regional development	10
Knowledge created	32
Total	97.5

overseas developers. Where Irish-developed designs are concerned, the aim should be to maximise total return. Where designs developed elsewhere are concerned, the aim should be to maximise the potential for Irish players to participate as suppliers of services to these developers, either in the Irish market or elsewhere. A very important issue is that there is, at present, no mechanism for drawing firms together under an ocean energy 'umbrella' and alerting them to the challenges and opportunities that lie ahead. Such a mechanism is required, both to co-ordinate development and to approach the issue from the perspective of commercial enterprise development, rather than simply meeting energy needs.

In the case of tidal energy, the projected costs do not auger well for barrage type projects on the Irish coast and this technology should not be pursued. Tidal stream technology holds greater possibilities but its feasibility is sensitive to the velocities that can be accessed in certain water depths. Informed strategic planning and decision-making is impossible, in the absence of fundamental information on the resource. Upon completion of the tidal stream study being carried out by SEI, it may be necessary to further assess the location and extent of the resource at projected tidal stream 'hot spots' and the applicability of presently available tidal stream converters. If the resource proves to be technically and commercially significant, policy should consider implementing a feasibility study for particular areas. Otherwise, the policy should be to maintain a watching brief only.

In summary, the consultants, while including the possibility of implementing a pilot study in this technology, cannot reach a definitive conclusion in the absence of fundamental resource information.

A number of conditions are required to achieve the successful realisation of benefits from ocean energy in Ireland. These include ensuring that:

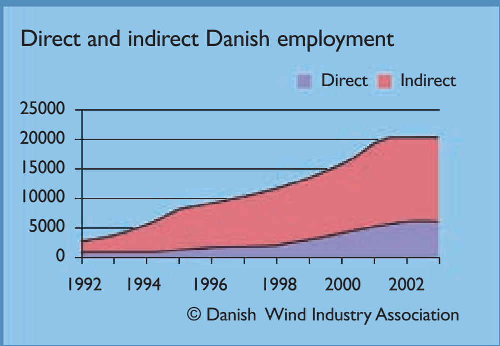
- The Irish wave energy resource is proven to be of adequate magnitude and consistency, and that access is maintained for energy production.
- The conversion technology is successfully developed in terms of efficiency, cost, and quality of output.
- Development consortia have adequate strength in terms of management and technical experience, financial strength and back up for the particular market place.
- Appropriate funding arrangements are made available for the pre-commercial stage of development.
- Administrative procedures are streamlined.
- A consistent market is established with an appropriate feed-in tariff.

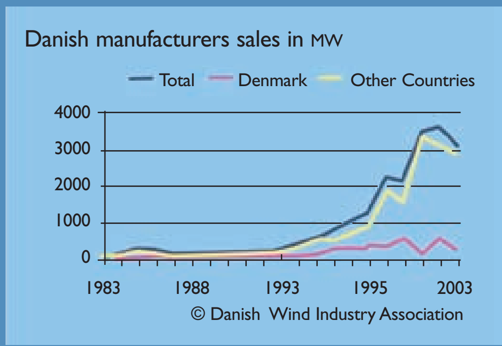
A number of countries are developing competencies, which suggest that, in the absence of a co-ordinated enterprise-oriented policy programme, Ireland, at best, may only exploit these resources without realising their full value added potential. However, much of the wealth-creating potential of the ocean energy sector is expected to be in activities related to the development and exploitation of the intellectual property encapsulated in the technologies involved. Experience with many natural resources indicates that much of the wealth associated with exploitation does not necessarily arise from the presence of the resources themselves, but from the development of the expertise that is required to exploit these resources. While the presence of the resource is an important feature, it is not a vital requirement for competitive advantage, as can be seen from the valuable industry that has been developed in wind energy in Denmark (See Figure 2). Rather, the vital requirement is that all the assets at the economy's disposal are harnessed to extract the overall wealth-generating potential that is present in Ireland's natural resources.[1]

[1] It should be noted that the development path of wind energy is not directly analogous to what can be expected for ocean energy as scale economies are not as readily available due to the fact that ocean energy can only be developed in coastal areas in the near term, and the physical characteristics and material contents, a large element of capital cost, of wave devices tend to grow more in line with output than is the case with wind.

Denmark – driving the wind industry

- Denmark has been the driver of the modern wind industry since 1976.
- 5,500 wind turbines with a total capacity of 3,100 MW.
- In 2004, wind power accounted for 20% of Danish electricity consumption compared to 2.4% in Europe.
- A national energy agreement from March 2004 plans for another 400 MW offshore and 350 MW onshore.
- The Danish wind turbine manufacturers hold a world market share of approximately 40%.
- The industry employs 20,000 in Denmark alone.
- The manufacturers have a combined turnover of almost €3 billion.
- Approximately half of the installed 40,000 MW globally are turbines produced by Danish manufacturers.





It should not be thought that the level of resources now being committed to ocean energy research and development in the UK automatically eliminates the possibility of success where Irish-based development is concerned. There is a joint commitment to an All-Island energy market in Ireland that will be one strand of a co-ordinated approach to energy management between Northern Ireland and the Republic of Ireland. One Irish development consortium, through their operations in Northern Ireland, stands to gain from UK funding, while others may engage in joint operations with UK players as suppliers of specialist services. It should also be recognised that while the leading UK system (Pelamis) is based on the use of hydraulic systems for electricity generation, at least two other types of system have been under development in Ireland. These are the McCabe Desalination System focused on meeting future fresh water needs in specific markets and the Reverse Duct Buoy equipped with rectifying air turbines for electricity generation. At the end of the day least cost per kWh is likely to be the dominating factor in the market place, all other things being equal, and it is not yet clear which system (Pelamis, Reverse Duct Buoy, Wavebob or Aquabuoy among others) will win out in this regard.

Experience, and research into industrial development over recent decades, in Ireland and elsewhere, indicates that the concept of clustering, developed around a Centre of Excellence, is very important for the development of competitive industries. While the concept is not yet fully explored, it is clear that an important issue is that development takes place in a co-ordinated manner. This applies to policy intervention, as well as to commercial situations where policy plays a less important role, such as the development of financing framework for the industry.

Looking forward, an active development programme is required, which takes due recognition of the following requirements:

- Actions/initiatives should be framed within an understanding of both the resource and the market to which it relates.
- Initiatives should be founded on a clear understanding of the conversion technologies and their unique features.
- Actions should be proactive, but realistic in assessing what is achievable. The policy should aim to establish working ocean energy systems at demonstration level by an early date.
- While the programme should utilise, where possible, the joint expertise and resources (including available R, D & D funding) of relevant

state agencies, primary accountability for ocean energy development should rest with one agency.

- The policy programme should have clear goals, objectives and means of monitoring progress and expenditure on a project management basis.
- The programme's administration should be developed in such a way as to minimise bureaucracy and maximise co-ordination and continuity.
- Recognising the limited nature of the supporting financial resources likely to be available, policies should be supportive of the partnering concept between Irish and overseas-based players to the maximum extent possible. For this to occur, Irish players will need support in maintaining credible profiles.

A development programme for this industry needs to be undertaken in a number of stages, with focused objectives and indicators set for each stage. Such a process is captured in Table 4.

The estimated cost of this development programme is €10.5 million. Most of this relates to research,

Table 4: Ocean energy development programme

Objective	Actions and indicators	Stakeholders and institutions responsible	Timing
Identify best option for development	• Analysis of the potential and opportunities • Agreement among stakeholders	Consultants, Marine Institute, SEI, DCMNR, EI	Ongoing from 2004
Decision to proceed	• Agreement by policymakers • Public statements of intent	MI, SEI, DCMNR, Dept. of Finance, DOcean energyLG, CER, ESB, EI	Ongoing from 2004
Clarify responsibility	• Assignment of responsibility for development • Identify institutional arrangements and funding • requirements • Obtain indications of agreement to co-operate from key players	MI, SEI, DCMNR, DETE, EI	Ongoing from 2004
Create a detailed plan for development	• Outline a detailed development programme and provide a clear outline of action • Research available resource • Identify potential blockages e.g. policy, legislative, regulatory etc. and indicate actions required	Ocean Energy Development Unit (Ocean energyDU), ESB, CER, Dept of Finance	2005
Develop funding	• Assign a multi-annual R&D budget • Commitment to provide funds going forward	Ocean energyDU, Dept of Finance	2005
Investment R, D&D	• Produce structured programme of R&D involving selected centres of knowledge • Provide funding to approved R&D programmes • Provide feedback and disseminate results • Provide funding to private R&D and access results	Ocean energyDU, third-level sector/ research centres, EI	Ongoing from 2006
Initiate pilot project	• Identify appropriate pilots • Secure funding	Ocean energyDU, third-level sector/ research centres, ESB, CER,	2006/7
Install pilot projects	• Install 3 projects in wave (and possibly 1 in tidal stream). • Assess results	Ocean energyDU, researchers ESB, industry	Starting 2007
Initiate production	• Establish conditions for private sector production – set conditions for access, feed-in tariffs, fiscal assistance etc.	Ocean energyDU, private investors, financial sector, Dept of Finance, ESB, CER	2008
Investment in productive capacity	• Ongoing investment and production by the private sector • Monitor and evaluate response to production incentives	Private investors, financial sector, Dept of Finance, ESB, CER, EI	Starting 2009
Industrial development	• Promote and monitor uptake of Irish systems • Provide assistance in marketing etc. • Ongoing R&D assistance	Ocean energyDU, DETE, EI	Ongoing from 2010

development and deployment of pilot machines and would be spent in the period up to 2010. This estimate does not include the subsidy to producers in respect of the externalities associated with ocean energy compared to alternative energy sources. It is estimated that the total cost of incentivising the production levels projected would be in the region of €80 million assuming a feed-in tariff providing approximately 10€cents/kWh.

This initiative has the ultimate objective of achieving installed capacity of 200 MW in wave energy by 2020. An appropriate timeline is required to achieve this. One is proposed covering the period 2004 to 2020. The overall objective is that by the end of this period, Ireland will be at the forefront of this industry and will be in a position not only to exploit the energy-producing potential of the natural resources that are available but, most importantly, the intellectual property that will be needed for the industry to develop in a number of countries.

The following series of recommendations is made to give effect to the proposed programme:

- All major stakeholders to pool expertise towards agreed ends, as a matter of urgency.
- Information deficiencies, in terms of the resource, should be addressed in the short term. A study should be undertaken to measure, model and map the Irish tidal stream resource. This should establish its extent and identify areas that may have the necessary velocity levels, with a view to the future deployment of energy converters. The nature of the resource must be more clearly understood not only to avoid surprises and possible disappointment but also to ensure that converter designers have the best information at their fingertips so that designs can be optimised.
- An Ocean Energy Development Unit (Ocean energyDU) should be created and charged with the development of the sector. This should have overall responsibility for driving development of the sector and should be located within an existing agency, such as the Marine Institute, to minimise costs through the reallocation of resources. Short-term secondment of personnel from other organisations should be envisaged to develop a momentum on a task-force basis.
- Adequate test facilities and verifiable standards should be provided so as to enhance the credibility of the technologies and incentivise investment.
- Strategic Development Zones, based on the natural resource, should be identified and utilised for pilot projects in the first instance. These should be further utilised to minimise delays and enhance credibility in order to facilitate investment in production in later years.
- The commitment by the public sector to this industry should go beyond funding, to ensure that appropriate actions are undertaken to remove all barriers to private sector investment by ensuring that appropriate fiscal, pricing and access regulations are introduced. In the R&D phase it will be important that those measures introduced in the Finance Act 2004 are sufficiently flexible to promote R&D in academic institutions.
- Appropriate targets should be set for development. These include: the institutional developments identified above, the creation and funding of a targeted R&D programme from 2004, the establishment of three pilot programmes by early 2006 in wave, with the possibility - contingent on the results of the resource measurement - of a project in tidal stream.
- A target for investment in generating capacity of 200 MW by 2020 should be set. This would be equivalent to 2.5% of total electricity demand in that year and would provide the required mass to drive development of supporting industries.
- The Ocean energyDU should have a significant focus on R&D in the early years. Then it should become more focussed on the creation and extraction of value through the promotion of exports and creation of regional employment, once initial commercial production has been achieved.

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