Oregon Wave Energy Trust
Utility Market Initiative

Task 3.2.1: Garrad Hassan Market Review (International)

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The Utility Market Initiative was prepared by *Pacific Energy Ventures* on behalf of the Oregon Wave Energy Trust.

Task 3.2.1 was completed by Garrad Hassan.

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About Oregon Wave Energy Trust

The Oregon Wave Energy Trust – (OWET) - with members from fishing and environmental groups, industry and government - is a nonprofit public-private partnership funded by the Oregon Innovation Council in 2007. Its mission is to serve as a connector for all stakeholders involved in wave energy project development - from research and development to early stage community engagement and final deployment and energy generation - positioning Oregon as the North America leader in this nascent industry and delivering its full economic and environmental potential for the state. OWET's goal is to have ocean wave energy producing 2 megawatts of power - enough to power about 800 homes - by 2010 and 500 megawatts of power by 2025.

WAVE ENERGY MARKET REVIEW

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1 OVERVIEW OF THE KEY MARKETS

A clear prerequisite for the development of a wave energy market is a good resource. Secondary drivers include access to the electrical grid and suitable offshore engineering skills and infrastructure. In addition, and possibly most significantly, the political will to develop a market through the provision of suitable incentives, is crucial.

This report focuses on the regions in the world where all of the above are present to a greater or lesser extent:

- Australia
- Canada
- Chile
- Ireland
- Portugal
- Spain
- United Kingdom
- United States

The report is divided into three sections. The first section describes key projects and test centers that are either already in place or planned, that aim to accelerate the development of wave energy devices. Emphasis is given to the European market. Secondly, the market incentives that are in place in each of the key markets are described and compared. The third section outlines the methods that can be used to perform a site selection exercise, drawing heavily on in the GH experience of matching the resource to the other key requirements of a wave energy project.

2 DESCRIPTION OF KEY PROJECTS

2.1 Existing test centers – European Marine Energy Centre (EMEC)

The European Marine Energy Centre (EMEC) was officially opened in Orkney, Scotland in August 2004. EMEC provides a centre at which to test both wave and tidal energy devices at two locations around Orkney.

The wave energy test site contains four berths, i.e. four connection points, off Billa Croo, Stromness at the 50 m depth contour. This site is located to the west of the islands in the prevailing direction of swells from the Atlantic, therefore creating an energetic location. The tidal site which is located at the Fall of Warness to the west of the island of Eday consists of five test berths in water depths of between 25 to 50 m. The site is located in a straight between islands with tidal flows of up to 7.8 knots. Both sites are equipped with subsea power cables connected to the UK electricity grid (2.2 MW capacity for the wave site; 5 MW capacity for the tidal site), resource measurement equipment and a SCADA system to monitor substation and environmental variables. In the case of the wave energy site this includes two wave measurement buoys giving wave amplitude, frequency and directional information. At the tidal site the flows are measured using Acoustic Doppler Current Profilers (ADCP).

Figure 2.1.1: Location of Orkney, Scotland

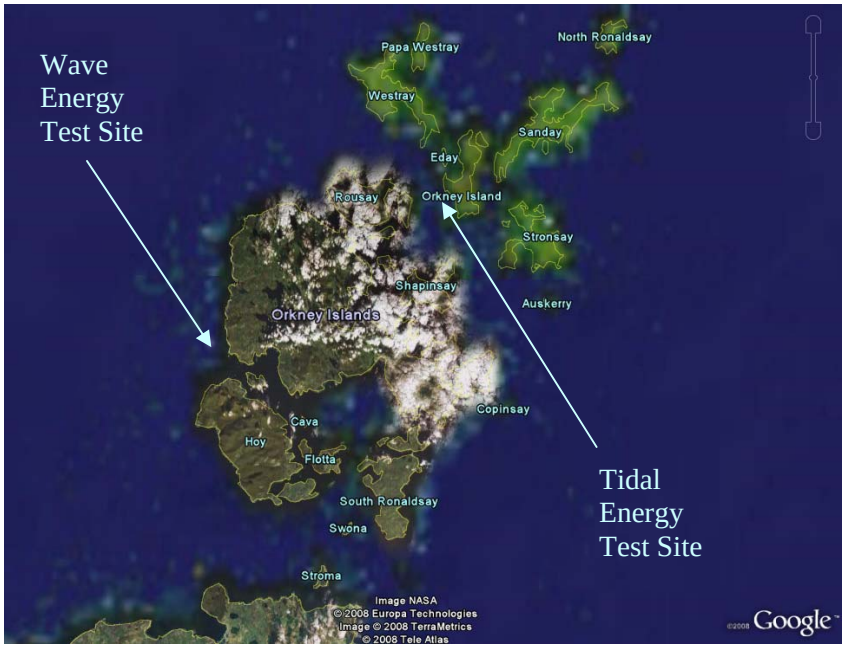

Figure 2.1.2: Location of the wave and the tidal test sites at EMEC

In preparation for the establishment of a test centre a site evaluation exercise was commissioned by the Highlands and Islands Enterprise, the economic development agency for the Highlands and Islands of Scotland. The scope for the evaluation, carried out in 2001, included the assessment of five potential sites for the location of the test centre, Stromness, Crosskirk, Baghasdal, Portnahaven and Eoropaidh. There is no publically available information regarding any zone selection process used to obtain these sites.

2.2 Planned test centers – European perspective

Apart from EMEC there are several existing and planned facilities for the testing of single units, small array and larger clusters of wave energy converters around Europe (Table 2.2.1). All (except the Galway Bay test site) are grid connected and three of the planned centers (Wave Hub, Bimep and the Pilot Zone in Portugal) have sufficient capacity to test the first multi-device array. Note that the Aguçadoura site where the first wave farm has been installed in September 2008 is privately owned by a consortium involving EDP, Enersis, Efacec and the technology developer, Pelamis Wave Power Ltd.

Name	Country	Planned Capacity (MW)	Operational Since / Planned Construction
EMEC	UK	2.2	2003
Nissum Bredning	Denmark	<0.5	2003
Galway Bay	Ireland	<0.5	2004
Wave Hub	UK	20	2008-2010
SEMREV	France	<2	2008-2010
Bimep	Spain	20	2008-2010
Pilot Zone	Portugal	80 (Phase 1)	2008-2010
Idermar	Spain		2010

Table 2.2.1: Summary of the existing / planned wave test centers in Europe

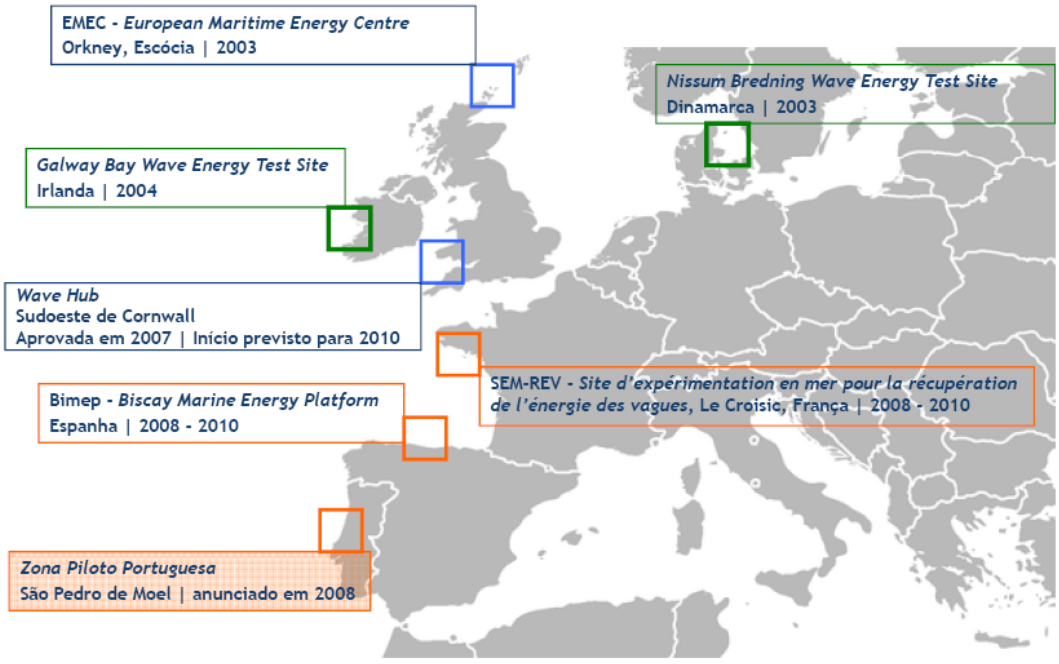

Figure 2.2.1: Location of the existing / planned wave test centers in Europe (source: Wave Energy Centre)

The Danish and the Irish sites are small scale (up to 1:4 scale) test centers, and hence will not be discussed in detail. Note that recently two additional test centers have been announced: a reduced scale facility in Runde (Norway) and a demonstration site in Mayo (Ireland).

The SEMREV site off the coast of Brittany in France is similar to EMEC in terms of installed capacity and in nature: it is meant for the test of individual units and there is no consideration for expansion of the installed capacity. Bathymetry and geology surveys are currently being performed. The project is led by Ecole Centrale de Nantes which has a strong tradition in wave energy R&D, including the development of a wave energy converter entitled SEAREV (a project now led by AREVA).

Wave Hub is to be built in the South West of England, approximately 16 km off the cost of Cornwall. With an area of 8 km^2 and four 5 MW berths, it is anticipated that it will house arrays of four different technologies (an initial phase of 8 MW has been recently announced, although it is not clear which technologies will be used). Various technology developers have been linked with the early stages of the project including Oceanlix, Ocean Power Technologies, Fred Olsen Renewables, Orecon and Pelamis (via a consortium led by E-On and Ocean Prospect Ltd.). All consents are in place, the project has been awarded significant funding from the EU and the UK government and recently (November 2008) JP Kenny was awarded the management contract for the site, with the goal of having the site operational in 2010/11.

A similar test centre, in terms of configuration is the Bimep – Bizcay Marine Energy Platform, which is being developed by the Basque energy board (EVE – Ente Vasco de la Energia) in Bilbao, Spain. The overall budget is €15m, and the main difference when compared with Wave Hub is in the distance to shore: the closest point of the 8 km^2 area is 750 m offshore.

The Cantabrian regional government is promoting the development of the Idermar experimental site, where a set of marine devices and floating wind turbines are planned for installation. The first marine buoy was recently commissioned and a second one should soon be installed. It is expected that the first floating wind turbine will be installed later this year. The entire experimental site is scheduled for completion by 2010.

Finally a more ambitious project is being developed in Portugal by the national government, which has the objective of developing an industrial cluster around wave energy and has identified the need to create the suitable conditions for the installation and further expansion of wave farms. A 320 km^2 sea area has been marked in central mainland Portugal, spanning between 5 to 8 km offshore and along the 30 to 90 m depth contours. Under Phase 1 the overall capacity will be 80 MW, which a further expansion of 250 MW planned for subsequent stages. The national grid (REN) has been named the management body and hence it represents a 'one-stop-shop' in the licensing and permitting associated with each project in the pilot zone. Most of the work to date has been related to the selection of the zone itself and with the preparation of the environmental monitoring program. It is envisaged that during 2009 the necessary pre-feasibility and pre-FEED (Front-End Engineering Design) studies will be initiated.

3 MARKET INCENTIVES

3.1 Type of support mechanisms

The different types of market support mechanisms available for electricity production from renewable energy sources (RES-E) are summarized in the table below. A fundamental distinction between direct and indirect policy instruments can be made: direct policies aim to stimulate the installation of RES-E technologies immediately whereas the indirect instruments focus on improving long-term framework conditions. Besides regulatory instruments, voluntary approaches for the promotion of RES-E technologies also exist, mainly based on consumers' willingness to pay premium rates for green electricity. Policy instruments can also be classified whether they address price or quantity, and whether they address investments or generation.

The most common adopted strategies over the countries are [3.1.1]:

Fixed feed-in tariffs

Feed-in tariffs (FITs) are generation-based, price-driven incentives in which the price per unit of electricity that a utility, supplier or grid operator is legally obliged to pay for electricity from RES-E producers is determined by this system.

It usually takes the form of either a fixed price to be paid for RES-E production or an additional premium on top of the electricity market price paid to RES-E producers.

Tradable Green Certificates

Tradable Green Certificates (TGCs) are generation-based, quantity-driven instruments, in which the governments define target for RES-E deployment and require a particular party in the electricity supply chain to fulfill certain obligations. A parallel market for renewable energy certificates is established and their price is set following demand and supply conditions.

Tendering systems

Tendering systems are quantity-driven mechanisms which can be both investment-focused and generation based. In the investment-focused tendering system, a fixed amount of capacity to be installed is announced and contracts are given following a predefined bidding process, which offers winners a set of favorable investment conditions, including investment grants per kW installed. The generation-based tendering system offer support in the form of a "bid price" per kWh for a guaranteed duration.

Investment incentives

Investment incentives are price-driven instruments that established an incentive for the development of RES-E projects as a percentage of total costs, or as a predefined amount of money per kW installed.

Tax incentives

Production tax incentives are price-driven, generation based mechanism that work through payment exemptions from the electricity taxes applied to all producers; in comparison with feed-in tariffs it represents a negative cost instead of additional revenue.

The following table presents a summary of the market incentives mentioned above:

	Direct		Indirect
	Price-driven	**Quantity-driven**	
Regulatory			
Investment focused	• Investment incentives • Tax credits • Low interest/Soft loans	• Tendering system for investment grant	• Environmental taxes • Simplification of authorization procedures
Generation-based	• (Fixed) feed-in tariffs • Fixed premium system	• Tendering system for long-term contracts • Tradable Green Certificate system	• Connection charges, balancing costs
Voluntary			
Investment-focused	• Shareholder programs • Contribution programs		• Voluntary agreements
Generation-based	• Green tariffs		

(source: Ragwitz,M. et al., 2007)

Table 3.1.1 Existing types of market support incentives for electricity generated from renewable sources

3.2 Overview of the support schemes

GH has conducted a high-level review of the RES-E support schemes for wave energy in Ireland, United Kingdom, Portugal, Spain, Canada, Chile, Australia and United States. Whenever possible, comparisons with the support schemes applied in onshore and offshore wind are presented.

3.2.1 *Australia*

Policy Drivers

Australia's electricity sector is dominated by fossil fuel generation, with over 75% of electricity generated from coal-fired power stations [3.2.1], with coal reserves estimated to last 500 years at current consumption rates [3.2.2]. The price of electricity in Australia has traditionally been very low, giving energy intensive industries a significant competitive advantage. As a result Australia is amongst the highest per capita greenhouse gas emitters in the world. Renewable energy policy is therefore driven by the desire to reduce greenhouse gas emissions rather than by concerns related to security of supply. A secondary driver is to stimulate economic growth and employment in 'green' industries.

The Australian Labor Party ratified the Kyoto Protocol as its first act of government in December 2007. Under the protocol Australia is required to limit its annual emissions to 108% of 1990 levels by 2012. Emissions from the electricity sector have increased by around 50% since 1990, and emissions from transport have increased by around 30%; however Australia is still on track to meet its Kyoto target due to a large reduction in the rate of land clearing during the early 1990s [3.2.3].

The conditions of the Kyoto Protocol are not particularly onerous for Australia and this is therefore not a key policy driver.

The Australian government has also committed to an emissions reduction target of 60% of 2000 levels by 2050. The key mechanism for achieving this will be Australia's planned emissions trading scheme, the Carbon Pollution Reduction Scheme (CPRS). However it is recognized that this scheme will not initially provide adequate support for the renewable energy sector and therefore a national Renewable Energy Target (RET) scheme is also planned.

It is noted that climate change and renewable energy policy in Australia is currently in a state of flux, with legislation for the two key market based mechanisms, the CPRS and the RET, introduced to parliament but not yet passed and currently facing significant opposition.

Political responsibilities and powers in Australia are distributed between federal and state or territory governments. In addition to the federal support schemes state and territory governments have implemented a number of independent funds and support mechanisms for RES-E.

Market Incentives – CPRS and RET

The CPRS is intended to be the primary mechanism for reducing emissions in Australia. Legislation for the CPRS has been introduced to parliament but has not yet been passed. The proposed CPRS is a cap and trade scheme, whereby the government will create a number of permits (one permit equal to one ton of CO_2-e) each year and obligated parties will be obliged to surrender permits equal to their annual emissions. A number of permits will be allocated for free to 'emissions-intensive, trade-exposed' industries and the remainder will be auctioned. Permits may be traded, with the price determined by the market but capped by the government, initially at \$40/t CO_2-e. The number of permits created each year will be determined by the emissions reduction target, currently proposed to be 5% of 2000 levels by 2020, with the possibility of increasing to 25% if global agreement is reached on a comparable target [3.2.3]. The CPRS will provide an incentive for RES-E in the long term by imposing additional costs on fossil fuel generated electricity.

It is recognized that the CPRS will not provide adequate support for RES-E in the short term and therefore a RET scheme is also proposed. The current Mandatory Renewable Energy Target (MRET) scheme was implemented in 2001 and has been the key support mechanism for RES-E in Australia to date. The MRET is a market-based scheme that places an obligation on retailers and other wholesale purchasers of electricity to procure additional renewable energy above existing 1997 levels. The target was originally set at 9,500 GWh/annum (2% of Australia's electricity production) by 2010, with interim targets every year [3.2.4]. Compliance has been close to 100% every year.

The current government has committed to replacing the MRET scheme with a substantially increased RET scheme, with a target of 20% renewable energy electricity generation by 2020.

Under both schemes liable parties are required to surrender Renewable Energy Certificates (RECs) to meet their proportional share of the target for that year. A REC represents 1 MWh of renewable generation. If a liable party fails to surrender sufficient RECs to meet its obligations in any year, a non tax-deductible shortfall charge is applied. Under the original MRET scheme the shortfall charge was set at \$40/MWh, equivalent to \$57/MWh when company tax rates are taken into account. The shortfall charge essentially represents a price ceiling for RECs. The shortfall charge under the new proposed RET legislation has been set at \$65/MWh for the life of the scheme.

Market Incentives – other benefits and incentives

In addition to the MRET and CPRS there are several capital grant schemes available for RES-E development in Australia. Federal government programs include the Renewable Energy Fund ($500m from 2009 to 2015), designed to fill the gap between post-research and commercial uptake for renewable energy technologies, the Energy Innovation Fund ($150m from 2009 to 2014), to provide competitive grants for research and development in clean energy technologies, the Climate Ready Program ($75m over 4 years), to provide matched funding for a variety of energy and climate related projects, and an R&D tax incentive scheme [3.2.1]. There are also several programs available in individual states which provide capital grants for the development of renewable energy technologies.

Recently, The Australian Resources & Energy Minister announced the award of funding under the Renewable Energy Demonstration Program (REDP) to four recipients. The recipients include Ocean Power Technologies (OPT), which is tasked with building a 19 MW facility off of Victoria, Australia. The REDP, which is aimed at supporting the government's target of meeting 20% of the national energy demand using renewables by 2020. Funding distributed to the four recipients totals A$235 million.

GH is not aware of any market incentive or capital grant scheme in Australia that is specifically focused on marine energy development. There are no feed-in tariffs for marine energy in Australia, although there are independent feed-in tariffs for solar photovoltaic power in several states.

Regulatory Framework

The following legislation is particularly relevant for wave energy projects in Australia:

- The Mandatory Renewable Energy Target (MRET)
- The Renewable Energy Target (RET), bills introduced to parliament but not yet passed
- The Carbon Pollution Reduction Scheme (CPRS), bills introduced but not yet passed
- The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The Australian government is also due to release an Energy Green Paper in August 2009 and an Energy White Paper by the end of 2009, which will provide a vision for Australia's energy strategy to 2030.

3.2.2 *Canada*

Policy Drivers

Canada is a signatory to the Kyoto Protocol and has so far met and is expected to continue to meet the requirements. Kyoto commits Canada to meet an average of 6% reduction in 1990 greenhouse gas emissions over the 2008-2012 period [3.2.7]. In November 2008, the government of Canada announced that it would reduce its total greenhouse gas emissions by 20 percent by 2020 [3.2.13].

In February, 2009, Prime Minister Harper and President Obama agreed to begin a Clean Energy Dialog. The Clean Energy Dialog will focus on three areas: expanding clean energy research and development, deploying clean energy technology and building a more efficient electricity grid based

on clean and renewable generation [3.2.7]. This Clean Energy Dialog, while not yet finalized is also set to potentially define a carbon cap and trade system for GHGs.

At this time, the provinces of British Columbia, Manitoba, Ontario and Quebec, in collaboration with some of the USA States have set up an organization called the Western Climate Initiative. The aim of the Western Climate Initiative is to set the groundwork for an international cap and trade program that would involve the US and Canada, with the goal to have this program implemented by 2015. In addition, the Western Climate Initiative aims to reduce greenhouse gas emissions by 15% from 2005 levels by 2020 [3.2.8].

While these policy drivers have not resulted in a direct federal energy policy, they emphasize the need to develop inherent resources into a cleaner energy supply for the country [3.2.13].

Market Incentives

Federally, wind energy projects were supported by a production incentive program called ecoEnergy, which provided of 0.01$/kWh for up to 10 years to renewable electricity projects. This production incentive program required the project to meet federal environmental assessment guidelines. The total budget for this program was $1.48 billion CAD. All of these funds for this program have, at this time, been awarded. This ecoEnergy production incentive program was not continued in the 2009 budget from the current government.

Currently, the federal government is offering the Clean Energy Fund, which comprises two applicable funds for the marine renewable industry: the 'Renewable Energy and Clean Energy Systems Demonstration Projects' ("RECESD") and the 'Research and Development Projects' ("RDP") funds. The RECESD program has $191.4 million CAD and intends to accelerate the deployment of renewable and clean energy systems into power supply systems. The RDP program is worth approximately $8.5 million CAD and is designed to support a range of activities from basic research to and including pre-demonstration pilot projects. The RDP program favours collaboration between government, utilities, universities and private companies in addition to US-Canada partnerships [3.2.14].

The Scientific Research and Experimental Development (SR&ED) Tax Incentive Program encourages Canadian businesses to conduct technical research and development ('R&D') in Canada. Claimants can apply for SR&ED investment tax credits for expenditures such as wages, materials, machinery, equipment, some overhead and SR&ED contracts. Generally, a Canadian-controlled private company can earn an investment tax credit of 35% up to the first $2 million CAD of qualified expenditures for SR&ED carried out in Canada [3.2.15].

Sustainable Development Technology Canada ("SDTC") federal funding program is set up to address the technology development stages between development (laboratory work) and demonstration ('real-world' testing). SDTC does not take an 'equity stake' in the project nor does it require any ownership of intellectual property. SDTC also aims to help technology developers strengthen their entrepreneurial skills and business cases. The SDTC Tech Fund is $ 550 million CAD and is aimed at supporting the late-stage development and pre-commercial demonstration of clean technology solutions. The SDTC Tech Fund does not require any repayments of the financial contributions it provides [3.2.16].

The Accelerated Capital Cost Allowance for Efficient and Renewable Energy Generation Equipment ("Class 43.1") is a federal financial incentive or tax measure which provides an accelerated rate of

write-off (depreciation) for equipment investments which produce electricity by using renewable energy sources [3.2.9]. The tax write-off is 30 per cent per year, on a declining basis of the capital cost of the assets. The intention of this program is to improve the after-tax rate of return on these investments.

Natural Sciences and Engineering Research Council of Canada ("NSERC") provides federal funding for academic graduate studies which contribute significantly to the advancement of science and engineering [3.2.17].

The National Research Council – Industrial Research Assistance Program ("NRC-IRAP") for small to medium sized business is aimed to stimulate innovation and wealth for Canada through technological innovation. The NRC-IRAP financial assistance provides non-repayable contributions to companies interested in growing by using technology to commercialize services, products and processes in Canadian and international markets. The NRC-IRAP program will also support the employment of post-secondary graduates [3.2.18].

Provincially, the predominant market incentive for renewable energy projects has been tender schemes. The provincial Utility announces a Request for Proposals ("RFP") and the bids detail the requested cost per kWh that the project requires. The winning bids will then receive Power Purchase Agreements (PPAs) which are in line with the energy price defined in their bid. The provincial utility will then pay that price for the energy produced from that project for the life of the PPA, which is often approximately 20 years.

The Ontario Green Energy and Green Economy Act, 2009 (Bill 150) ("Act") was passed in May 2009 and the details of the Act have yet to be finalized. However, the Act will offer a competitive feed-in tariff (FIT) for renewable energy generation and place a priority on connecting renewable energy projects to the grid. This Act is also drafted to require a percentage of the project to be "Provincial Content" (i.e.: local content). The proposed FIT program is drafted so that the Supplier of electricity delivered will receive payment for a 40 year period for waterpower projects, while other renewable energy projects will have 20 year contracts. Currently, the proposed FIT rates for waterpower projects under 10 MW is 0.131$/kWh CAD and 0.122$/kWh for projects between 10 MW and less than or equal to 50 MW. By comparison, wind power projects of any size will receive 0.135$/kWh if they are onshore and 0.19$/kWh if the project is offshore [3.2.19]. Discussions between the Ontario Power Authority (OPA) (who is developing the fit program) and the Ocean Renewable Energy Group (OREG – Marine Energy Industry Association) are being undertaken to revise the FIT program to address the requirements of potential hydrokinetic projects.

The Ontario Green Energy and Green Economy Act, 2009 ("Act") follows the former Standard Offer Contract (SOC) program that the OPA offered. The SOC program was directed towards wind power projects equal to or less than 10 MW in size. The FIT schedule for the SOC program was 0.11$/kWh for 20 years. This rate was increased if the project met certain local management and ownership requirements.

The Utilities in Canada are generally public and provincial. Many of the provincial utilities have funding programs to promote technology innovation, clean energy and GHG reduction. The Ontario, Quebec, BC and Nova Scotia offer funding programs of interest to the marine renewable industry. The OPA Tech Fund is designed to help promote the development and commercialization of technologies that have the potential to improve the electricity supply, provide clean, renewable supply options and enable technologies for distributed generation. The OPA Tech Fund budget for 2009 is $1.5million CAD and any one project will receive at most $250k CAD [3.2.20]. The HQ

IDEAS – Technology Demonstration and Experimentation Initiative fund is set up to help emerging energy efficiency technology at the stage between R&D and commercialization. HQ IDEAS supports the experimentation and demonstration of the technology up to $75k CAD of the total costs of an experimental project and up to $250k for a demonstration project [3.2.21]. The BC Innovation Clean Energy Fund (ICE) is a $22.6 million CAD fund that aims to help commercialize British Columbia's clean, efficient energy technologies and create jobs in BC [3.2.22]. The ecoNova Scotia Environmental Technology Program (ETP) is set to invest $9.5 million CAD into projects initiated from Nova Scotia that meet the technology innovation and GHG emission reduction requirements for Nova Scotia [3.2.23].

Regulatory Framework

At this time, all marine energy projects are required to request permits from the federal Department of Fisheries and Oceans ("DFO"), Environment Canada and from Transport Canada. These permit requests trigger the requirement for the project to undergo a federal Environmental Assessment (CEA) [3.2.5].

Currently, the government of Canada is working on the regulatory framework for the management of offshore renewable energy resources (including ocean energy) in areas under federal jurisdiction [9]. This framework is intended to provide an effective and efficient regulatory environment for future ocean energy projects [3.2.13]. However, in general the provinces see the coastal waters as being under their jurisdiction [3.2.5].

3.2.3 *Chile*

Policy Drivers

The Chilean energy matrix is strongly dependent on large hydro and fossil fuel power stations. The motivation to develop the use of other renewable energy sources is directly inline with the objectives of the key entities which define the energy policy in Chile: the National Energy Comission (CNE, Comisión Nacional de Energía), under the auspices of a recent Ministry of Energy, and the economic development agency CORFO (Corporación de Fomento de la Producción). CORFO's objectives for the 2006-2010 period are:

- Contribute to a large technological leap in Chile;
- Integrate the SME's in the development process;
- Promote the regional development by gathering investment and strengthening local clusters.

Chile's marine energy resources are particularly attractive and could make a significant contribution to the Chilean energy matrix. Figures from CNE (2008) show that to meet the 2020 targets (and in the more optimistic scenario), 12.870 GW and 1.181 GW need to be added to the SIC and SING grid systems (the central and the north systems, respectively). This corresponds to an increase of 132% and 50% when compared to the 2008 values in these systems. Approved projects (2007) account for 5.206GW, with 97.35% from conventional power plants (thermal plus large hydro), with most of the developments concentrated in Regions II, III, V and VIII.

The development of a marine energy strategy for Chile and the subsequent demonstration (single units) and pre-commercial projects (first arrays) have been approached in a recent study [3.2.25]

conducted by Garrad Hassan and Partners Ltd (GH) which was commissioned by the Inter-American Development Bank for the Ministry of Energy, whose main directives are:

- Diversify the energy mix with additional renewable energy sources;
- Actively contribute to the increase in energy efficiency, sustainability and security of supply;
- Stimulate industrial R&D (including cooperation with international entities).

The objectives from CORFO and the Ministry of Energy are complementary, and are both well addressed by the development of policies and project guidelines for marine energy. The GH study outlines the priority zones for marine energy developments, by considering the key attributes and constraints. Given the status of marine energy technologies a staged development is appropriate, hence the immediate (2010) contribution is less likely to overcome the concern on the electricity demand and be more focused on the development of suitable technologies. However, for the 2014, 2020 and 2024 targets, and in particular if the initial steps to establish demonstration and pre-commercial projects in Chile are taken, the country could not only benefit from a significant technological advantage but also a significant contribution to its energy matrix, given the inherent marine energy resources.

Market Incentives

A recent presentation from the Ministry of Energy [3.2.24] shows a suggested a modification to the general law for electrical services (Ley General de Servicios Eléctricos) which, when fully implemented, will be particularly well suited to the development of marine energy projects, as it enforces the development of renewable energy projects of the non-conventional type - ERNC (wind, marine, etc.).

Such a modification to the law will ensure that utilities to have in their energy mix a minimum of 5% of projects with these energy sources in the 2010-2014 period, with a further annual increase of 0.5% over 10 years to reach 10% in 2024 (2005 figures from CNE show that only 3.1% and 0.4% of the SIC and SING capacity is from this type of energy sources).

As listed in Table 3.1.1 there are a variety of ways open to the Ministry of Energy when implementing policy – but at the time of writing of this report it is still unclear which will apply to wave energy. It is predicted that lessons from the wind energy policies (which are leading to large developments in Chile) can be directly extrapolated to wave energy.

Regulatory Framework

Given the recent interest in alternative renewable energy sources, there is still no regulatory framework in place for wave energy, nor is there any indication of which will be the key incentive (apart from the change to the general law for electrical services mentioned above. The SEIA (Sistema de Evaluación de Impacto Ambiental) website implemented by CONAMA (Comisión Nacional del Medio Ambiente), the environmental agency, lists 5.2GW in evaluation with regard to electricity generation facilities, 76% of which are coal, gas or fuel fired power stations.

The regulatory framework is being prepared by the Centre for Renewable Energies which is being setup by the Ministry of Energy. This follows the recommendations listed in [3.2.26], in which a list of key actions for the development of renewable energy projects in Chile were identified:

- Establishment of a ruling body: the creation of a Centre for Renewable Energies with sufficient autonomy (human resources, financial and technical support) is vital to stimulate the development of projects;
- Creation of databases: resource data, preliminary studies (site selection), GIS databases, etc; such information should be compiled and made available to the private sector;
- Coordination with regional entities to ensure that local development plans are covered by National policy;
- Creation of a clear regulatory framework for wave energy;
- Grid upgrades where necessary.

3.2.4 *Ireland*

Policy Drivers

Ireland's Kyoto commitment is not to exceed greenhouse gas emissions by more than 13% of 1990 levels by 2012. The key actions to be taken in order to meet this target are drawn from the National Climate Change Strategy 2007-2012 and the Energy White Paper 2007 which describes the actions and targets for the energy policy framework out to 2020.

The RES-E target for Ireland, set by EU Directive to be met by 2010, is 13.2% of gross electricity consumption. Currently, Ireland imports most of its energy needs and in this sense is particularly vulnerable to energy price and supply uncertainties. To tackle this, the country's own goal is to have 15% of electricity coming from renewable sources by 2010. It is an ambitious goal considering that the total electricity generated from renewable sources in 2007 accounted only for 9 % of Ireland's electricity consumption. However, this figure is rising due to a large increase in wind powered generation.

The government's White Paper sets a target of 33% of electricity to be generated from renewable sources and 500 MW of installed ocean energy – wave and tidal – by 2020. An intermediate target of 75 MW of ocean energy installed by 2012 has also been drawn, among other measures.

Market Incentives

A tender scheme used to support RES-E up to 2003 has been replaced by the Renewable Energy feed-in tariff program (REFIT) in early 2006. This new scheme is expected to provide some investor certainty due to a 15-year feed-in tariff guarantee. In 2006 a fixed price tariff of 57 €/MWh for large onshore wind farms were indexed to the annual change in the national consumer price index. In February 2008, the Irish government announced that an incentive scheme for offshore wind would be created, providing a feed-in tariff of €140/MWh.

In 2006, the Marine Institute (MI) and Sustainable Energy Ireland (SEI) prepared the National Strategy for Ocean Energy. This strategy aims to introduce ocean energy into the renewables portfolio in Ireland and to develop an ocean energy sector. A €26M fund has been established for the initial 3 years to support:

- the establishment and operation of the Ocean Energy Development Unit (OEDU) in SEI
- the enhancement of the national wave tank facility (HMRC)
- a feed-in tariff of 220€/MWh for electricity produced from Ocean Energy

- the establishment of wave and tidal test facilities (Galway Bay ¼ scale test site and planned full-scale test facility in Mayo)
- research and prototype developments by industry

The Ocean Energy Development Unit was set by SEI and is responsible for the implementation of the National Ocean Energy Strategy. It aims to support national developers of wave energy devices through concept validation, model optimization and scale testing and optimization. The OEDU program includes a wide range of proposed actions, namely: the development of an offshore test site for ¼ scale prototypes in Galway Bay; support for the demonstration of pre-commercial single devices; pre-commercial small array testing and evaluation over a sustained period.

The fixed price for ocean energy (wave and tidal) is 220 €/MWh. The price will be available to projects operating at a full size offshore national test facility as part of the domestic RD&D program for ocean energy.

Regulatory Framework

The following laws and programs are particularly relevant for wave projects in Ireland:

- Energy White Paper 2007 – Delivering a Sustainable Energy Future for Ireland
- Energy Green Paper – Towards a Sustainable Energy Future for Ireland
- Renewable Energy Feed-in tariff (REFIT)

Building on the energy "Green Paper" and related consultation process conducted during 2006, the Irish government released the energy "White Paper" in March 2007. This paper sets out a national energy policy framework for the years 2007 to 2020. The strategic goals of the paper relate to security of supply, sustainability of energy and competitiveness of energy supply.

The Renewable Energy feed-in tariff program (REFIT) provides a financial incentive in the form of long term feed-in tariffs designed specifically to encourage new capacity development in individual categories in proven technologies and short term feed-in tariffs to support the development of emerging ocean energy technologies.

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3.2.5 *Portugal*

Policy Drivers

The current Portuguese energy scenario is characterized by a strong external dependence, with an energy demand growth rate significantly higher than the GDP growth rate. Portugal's shortage in primary energy sources leads to a significant external dependence (82.9% in 2007) which accounts

for the dependence on the imports of primary sources of fossil origin. Despite this dependence, approximately 28% of the total electricity consumption in Portugal came from renewable sources in 2008.

With the aim to promote economic growth, reduce external dependence and tackle climate change, the Portuguese government has reviewed the established targets to 2010:

- Increase the target for power generation based on renewable energy sources from 39% to 45% of the final electricity consumption by strongly investing in all types of renewable energy sources;
- Increase biofuels penetration target from 5.75% to 10% of the total road transport fuel placed in the market;

The goals defined in Cabinet Resolution nº63/2003, October 19th , for wind and wave energy are:

- Wind power: Increase by 1950 MW the installed capacity goal for 2012, reaching a new total of 5100 MW and promote the creation of new technological and investments clusters linked to wind power;
- Wave power: Increase installed capacity by 200 MW through the creation of a Pilot Zone with a total exploitation potential of up to 250 MW for new emerging industrial and pre-commercial wave energy converter prototypes.

Market Incentives

The Portuguese government strategic guidelines for the energy sector are defined by the National Energy Strategy, approved by the Resolution of the Council of Ministers nº169/2005, dated October 24th. The Decree-Law nº225/2007, dated May 31st , revised the feed-in tariffs established by the previous Decree-Law 33A/2005. These cover a wide variety of renewable energy sources, and tariffs vary by source and capacity.

The main electricity support scheme for wind and wave energy are feed-in tariffs (FITs) guaranteed for 15 years combined with investment incentives. In the case of onshore wind energy, the power purchase agreement (PPA) is let by the state owned Transmission System Operator "REN", and the price payable is defined by the "Decree-Law 33-A/2005". Tariffs are also periodically modified to reflect inflation. The average value for 2006 was 74 €/MWh.

The feed-in tariff for wave energy projects have three levels, with each level corresponding to a category of development status. The level of tariff also depends on other factors, such as the installed capacity for the technology both within and outside Portugal. In summary, these levels are:

- Demonstration projects (up to 4 MW): 260 €/MWh
- Pre-commercial projects (from 5 MW up to 20 MW): 191 €/MWh
- Commercial projects (above 20 MW): 131 €/MWh

There is no definitive policy for offshore wind projects, but these should occupy (at least initially) the Pilot Zone. A mix between the wave and the offshore wind tariff scheme is expected. Offshore wind will be challenging due to the water depth and advanced support structures, either fixed or floating, will be necessary for all but a limited number of sites.

Regulatory Framework

The following laws are particularly relevant for wave projects in Portugal:

- Decree-Law 5/2008 (8th of January) – Legal regime for the use of territorial sea for wave energy projects; creation of a Pilot Zone
- Decree-Law 238/2008 (15th of December) – Concession of the Pilot Zone to REN
- Despacho 32277/2008 (18th of December) – Guidelines for marine spatial planning in the Portuguese economic exclusive zone (including ports and marine reserves)
- Decree-Law 33-A/2005 – Legal tariff regime for the electricity generated from renewable sources

In the first two, the already mentioned Pilot Zone and its management body are defined. Offshore wind technologies are not explicitly covered, nor excluded, i.e. the Pilot Zone was not exclusively defined for wave energy technologies. Given the technical constraints already discussed there have been high-level discussions in the Ministry of Economy regarding shared use of the facilities, namely the offshore grid, engineering capacity and the onshore substation. Onshore works for the Pilot Zone are due to commence in 2009, to ensure a fully operational status by 2011.

Other legislation and general rules would apply should a developer wish to obtain a permit to develop an offshore site, but Resolution 32277/2008 sets in motion the creation of a marine space usage plan which will cover all economic activities (it is not clear at this stage if this will cover explicitly offshore renewable energy projects, but it will cover other sea uses which may present non-technical constraints).

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3.2.6 *Spain*

Policy Drivers

Spain is committed to decreasing its greenhouse gas emissions by 15% from the 1990 baseline during the 2008-12 period; this contributes to the intra-European agreement to achieve an overall reduction in emissions. The *Estrategia Española de Cambio Climático y Energía Limpia* establishes the basis for achieving this target by means of: greater energy efficiency, reduction in energy consumption and increase in generation of clean energy.

In 2005, the Spanish greenhouse gas emissions reached 440.6 Mt of CO_2 equivalent; this entails a 52.2 % increase upon 1990 levels. Two main reasons were behind this increase:

- The strong growth of the Spanish economy in recent years.
- The recent growth of the Spanish population with origin in the arrival of migrant labour attracted by the growing economy and in the arrival of people in retirement age moving from Northern Europe.

As a result of this increase, a review of the Spanish Strategy on Climate Change and Clean Energy (*Estrategia Española de Cambio Climático y Energía Limpia*) has been undertaken. In this review [Urgent Measures for the Spanish Strategy on Climate Change and Clean Energy (*Medidas Urgentes de la Estrategia Española de Cambio Climático y Energía Limpia*)], a revised goal of limiting the increase of greenhouse gas emissions to 37 %, compared to 1990 levels, was set for the period 2008-2012. This represents a 22% increase in emissions from the original figure, to which Spain committed under the European implementation of the Kyoto protocol.

The Spanish government has set the following targets, regarding renewable energy generation for 2010 (*Plan de Energías Renovables 2010*). (These targets are in line with European policy.):

- 12% primary consumption, as a minimum;
- 29.4% electricity generation; and
- 5.75% bio-oil, for transportation.

Wind energy is currently the main source of renewable power generation, although biogas and bio-oil also contribute to these goals to a slight degree. All other sources have not grown as expected. Nevertheless, Spain has some strong reasons for supporting renewables:

- The Kyoto protocol;
- A large annual increase in energy consumption;
- A high level of external energy dependence (80% of the energy necessary to cover its needs); and
- General concern about climate change and sustainability.

The national government has not traditionally considered wave energy to be an important source of renewable energy. Currently, no specific target has been set for this renewable energy source. However, it is expected that wave energy will be included in the future 2011-2020 Renewable Energy Plan, where targets and other supporting measures are expected to be defined. Five regional governments - namely Asturias, the Basque County, the Canary Islands, Cantabria and Galicia – are placing wave energy at the top of their Energy Agendas and are planning to develop wave test sites. A description of the activities carried out by some of the afore-mentioned regional governments is given below.

The Basque test facility will allow full-scale prototype testing and the installation of demonstration and pre-commercial wave energy farms – up to 20 MW. The site (Biscay Marine Energy Platform, BIMEP) is expected to be commissioned in 2010.

The Cantabrian regional government is promoting the development of the Idermar experimental site, where a set of marine devices and floating wind turbines are planned for installation. The first marine buoy was recently commissioned and a second one should soon be installed. It is expected that the first floating wind turbine will be installed later this year. The entire experimental site is scheduled for completion by 2010.

In 2008, the Canary Islands regional government provided funds for costing the development of a wave energy atlas within the islands.

Market Incentives

In 2004, the Spanish government published RD 436/2004, which introduced two options for selling electricity produced from commercial renewable energy projects:

- Selling electricity to the electricity company at a fixed tariff; and
- Selling electricity on the market (pool) via a market agent, whereby an additional premium is paid in addition to the electricity market price.

Three years later, the current Royal Decree 661/2007 was introduced, without any major changes to the support mechanism; hence, the two-tariff system is still in force. The 2009 updated tariffs, applicable to wave energy and based on the year since the original commissioning date, are as follows:

Years 1-20:	73.562 €/MWh (fixed tariff) and 41.046 €/MWh (premium)
Year 20 onwards:	69.505 €/MWh (fixed tariff) and 32.671 €/MWh (premium)

These tariffs are updated on a yearly basis, via an inflation factor. It is worth noting that, as with other renewable energy sources - such as wind energy, biomass and solar plants (both PV and CSP) - it is likely that the final energy tariff (applicable to future commercial wave farms under these two tariff systems) will be adjusted via a bonus on reactive power and via a penalty, due to deviations from power output predictions.

As a result of the low tariffs currently available and with the intention of promoting *demonstration projects*, the Spanish government introduced the option of defining a specific tariff (per project basis) for the first 15 years of lifetime, under RD 661/2007. The reviewed tariff will be based on the project investment cost, although no details on the calculation are provided; as part of the consent process, the developer is requested to submit an *Anteproyecto* (preliminary design work), which consists of an outline design, budgetary costing (CAPEX and OPEX) and an energy production assessment. A list of the specific contents is provided in RD 661/2007. It is expected that the price increase via this alternative scheme will be sufficiently attractive to interest developers and technology suppliers to develop further demonstration sites.

In terms of R&D funding, the Spanish government has provided some money through the R&D National Plan, despite no specific funds being set aside for the wave energy sector. The best representative project is the PSE-MAR project, which aims to develop three wave energy converters based on technology supplied by Hidroflot, Pipo Systems and Tecnalia. €3.5M has been allocated for this project, covering the period 2008-2010. Another example is the Abencis Seapower project, which is developing low-cost onshore technology for electricity production and for desalination purposes.

Regulatory Framework

The principal laws governing the administrative procedure for developing a wave farm are, as follows:

- Royal Decree 1028/2007: establishes the administrative procedure for installing offshore wind farms. The authority responsible is the *Ministerio de Industria, Turismo y Comercio*, via *Dirección General de Política Energética y Minas*. This Royal Decree incorporates the following:

- Royal Decree 661/2007 - regulates energy production for renewable and non-conventional sources of energy. The authority responsible is the *Ministerio de Industria, Turismo y Comercio*.
- Royal Decree 1995/2000 - regulates transport, distribution, trade and supply activities, as well as authorization procedures for electrical energy installations. The authority responsible is the *Ministerio de Economía*. Three further organizations also take on important responsibilities in this matter: *Operador del Mercado Ibérico de Energía* (OMEL), *Red Eléctrica Española* (REE) and *Comisión Nacional de Energía* (CNE).
- Royal Decree 1302/1986 - guides the environmental impact assessment process. The authority responsible is the *Ministerio de Medio Ambiente*.
- Law 22/1998 - coastal regulation. The relevant authority for this is *Ministerio de Medio Ambiente*, via *Dirección General de Costas*.
- Law 3/2001 - marine fishing. This is the main law for dealing with fishing activities in Spain. The authority responsible is the *Ministerio de Agricultura, Pesca y Alimentación*.

Upon its creation in July 2007, Royal Decree 1028/2007 was the first legal statute to mention offshore wind and other offshore renewable technologies. This RD also includes a simplified consent regime for wave energy sites. The main details are, as follows:

- There is no minimum project size;
- Application for *Administrative Authorisation.* The *Administrative Authorization* is a pre-requisite for obtaining project approval for any power generation facility in Spain;
- Unlike offshore wind farms, details to be included in the application for a wave farm have not been specified. Based on conversations held between GH and a wave farm developer, GH is aware that the Spanish authorities have made a preliminary request for the following studies: an *Anteproyecto,* a basic *Environmental Impact Assessment* and a *Study on Occupation of the Public Maritime and Land Domain*, in order to apply for project licensing;
- Ministry of Industry, Tourism and Commerce awards construction permit;
- Ministry of Environment awards concession; and
- Proposal is submitted, with a deposit of 2% of the estimated capital investment.

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2008 International Energy Agency (IEA) - Ocean Energy Systems (OES) Report

3.2.7 *United Kingdom*

Policy Drivers

The UK is a signatory to the Kyoto Protocol and this can be considered as the most important international commitment for the UK Government in the context of climate change although it has limited direct relevance to renewable energy in this particular national market. The protocol commits the UK to reduce a basket of six greenhouse gases by 12.5% (compared with 1990 levels) by 2012. Despite a gradual rise in CO_2 emissions since signing the protocol, the UK is on course to meet the Kyoto target due largely to a move away from coal- to gas-fired electricity generation throughout the 1990s.

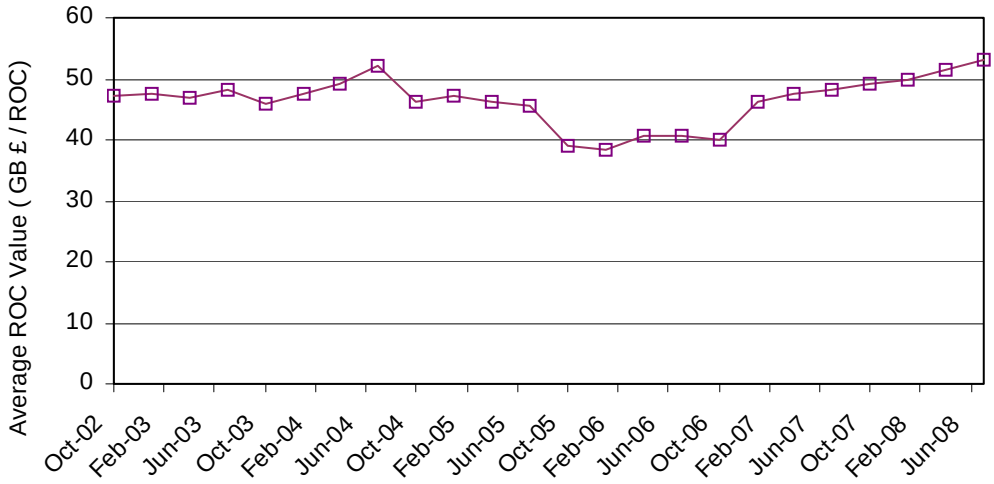
With regard to renewable energy, perhaps a more important recent development is the agreement in February 2007 of all 27 EU states to cut CO_2 emissions by 20% before 2020. This overall binding target is to be achieved through more stringent cuts on developed countries to allow the economic impact of the cuts to be mitigated for lesser developed countries. In this context, the UK has committed to a 30% reduction in CO_2 emissions by 2020 (based on 1990 levels). This constitutes a very challenging target for the UK and is broadly expected to require a substantial shift in the electricity generation framework away from carbon intensive technologies.

Another important legislative driver in the longer-term timeframe is the UK Government's Climate Change Act which became law in November 2008. The Act commits the UK to cutting CO_2 emissions by 80% before 2050 (again referenced to 1990 levels). It also includes an intermediate target at 2020 which, at 26%, is lower than the EU agreement described above. The Act also provides for “carbon budgeting”, which entails the setting of emissions caps at five yearly intervals.

Market Incentives – The Renewables Obligation

The Renewables Obligation (RO) was implemented in England, Wales and Scotland in 2002, and Northern Ireland in 2005. Although the RO is technically made up of systems applying to England and Wales, Scotland, and Northern Ireland, it can be viewed as a single system.

The RO places an obligation on electricity retailers to source an increasing percentage of energy from eligible renewable energy sources. Retailers must prove compliance through the surrender of Renewable Obligation Certificates (ROCs). These certificates are issued to licensed generators at the rate of 1 ROC per MWh of renewable energy produced; In order to encourage less developed renewable energy technologies such as wave and tidal energy, a new system has been proposed in which less developed technologies will receive more than 1 ROC per MWh. In this proposed scheme, electricity generated from waves on the sea will receive 2 ROCs per MWh in England and Wales and 5 ROCs per MWh in Scotland, meaning Scottish wave device operators would receive more revenue for the electricity generated, stimulating further investment; the generators are then able to sell the certificates on the open market. The average ROC sale price (2002 – 2008) is given in Figure 3.2.1.



Source: Non-Fossil Purchasing Agency

Figure 3.2.1 Average ROC sale price at auction (2002 – 2008)

As an alternative to buying ROCs, electricity suppliers may opt to pay the "buy-out" price, which is the price charged, per megawatt-hour where the supplier fails to surrender sufficient ROCs to cover its RO. Where a supplier opts to pay the buy-out price, the payment feeds into the “buy-out fund” which is redistributed (or "recycled") on a pro-rata basis to parties who surrendered ROCs in the given compliance period.

In response to requests from the renewable energy industry to be given greater long-term certainty, particularly in relation to concerns over the finance-ability of projects whose pay-back time would extend beyond 2010, the Government revised the RO targets in 2006. The revision included introduction of further progressive increases up to 15.4% by 2015, after which time this level would be held until 2027.

For the most recent 'compliance period' (2007/2008), the buy-out price was £ 34.30 / MWh, for the current compliance period (2008/2009) it is £ 35.76 / MWh, and for the next compliance period (2009/2010) it is expected to be £37.19. This price is linked to the Retail Price Index (a national measure of inflation) and is revised annually.

The price of a ROC is the driving force behind the market for renewable energy generation in the UK. Factors determining the price of a ROC are the RO level, buy-out price and the so-called "recycle benefit" as well as the scale of renewable generation deployment in any given year. Electricity suppliers can opt to meet their obligation by paying the buy-out price and the funds accrued in this way are paid to suppliers complying through surrender of ROCs. The less the obligation is met through *bona fide* renewable energy generation, the more valuable a single ROC becomes.

As well as the annual recycling of the buy-out fund, quarterly auctions of ROCs are held by the Non-Fossil Purchasing Agency offering the opportunity for electricity suppliers to buy ROCs rather than opting for the buy-out route.

Market Incentives – Other Benefits and Incentives

The Climate Change Levy (CCL) was introduced in April 2001 and is essentially a tax on business and public sector energy users in the UK. Electricity generated from renewable sources is exempt from this tax which adds a value of up to £ 4.3 / MWh to such electricity.

The Marine Renewables Deployment Fund (MRDF) was announced in August 2004 by the Secretary of State for Trade and Industry with a budget of £50M. The MRDF has four components, the Wave and Tidal-stream Energy Demonstration Scheme, environmental research and infrastructure support. The wave and tidal-stream energy demonstration scheme provides capital grants and revenue support to multi-device early stage commercial generation facilities using technologies that have completed their R&D and are ready to move into a commercial environment.

The Marine Renewables Proving Fund (MRPF) aims to accelerate the leading and most promising marine devices towards the point where they can qualify for the Governments existing Marine Renewables Deployment Fund (MRDF) support scheme and, ultimately, be deployed at a commercial scale under the standard Renewables Obligation. The scheme will lead to faster progress in the marine energy sector and lower risk investment propositions for the private sector - driving the industry towards large scale deployment. This new £22.5m initiative is designed and managed 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, with the rest to be matched by technology developers and their partners.

The Satire Prize is a Scottish challenge that will award £10M to the team that can demonstrate a commercially viable wave or tidal energy technology that achieves a minimum electrical output of 100 GWh over a continuous 2 year period using only the power of the sea.

Regulatory Framework

The following laws and programs are particularly relevant for wave projects in the United Kingdom:

- Energy Act 2008

- Energy Technology Institute – Marine Program
- Marine Research Development Fund (MRDF)
- Energy Act 2004

The Energy Bill became law in 26 November 2008 and it contains legislative provisions required to implement UK energy policy following the publication of the Energy Review 2006 and the Energy White Paper 2007.

The Marine Programe launched by ETI is a technical programs in "Offshore Wind", "Wave and Tidal Stream" Energy and "Distributed Energy" and brings together UK government and industry.

The MRDF provides a package of measures central to which is the "Wave and Tidal Stream Energy Demonstration Scheme". This provides capital grants and revenue support to multi-device early stage commercial generation facilities using technologies that have completed their R&D and are ready to move into a commercial environment.

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3.2.8 *United States*

Policy Drivers

Currently, electricity demand in the United States is met primarily by coal (45%), nuclear (21%), natural gas (21%), conventional hydroelectric (8%), plus a variety of other sources including renewables, which account for approximately 3% of the total demand. The renewables sector is led by wind, which comprised slightly less than half of the generation during the past 12 months [3.2.27].

Political support for renewables development in the US has had a somewhat boom-and-bust history, with federal incentives available on an inconsistent basis. This restrained the wind energy sector to some degree both in terms of project and supply chain development. Recently, federal support has become more stable and the wind sector has seen dramatic growth as a result.

There is good support for renewables development in the US, both from the Obama administration and in congress. That said, there is no national target or mandate for renewable energy contributions; however several States have placed requirements on their electricity providers. This has resulted in increased growth in renewables development in or near these States.

Renewables development in the United States is driven at both the state and federal levels. At the state level, these drivers include renewable portfolio standards, feed-in tariffs, grants, and tax incentives and credits. At the time of writing, the US House and Senate are both considering bills

that contain some form of renewable portfolio standard calling for at least 15% of the country's electricity to come from renewable sources by the year 2020. While this legislation is still under discussion, it highlights the increased attention that is being paid to renewables. Should such a bill become law, it can be expected to lead to significant growth across the renewables sector.

Market Incentives

President Obama signed the American Reinvestment and Recovery Act of 2009 (ARRA) into law on February 17, 2009. This law extends the production tax credit (PTC), which has been a valuable tool for the wind energy industry, for three years. More importantly to the marine renewables industry, it provides a project developer with the option of taking advantage of the federal business energy investment tax credit (ITC) instead of using the PTC. In addition, a third option – a grant from the US Treasury Department – was also included [3.2.28]. These options provide a younger technology, such as wave and tidal, with increased options for lowering the cost of early deployments.

The federal renewable electricity production tax credit (PTC) was first enacted in 1992, primarily to support the growing wind energy industry. This credit has been renewed periodically and has now been in effect continuously since 2005. The PTC is applicable to companies that pay federal corporate taxes and is in effect for the first 10 years of electricity production. Its value is indexed for inflation and is currently worth approximately 1.1 ¢/kWh ($11/MWh) for marine and hydrokinetic projects (the value varies by technologies). Currently, this credit applies to a variety of renewable technologies. For marine renewables, including wave, projects with capacities of at least 150 kW that are brought on-line by the end of 2013 are eligible for the credit [3.2.28]. This deadline may be extended in the future.

The recently enacted ARRA also provides the option for projects eligible for the PTC to elect instead to utilize the ITC or a cash grant. The ITC could be applied to up to 30% of the eligible cost basis. The same timeline assigned to the PTC has been also applied to the ITC as well.

The ARRA also introduced a third option for PTC-eligible projects – a US Treasury grant. As with the ITC, the amount of this grant can be as much as 30% of the eligible cost. Applications are currently being accepted and must be submitted by October 1, 2011 to qualify [3.2.29].

Also included in the ARRA is the Advanced Energy Manufacturing Tax Credit (MTC). This production incentive, which has a total budget of $2.3 billion and can provide a 30% investment credit for manufacturing projects that result in the production of electricity from renewable resources. Applications for this credit are being accepted from August 14, 2009 through October 16, 2009 [3.2.30]. While the application window is small and may not be directly relevant to the reader, this credit illustrates one of the primary objectives of the ARRA, incentivizing jobs and infrastructure related to renewable energies.

In addition to the federal incentives, several states including Oregon also offer their own incentives. The state of Oregon provides an incentive for investment in energy sustainability, conservation, and renewable energy projects. It is specifically targeted at device and system developers. Oregon's Business Energy Tax (BETC) applies to a broad range of renewables, including wave and tidal energies, and provides up to 10% of the eligible costs for up to 5 years [3.2.31, 3.2.32].

Regulatory Framework

The framework within which wave energy projects are regulated in the US is slowly taking shape. Historically, offshore oil and gas facilities have fallen under the oversight of the US Dept. of the Interior's Minerals Management Service (MMS), while non-federal hydro-electric facilities have been regulated by the Federal Energy Regulatory Commission (FERC). Offshore renewable energy projects presented the agencies with a dilemma in that there was overlap in their jurisdiction.

FERC and MMS signed a memorandum of understanding (MOU) in April of 2009 [3.2.33] that delineated the shared responsibilities over the leasing and licensing for renewable energy projects on the Outer Continental Shelf (OCS). According to the MOU, and later clarified through a guidance document issued in August of 2009 [3.2.34], MMS controls the issuance of leases for the land required for hydrokinetic projects, while FERC controls the licensing of the projects. The two agencies plan to work together such that FERC does not grand a license until MMS has issued a lease, and vice versa. Further information is presented in a report by EPRI [3.2.35].

3.2.9 *Comparative Summary*

Table 3.2.1 summarizes the information presented in the previous sections for each of the countries examined. It can be seen as a guideline to the support mechanisms that are currently in place to attract investment in the wave energy field and that can thus act as market accelerators.

Country	Main support mechanisms for wind	Main support mechanisms for wave	Legislation / Funds	Wave Test Zones
Australia	• Mandatory Renewable Energy Target (MRET), soon to be replaced by an expanded RET scheme • Quota obligation system with tradable certificates, shortfall charge of $40/MWh	• Same as wind, no specific support scheme for wave	• MRET, RET & CPRS legislation (not yet passed) • EPBC Act • Energy Innovation Fund • Renewable Energy Fund • Renewable Energy Demonstration Program (REDP)	• No dedicated test zone but licenses granted to several developers
Canada	• Ontario feed-in tariff for off shore and on shore projects: 0.135 and 0.190 $CAD/kWh	• Ontario feed-in tariff for waterpower projects: between 0.131 and 0.121 $CAD/kWh	• Canadian Clean Energy Fund • Ontario Green Energy and Green Energy Act	• No dedicated test zone
Chile	• Obligation of all electricity supplies to have a portfolio of renewable energy plants (solar, wind, wave, tidal, biomass) excluding large hydro which account for 5% (until 2014) of the total portfolio followed by annual 0.5% increases until 2024 (reaching 10% in 2024).		• General law for electrical services (Ley General de Servicios Eléctricos)	• Priority areas identified in GH study commissioned by the Inter-American Development Bank for the Ministry of Energy
Ireland	• Renewable energy feed-in tariff guaranteed for 15 years • Average price for onshore wind in 2006 was 57 €/MWh	• Fixed feed-in tariff (220 €/MWh)	• Renewable Energy Feed-in Tariff (REFIT) • Sustainable Energy Incubator Program	• Galway Bay • Mayo full scale test site (5 MW)
Portugal	• Tendering procedures • Feed-in tariffs combined with investment incentives • Average price for onshore wind in 2006 was 74€/MWh	• Fixed feed-in tariffs guaranteed for 15 years (131-260 MWh)	• Decree-Law 33A/2005 • Decree-Law 225/2007 • Decree-Law 5/2008 • Decree-Law 238/2008	• Pilot Zone (320 km2, 250 MW)

Country	Main support mechanisms for wind	Main support mechanisms for wave	Legislation / Funds	Wave Test Zones
Spain	• Feed-in tariff guaranteed for project lifetime (20 years): • Years 1-20 (78.18 €/MWh) or Premium (31.27 €/MWh) • There is a "cap" of 90.69 €/MWh and a "floor" of 76.10 €/MWh for the market price plus Premium scheme	• Similar to wind but project lifetime above 20 years: • Years 1-20 (73.56 €/MWh) or Premium (41.05 €/MWh), • Year 20 onwards (69.505 €/MWh) or Premium (32.671 €/MWh) • Optional increased tariff for demonstration projects	• Royal Decree 661/2007 • Royal Decree 1028/2007 • Spanish R&D National Plan	• Bimep (20 MW) • Idermar
United Kingdom	• Green certificate system (ROCs) • Quota obligation system with tradable green certificates • Electricity from renewable sources are exempt from the climate change levy on electricity (4.3 £/MWh) • ROC average price for April 2006 was £40.6	• Similar to wind but 5 ROCs/MWh for electricity generated by waves in Scotland	• Energy-Act 2008 • Energy Technologies Institute • Marine Research Development Fund • Energy Act 2004	• Wave hub • EMEC
United States	• Production tax credits (11 $/MWh) • Investment tax credits (up to 30% eligible cost basis) • Optional grant instead of ITC		• No direct mandates that apply to hydrokinetic • ARRA 2009 extended the PTC and ITC • DOE grants • Project support from US Navy	• PG&E's WaveConnect project in planning stage • NNMREC's mobile ocean test berth (2011) at OSU

Table 3.2.1 Comparison of the market support mechanisms for different countries

4 SITE SELECTION METHODOLOGY

Once a region has been identified as being suitable for the development of a wave energy market a site selection exercise is required to identify the most promising areas for development taking into account not only the resource but other constraints that may apply.

This section outlines a methodology that may be applied to such a site selection exercise based on similar work conducted by GH in a recent study for the Chilean government and others in Portugal.

4.1 Background

Experience in zone and site selection exercises is mostly focused in European countries, where project developers and local governments are promoting the development of wave energy conversion technologies. Project developers typically address site specific exercises from the start whereas local governments tend to initiate the selection process by searching for considerably larger areas (or zones), which may be used for demonstration, pre-commercial and commercial projects, promoting the development of innovation or technology clusters.

One of the European countries where a significant number of site and zone selection studies have been developed is Portugal. The Wave Energy Centre has conducted a study1 to identify the most suitable areas for development of wave energy projects at a utility-scale, using a non-quantitative approach, i.e. several information layers were compiled in a GIS database but no quantitative ranking was implemented, and thus recommendations limited. A limitation linked with this study is the absence of information regarding access to the National electricity grid, which is minimized due to the country's specific conditions (i.e. the major cities in Portugal, and thus the backbone of the electricity grid, are located close to the shore).

More quantitative approaches can also be found in the literature. One of these reflects a study also applied to the Portuguese coastline2. The authors created a GIS database and defined the study area by removing from the initial scoping area the most limiting constraints (i.e. the decisive factors) such as bathymetry (e.g. shallow sites are associated with lower energy levels), environmentally protected areas or militarily exercise areas. The result is a reduced area (the 'mask') where the projects can be developed and thus where the analysis can be conducted.

The technical constraints are then defined; in this particular study the constraint layers included:

- Distance to coastline;
- Distance to ports;
- Distance to National electricity grid;
- Seabed geology;
- Wave energy resource.

All the criteria above are objective with the exception of the first one (Distance to coastline), as it is unclear which situation is more beneficial to a project. From the technical point of view the priority is to minimize the distance to shore to minimize the costs related to the access to electricity grid and the

[1] Potential and Strategy for the Development of Wave Energy in Portugal, WavEC, 2004 (http://www.wavec.org/client/files/Summary_DGGE_ingl.pdf).
[2] 'Geospatial multicriteria analysis for wave energy conversion system deployment', Nobre et al. (2009), Renewable Energy, Vol. 34, pp. 97-111.

response time for any planned or unplanned O&M. However such objective categories are handled explicitly in the second and third criteria. Furthermore, from the non-technical point of view it can be more beneficial to the project to maximize the distance to shore, to minimize the impacts associated with its development (in particular the socio-economic and the environmental ones).

The next step is related to the reclassification of the masked area. Here the above mentioned criteria are applied to the area of interest by defining the objective function associated with each one. For example, the objective function associated with any of the above distance criteria is to search for the locations that minimize such distance, and the objective function associated with the wave energy resource is to search for the locations that maximize the resource levels. In the Nobre et al. (2009) study the seabed geology attribute was reclassified to reflect the type of seabed (sand being the best suited). The masked area was therefore reclassified from 0 to 100, with 100 being given to the grid point which maximizes the objective function and 0 being the grid point that it is the farthest away from such objective.

Once the constraints are defined and the masked area is reclassified according to the selected criteria, weights needs to be attributed to each of the criteria to obtain a final ranking of the area. This step corresponds to the main subjective component of the process and may lead to different conclusions, according to the sensitivity of the selection process to each constraint. As the reclassification procedure used a scale from 0 to 100, percentages can be attributed to each weight and the final percentage rating will result from the weighted sum of the individual contribution associated with each attribute.

Finally, once the area of interest is ranked, it is possible to zoom in the best suited sites and make objective conclusions regarding the preliminary sites. It is important at this stage to introduce information layers in the database, to assess non-technical constraints or any zone or site specific constraints that may condition the development of projects in the candidate areas. This level of complexity was not included in the Nobre et al. study.

4.2 Examples

Figure 4.2.1 and Figure 4.2.2 illustrate both the Nobre et al. results and also a similar study conducted by GH for the Chilean government. In the latter the decisive factors limited the are under study to the dashed area (between the 50m and 200m depth contours). All the technical constrains are listed in Figure 3.2.2 together with additional information layers that do not contribute to the ranking but allow an assessment of potential conflicts in a high-ranked site.

The application of a similar exercise to Oregon would contribute to the identification of the most suitable areas for wave energy developments; more detailed exercises could then focus specific sites, where site data would need to be acquired beforehand, but the early and preliminary recognition of the most promising areas would allow the start of preliminary activities (e.g. regulatory; mitigation of potential conflicts of use), avoid site speculation and contribute to Oregon’s desire to become a hub for the novel wave energy industry.

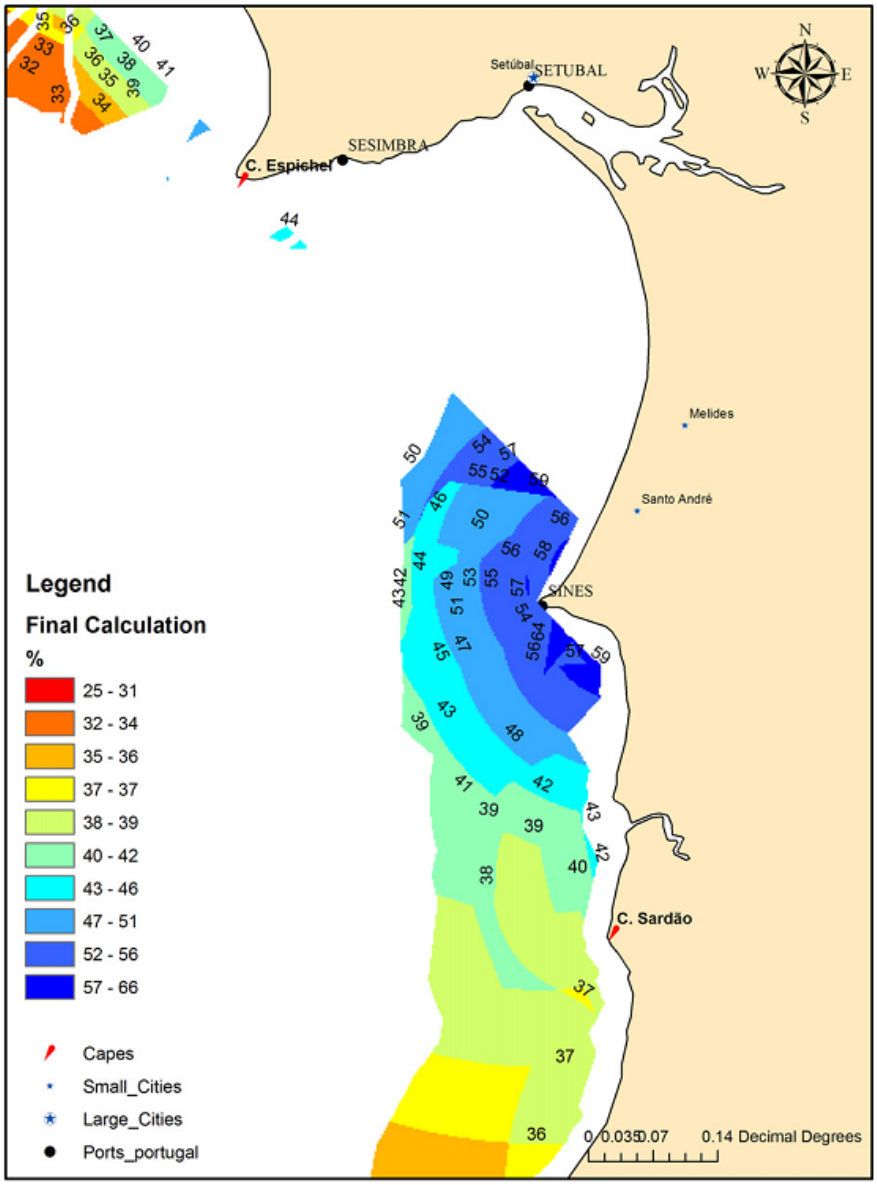

Figure 4.2.1 Example of a site selection exercise using a quantitative approach (Nobre et al., 2009)

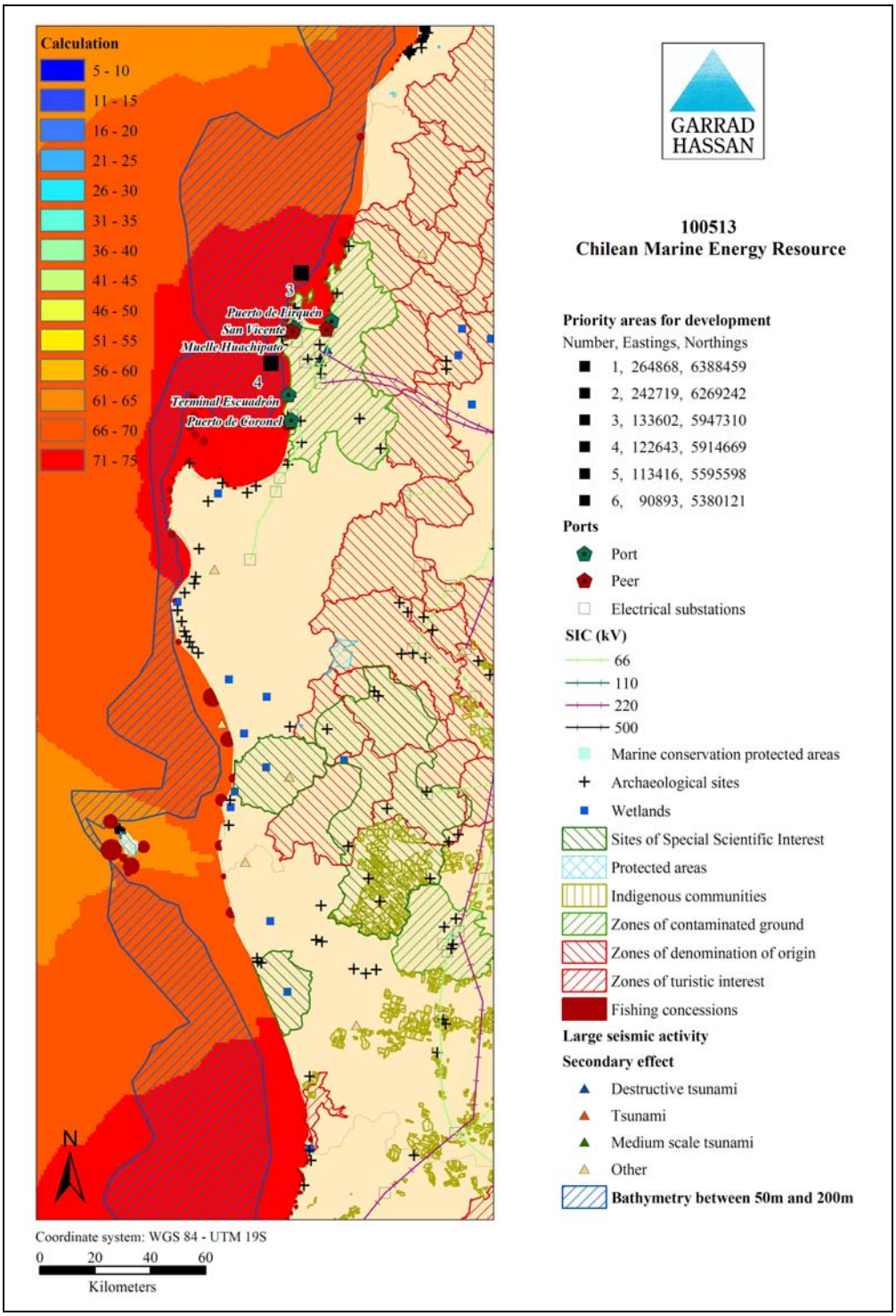

Figure 4.2.2 Example of a site selection exercise using a quantitative approach (GH report 100513)

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