Wave

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4 WAVE

4.1 Resource

Estimates for the amount of potential wave energy in the world range from 1-10 TW. The World Energy Council estimates that a potential 2TW of energy is available from the world's oceans, which is the equivalent of twice the world's electricity production. Whilst the recoverable resource is many times smaller it remains very high. For example, whilst there is enough potential wave power off the UK to supply the electricity demands several times over, the economically recoverable resource for the UK is estimated at 25% of current demand; a lot less, but a very substantial amount nonetheless.

Western Europe is one of the world's leading regions in terms of this natural resource. Key countries include the UK, Ireland, Norway and Portugal. Around the United Kingdom which has half of Europe's total wave resource, the average wave power ranges from 30 to 90 kW per metre of crest width.

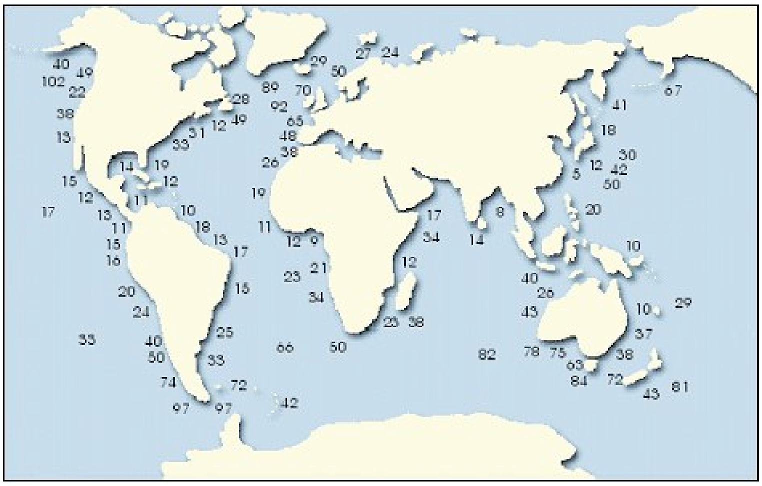

Figure 4-1: Average annual wave power kW/m of crest width

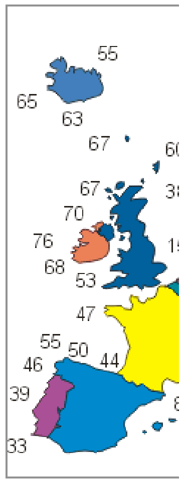

Figure 4-2: European annual average wave crest width

For the UK, waves with the greatest energy are situated off the northwest coast of Scotland, where the power (energy per second) averages nearly 50kW per metre and can reach 90kW per metre. Seas to the west of Cornwall are also high in potential.

Wave power is highest in open seas, as the waves move closer to shore a reduction in wave strength occurs and by the time the wave hits the shore, it is estimated that on average the wave has only a tenth of its original power remaining. To maximise output, therefore, wave power devices should ideally be located about 10km offshore to intercept waves before they begin to lose energy in shallower waters.

Unlike wind energy which is subject to fluctuations over a small time-span, wave power is much more predictable. Another key advantage is that wave power increases at the times of the year when electricity demand is at its highest in Western Europe – during the winter.

Differing estimates of the potential of the world's oceans will continue to be released, but what needs to be borne in mind is that there is a sufficient resource to allow the widespread commercialisation for wave energy. Unlocking that resource is the challenge that hundreds of prototype devices have taken up, and that only very few are making headway towards.

4.2 Development History

Wave energy devices can be split into three categories depending upon their deployment location: shoreline, nearshore, and offshore. Whilst shoreline wave energy converters have been tested for many years and several very successful devices have been installed, the most exciting developments at present are in nearshore and offshore wave energy. Since the first edition of this report the first offshore grid-connected wave energy device, the Wave Dragon, has been installed off Denmark. The move offshore is examined in more detail in section 4.3 below.

In total, there has been close to 300 concepts for wave energy devices to date. This tremendous number of devices demonstrates the difficulty of developing an efficient, reliable and cost effective wave energy converter. Of all the concept devices, fewer than ten are likely to have progressed to a sufficient state to meet commercial demands by the end of the decade.

4.3 Issues

The key challenge facing the wave and tidal industries is for them to prove themselves over the next few years. Within the time period of this report it is expected that several wave energy devices will have progressed through to commercialisation, and be installed in farm-style grid-connected configurations. This development will require significant financial help; if subsidies and other economic aids are not sustained then wave energy will not be significantly developed, simply because of the high costs at present.

Government support, financing and long-term funding are all issues that need to be tackled imminently and then sustained into the future. Whilst it is easy to be optimistic about the sector, there is no escaping the challenges ahead.

The recent Innovations Review, jointly conducted by the DTI and the Carbon Trust was undertaken to identify the barriers to the development and deployment of new technologies. Its findings will be considered within this section.

4.3.1 The Move Offshore

Wave energy is moving offshore. Although a number of successful devices have been installed at shoreline locations, the true potential of wave energy can only be realised in the offshore environment where large developments are conceivable. Commercial wave energy will grow on the back of modular offshore wave energy devices that can be deployed quickly and cost effectively in a wide range of conditions. Multiple unit projects will typify wave energy moving into the next decade, for it is only in this way that wave energy is able to become commercial.

Shoreline wave energy is limited by fewer potential sites and a high installation cost. Whereas a 50 MW wave farm is conceivable offshore, and will in time be realised, no shoreline wave energy converter is able to offer such potential for deployment in this way. Deployment costs for shoreline wave energy devices are very high because they are individual projects and economies of scale are therefore inapplicable. The site specific nature of shoreline wave energy devices is a further barrier to growth in this sub-sector. Ultimately the high kWh price of shoreline wave energy will prevent any conceivable large scale development.

Shoreline wave energy will continue to be relevant, however, as the average unit capacity is generally higher than offshore technology and therefore individual devices can be very effective, especially for remote or island communities where, for example, an individual unit of 4 MW would have a big impact.

In terms of power potential, offshore locations offer more than shoreline locations. The negative side is that devices in offshore locations have more difficult conditions to contend with. Shoreline technologies have the benefit of easy access for maintenance purposes, whereas offshore devices are, in most cases, more difficult to access. Improving reliability and accessibility are, therefore, important considerations for the multitude of devices in development that are aiming for a commercial future.

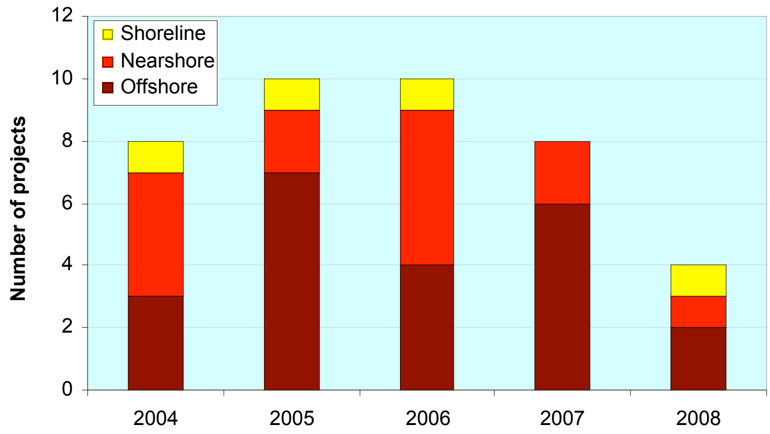

Figure 4-3: Number of projects by location

Table 4-1: Number of projects by location

No. projects	2004	2005	2006	2007	2008	Total
Shoreline	1	1	1		1	4
Nearshore	4	2	5	2	1	14
Offshore	3	7	4	6	2	22
Total	8	10	10	8	4	40

Although projects to date have been small with few grid connected, as the period progresses more and more projects will need a grid connection. A further advantage of shoreline devices is easier access to the grid. Offshore, this is more troublesome and costly although not prohibitively so.

Table 4-2: Wave energy location comparison

	Shoreline	Nearshore	Offshore
Power potential	Low	Medium	High
Connection	Easy	Hard	Hard & expensive
Servicing	Low	High	Very high
Maintenance	Low	High	Very high
Opex	Low	Medium	High
Capex	Low	Medium	High
Conversion method	Turbine/generator	Turbine/generator	Turbine/genset or direct drive

Despite the problems facing offshore wave energy development, it is forecast to be the most promising sector over the 2004-2008 period and indeed into the long-term future. It is anticipated that shoreline devices will grow in size, but the greater cost, lengthier set-up period, and shortage of sites (due more to market conditions than any shortage of natural locations) will mean offshore wave becomes more important in terms of commerciality and sheer installed capacity when looking forward.

4.3.2 Technology Development

The development process of wave energy can be looked at in three phases. It begins with small-scale prototype devices that typically have a low capacity. Successful devices lead on to larger capacity prototypes, at this stage outside funding from government or private investors is possible for the most promising devices. The final stage, representing the culmination of development is the production of full-scale grid-connected devices that will, in some cases, be deployed in farm style configurations (not applicable to shoreline devices). With wave energy, there have been many hundreds of prototype devices, of which approximately 20 have progressed to the second stage. At this point in time only a quarter of these are close to entering the final stage and commercial deployment.

Despite the fact that a number of wave energy devices are getting closer to full-scale deployments, the fact remains that little real-world operational experience has yet been gained. Large-scale demonstrations are required in order to test survivability and efficiency issues that have not yet been resolved. It is difficult to assess potential of a system until it is tested in its final state. Leading devices in the wave (and tidal) industries have implemented programmes that slowly but publicly build up to commercial scale deployments (Pelamis, Stingray, etc.).

Statistically speaking, a tiny proportion of all wave energy concepts are realisable to a commercial level. Drawing together resources will ensure that the devices that do progress stand the best chance possible of succeeding. The SME dominance of the sector is a barrier to development, as limited resources in many cases limit progresss. These small companies are, in most cases, unwilling to collaborate as they naturally wish to protect their investment. A more active role by regional and national organisations can aid this necessary cohesion, such as the move by the British Wind Energy Association to take wave and tidal energy under its wing.

4.3.3 Financing

Finance and market incentives are extremely important to the developing wave and tidal industry. Although there are a huge number of concept devices being planned worldwide, the only ones that have made any real strides towards a commercial end product are those that have had significant funding through shareholders or government grants. Investment in technology is crucial, but so is the market subsidies and guaranteed purchase prices available to developers looking to install their devices in a grid-connected location. Portugal has historically proved a popular location for wave energy developers with many companies considering testing prototype devices there. A 12 year index-linked tariff of 0.235/kWh offered to wave power projects offers a major incentive (although it is limited to the first 20 MW of generation only).

In the UK it is felt that there is a need for either capital grants or feed-in tariffs to help establish a more confident market place for emerging wave technologies. Bringing these measures into the present Renewables Obligation could push wave (and tidal) forwards. A 'wet' equivalent of the ROC is being called for by both the wave and tidal industries because the current system is a market-led mechanism which favours wind as the most economic current technology.

The Renewables Innovation Review found that a number of possible mechanisms for supporting wave (and tidal) projects at a pre-commercial level exist, including capital grants, fixed power purchase type arrangements and amendments to the Renewables

Obligation system. Compatibility with the existing Renewables Obligation was found to be an issue for any option other than a capital grants system. Adopting a long-term view of the sector, a capital grants scheme may be required to fully stimulate wave and tidal market entry.

The technical risks of the sector can be reduced by increased research and development work, but this requires funding that can be hard to find because the industry is still largely unproven. This chain can be broken by the government displaying confidence in wave energy. The risks potential investors face need to be offset.

Without strong signals from government there is a danger that UK wave technologies could increasingly head for foreign countries in a search for more attractive market conditions. It is known that a number of key developers are already shifting their focus to the rest of Europe and beyond.

4.3.4 Leading Technology

Taken as a whole, the potential wave energy industry has a very high number of conceptual technologies striving for success, very few of which will progress through to the ultimate goal – that of commercialisation. At the present time Ocean Power Delivery are viewed as the market leader for the future five-year period, having a product that is already at an advanced stage that can be easily installed in farm style configurations and that is cost effective. Pelamis wave farms will be installed by 2008. By partnering with established wind farm developer Wind Prospect, and forming Ocean Prospect, the Pelamis technology is extremely well poised for projects off the UK and abroad.

4.4 Project Examples

Ocean Power Delivery - Pelamis

Ocean Power Delivery was founded in 1998 in Scotland to develop the Pelamis concept. The Pelamis wave energy converter is a long thin semi-submerged device which is flexibly moored so that it is always orientated head on to the oncoming waves.

The Pelamis is made up of five cylindrical segments connected by hinged joints. The wave induced motion on these sections is resisted by hydraulic rams which pump high pressure fluid through hydraulic motors via smoothing accumulators to drive electrical generators. The power is fed through a cable to a junction on the seafloor where a single cable carries the electricity to shore. The first full-size Pelamis has a rated capacity of 750 kW, although subsequent advancements in the technology may allow a 1 MW+ model to be developed in the future.

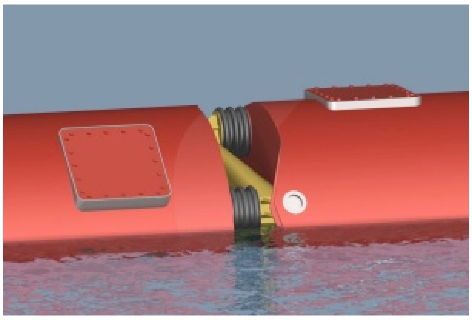

Figure 4-4: Pelamis joint

Picture: Ocean Power Delivery

Off The joint configuration induces a tuneable, cross-coupled resonant response which greatly increases power capture in small seas. Control of the restraint applied to the joints allows this resonant response to be 'turned-up' in small seas where capture efficiency must be maximised or 'turned-down' to limit loads and motions in survival conditions.

After two sets of successful sea trials, Ocean Power Delivery’s first full-size, pre-production prototype rated at 750 kW is due to be installed at the UK Marine Energy Test Centre off Orkney, Scotland, in June 2004. It will generate electricity to the grid through the Test Centre’s offshore cable to shore. The Pelamis is 150 metres long, has a diameter of 3.5 metres and a weight of approximately 700 tonnes. It was constructed by Scottish engineering company Ross Deeptech, who have considerable offshore oil and gas experience. The machine was completely assembled and fabricated in Scotland with over 90% of the machine’s content being sourced from the UK.

Figure 4-5: Pelamis wave farm

Picture: Ocean Power Delivery

The ultimate goal of the company is to develop Pelamis wave farms. By installing multiple units together, infrastructure, installation, and operations and maintenance costs are dramatically reduced, making the Pelamis a viable concept. A possible configuration for a Pelamis wave farm is shown below. In this case, 39 off 750 kW Pelamis devices are connected, which installed in a location with a wave resource of 50 kW/m (there is no shortage of such locations off the British Isles), would produce more than 100 GWh per year. A farm such as this would take up one square kilometre. A comparable offshore wind farm, using top of the range 5 MW turbines, would take up at least 50% more sea surface area.

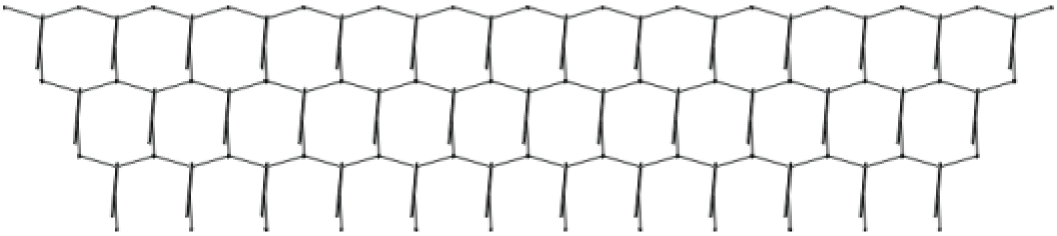

Figure 4-6: Possible configuration of a Pelamis wave farm

Picture: Ocean Power Delivery

OPD believe that the first Pelamis wave farms would have an approximate electricity generation cost of 4.3p/kWh, making them an attractive proposition. By the end of the decade, however, the company is confident that the price will have dropped to 2.5p/kWh, making the technology extremely competitive, not only with other renewables, but also with more traditional energy sources. The technology has progressed rapidly and the Pelamis is now the leading wave energy device.

In conjunction with wind developer Wind Prospect, OPD are planning a Pelamis wave farm off Cornwall. Although exact specifications are not finalised, the developers are looking at a total capacity of or above 50 MW. Two sites are under consideration for the project and consultations have begun with the Ministry of Defence.

This partnership between the two companies, known as Ocean Prospect is an interesting development as it brings together OPD's market leading technology with the knowledge and experience of a major onshore wind developer.

The company is also developing a multi-megawatt Pelamis farm off Portugal. Portugal is a popular location for wave and tidal projects; its excellent wave resource coupled with a 12 year index-linked tariff of 0.235/kWh is very attractive to developers. In April 2004, OPD won a £100 million deal to supply Enersis with Pelamis technology for a project in the Bay of Biscay. The deal came about after Enersis were awarded 20 MW of grid capacity to build a wave farm. The first phase of the project, timetabled for 2005, would be 3-5 MW in size, with future phases possible.

Ocean Power Technologies - PowerBuoy

US company Ocean Power Technologies (OPT) is the developer of the PowerBuoy, a wave energy converter with a potentially strong future. Several demonstration installations are already planned for the next two years (detailed below). The company recently floated on the London Stock Exchange to raise £25 million to establish a UK operation.

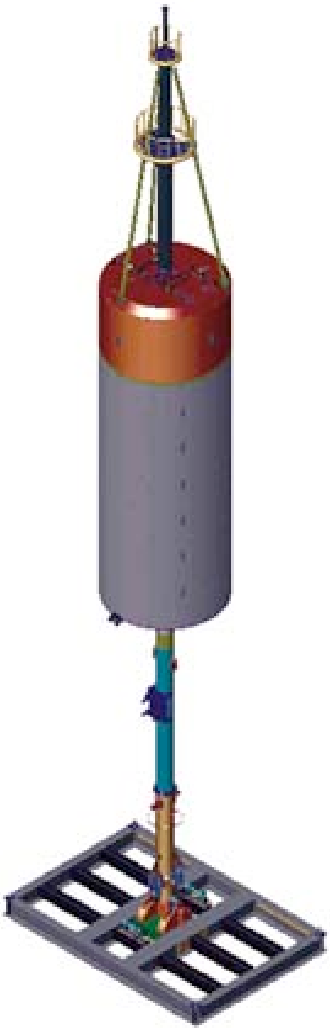

Figure 4-7: PowerBuoy

Picture: Ocean Power Technologies

The PowerBuoy is based on a simple concept: as the waves rise and fall, a piston moves inside the PowerBuoy driving a generator located at the base of the structure on the ocean floor. The generated electricity is carried to shore using subsea cables. Fixed to the seabed using a proprietary anchoring system, the main body of the PowerBuoy is fully submerged. A mast protrudes from the top of the device and is fitted with marking lights and navigational aids.

Whilst the prototypes to date have a low output, OPT plan to increase the PowerBuoy's output and install them in multiple unit configurations. A 1 MW system off Hawaii could have a generating cost of 7-10 cents/kW. A 100 MW system on the other hand, consisting of many PowerBuoys installed in a farm-style development could have a generating cost of 3-4 cents/kWh according to OPT. If such a target could be met, the PowerBuoy's future would be assured. OPT have stated that the wave energy in a 16 by 16 km area of ocean would be sufficient to power California. Sites suitable for PowerBuoys include those with water depths between 35 and 100 metres, located between 1 and 8 kilometres offshore.

OPT have a $9.5 million contract from the Office of Naval Research to test if their PowerBuoy technology can efficiently generate the electricity for Marine Corps Base Hawaii-Kaneohe. Hawaii has the highest recorded wave power in the world and the waters are otherwise famous for their excellent surfing properties.

For the first phase of the project a PowerBuoy was installed in November 2003 one mile off the housing area of the base. The 12 metre long PowerBuoy has an average output of 20 kW and a peak output of 50 kW, which is enough to serve between five and eight homes. A second device will later be deployed and they will be tested for a period of at least two years before a decision is made to expand the project for permanent use. Ultimately, it is envisaged that a 1 MW configuration of PowerBuoys will be installed which could be made up of ten 100 kW machines.

In conjunction with Woodside Petroleum, Ocean Power Technologies have installed a 20 kW PowerBuoy nearly 2 km off Portland in the Bass Strait. Although only a single unit will be installed initially, more of the devices will join it to take the capacity to around 1 MW.

Wavegen – Limpet and Osprey
Scottish company Wavegen was established in 1992 by Professor Alan Wells, inventor of the Wells Turbine, and the company can now lay claim to be the world leader in wave energy technology. The company is nearing the next progressive level with its technology, that of commercialisation.

Figure 4-8: Limpet

Picture: Wavegen

Wavegen became the first company in the world to install a full-sized grid-connected wave energy generator in 2000 when it completed the Limpet on Islay off Scotland's west coast. The Limpet is a shoreline wave energy device which uses the oscillating water column principle coupled with a Wells turbine. The Limpet is rated at 500 kW and has been operating successfully since installation.

Wavegen's shoreline technology will be installed on the Faroes Islands in the near future. Wavegen has joined forces with the Faroese electricity company, SEV, in a venture to develop a full sized grid-connected station in a project worth over £7 million.

The technology that will be used in the Faroes is based on Wavegen's existing oscillating water column technology. Whilst the Faroes have an excellent wave resource it has not been taken advantage of to date because of the high cliffs that surround the islands. Overcoming this natural barrier to development, tunnels will be cut into the cliffs on the shoreline to form the energy capturing chamber. The unobtrusive and well protected design offers a new approach to shoreline wave energy conversion.

Wavegen is also developing the Nearshore OWC technology, and is in negotiations over two potential projects off Spain. The Nearshore OWC rests directly on the seabed and is designed to operate in the near-shore environment in a nominal mean water depth of 15m. Optimum performance will be achieved when driven by a long ocean swell generated over a fetch of more than 400km.

In extreme storms the incoming power will be greater than the device capacity and the automatic control system will cap power generation at the maximum rating. The pneumatic power of the Oscillating Water Column (OWC) is converted to electricity by a Wells turbo generator and specially designed induction generators. Power is brought ashore by subsea cable.

Wave Dragon A/S – Wave Dragon
In summer 2003, the Wave Dragon became the world's first operational grid-connected offshore wave energy device when it was installed at Nissum Bredning off Denmark. Installation had been previously attempted in March, but fierce conditions dislocated the two wave reflectors, resulting in postponement of the installation.

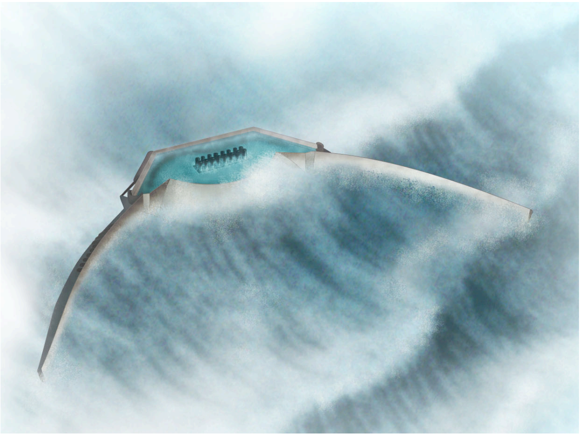

Figure 4-9: Wave Dragon visualisation

Picture: Wave Dragon and Earth-Vision

The Wave Dragon is a slack-moored device which works on the overtopping principle. Two wave reflectors focus the waves towards the ramp, where water overtops into a reservoir. The pressure head in the reservoir is converted into power through a number of variable speed axial turbines and permanent magnetic generators, when the water in the reservoir flows back into the sea.

The prototype Wave Dragon that has been installed has an output of 20 kW. The device is meant only as a test platform and its capacity is not comparable to a full commercial Wave Dragon.

Three different models are proposed for the different levels of wave resource that are prevalent off Europe. The lowest capacity is 4 MW for a Wave Dragon designed for the North Sea. The developers expect that a Wave Dragon designed for deployment in the Atlantic would have a capacity of 7 MW. For the waters off the UK, the company want to ultimately develop an 11 MW machine which would have a 14,000 m^3 reservoir and weigh 54,000 tonnes.

In September 2003, six additional turbines and generators were installed on the Wave Dragon. The additional turbines will allow power to be increased by approximately 20%. Later in the year the Wave Dragon will be towed to a second test site where the wave resource is more intense. The device will be tested here for two years to enable the developers to gain as much knowledge and experience as possible before embarking on the next stage in the Wave Dragon's evolution.

Figure 4-10: Wave Dragon prototype offshore in Nissum Bredning

Picture: Wave Dragon and Earth-Vision

The development company Wave Dragon ApS plans to enter into full commercialisation from 2006. The company has begun negotiations into various sites off Europe.

In December 2003, the company announced it had set up a UK subsidiary and has plans to install a 7 MW machine off the UK coastline (either the southwest or south Wales) in 2006. The Wave Dragon will be grid connected and sites are being considered with water depths of 30 metres.

4.5 Prospects and Forecasts

Within the following market information future projects have been classified using an assigned status, which reflects the evaluation of the current development phase of projects and their likelihood of success. Not every project will become reality and it is important to note the difference between **potential** future projects (prospects) and **forecasts** of expenditure and capacity. The potential is an indication of the market if all projects become reality, whereas the forecast reflects a view of those future projects that will become operational. Forecasts by their very nature are lower than the potential.

A full description of the forecasting process can be found in the Global Market Forecast chapter of this report.

It is important to note that a number of the projects will not be grid-connected. This especially applies to early projects, the majority of which are for prototype devices. Grid-connected commercial projects will increase in number towards the end of the period. Also, many of the early devices are prototypes, not destined for long periods of operation, and may be removed after a period of months.

The Renewables Innovation Review demonstrates that now is a crucial time for wave energy in the UK because of the number of devices that are at, or close to, the demonstration phase such as Ocean Power Delivery's Pelamis technology. It is now that these devices need to be proven both technically and commercially viable. The Review foresees the phased development of grid-connected farms within six years after which the industry would enter into a commercial phase. This timeline is dependent upon financing options outlined within the Review, and even at the commercial level, market entry is likely to require further capital grants equivalent to the UK's round one of offshore wind farms.

The UK was estimated a total resource of 70 TWh/y of wave energy in the Review. This report gives what a forecast of what we believ could realistically be installed within the next five years.

4.6 Forecast Capacity

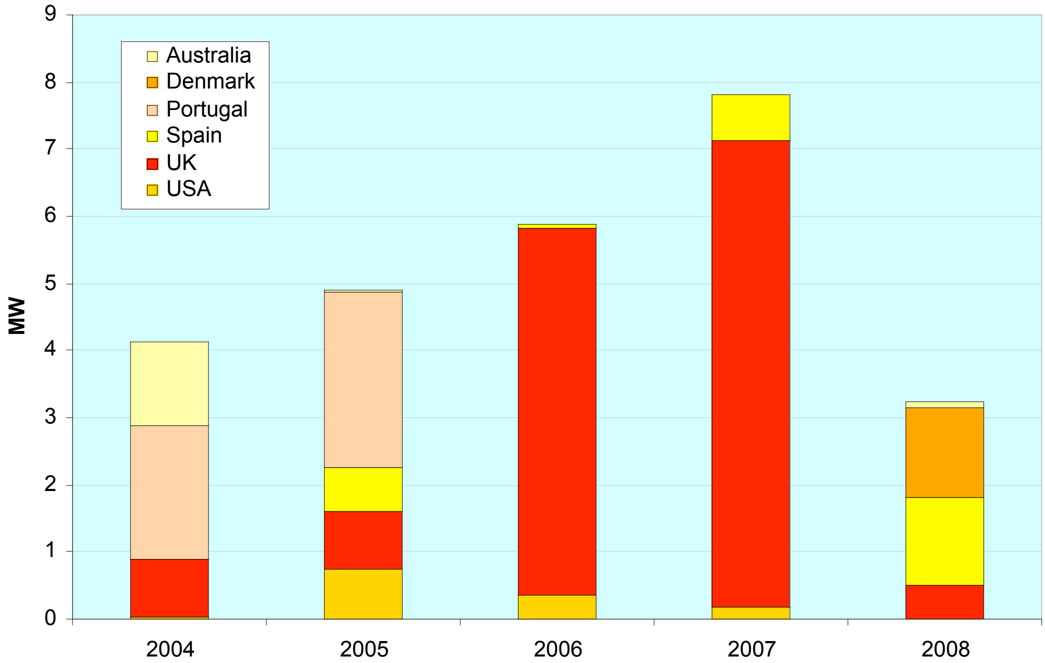

Figure 4-11: Forecast installed capacity (MW)

The UK is forecast to be the dominant player in wave power over the next five-years, with a forecast capacity of 14.7 MW. In comparison with other countries, the UK has forecast capacity every year to 2008, whereas installations elsewhere are more intermittent. Portugal, Spain and Denmark are other significant markets but lag far behind the UK.

The UK's high forecast capacity is a result of a number of advanced wave technologies that have good prospects together with a growing number of prototype devices. The UK government's support has injected many technologies with valuable grants. Coupled with a world class natural resource, the UK could feasibly be the undisputed world leader in wave energy by 2008. Prospects post 2008 are even brighter.

Table 4-3: Forecast installed capacity (MW)

MW	2004	2005	2006	2007	2008	Total
Australia	1.3	0.0			0.1	1.4
Denmark					1.3	1.3
Portugal	2.0	2.6				4.6
Spain		0.6	0.1	0.7	1.3	2.7
UK	0.9	0.9	5.5	7.0	0.5	14.7
USA	0.0	0.7	0.4	0.2		1.3
Total	**4.1**	**4.9**	**5.9**	**7.8**	**3.2**	**26.0**

The fall-off in 2008 is due to the small number of currently identifiable projects. With developers hesitant to indicate future plans beyond the proving of existing devices this is not surprising. As the period progresses developers will negotiate and plan larger-scale projects based on proven technology which could see installation in 2007 and 2008. It is at this time that potential wave energy farms could begin to emerge. When devices are at this advanced stage the prospect capacity will begin to increase significantly. Realistically, large-scale wave farms will not see installation until after 2008.

The UK has a 57% share of the five-year market, eclipsing all countries. Australia, Portugal and Demark are significant, but they look small when compared to the UK. Whilst there are a number of devices forecast for installation in the next five years, the potential of these technologies is not currently as high as those planned off the UK. The US is an intriguing market as there is an encouraging level of interest in wave technology. Government involvement, however, is lacking.

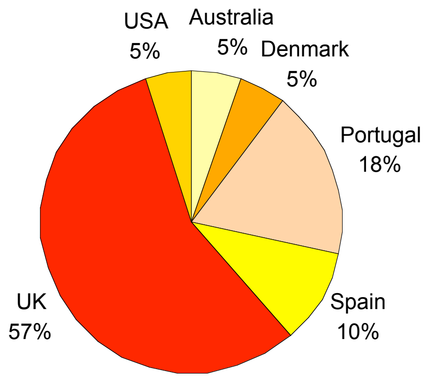

Figure 4-12: Forecast capacity by country

MW by Location

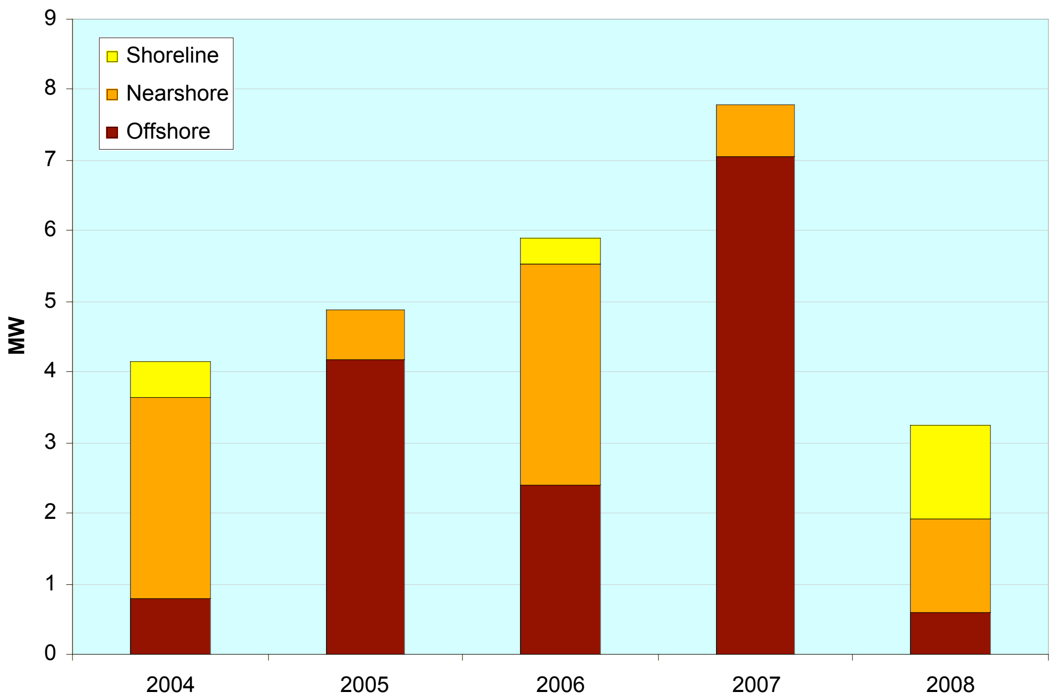

Figure 4-13: Forecast capacity by location

Table 4-4: Forecast capacity by location

MW	2004	2005	2006	2007	2008	Total
Shoreline	0.5		0.4		1.3	2.2
Nearshore	2.9	0.7	3.1	0.8	1.3	8.8
Offshore	0.8	4.2	2.4	7.0	0.6	15.0
Total	**4.1**	**4.9**	**5.9**	**7.8**	**3.2**	**26.0**

Offshore clearly represents the most significant wave energy sector, with 58% of all forecast capacity coming from devices located there. Nearshore devices are significant, making up a quarter of the market. Offshore is so dominant because devices here are typically of a larger capacity than their nearshore compatriots. Although there are a number of established shoreline technologies, there are currently only limited installation plans for the next five-years. The relatively large size of shoreline devices would represent boost the sector's share if projects are announced in the future. The nearshore sector could be boosted if technologies ultimately designed for offshore areas are deployed closer to shore.

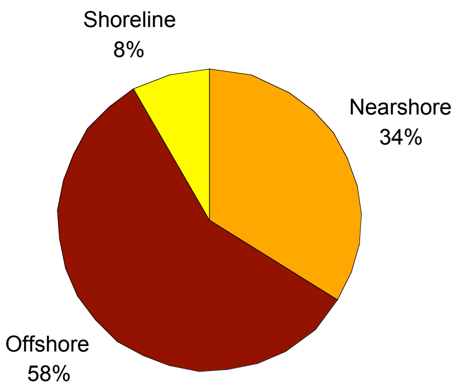

Figure 4-14: Forecast capacity share by location

4.7 Forecast Capex

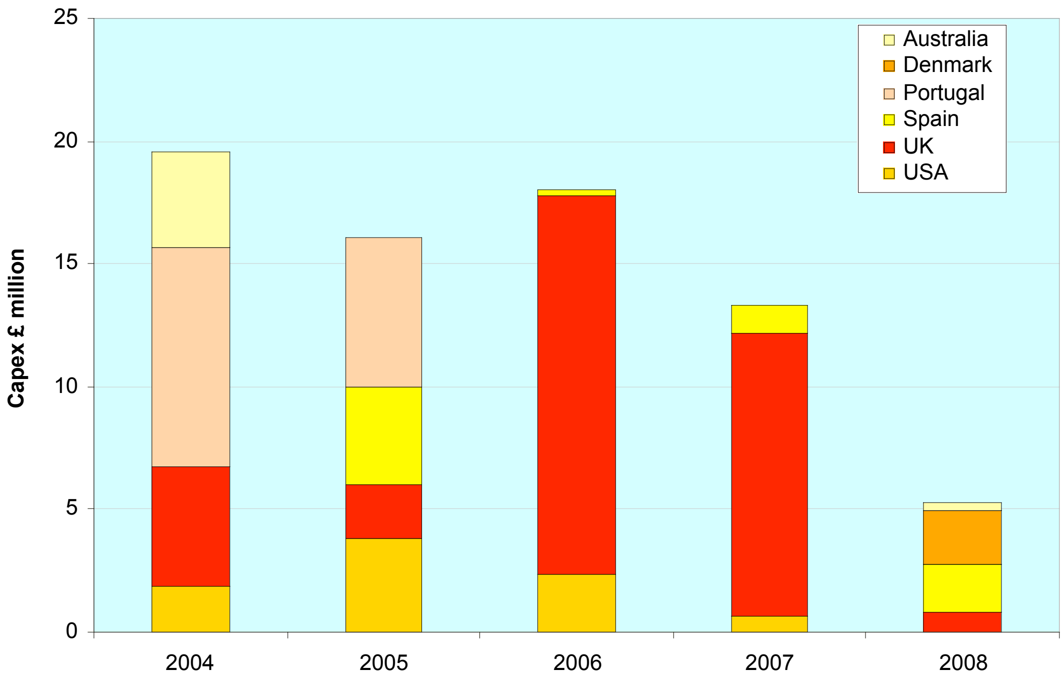

Figure 4-15: Forecast Capex (£m)

Wave energy is forecast to see a total spend of some £72.2 million over the five-year period to 2008. Although spending in 2008 is low, this represents a lack of announced projects rather than a collapse in the industry. It is important to note although there is no growth forecast here, the lack of currently announced projects is largely responsible. As prototypes are developed, plans will be made for offshore installations.

The UK will see a total spend of £34.8 million over the future five-year period, more than all other countries' combined spending. 2006 and 2007 are currently major years for the UK where market share stands at 86% for both.

As time progresses, the initial high costs of development and research will level out, and individual technologies will become more cost effective. Once a device is established, serial production will result in much lower costs. At this stage there are a number of devices that have very promising electricity generation costs forecast which would further benefit their take-up.

Table 4-5: Forecast Capex (£m)

£m	2004	2005	2006	2007	2008	Total
Australia	3.8	0.0			0.3	4.2
Denmark					2.2	2.2
Portugal	9.0	6.1				15.1
Spain		4.0	0.2	1.1	2.0	7.3
UK	4.8	2.1	15.5	11.5	0.8	34.8
USA	1.9	3.9	2.3	0.7		8.7
Total	**19.5**	**16.1**	**18.0**	**13.3**	**5.3**	**72.2**

The UK has a 48% Capex share for the forecast period, more than double the nearest other country. Portugal and the US are the next largest markets, with 21% and 12% market shares respectively.

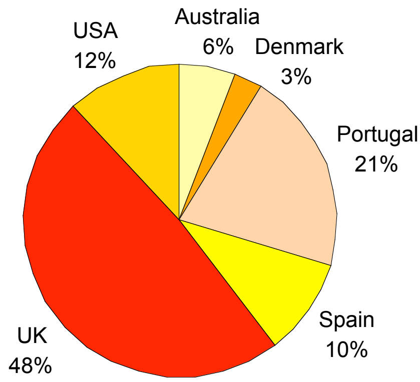

Figure 4-16: Forecast Capex by country