

Responsible Investment

Harnessing the sea



The sea is a vast, largely untapped source of renewable energy. While technologies designed to exploit this resource are at an earlier stage of development than wind and solar, there are signs that the marine energy sector is maturing, with an increasing number of demonstration and commercial-scale projects being initiated. However, despite the many companies involved, direct investment opportunities remain limited for most investors.

Market drivers are strong

Concerns about energy security, climate change, and high energy prices are driving the market for all renewable energies. Governments around the world, including that of the EU and Canada, have recently made commitments (both binding and voluntary) to generate a portion of their electricity from renewable energy and have encouraged investment in this sector through tax breaks, subsidies, etc. Marine energy has, indeed, benefited from these actions, although, to date, perhaps not as much as wind and solar energy.

A smorgasbord of technologies

An astounding array of concepts to extract power from the sea is currently in development across the globe, including those that capture energy from the movement of waves or tides, as well as those from differences in the temperature or salinity of sea water. The primary methods – from tides and waves – are discussed in more detail below.

Tidal energy

Tidal devices capture the energy associated with the natural rise and fall of the level of the sea. There are two main types: tidal stream and tidal range.

Tidal stream – or tidal current – systems make use of moving water associated with the ebb and flow of naturally occurring

tides to power turbines. The turbines can either be fixed to the sea floor or floating, and are configured in a number of different ways (sizes and shapes).

Tidal stream systems need to be located in areas with fast currents. This often occurs where water flows are concentrated between obstructions (for example, at entrances to bays and rivers, around rocky points or headlands, or between islands or other land masses). Good potential sites can be found around the globe, but particularly off the west and east coasts of Canada and the UK, in the straits of Gibraltar and Bosphorus and at numerous locations in Southeast Asia and Australia.

Tidal stream systems are more efficient than wind power systems. As water is significantly denser than air, a single tidal stream turbine can provide much more power at low tidal flow velocities than a wind turbine can at low wind speeds.

The world's first commercial-scale, tidal stream turbine system – the 1.2 megawatt (MW) SeaGen system built by British tidal power developers Marine Current Turbines Ltd (MCT) – is located off the coast of Northern Ireland. It delivered electricity to the UK National Grid for the first time in July of this year. Once operating at full capacity, it will supply enough electricity for the equivalent of 1,000 homes.

In recent months, several other commercial-scale projects have been announced including off the coasts of north Wales, eastern Canada (in the Bay of Fundy), South Korea, and Brittany, France.

The Carbon Trust, a UK-based non-governmental organisation that helps firms develop low-emission technologies, believes that 18 terawatt hours (TWh) of electricity per year could potentially come from tidal stream installations in the UK – about 5% of the country's annual electricity requirement¹.

¹See The Carbon Trust's 2006 report of its 'Marine Energy Challenge'.

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Tidal range devices, on the other hand, make use of the potential energy in the difference in height between high and low tides. Some of these systems involve the construction of a **barrage** (a dam-like structure) across the opening of a tidal basin such as a bay or river estuary. Others involve the construction of artificial **lagoons** on shallow tidal flats. As the tide rises, sluice gates are opened to allow the tide to flow into the basin or lagoon. The sluice gates are then closed. After the level of the sea has dropped (when the tide has gone out), the water behind the barrage or within the lagoon is released. Electricity is generated when the water turns turbines – on its intake and/or release. This technology is very similar to that utilised in hydroelectric power plants.

There are currently only three operating barrage tidal power plants in the world: Rance River in France (the first and largest at 240MW), Bay of Fundy in Nova Scotia, Canada (18MW), and Kislaya Guba in Russia (1.2MW). Globally, numerous barrage projects are being considered, including several options for the Severn tidal estuary in the UK. In October 2007, the UK's Sustainable Development Commission (SDC) published a report that looked at the potential of tidal power in the UK and gave its (somewhat conditional) support to a Severn barrage, despite significant opposition from environmental organisations. A 60MW lagoon scheme covering an area of five square miles located about a mile offshore is currently being considered for Swansea Bay in Wales.

As with tidal stream systems, location is key. Tidal basins with significant tidal reaches (the difference between high and low tides) such as bays and river estuaries are pre-requisites for barrages, as are shallow tidal flats for lagoons. Suitable sites are found in Russia, USA, Canada, Australia, Korea and the UK.

Wave energy

Wave energy devices capture the energy that is stored in waves, which are caused by wind blowing over the surface of water. The amount of energy within a given wave is determined by its height, speed and length, as well as by the density of the water of which it is composed. Wave energy devices are extremely diverse and vary by method of energy capture, location and power take-off.

The best sites for capturing wave power are located in the north and south temperate zones; potential sites have been identified off of the UK and Ireland; the western seaboard of France, Spain, Portugal and Norway; and the Pacific coastlines of North and South America. Southern Africa, Australia and New Zealand are also attractive locations.

The world's first commercial wave farm – the 2.25MW Aguçadora Wave Park – is located in Portugal. The system, developed by Pelamis Wave Power of Scotland, consists of three red tubes or 'sea snakes' (each the size of a small commuter train) linked together and pointed in the direction of the waves. The waves travel the length of the tubes, causing them to bob up and down. A hydraulic system harnesses this movement to generate electricity. The floating system is moored to the seabed and connected to sub-sea electrical cables. There are plans to expand this system by a further 20MW (generating enough energy to power 20,000 homes), as well as plans to build similar wave farms off the north coasts of Scotland, Cornwall in the UK, and California in the USA and buoy-based systems off the coasts of Oregon in the USA and Australia.

The World Energy Council believes that, when fully mature, current wave energy technologies could provide 140-750TWh of electricity per year globally, rising to 2,000TWh/year (about 10% of current global electricity demand) if technological improvements are realised². The Carbon Trust believes that 50TWh could potentially come from wave farms in the UK alone³.

Significant advantages, but challenges remain

Marine energy has many advantages. Similar to solar and wind energy, tidal and wave energies are renewable and 'clean': unlike carbon-based sources of energy, these forms of energy are (at least theoretically) inexhaustible and produce negligible amounts of CO². Most significantly, tides and waves are relatively constant and easy to predict – giving them a major advantage over sun and wind, which are intermittent and erratic.

However, at the present time, marine energy technologies are not without their drawbacks, the most significant being:

- **Negative environmental impacts.** Tidal and wave energy systems are not environmentally benign. All affect the marine ecosystems in which they are placed to some degree, and most are associated with some level of marine animal (fish, seal, porpoises, etc.) mortality. Barrages are particularly problematic, as they can cause conditions that upset the delicate balance of the ecosystem in which they are located including:
 - Phytoplankton blooms due to decreases in turbidity (the amount of matter in suspension in the water).
 - A fall in the average salinity inside the basin, as a result of less water exchange with the sea.
 - Sediment and/or pollution accumulation within the barrage as these are less efficiently dispersed.

² See The World Energy Council's 2007 Survey of Energy Resources.

³ See Note 1.

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- **High capital costs.** The capital costs of marine energy systems are high, as: a) they require materials and technologies that are suitable for harsh marine environments, and b) because of their locations, they are more difficult to install than land-based counterparts such as wind turbines. As they are essentially large infrastructure projects, barrages are more capital intensive than most tidal stream and wave devices (although their running costs tend to be lower). Because of the fact that they may not produce returns for many years, investors may be reluctant to participate in the financing of barrages.
- **Aesthetics.** Many (but not all) marine energy devices are visible from shorelines, and some people oppose them, labelling them 'eyesores'. This is not unlike the opposition faced by some onshore and offshore wind turbines.
- **Shortage of viable sites.** As discussed earlier, marine energy devices must be located in places with favourable tide or wave characteristics. Suitable sites are relatively more limited than those for wind and solar installations.

Limited opportunities for most investors at present

Numerous organisations across the globe are currently developing marine energy technologies. The European Marine Energy Centre has identified over 40 involved in tidal energy and about 70 in wave energy. Some of these organisations are universities; but the majority are private start-up companies, whose technologies are at the early stages of development. At the present time, it is difficult for most investors to gain direct exposure to the sector, as the only publicly traded companies with technologies approaching commercialisation are:

- **Ocean Power Technologies (USA)**, which is installing its PowerBuoy® system in a 1.39MW wave farm off the north coast of Spain.
- **Renewable Energy Holdings (REH) plc (UK)**, which holds the technology patents for 'CETO', a wave energy system that delivers zero-emission electricity and freshwater (through reverse osmosis desalination).
- **Carnegie Corporation Ltd (Australia)** – which is commercialising REH's CETO technology and has the exclusive rights to 100% own and operate all commercial CETO wave farms in the Southern Hemisphere.

Indirect exposure to the sector can be achieved by investing in listed utility or energy companies that have, themselves, invested in the sector (e.g EDF of France, E.on of Germany and Total of France, which have taken stakes in tidal stream system developers MCT, Scotrenewables and Lunar Energy, respectively).

The marine renewables sector looks promising and is likely to present additional investment opportunities as it matures. Many of the sector's current challenges will be addressed by design and technical efficiency improvements, upscaling and component standardisation. However, additional political support – in the form of economic incentives – is critical in order to make this a reality.

October 2008.

Produced by the Insight Responsible Investment Team

Web: http://www.insightinvestment.com/responsibility/investor_responsibility_home.asp
Tel: 020 7321 1162