Introduction

South West England is taking a leading position in marine renewable energy. The region has the potential to generate substantial amounts of renewable energy from its wave and tidal resources and has the skills and facilities to support development of the industry.

Tidal stream energy is already being exploited at Marine Current Turbines 300KW demonstration turbine in the Bristol Channel off Lynmouth. The south west is capable of providing 10-16% of the UK's tidal stream output. The Wave Hub aims to create the world's first wave energy farm off the coast of Cornwall by building an electrical socket on the seabed around 10 miles out to sea and connected to the National Grid via an underwater cable.

Technology

Tidal energy

The regular rise and fall of the tides provides a source of renewable energy powered by the moon and the sun. In order to make use of this alternative energy source we either need to:

- collect the water at high tide, then wait until the receding tide has created a sufficient head and drain the basin through a water turbine to generate electricity, or
- use the kinetic energy of tidal currents to spin turbines directly in much the same way as the kinetic energy of the wind is harvested by wind turbines.

The south west has some of the best tidal stream resources in the UK. The two best areas of tidal resource in the south west are in the Bristol Channel, where there is a large area of tidal stream, although somewhat shallow, and off Portland Bill, Dorset where there are fast currents but the flow pattern is complex.

Tidal power could provide a regular source of energy and, if some form of pumped storage facility were included in a scheme, continuous power would be attainable. This regularity of supply is one of the major advantages of tidal power compared with wind. Another is the greater density of water, as much greater amounts of power could be extracted compared to wind for the same size machine. Despite this, tidal power, unlike wind, is not a common form of power generation. Reasons for this are cost (due to tidal turbines being a recent development), the site specific nature of the resource and environmental concerns about the effects of altering tidal habitats.

Tidal Basins

Leaving aside tidal streams, harnessing tidal power requires holding a large amount of water behind a dam at high tide and letting it out through a water turbine at low tide. The depth of water is very important; the stored energy is not only proportional to the enclosed area, but proportional to the square of the water depth. However, power can also be extracted during the filling of the basin if the incoming water is allowed to flow through the turbines. The whole basin needs to be emptied if possible in a single tidal cycle (approximately twelve hours), therefore a large number of turbines is required, 216 in the case of the proposed Severn barrage, which is described below.

Although none have yet been built, tidal lagoons have been suggested as an alternative to barrages. This system would involve the creation of lagoons within a tidal estuary which fill and empty through tidal turbines. This system avoids the need to impound the entire estuary, but would need very large quantities of aggregate and each lagoon would have a significantly lower output than a barrage across the whole estuary.

Importantly, tidal basins could also operate as pump-storage facilities, with the turbines being used as pumps to increase the water level in the basin for later release. This suggests a natural symbiosis between wind and tidal power. Another possibility is to use multiple interconnected smaller basins. Water could then be pumped between basins and released sequentially in order to even out energy production.

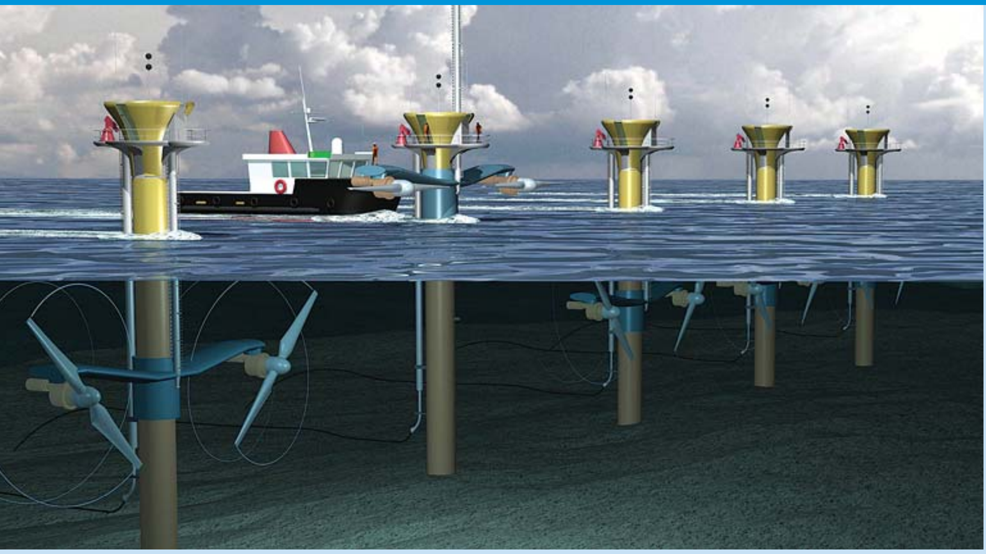
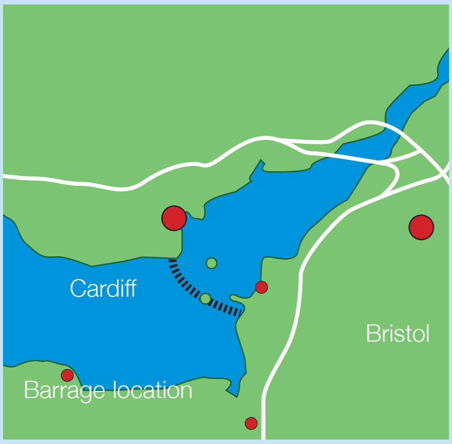


Figure 1.
Artist's impression of the "Seagen" concept, developed by Marine Current Turbines, building on the experience of the "Seaflow" prototype (see below). It shows a row of tidal current turbines, with one of them raised for maintenance. [MCT03].
Image supplied by Marine Current Turbines.

Figure 2.
300kW tidal stream turbine, Lynmouth [MCT03].
Image supplied by Marine Current Turbines.

Figure 3.
Location of the proposed Severn Barrage (dotted line). The barrage is 16 km long [TAY02].



Tidal Stream

It is possible to generate electricity from the kinetic energy of tidal currents near land masses. The general tidal flow is greatly altered by local coastal geography and this leads to higher than average water speeds past headlands and through constrictions. If these tidal streams have a speed greater than about 2.5 m/s (9 km/h) (mean springs peak flow) and are in water with a depth of about twenty to thirty metres, then it is possible to use a device very similar to a wind turbine to produce power (**Figure 1**). there are also a number of other designs. Although the tops of some designs would be visible to shipping, the amount of the structure above the surface would be small and therefore probably less visually obtrusive than an off-shore wind farm close to the coast.

Example Systems

Marine Current Turbines' tidal stream device: 2003 saw the installation of the first large monopile-mounted experimental 300kW single 11 m diameter rotor system off Lynmouth, Devon, UK (**Figure 2**). This is an experimental machine which uses a dump load in lieu of a grid-connection and will only generally operate with a single tidal direction.

Severn Barrage: The proposed project consists of a 16 km (10 mile) tidal barrage and a major road between Lavernock Point, near Cardiff and Brean Down, near Weston-super Mare, and would contain a basin of 480 km^2 (185 square miles) (Figure 3). The scheme uses ebb generation and reverse pumping at high tide to further increase the head and volume of trapped water.

Turbines would be housed in caissons built off-site and towed into position. The design includes 216 turbines rated at 40 MW each, providing a total of 8640 MWe with an annual average output of 17 TWh. Construction is estimated to take seven years, at a cost of £8,283M with an additional £1,230M for strengthening the electricity grid.

Following construction, tidal currents might be half those at present landward of the barrage. This would cause a major change in sediment transportation and hence an increase in primary biological production and food available for birds and fish. Taylor [TAY02] suggests the need for further work into the damage to small life forms caused by the turbines and the design of fish deterrents and passes.

Wave Power

Wave power is an indirect form of solar power, like wind power. Because water has a higher density than air, much higher energy densities are realised, 70 kW per metre of wave front or greater at some sites, and it would in theory be possible to generate all the world's electricity from the world's waves [FES]. The South West has very good wave energy resources particularly the areas exposed to the prevailing westerly ocean swell, broadly the sea area offshore from Ilfracombe to the Isles of Scilly.

Many of the wave power devices prototyped so far would be placed a considerable distance from the shore and therefore would have a very low environmental impact. Even designs which need to be on the seashore are likely to have scant impact on the marine environment or on nesting and feeding bird populations, as they have little effect on the general flow of water around them. The central issue for the development of wave power is not the size of the resource, nor possible environmental impacts, but the problem of harnessing it economically within the harsh marine environment.

On-Shore Devices

As the sea becomes increasingly shallow toward the shore, the speed of a wave will reduce and the energy content of the wave decrease due to friction between the wave and the sea floor. This suggests that only locations such as parts of west Cornwall where deeper water is maintained all the way to the shore line will be suitable for the siting of wave power devices. Such locations are typified by cliffs or rocky landscapes. However as much of the coast is a designated area there is little prospect of onshore or near shore devices being built.

Off-Shore Devices

Off-shore wave energy converters should be able to harvest more energy than their on-shore cousins as the size and reliability of the waves around them will be greater. However installation and maintenance costs are likely to be greater.

There are three basic methods for converting wave energy to electricity:

1. Float or buoy systems that use the rise and fall of ocean swells to drive hydraulic pumps. The object can be mounte to a floating raft or to a device fixed on the ocean floor. The hydraulic pressure is used to turn an electrical generator and the electricity is transmitted ashore by sub-sea cable.

2. Oscillating water column devices in which waves enter a column that fills with water as the wave rises and empties as it descends. The air is drawn in and out of the top of the column through a double-acting turbine. The turbine is connected to a generator and the electricity is sent to shore by sub-sea cable.

3. Tapered channel or "tapchan" systems rely on a shore-mounted structure to channel and concentrate the waves, driving them into an elevated reservoir. Water flowing out of this reservoir is used to generate electricity, using standard hydropower technologies.

Wave Hub

The Wave Hub concept is to build an electrical grid connection point approximately 12 miles off Hayle in Cornwall into which wave energy devices would be connected. It will provide a well defined and monitored site with electrical connection to the onshore electricity grid and will greatly simplify and shorten the legal consents process for developers. Wave Hub would reduce the risk for developers of the first pre-commercial wave machine arrays and could be commissioned by 2008. Four developers are currently negotiating to connect to Wave Hub: Ocean Prospect/E.ON, Ocean Power Technologies, Fred Olsen Ltd and Oceanlinx. For updates on the Wave hub Project go to: www.wavehub.co.uk

Issues |

Visual Impact.

The deployment of both on-shore wave power and tidal barrages would have a clear visual impact. Submerged tidal stream generators or off-shore wave machines much less so.

Ecological Impact.

Many have voiced concern about the impact on internationally important wetland areas of the proposed Severn tidal barrage. How such concerns are considered against the impact climate change will have on such areas is a difficult question. Tidal lagoons not attached to the coast would cause less concern. All marine energy projects, wave, tidal stream or tidal barrage require an Environmental Impact Assessment as part of the consents process.

More Information |

- South West Seapower Report www.regensw.co.uk/publications/seapower/
- The British Wind Energy Association's web site contains much information on marine renewables.
- The Department of Trade and Industry's marine resource atlas (www.bwea.com/marine/atlas.html) allows one to examine where the tidal or wave climate might be suitable for energy generation.
- www.wavehub.co.uk

References |

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