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THE TIDE AS AN ENERGY RESOURCE: AN OVERVIEW

Introduction:

Since the government set out its Renewable Energy plans and claimed that 10% of the UK's energy would be produced from renewable sources the pressure has been on to develop our renewable technology. It has long been noted that the tides offer a huge amount of energy, and that if this power could be harnessed the targets could be easily reached. Worldwide, approximately 3 TW of energy is continuously available from the action of tides although there are insufficient suitable sites to harness this fully.

The power available in any specific location is a function of the square of the tidal range and thus the largest tidal ranges are the most attractive areas for tidal power generation. It is for this reason that the UK boasts the greatest potential for the development of this resource, as some of its coasts are witness to the worlds greatest tidal ranges. The Servern estuary, for example, has a tidal range of over 13 meters during spring tides. In fact, in the Departments of Trade and Industry's last report it was estimated that if the technology was refined, around 20% of Britain's energy needs could be sourced from the tide.

However, most of the required technology mentioned is in its infancy, and although some power has been extracted in an experimental form, the tidal power industry is still at the research and design stage.

There are two main concepts for harnessing energy from the tide. One focuses on tidal streams, utilizing a flow of water to turn underwater turbines, much like a wind turbine, the limitations here are very much technological, though problems also lie with the location of suitable sites. The other method of harnessing tidal energy is through tidal barrages, building a wall along the mouth of an estuary and catching incoming tides much like a hydro damn. The difficulties here a mainly financial, and environmental concerns play there role too.

A new idea has emerged recently, called a tidal lagoon. This is similar to the barrage method, only the damn would be a circular one, built along an estuary and independent from the coastline. This would relieve some of the environmental concerns, but the financial problems still prevent immediate development. Many case studies have been undertaken to prove the feasibility of such a method, and indeed, if tidal energy is going to help the UK meet its renewable obligations then a barrage or lagoon is the only way that the tides will offer a significant advantage.

Marine turbines - seaflow/seagen:

Tidal streams are underwater currents that are caused by the incoming and outgoing tides. They can involve the transport of huge amounts of energy around the world, but locations close enough to land to be feasible for harnessing are limited. But the opportunities around the Scottish coastline are some of the best that the planet has to offer.

Although the technology is still a generation behind the other renewables, such as wind turbines, the development of small scale modular tidal and current stream technologies is progressing rapidly. In the summer of 2002 a device known as the Stingray was deployed in Yell Sound off the Shetland Islands. It had a capacity of 150 kW and it tested successfully. In the summer of 2003 Marine Current Turbines installed its first current stream turbine off Lynmouth in Devon. These tests were also successful and the device was rated at 300 kW. Then September 2003 saw the first grid connected scheme. All these were promising developments, but they were a long way from commercial viability.

At the moment the focus is on improving the present technology and finding ways to develop it into reaching its full potential. Due to the fact that devices are being funded, constricted and installed on a one by one basis many of the issues are project specific. It is felt by some that the most important factor for the immediate future is helping the industry, which is perceived as young and promising, develop sufficient momentum to carry it forward. Researches feel that the a greater level of interest needs to be generated in the sector, which is often overlooked in favour of the attention-grabbing offshore wind market. But in turn, the wind market feels that it is unwise to develop a struggling tidal technology when an investment in a wind farm would provide immediate dividends. The consensus seems to lie with the wind farms, and funding for tidal projects has been limiting.

For these reasons tidal current stream technology is characterised by smaller units than the large-scale tidal barrages. The technologies and devices in operation and planning fall into two groups: tidal current turbines, and tidal stream generators. Operating as devices that are standalone units, they are sometimes deployable individually but can often be organised in farm-style developments featuring multiple units. Tidal current turbines are basically an underwater turbine that uses tidal currents to turn a rotor generating electricity. Tidal stream generators use the tidal stream to generate power from, for example, the raising and lowering of a hydraulic arm. Tidal currents are both predictable and reliable, thus providing an advantage over wind power. Ideal sites are typically around 1km or more from shore with water depths of 20-30 metres.

Another problem is the location of all these projects. Any electricity produced will somehow have to be transmitted to a mains grid. As all the potential sites are not only out at sea, but far away from built up areas, transmission costs will greatly way down the efficiency.

There is little doubt that tidal streams will one day be developed to their full potential, but this development will likely be in stops and starts over the next few decades. A significant contribution to the UK energy supply will only occur when a significant investment of money is made to the technology. This will probably not happen until other renewables, such as wind power, have reached a saturation point and investment in other areas is no longer attractive.

Tidal Barrage:

Tidal energy traditionally involves erecting a dam across the opening to a tidal basin. The dam includes a sluice that is opened to allow the tide to flow into the basin; the sluice is then closed, and as the sea level drops, traditional hydropower technologies can be used to generate electricity from the elevated water in the basin. The energy potential of tidal basins is large, with a facility, in the La Rance station in France generating 240 megawatts of power. However, France is the only country that successfully uses this power source.

Plans to build a tidal barrage on the Severn Estuary have been around since the 1980s It may have over 200 large turbines, and provide over 8,000 Megawatts of power, which is equivalent to over 12 nuclear power station's worth. It would take 7 years to build, and could provide 7% of the energy needs for England and Wales. It has always been mentioned by the government when energy plans are discussed, but the official line has always been to leave it as an option, with out ever suggesting serious development. The debate has also been brought into the House of Lords recently, and again, although interest was shown the project has not been accepted yet.

The problems are mainly financial. Originally costs were estimated at £10-12 billion, and even with engineering improvements, the cost is still £8 billion. It has been suggested that the cost can be ameliorated by added benefits that the barrage would bring. The construction could offer a transport link, acting a bridge across the estuary. It also has potential as a flood prevention barrage, as the government planned to build smaller barrages to protect the area from flooding anyway.

There is also a problem with shipping. The river is home to a thriving commercial and industrial port, and a barrage could prevent the passage of boats. This could be partly solved by a lock, allowing boat in and out much like they would through a canal. There is also the argument that the commercial dock may be improved by a barrage, as it would create a marina environment for smaller leisure vessels.

The environmental implications are probably the most serious problem. The Severn Estuary is being proposed for a special area of conservation and it is used by 50,000 water vole on major migration routes. On these grounds many environmental pressure groups have lobbied against the barrage proposal.

There is also the problem of a low load factor against a high maxim wattage. The barrage would operate with a low load factor but a maximum output of nearly 9.5 GW, so heavy improvement to local grid connection needed. The advantage here of course is that the predictability of tides means it is a predicable energy source. The system can also be used to store energy if pumps were added to the contruction.

Tidal lagoons:

Offshore tidal power generation resolves the environmental and economic problems of the barrage system. It is completely self-contained and independent of the shoreline, basically a circular dam, built on the seabed. Turbines are situated in a powerhouse that is contained in the impoundment structure and is always underwater and power is transmitted to shore via underground/underwater cables and connected to the grid.

The lagoons offer many advantages over a tidal barrage. Firstly, lagoons are cheaper. Building a complete impoundment structure offshore may seem to be more expensive than building a relatively short barrage but the cost per unit output of the offshore tidal power generator is less than that of the barrage. This is because the impoundment structure is built on near-shore tidal flats proximal to the low tide level and avoids deeper areas, whereas the barrage must span an estuary and must cope with whatever depths exist on the site.

Secondly, barrages must generate primarily in one direction (on the ebb tide) in order to minimize disruption and silting up of the head pond. The offshore tidal power generator is free to utilize both the ebb and the flood tides. The environmental issues are resolved as the coast line is not blocked and no migration routes are inhibited.

A feasibility study for a tidal lagoon in Swansea bay has been completed, proving that the technology may be new, but that it is not experimental. An impoundment area of approximately 5Km2 was suggested, predominantly in water depth of 1-5 metres at mean low water springs. The plant would require bi-directional generation turbines Installed hydro-turbine capacity of 60MW and it is anticipated that the generators will operate at a voltage of 11kV and that this will be stepped up to 132KV for the export line to shore. It was concluded that it was practical to install 24 turbines of 2.5MW capacity with runner diameter in the region of 3.3 metres. The annual output of the scheme could then be expected to produce 187,000MWh per year.

It was estimated that it would take three years for the construction to be built, and that the building programme looked practical. As the intent would be to run the power plant as a remote, unmanned station, maintenance costs would be minimal. The life expectancy of the plant would be at least 120 years and so the generation cost would be roughly 3.4 p/KWh. A similar study showed that if a lagoon on the Severn estuary would be much more attractive than a tidal barrage. It could generate 30% more electricity annually from the Estuary at less than half the kWhr output cost of the Barrage. It would also have an impound an area 40% smaller than the Barrage and would not impede shipping to Bristol, Newport and other Severn ports.

Perhaps the most crucial advantage offered by a lagoon is the possibility of a phased approach. As the lagoon scheme consist of many small damns, one construction at a time could be built, thus lowering investment risks and making grants seem less of a gamble.

Conclusion:

Tidal stream technology is a promising development that deserves investment and time. But for the government to reach its renewable obligations the projects are too young to invest in. The only way that the tide can be used to significantly help in the UK's targets would be to use our existing technology. This means building a barrage or a lagoon. A barrage is bound to be contentious and it is unlikely that such a large scale investment will ever be made. There fore it seems that the only available option is a tidal lagoon project. With a possible 3GW of energy estimated as a potential through the building of lagoons, it could prove to be the best chance that the industry has at a significant renewable sector.