The Future of Ocean Power

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Abstract- *Renewable energy can be used to decrease global dependence on natural resources, and tidal power can be the primary form of renewable power utilized. Built upon steam turbine knowledge, tidal turbines draw on innovative technology and design to operate on both the inflow and outflow of water through them. The tidal power plants are capable of producing reliable and efficient power. Problems, such as initial cost and power transportation hinder future implementation of tidal power plants. This paper emphasizes the possibilities of utilizing the power of the oceans by pollution free, tidal Power generation.since india is surrounded by sea on three sides,it's potential to harnesstidal energy has been reconised by Govt. of India.*

Keywords- Tidal power,Blue energy, Ocean energy.

I. INTRODUCTION

The sources for 90% of the electric energy generated today are non-renewable. Natural resource emissions are over 120 times greater than that of renewable emissions. The depletion of the finite resources, environmental pollution, global warming became more apparent near the end of the 20th century. World energy consumption is expected to rise 60 per cent by 2020. In order to meet that demand, while limiting production of green house gases, renewable energy sources considered as an alternative to traditional forms of energy production.

Renewable sources of energy are necessary because the Earth will eventually run out of the resources to create non-renewable energy. There are three types of renewable energy sources: solar, wind, and waterpower. Both solar and wind power are drastically affected by weather variations, while tidal power varies little when the weather changes power. Over the last fifty years, engineers have begun to look at tidal and wave power on a larger, industrial scale. However, until the last few years, wave power and tidal power were both seen as uneconomic. Although some pilot projects showed that energy could be generated, they also showed that, even if cost of the energy generated was not considered, there was a real problem making equipment which could withstand the extremely harsh marine environment.

Tidal energy is an essentially renewable resource which has none of the typical environmental impacts of other traditional sources of electricity such as fossil fuels or nuclear power. Changing the tidal flow in a coastal region could, however, result in a wide variety of impacts on aquatic life, most of which are poorly understood. Tidal are generated through a combination of forces exerted by the gravitational pull of the sun & the moon and the rotation of the earth. This is very convenient because scientist's can predict the electricity production on a daily basis. .

A. Using the Energy of the Ocean:

There are three basic ways to tap the ocean for its energy.

- We can use the ocean's waves,
- we can use the ocean's high and low tides, or
- We can use temperature differences in the water.

Let's take a look at each,

1) Wave Energy

Kinetic energy (movement) exists in the moving waves of the ocean. That energy can be used to power a turbine. In this simple example, to the right, the wave rises into a chamber. The rising water forces the air out of the chamber. The moving air spins a turbine which can turn a generator. When the wave goes down, air flows through the turbine and back into the chamber through doors that are normally closed. This is only one type of wave-energy system. Others actually use the up and down motion of the wave to power a piston that moves up and down inside a cylinder. That piston can also turn a generator. Most wave-energy systems are very small. But, they can be used to power a warning buoy or a small light house.

2) Tidal Energy

Another form of ocean energy is called tidal energy. When a tide comes into the shore, they can be trapped in reservoirs behind dams. Then when the tide drops, the water behind the dam can be let out just like in a regular hydroelectric power plant.

In order for this to work well, you need large increases in tides. An increase of at least 16 feet between low tide to high tide is needed. There are only a few places where this tide change occurs around the earth. Some power plants are already operating using this idea. One plant in France makes enough energy from tides to power 240,000 homes.

3) Ocean Thermal Energy

The final ocean energy idea uses temperature differences in the ocean. This is similar to the geothermal power generation where heat trapped in the earth surface converted in to the electrical energy . If you ever went swimming in the ocean and dove deep below the surface, you would have noticed that the water gets colder the deeper you go. It's warmer on the surface because sunlight warms the water. But below the surface, the ocean gets very cold. That's why scuba divers wear wet suits trapped their body heat to keep them warm. Power plants can be built that use this difference in temperature to make energy. A difference of at least 38 degrees Fahrenheit is needed between the warmer surface water and the colder deep ocean water. Using this type of energy source is called Ocean Thermal Energy Conversion or OTEC. It is being used in both Japan and in Hawaii in some demonstration projects

B. Wave Energy:

1) Wave Power I - sea-based devices

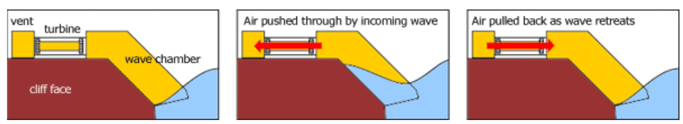
A recent review has shown that there are new types of wave power devices which can produce electricity economically. The “Salter” Duck is the device which can produce electricity for lower cost. `The “Salter” Duck was developed in the 1970s by Professor Stephen Salter at the University of Edinburgh in Scotland and generates electricity by bobbing up and down with the waves. Although it can produce energy extremely efficiently it was effectively killed off in the mid 1980s when a European Union report miscalculated the cost of the electricity it produced by a factor of 10. In the last few years, the error has been realized, and interest in the Duck is becoming intense.

The “Clam” is another device which, like the “Salter” Duck can make energy from sea swell. The Clam is an arrangement of six airbags mounted around a hollow circular spine. As waves impact on the structure air is forced between the six bags via the hollow spine which is equipped with self-rectifying turbines. Even allowing for cabling to shore, it is calculated that the Clam can produce energy for around $US0.06kW/hr.

2) Wave Power II- Shore based systems

Where the shoreline has suitable topography, cliff-mounted oscillating water column (OWC) generators can be installed. OWC systems have a number of advantages over the Clam and the Duck, not the least of which is the fact that generators and all cabling are shore-based, making maintenance much cheaper. The OWC works on a simple principle. As an incoming wave causes the water level in the unit's main chamber to rise (see diagram), air is forced up a funnel which houses a Well's counter-rotating turbine. As the wave retreats, air is sucked down into the main chamber again. The Well's turbine has been developed to spin in the same direction, whichever way air is flowing, in order to maximize efficiency. Although most previous OWC systems have had vertical water columns that in LIMPET is angled at 45° - which wave tank test show to be more efficient.

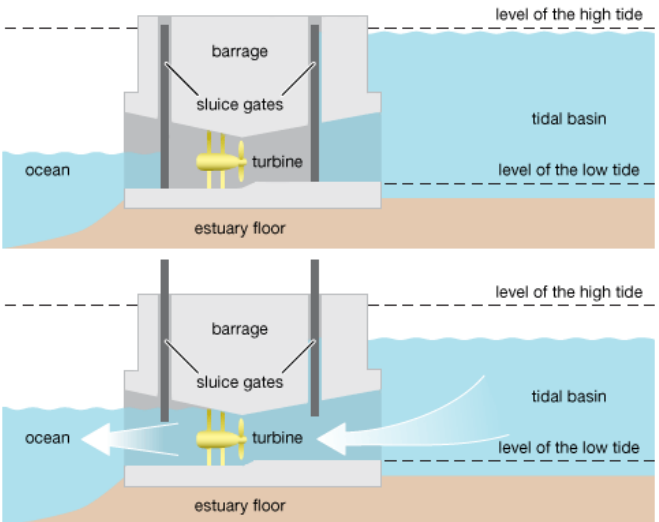
OWC schematic



OWC machines have already been tested at a number of sites, including Japan and Norway. A commercial-scale (500 kW) installation is due to be commissioned on the Scottish Island of Islay in September 2000. The Islay OWC (known as LIMPET) is a joint venture between Queens University, WAVEGEN, Instituto Superior Técnico (Portugal), the European Union and Charles Brand Engineering. It is the direct successor of an experimental 75 kW turbine (built by researchers from the Queen's University of Belfast) which operated on the island between 1991 and 1999. Another LIMPET is currently being developed (at pilot-plant scale) on the Azores.

3) Tidal Energy

Tidal energy works from the power of changing tides. Tidal changes in sea level can be used to generate electricity, by building a dam across a costal bay or estuary with large differences between low and high tides. The high tides allow immense amounts of water to rush into the bay. The gates of the dam then shut when water level is at its maximum height. Holes in the bottom of the dam let water (at great speed and pressure) to rush past turbines. The flow of water generates enough power to turn the turbines which creates electricity. The entire process repeats with each high tide.



Two current technologies which are used to harness the kinetic energy of tidal flow:

1) Lift Devices Turbines:

- Wind mill technology applied to liquid environment
- More efficient then drag devices

2) Drag Devices Water wheels:

- Insufficient compared to other modes of generation
- Blade speed can not exceed that of the current
- Refined propeller achieves speeds several times faster then the current

4) Tides: Gravitational Energy

Tides, the daily rise and fall of ocean levels relative to coastlines, are a result of the gravitational force of the moon and sun as well as the revolution of the earth. The moon and the sun both exert a gravitational force of attraction on the earth. The magnitude of the gravitational attraction of an object is dependant upon the mass of an object and its distance. The moon exerts a larger gravitational force on the earth because, although it is much smaller in mass, it is a great deal closer than the sun. This force of attraction causes the oceans, which make up 71% of the earth's surface, to bulge along an axis pointing towards the moon. Tides are produced by the rotation of the earth beneath this bulge in its watery coating, resulting in the rhythmic rise and fall of coastal ocean levels.

The gravitational attraction of the sun also affects the tides in a similar manner as the moon, but to a lesser degree. As well as bulging towards the moon, the oceans also bulge slightly towards the sun. When the earth, moon and sun are positioned in a straight line (a full or new moon), the gravitational attractions are combined, resulting in very large "spring" tides. At half moon, the sun and moon are at right angles, resulting in lower tides called "neap" tides. Coastal areas experience two high and two low tides over a period of slightly greater than 24 hours. The friction of the bulging oceans acting on the spinning earth results in a very gradual slowing down of the earth's rotation. This will not have any significant effect for billions of years. Therefore, for human purposes, tidal energy can be considered a sustainable and renewable source of energy.

Table 1 Highest tides (tide ranges) of the global ocean

Country	Site	Tide range (m)
Canada	Bay of Fundy	16.2
England	Severn Estuary	14.5
France	Port of Ganville	14.7
France	La Rance	13.5
Argentina	Puerto Rio Gallegos	13.3
Russia	Bay of Mezen (White Sea)	10.0
Russia	Penzhinskaya Guba	13.4

Certain coastal regions experience higher tides than others. This is a result of the amplification of tides caused by local geographical features such as bays and inlets. In order to produce practical amounts of power (electricity), a difference between high and low tides of at least five meters is required. There are about 40 sites around the world with this magnitude of tidal range. In Canada, the only practical site for exploiting tidal energy is the Bay of Fundy between New Brunswick and Nova Scotia. The higher the tides, the more electricity can be generated from a given site, and the lower the cost of electricity produced. Worldwide, approximately 3000 giga watts (1 giga watt = 1 GW = 1 billion watts) of energy is continuously available from the action of tides. Due to the constraints outlined above, it has been estimated that only 2% or 60 GW can potentially be recovered for electricity generation.

Exploiting the Resource:

The technology required to convert tidal energy into electricity is very similar to the technology used in traditional hydroelectric power plants. The first requirement is a dam or "barrage" across a tidal bay or estuary. Building dams is an expensive process. Therefore, the best tidal sites are those where a bay has a narrow opening, thus reducing the length of dam which is required. At certain points along the dam, gates and turbines are installed. When there is an adequate difference in the elevation of the water on the different sides of the barrage, the gates are opened. This "hydrostatic head" that is created, causes water to flow through the turbines, turning an electric generator to produce electricity.

Electricity can be generated by water flowing both into and out of a bay. As there are two high and two low tides each day, electrical generation from tidal power plants is characterized by periods of maximum generation every twelve hours, with no electricity generation at the six hour mark in between. Alternatively, the turbines can be used as pumps to pump extra water into the basin behind the barrage during periods of low electricity demand. This water can then be released when demand on the system it's greatest, thus allowing the tidal plant to function with some of the characteristics of a "pumped storage" hydroelectric facility.

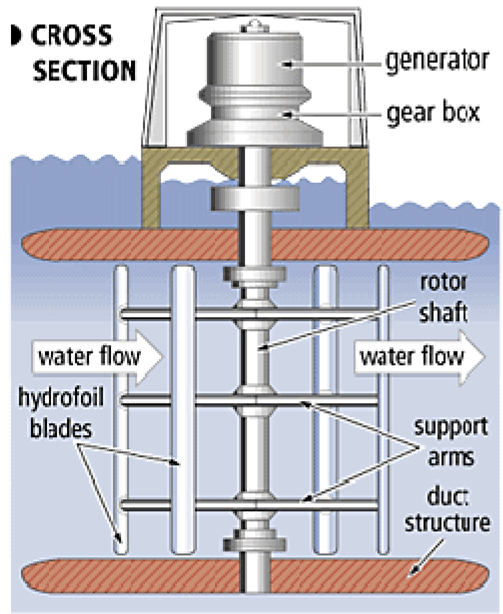
How it works?

Tidal power works rather like a hydro-electric scheme, except that the dam is much bigger. A huge dam (called a "barrage") is built across a river estuary. When the tide goes in and out, the water flows through tunnels in the dam. The ebb and flow of the tides can be used to turn a turbine, or it can be used to push air through a pipe, which then turns a turbine. Large lock gates, like the ones used on canals, allow ships to pass. If one was built across the Severn Estuary, the tides at Weston-super-Mare would not go out nearly as far - there'd be water to play in for most of the time. But the Severn Estuary carries sewage and other wastes from many places ster out to sea. A tidal barrage would mean that this stuff would hang around Weston-super-Mare an awful lot longer.

5) Blue Energy

The Blue Energy Ocean Turbine acts as a highly efficient underwater vertical-axis windmill. Sea water is 832 times denser than air and a non-compressible medium, an 8 knot tidal current is the equivalent of a 390 km/hr wind. Developed by veteran aerospace engineer Barry Davis, the vertical-axis turbine represents two decades of Canadian research and development. Four fixed hydrofoil blades of the Blue Energy Ocean Turbine are connected to a rotor that drives an integrated gearbox and electrical generator assembly. The turbine is mounted in a durable concrete marine caisson which anchors the unit to the ocean floor, directs flow through the turbine further concentrating the resource supporting the coupler, gearbox, and generator above it. These sit above the surface of the water and are readily accessible for maintenance and repair. The hydrofoil blades employ a hydrodynamic lift principal that causes the turbine foils to move proportionately faster than the speed of the surrounding water. Computer optimized cross-flow design ensure that the rotation of the turbine is unidirectional on both the ebb and the flow of the tide.

The design of the Blue Energy Ocean Turbine requires no new construction methodology: It is structurally and mechanically straightforward. The transmission and electrical systems are similar to thousands of existing hydroelectric installations. Power transmission is by submersible kV DC cabling and safely buried in the ocean sediments with power drop points for coastal cities and connections to the continental power grid. A standardized high production design makes the system economic to build, install & maintain.



Tidal Turbines:

Rather like an underwater wind farm. This has the advantage of being much cheaper to build, and does not have the environmental problems that a tidal barrage would bring.

Tidal turbines are the chief competition to the tidal fence. Looking like an underwater wind turbine they offer a number of advantages over the tidal fence. They are less disruptive to wildlife, allow small boats to continue to use the area, and have much lower material requirements than the fence.

Tidal turbines function well where coastal currents run at 2-2.5 m/s (slower currents tend to be uneconomic while larger ones put a lot of stress on the equipment). Such currents provide an energy density four times greater than air, meaning that a 15m diameter turbine will generate as much energy as a 60m diameter windmill. In addition, tidal currents are both predictable and reliable, a feature which gives them an advantage over both wind and solar systems. The tidal turbine also offers significant environmental advantages over wind and solar systems; the majority of the assembly is hidden below the water

Small Scale Tidal Power:

Although harnessing the tides for electrical (or mechanical) energy is not new, it's not widely implemented; because, basically a barrage is to be build. The Bay of Fundy, which experiences the world's largest tides, is one location that produces tidal electricity. This tidal power can also be utilized for small scale power production. Basically, the device would be anchored to the bottom of the ocean by a post (with gear notches along one side), just a bit further than the low tide mark. A floating section, provided by a large buoyant device would then float on the surface of the water. The relative motion between the buoyant section and the post would produce energy, via a gear system that engages the teeth on the post. Obviously the relative motion is quite small... a tide may only rise a few feet. The brawn comes from how the gears are implemented, and how much force the floating section can produce. The floating section should to be fairly light, and having it ride the ocean back to low tide wouldn't produce enough force (only the force of gravity) to generate power.

Advantages :

Wave power (and tidal power) are beginning to come into their own. Benefits Deep Ocean.

- Renewable and sustainable resource
- Reduces dependence upon fossil fuels
- Produces no liquid or solid pollution
- Little visual impact
- Construction of large scale offshore devices results in new areas of sheltered water, attractive for fish, sea birds, seals and seaweed
- Present no difficulty to migrating fish (except tidal fences)
- Shelter the coast, useful in harbor areas or erosion zones
- Resource exists on a worldwide scale from deep ocean waters
- Short time scale between investing in the modular construction and benefiting from the revenue

Disadvantages :

- Very expensive to build.
- Affects a very wide area **-** the environment is changed for many miles upstream & downstream.
- Many birds rely on the tide uncovering the mud flats so that they can feed.
- Only provides power for around 10 hours each day, when the tide is actually moving in or out.
- There are very few suitable sites for tidal power stations.

II. CONCLUSION

The Department of Energy has shown great enthusiasm regarding tidal power as a future energy source than any other renewable energy sources. Our philosophy regarding energy will change drastically from the present into the future. In a society with increasing energy demands and decreasing supplies, we must look to the future and develop our best potential renewable resource. Tidal power fits the bill, a natural source of energy with many benefits. The planet's tidal capability greatly exceeds that of the world’s entire coal and oil supply. It is an ideal source of energy with great potential. When developed, tidal power could be a primary provider for our future energy requirements. Such power stations can provide clean energy to small communities or even individual households located near continental shorelines, straits or on remote islands with strong tidal currents.

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