Power Production using Tidal Energy

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Abstract

Tidal energy is a form of hydropower that converts the energy of tides into electricity or other useful forms of power. It's also a renewable source of electricity which does not result in the emission of gases responsible for global warming or acid rain associated with fossil fuel generated electricity. Use of tidal energy could also decrease the need for nuclear power, with its associated radiation risks. The few studies that have been undertaken to date to identify the environmental impacts of a tidal power scheme have determined that each specific site is different and the impacts depend greatly upon local geography. If fossil fuel resources decline during the 21st century, as predicted by Hubbert peak theory, tidal power is one of the alternative sources of energy that will need to be developed to satisfy the human demand for energy. Whatever the process is a traditional power generation using a alternator and mechanical energy (for rotation) are collected from tidal energy using a simple floating device but create an artificial floating dam to hold huge energy, a system also involved to convert linier motion to rotary motion not using any traditional turbine.

Keywords: Tidal Energy, Power Generation, Waves, Renewable Energy, Hydropower.

Introduction

Increasing population, rising energy consumption, climate change and peak oil are accelerating the search for practical alternative energy sources to fossil fuels. Some renewable sources of energy, such as wind and solar, are well known, use reliable technology, and have established markets. Other renewable technologies that are still in development show promise for meeting a portion of future electricity needs.

Many governments are encouraging this search by instituting mandatory goals for Diversification of their energy resources by certain deadlines and pledging to dedicate a larger proportion of their energy consumption to renewables.

Tidal energy is generated by the relative motion of the Earth, Sun and the Moon, which interact via gravitational forces. Periodic changes of water levels, and associated tidal currents, are due to the gravitational attraction by the Sun and Moon. The magnitude of the tide at a location is the result of the changing positions of the Moon and Sun relative to the Earth, the effects of Earth rotation, and the local shape of the sea floor and coastlines. Because the Earth's tides are caused by the tidal forces due to gravitational interaction with the Moon and Sun, and the Earth's rotation, tidal power is practically inexhaustible and classified as a renewable energy source. A tidal energy generator uses this phenomenon to generate energy. The stronger the tide, either in water level height or tidal current velocities, the greater the potential for tidal energy generation. Tidal movement causes a continual loss of mechanical energy in the Earth–Moon system due to pumping of water through the natural restrictions around coastlines, and due to viscous dissipation at the seabed and in turbulence. This loss of energy has caused the rotation of the Earth to slow in the 4.5 billion years since formation. During the last 620 million years the period of rotation has increased from 21.9 hours to the 24 hours we see now; in this period the Earth has lost 17% of its rotational energy. While tidal power may take additional energy from the system, increasing the rate of slowdown, the effect would be noticeable over millions of years only, thus being negligible. Tidal power is non-polluting, reliable and predictable. Tidal barrages, undersea tidal turbines - like wind turbines but driven by the sea - and a variety of machines harnessing undersea currents are under development. Local tides changed only slightly due to the La Rance barrage, and the environmental impact has been negligible, but this may not be the case for all other sites. It has been estimated that in the Bay of Fundy, tidal power plants could decrease local tides by 15 cm. This does not seem like much when one considers that natural variations such as winds can change the level of the tides by several meters. A tidal power scheme is a long-term source of electricity. A proposal for the Severn Barrage, if built, has been projected to save 18 million tons of coal per year of operation. This decreases the output of greenhouse gases into the atmosphere. Although not yet widely used, tidal power has potential for future electricity generation. Tides are more predictable than wind energy and solar power. Historically, tide mills have been used, both in Europe and on the Atlantic coast of North America [Dilder Hossain, 2000].

Gravitational forces between the moon, the sun and the earth cause the rhythmic rising and lowering of ocean waters around the world those results in Tide Waves. The moon exerts more than twice as great a force on the tides as the sun due to its much closer position to the earth. As a result, the tide closely follows the moon during its rotation around the earth, creating diurnal tide and ebb cycles at any particular ocean surface. The amplitude or height of the tide wave is very small in the open ocean where it measures several centimeters in the center of the wave distributed over hundreds of kilometers. However, the tide can increase dramatically when it reaches continental shelves, bringing huge masses of water into narrow bays and river estuaries along a coastline. For instance, the tides in the Bay of Fundy in Canada are the greatest in the world, with amplitude between 16 and 17 meters near shore. High tides close to these figures can be observed at many other sites worldwide, such as the Bristol Channel in England, the Kimberly coast of Australia, and the Okhotsk Sea of Russia [Gorlov,2003].

Advantages: Tides are free once the power station has been built and will not run out. No greenhouse gases are produced when we make the electricity. We know exactly when the tides happen so we know when electricity will be made.

Disadvantages: You may need to build a large wall called a dam to make the water flow through the generators. This may not be good for plants and animals that live nearby. The tides only happen twice a day, so can only produce electricity for that time.

Tidal Energy Logistics

Harnessing energy from such an extremely predictable source seems rather practical and ingenious. However, significant tidal range, the one crucial component of the system, can only be found in isolated areas of the world. Figure 1.5 illustrates five of the most promising sites for tidal energy due to their extreme tidal range. Several, including La Rance, already have tidal energy systems through the use of barrage structures. The mean tidal range, which is found by simply doubling the value of the tidal amplitude, is the distance between the highest water level at high tide and the lowest water mark at low tide. Interestingly, these amplitudes are only means. In fact, tidal ranges in the order of eight to nine meters are not uncommon during full moon periods. Noticeably, there are two areas which are noteworthy in terms of their tidal range; Southeast Canada and the Western Shore of Great Britain. Determining potential tidal energy systems for both of these locations will be discussed in greater detail later in this document [Peter,2003].

Tidal stream generators draw energy from currents, which is the same way as wind turbines. The higher density of water, 832 times the density of air, means that a signal generator can provide significant power at low tidal flow velocities as compared with wind speed. In another words, water speeds of nearly one-tenth of the speed of wind provide the same power for the same size of turbine system [Yun Seng,2000].

Energy Calculations:
Various Generator designs have varying efficiencies and therefore varying power output. If the efficiency of the
Generator "Cg" is known the equation below can be used to determine the power output. The energy available from these kinetic systems can be expressed as:

$P = Cp \times 0.5 \times \rho \times A \times V^3$ [1]

Where:
Cp is the coefficient of performance

P = the power generated (in watts)

ρ = the density of the water (seawater is 1025 kg/m^3)

A = the sweep area (in m^2)

V^3 = the velocity of the flow cubed (i.e. V x V xV)

Sample of calculation:
Assumptions:
• Let us assume that the tidal range of tide at a particular place is 39 feet = 12 m (approx.)

• The surface of the tidal energy harnessing plant is 9 km^2 (3 km × 3 km)= 3000 m × 3000 m = $9 \times 10^6 m^2$

• Density of sea water = 1025.18 kg/m3
Mass of the sea water = volume of sea water × density of sea water

= (area × tidal range) of water × mass density
= $(9 \times 10^6$ m2 × 12 m) × 1025.18 kg/m3
= 11.07×10^{10} kg (approx.)

Potential energy content of the water in the basin at high tide
= ½ × area × density × gravitational acceleration × tidal range squared
= ½ × 9 × 10^6 m2 × 1025 kg/m3 × 9.81 m/s2 ×$(12 \text{ m})^2$
=6.5 × 1012 J (approx.)

Now we have 2 high tides and 2 low tides every day.
Therefore the total energy potential per day = Energy for a single tide × 4

= 6.5×10^{12} J × 4
= 2.6×10^{13} J
Therefore, the mean power generation potential = Energy generation potential / time in 1 day
= 18×10^{12} J / 86400 s
= 301.6 MW

Assuming the power conversion efficiency to be 60% :
The daily-average power generated = 301.6 MW * 60% /
= 180.9 MW (approx.)

Whatever, 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 twenty – twenty-two hours in a day, remaining hours not possible due to stability in tidal current flow. Since by this proposed method an artificial floating dam is creating, so it has minor impact to environment.

Results and Discussion

Results were obtained in the present work for using tidal energy in dams for producing electricity. These results were calculated by using some equation that available in[Dilder Hossain, 2000].The theoretical results that calculated were compared with actual value of power in some selected power station in the world. The increase in tidal range will increase power generated(as shown in Fig.(1)) up to 9.1 m of tidal range, then decreased until 10.9m tidal range, then increased at 12.4m tidal range.

One can observe that the maximum value of power generated can be obtained at tidal range of 9.1m.

Table (1) Theoretical and actual power generated in some power stations in the world

Tidal range(m)	Sweep area(km^2)	Theoretical Power(MW)	Actual power(MW)	Station Name
2.1	947	583.24	200	Newzland
4.7	100	308.5	480	Garolim,south korea
5.2	5.5	20.76	33	Conwy,british
5.3	170	666.9	900	Kutch,india
6	20.5	103.06	87	Penzlinslenby
6.5	61	359.9	700	Marsely,british
6.8	1970	1272.67	7000	Cambay,india
7.8	450	3823.5	8640	Severn,british
9.1	2300	26599.34	19200	Mezen
10	115	1606.04	1800	Shepody,Canada
10.9	90	1493.33	1400	Cumberland,Canada
12.4	240	5153.65	5338	Cobequid,canada

Conclusions

The flow pattern caused by tidal influence is much more difficult to analyze, and also, data is much more difficult to collect. A tidal height is a simple number which applies to a wide region simultaneously—often as far as the eye can see. A flow has both a magnitude and a direction, which both can vary substantially over just a short distance due to local bathymetry, and also vary with depth below the water surface. Also, although the center of a channel is the most useful measuring site, mariners will not accept a current measuring installation obstructing navigation, so a flexible approach is required. A flow proceeding up a curved channel is the same flow, even though its direction varies continuously along the channel. But contrary even to the obvious expectation, flood and ebb flows are often not in opposite directions.

The direction of a flow is determined by the shape of the channel it is coming from, not the shape where it will shortly be. Likewise, eddies can form in one direction but not the other.

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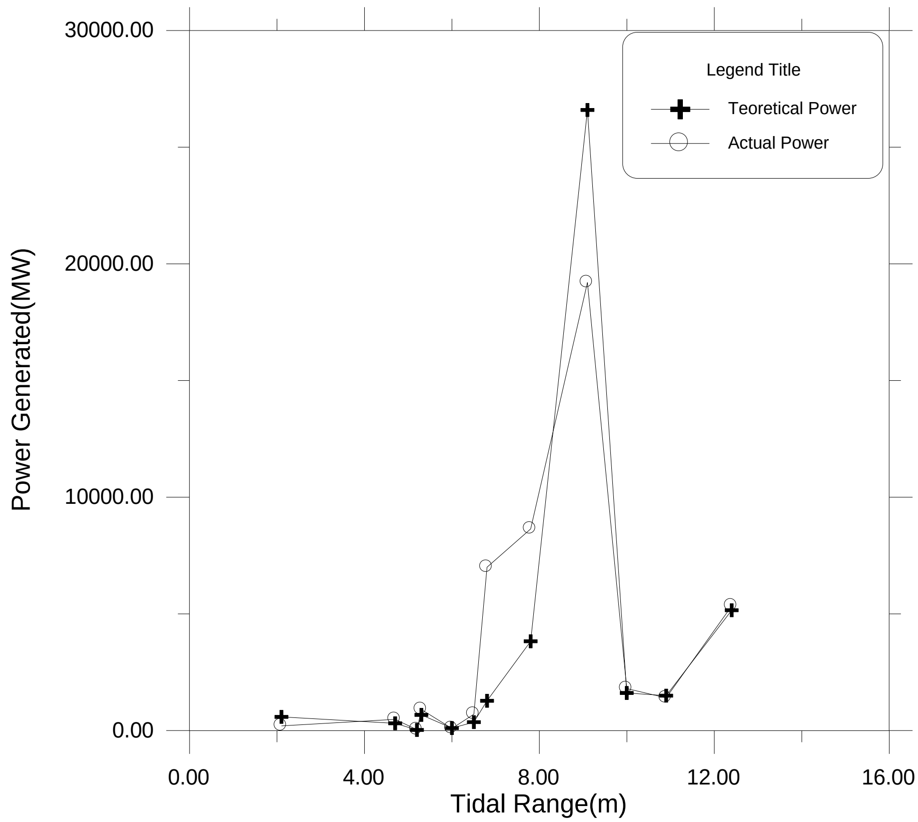

Fig.(1) Variation of Theoretical And Actual Power Generated with Tidal Range in Some Selected Tidal Power Station in the World.