A Review on Tidal Power & Its Scope in Indian Peninsular Area

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Abstract

Now days and in the coming years, increased attention is being given to the tidal current energy development all over the world. This article is about tidal power generation. It describes tidal power and the various methods of utilizing tidal power to generate electricity.

The paper focuses on the potential methods of generating electricity and why this could be a common way of producing electricity in the near future. It also focuses on the scope of tidal power in coastal areas of India & their comparisons.

1. INTRODUCTION

Oceans cover 70 percent of the earth's surface and represent an enormous amount of energy in the form of wave, tidal, marine current and thermal gradient. The energy potential of our seas and oceans well exceeds our present energy needs. India has a long coastline with the estuaries and gulfs where tides are strong enough to move turbines for electrical power generation. A variety of different technologies are currently under development throughout the world to harness this energy in all its forms including waves (40,000 MW), tides (9000 MW) and thermal gradients (180,000 MW). Deployment is currently limited but the sector has the potential to grow, fuelling economic growth, reduction of carbon footprint and creating jobs not only along the coasts but also inland along its supply chains.

The total available potential of wave energy in India along the 6000 Km of India's coast is estimated to be about 40,000 MW – these are preliminary estimates. This energy is however less intensive than what is available in more northern and southern latitudes.

In 2000 NIOT Goa, launched a programme to conduct study on technologies for producing high quality clean drinking water and energy from the ocean. The objective was to generate 2 - 3 lakh litres per day freshwater using the Low Temperature Thermal Desalination technology by 1 MW OTEC Power Plant. But it was dropped due to difficulties in installations.

In 2010 Kalpasar Tidal Power Project at The Gulf of Khambhat was identified as a promising site for tidal power generation by UNDP Expert.

In Jan 2011, the state of Gujarat announced plans to install Asia's first commercial-scale tidal current power plant; the state government approved the construction of a 50 MW project in the Gulf of Kutch.

None at the moment, but India's Ministry of New and Renewable Energy said in Feb., 2011 that, it may provide financial incentives for as much as 50 percent of the cost for projects seeking to demonstrate tidal power.

In 2014 Atlantis Energy proposed to install and develop 50-200 MW Tidal stream based power plant at Gulf of Chambey.

2. TIDAL POWER

The tidal cycle occurs every 12 hours due to the gravitational force of the moon. The difference in water height from low tide and high tide is potential energy. Similar to traditional hydropower generated from dams, tidal water can be captured in a barrage across an estuary during high tide and forced through a hydro-turbine during low tide. To capture sufficient power from the tidal energy potential, the height of high tide must be at least five meters (16 feet) greater than low tide. There are only approximately 20 locations on earth with tides this high and India is one of them. The Gulf of Cambay and the Gulf of Kutch in Gujarat on the west coast have the maximum tidal range of 11m and 8m with average tidal range of 6.77m and 5.23m respectively.

2.1 History

Now a day's tidal power is knocking the future for electricity production. The use of tidal power originated in around 900 AD when early civilizations constructed tide mills. These mills used the force of the tide to turn a waterwheel, which in turn was used to grind grain into flour. Britain and France are using the tidal power concept since 11th century for milling grains. The first study of large scale tidal power plants was initiated by the US Federal Power Commission in 1924 which would have been located if built in the northern border area of the US state of Maine and the south eastern border area of the Canadian province of New Brunswick, with various dams, powerhouses and ship locks enclosing the Bay of Fundy and Passamaquoddy Bay. Nothing came of the study and it is unknown whether Canada had been approached about the study by the US Federal Power Commission. The world's first large-scale tidal power plant (the Rance Tidal Power Station) became operational in 1966 the facility is located on the estuary of the Rance River, in Brittany. With a peak rating of 240 Megawatts, generated by its 24 turbines, it supplies 0.012% of the power demand of France.

The second tidal barrage was put in service at Annapolis Royale Nova Scotia, Canada in 1982 in order to demonstrate the functioning STRAFLO turbine, invented by Escher-Wyss of Switzerland and manufactured by GE in Canada. This 16 MW turbine has some difficulties with clogging seals necessitating two forced outages, but has been functioning without interruption since its early days. There are approximately 10 small barrages scattered throughout the world, but they are not intended for commercial power generation. For example there is a 200KW tidal barrage on the river Tawe in Swansea Bay. China has several tidal barrages of 400KW and less in size.

2.2 Generation of Tidal Energy

Tidal power is the only form of energy which derives directly from the relative motions of the Earth–Moon system, and to a lesser extent from the Earth–Sun system.

Tidal forces produced by the Moon and Sun, in combination with Earth's rotation, are responsible for the generation of the tides. Other sources of energy originate directly or indirectly from the Sun,

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including fossil fuels, conventional hydroelectric, wind, bio-fuels, wave power and solar. Nuclear energy makes use of Earth's mineral deposits of fissile elements, while geothermal power uses the Earth's internal heat which comes from a combination of residual heat from planetary accretion (about 20%) and heat produced through radioactive decay (80%).

Tidal energy is extracted from the relative motion of large bodies of water. Periodic changes of water levels, and associated tidal currents, are due to the gravitational attraction of the Sun and Moon. 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 geography of the sea floor and coastlines.

Because the Earth's tides are ultimately 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 resource.

A tidal generator uses this phenomenon to generate electricity. Greater tidal variation or tidal current velocities can dramatically increase the potential for tidal electricity generation.

The large underwater turbines are placed in areas with high tidal movements and designed to capture the kinetic motion of the ebbing and surging of ocean tides in order to produce electricity. Tidal power has great potential for future power generation because of the massive size of the oceans and if there is one thing we can safely predict and be sure of on this planet, it is the coming and going of the tide. This is the distinct advantage over other sources that are not as predictable and reliable, such as wind and solar. Tides come and go for the gravitational force of the Moon and Sun and also the rotation of the Earth. The rotational period of the moon is about 4weeks, while the earth takes 24hours for one rotation which occurs a tidal cycle of around 12.5hours. Moreover, once the construction of the barrage is complete, the maintenance & running costs are very small and the life time of the turbines are generally very high for instance, around 30years. The above discussion suggests that tidal energy will be a preferred option over the other choices to meet the sky rocketing demand of electricity. There are two types of generation methodologies that are available to generate power. They are (1) one way generation & (2) two way generation system.

2.2.1 One Way Tidal Power Generation System

This section of the paper provides a brief overview of the one way tidal power generation system with the view of graphical representation. In one way tidal power generation system one way turbine is used. In order to generate tidal power both sea water level and the river basin water level is considerable. From Figure-1 it is seen that sea water level is varying approximately sinusoidal. During high tide basin water level will follow sea water level very closely because sluice gates are open. When the sea and basin water levels are equal at point P1, both sluice gates and turbines are closed. It will be closed until a sufficient head H1 builts up. When the heads built up sluice gates at point Q will be open and the basin water level will fall with duration of T. At point P1' there is not sufficient head H1' is present to produce electricity. As a result both turbine and sluice gates will be closed until the two levels are equal. The moment these two levels are equal again then next cycle will start. Hence total power generation duration will be T. The advantage of this kind of plant is only one turbine is required for the plant and the cost of the turbine, operation and maintenance are low. Turbine model required for this kind of plant is also industrially available.

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However, the disadvantage of this plant is the amount of power produced is less. Apart from its demerits this kind of power plant is widely used.

2.2.2 Two Way Tidal Power Generation System

This part of the paper provides a summary of the two way tidal power generation systems with the help of graph, indicating the water flow and position of the turbines, basin water level & sluice gates. This section has also enlightened the benefits and hazards of this system and further modification idea for a better output. During high tide water will go through the turbine and therefore there should be a difference between the points L1 and L2. Water is passing into the basin from sea eventually basin water level will up. It will be rising until it reaches at point P2 and a sufficient head build up. At point P2 sluice gates will be open but turbines are closed until the basin and sea water levels are equal at point M1. At point M2 a sufficient head will build up for power generation and then at point M2, turbines will open in opposite direction and basin water level will fall. The dive will last until it reaches at point P2'. While there is not enough sufficient head to produce electricity (up to H2'), turbines will be closed but sluice gates are open still at point Q1. The moment they are equal and will be equal at point Q1' sluice gates will be closed. After building the next head H2' sluice gate opens and new cycle begins. From the power output curve it is seen that power duration will be T1, T2 and T3. This obviously illustrates power generation will be higher compared to previous power generation regime. However, the problem is associated with the no load period (NLP). During the no load period the system does not produce any power. This is the foremost problem of two way tidal power Generation system. When no load period occurs there is load shedding for some time. This creates a problem in large tidal power plants. In case for the massive generation using two way tidal power generation systems the no load period gets higher. Because of this problem two way tidal power generation System is normally not preferred and most preferable is one way tidal power generation system. However, two way tidal power generation systems has the capability to produce larger amount of electricity which actually attracted the researcher to invent a regime to curtail the portion of no load period and eventually treat this method as a viable option to ensure the energy security.

The movement of the tides causes a continual loss of mechanical energy in the Earth–Moon system due to pumping of water through the natural restrictions around coastlines, and consequent 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.

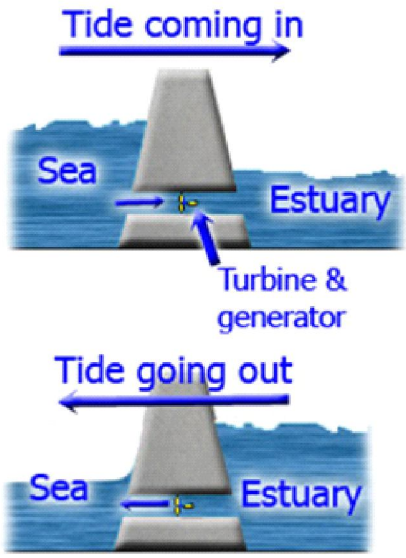

Fig.1: Tidal Energy Generation.[6]

3. SCOPE OF TIDAL ENERGY IN INDIAN PENINSULAR AREA

According to a study by the Indian Institute of Technology Madras (IIT-Madras), India has 150GW of renewable energy potential, yet it has only developed about 14% of this. Conversely, the National Action Plan on Climate Change (NAPCC) deemed it necessary to raise renewable energy to 10% by 2015 and to 15% by 2020. As such, ocean energy, which India has the potential for but is, seeing no progress in its usage due to various restrictions, has been garnering attention.

According to tidal energy estimates by the National Institute of Oceanography (NIO) and IIT-Madras, the highest levels of tidal energy were measured at Sunder bans in West Bengal, as well as at the Gulf of Khambat and the Gulf of Kutch in Gujarat. When six candidate sites such as these are added together, the tidal energy potential comes to 12.5GW.

Moreover, the west coast has enormous potential when it comes to wave energy due to the effects from seasonal winds there, amounting to 15 - 20kW per 1m of coastline. When sections of the coastline with 10kW or more of wave energy per 1m are added together, the wave energy potential comes to 41GW.

The total potential from tidal energy and wave energy is 53.5GW, which is roughly equivalent to 1/3 of India's total renewable energy potential of 150GW.

In terms of specific moves by India, priority is being given to the development of tidal energy, which is being promoted by the issuance of subsidies for 50% of the costs for this by the Ministry of New and Renewable Energy (MNRE) starting from 2011. In 2011, Gujarat State gave its approval for the construction of a 50MW tidal power plant in the Gulf of Kutch to a group consisting of Gujarat Power Corporation Limited from India and Atlantis Resources Limited from the United Kingdom. In addition, in 2014 Atlantis Resources Limited proposed installing a 50-200MW tidal power plant in Khambhat. (October 2015)

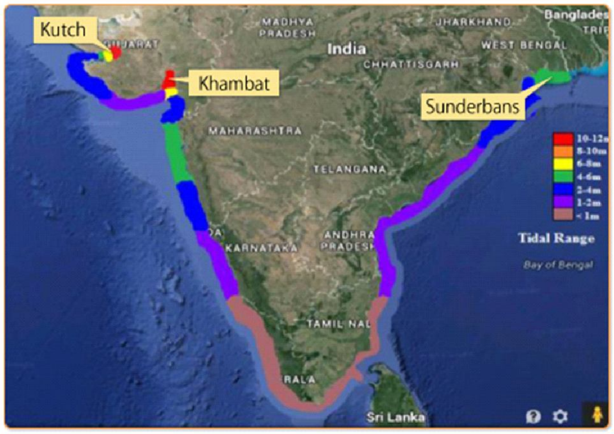

Fig.2: Tidal Range Along Indian Peninsular Region.[8]

4. CONCLUSION AND PERSPECTIVES

Now a days, as more and more people have recognized the importance of renewable energy, the enormous energy contained in ocean has gained more attentions recently and consequently have developed considerably, such as the tidal current energy and wave energy, etc. In this paper, the distribution and current development of tidal current energy in India is presented.

The tidal current energy is estimated to be about 53.5GW in India which is 1/3rd of total renewable power developed, and it has several competitive advantages over other renewable energy sources, such as predictability, regularity and low environmental impact, thus it ought to be an effective option for solving energy shortage and environmental pollution. At present, many institutions or universities and corporations have started doing more research into the tidal current turbine, and it can be expected that more achievements would be obtained in near future.

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