

Theoretical Prediction of Annual Energy Generation from a Tidal Barrage with Reference to Tidal Range at Chennai

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Abstract

Objectives: Tidal Energy, one of the clean and green energy sources, has the potential to replace the conventional fuels like Coal and Petroleum. In this paper, an attempt has been made to measure the tidal range in Chennai and theoretical calculations have been performed to find how much energy can be harnessed from tidal source. **Methods/Statistical Analysis:** Chennai city, one of the metropolitan cities of India has been selected as the study area. The Chennai port which is the second largest port in India is the specific site for the tidal measurement using the Tidal gauge. Tidal gauge, usually measures the change in the sea level with respect to a datum for a month period. From the measured tidal range, the power output that can be harnessed from a tidal barrage arrangement has been theoretically calculated. **Findings:** At Chennai port, there has been a maximum spring tide of about 1.2 m. By approximating the tidal range to 1 m and by considering a tidal barrage having a km² area, with electrical conversion efficiency of 0.2, the total annual electricity generation capacity is approximately 10 GWh per year is theoretically calculated. **Application/Improvement:** By increasing the electrical conversion efficiency to 0.4 to 0.5, the production can be more than 20 GWh power. Which definitely helps the government in replacing the conventional and problematic Non-Renewable energy sources?

Keywords: Energy Estimation, Renewable Energy, Tidal Energy, Tidal Range

1. Introduction

Wind, Hydro, Solar, Tidal, etc are some of the examples for renewable energy sources while, Coal, natural gas, petroleum and uranium are non-renewable energy sources.

While the renewable sources are not so popular at present but in future, due to the global warming and green house effect which mainly due to the non-renewable energy sources, the renewable energy sources will play a major role¹.

One such energy, which can have the capacity to replace the conventional non-renewable energy sources is tidal energy. Tides are nothing but the rising and falling of water level in the sea which is caused due to the gravitational effect of sun and moon on earth's atmosphere and due to the earth's rotation². It is time

varying quantity, naturally in a day, two times there will be a high tide and two times there will be low tide. Based on the number of high and low tides and their relative heights each tidal day, tides are described as semi-diurnal, mixed, or diurnal. Tides can be classified basically upon the higher (Neap tide) or lower (spring tide) than average, they occur twice monthly appears³.

1.1 Methods for Producing Energy

For producing useful energy from the tides there are two basic methods are available. One is tidal barrage and another is installing water turbine in tidal stream. Tidal barrage methods of producing electricity is a traditional approach where a barrage or lagoon usually using a dam is construct for offshore impoundments to block the ebb and flood mode tides⁴. Constructing a dam like structure at suitable sites, where there is an expectation of high

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tide will serve the purpose. Another approach where is not possible to build a dam, but high tidal stream (flow of water) is available; water turbine can be installed in a similar fashion to wind turbine to extract the energy from the tidal stream^{5,6}.

1.2 Estimating the Available Power from the Tide

As per the literatures, there are various theoretical as well as numerical very rarely experimental methods are available to calculate the amount of energy that can be harnessed from the tides are available. Various methodologies are adopted for the calculating the tidal power output which includes one dimensional model⁷, two dimensional model⁸⁻¹⁰, flat-estuary model⁶ etc. In this paper the model used by, has been used to predict the available amount of power from the tides, calculated the potential energy contained in a water volume contained in a basin by the formula $E_p = 0.5 * g * A_b * \Delta h_b^2 \rightarrow (1)$

Where g is the acceleration due to gravity, A_b is the horizontal area of the basin, Δh_b is the mean tidal range in the basin¹¹. From the equation it is clear that the tidal ranges (head differences) has a great influence in the potential energy determination. In a 24 hour period, there is a possibility of having two floods (water flows towards the shore between low and high tide) and two ebb tides (water flow away from the shore between high and low tide) having 12.42 hours as semi-diurnal period. So, the total potential energy can be harnessed per day is from the barrage is approximately $24/12.42 * E_p$ and the corresponding power is $P = (0.11263 * A_b * h_b^2)$. But tidal energy conversion projects are always associated with another factor η , which is power conversion efficiency, which is usually ranging from 20-40 %. Therefore the total annual energy output^{12,13} is $E_{yr} = 0.9872 * A_b * h_b^2 * \eta \rightarrow (2)$.

2. Study Area

Chennai City (Madras) has been selected as study area. It is one of the four metropolitan cities in India and known for its cultural heritage. It is the capital of Tamil Nadu State and located at south of India. It has Bay of Bengal in its east side and having a very long east coast covering around 700 km stretch. Chennai port, is the second largest port in India, operating since 1881. It has an annual cargo tonnage around 50 million tones. Chennai

port located at 13.08441°N, 90.2899°E coordinates. Very near to Chennai port, an estuary namely Cooum Estuary is available because of the Cooum river flows into the west Bengal sea. The river mouth has groynes running to a total length of nearly 250 meters. The opening between the groynes is about 170 meters to facilitate tidal action. The impact of high tide bringing in sea water is felt for nearly 3 kilometers in the river.

2.1 Tidal Range Measurement

At the Chennai tidal range has been measured using the Tidal gauge, which usually measures the change in the sea level with respect to a datum for a month period, then from the literature available at National Institute of Oceanography has been taken as a result for this study.

3. Annual Average Power Estimation at Chennai

At Chennai port there one can witness semi-diurnal tides in a day having two high and low tides. The tidal range varies from 0.914 to 1.219 m during spring tides and from 0.805 to 0.610 m during neap tides and having a maximum spring tide of about 1.2 m. Considering 1 m tidal range as average and if a tidal barrage having a 1 km^2 with electrical conversion efficiency of 0.2, the calculated total annual electricity generation capacity using the equation 2, is approximately 10 GWh per year. By increasing the electrical conversion efficiency to 0.4 to 0.5 the production can be more than 20 GWh power. Thus from our study it is clear that at Chennai area even though the tides are not high to produce maximum tidal range, one can expect approximately more than 10 GWh of energy per year. Which definitely help the government in replacing the conventional and problematic Non-Renewable energy source. By installing more number of tidal barrages one can expect more tens of GWh of power.

4. Conclusion

From this work, at Chennai the average tidal range is measured as 1 m and by considering 1 km^2 tidal barrage and by installing an electrical conversion device having an efficiency of 0.2, it is estimated that approximately 10 GWh per year can be generated. By increasing the size of the tidal barrage and increasing the efficiency of electrical

conversion devices it is possible to generate more GWh per year.

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