To Study Feasibility of the Generation of Tidal Power Energy at Pakistan Creek Areas

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Abstract: Generation of Electricity from tidal power energy is a form of pollution free renewable energy which has a lot of prospective. This prospective can be utilized more efficiently in creek areas of Pakistan. There are a number of creeks along the coastal belt of the Sindh. Maximum creek area has 1m-3m tidal rise twice everyday due to this rise and fall the water go in and out of the basin. The width of creek is very narrow, and solid rocks are available locally to give strong foundations. This paper will helpful to build up any tidal power generation plant by using the available data of these areas. The National Institute of Oceanography and Hydrography Department of Pakistan Navy are played an important role to provide the physical data of the creek area of Pakistan.
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1. Introduction

At present time there is concern over global climate change, as well as a growing awareness on worldwide population about the need on reducing greenhouse gas emissions. This in fact, has led to an increase in power generation from renewable sources. Tidal energy has the potential to play a valuable role in a sustainable energy future. Its main advantage over other renewable sources is its predictability; tides can be predicted years in advanced. The energy extracted from the tides can come from both, the vertical movements of the water associated with the rise and fall, i.e. potential energy, and from the kinetic energy, namely, tidal currents (Eleanor Denny and Huajun Li and Guoxiang Wu and Bingchen Liang, and Fan Fei, 2010).

Tidal energy is derived from the gravitational forces of attraction that operate between a molecule on the earth and moon, and between a molecule on the earth and sun. The force is $f = K M m / d^2$, where m is the mass of the molecule on the earth, M is the mass of the moon or sun, d is the distance between the bodies, and K is the universal constant of gravitation. The attractive force exerted by the sun is about 2.17 times less than that due to the moon due to the mass and much greater distance that separates the earth and sun. As the earth rotates, the distance between the molecule and the moon will vary. When the molecule is on the dayside of the earth relative to the moon or sun, the distance between the molecule and the attracting body is less than when the molecule is on the horizon, and the molecule will have a tendency to move away from the earth. Conversely, when the molecule is on the night side of the earth, the distance is greater and the molecule will again have a tendency to move away from the earth. The separating force thereby experiences two maxims each day due to the attracting body (T. J. Hammons, 2011).

2. Sites in Sindh

There are several sites identified in Sindh like Gharo Creek, Waddi Khuddi Creek, Paitiani Creek, Dabbo Creek in Mirpur Sakro area on the coast of Sindh, Pakistan as shown in Figure-3, but true potential has not been reported based on any detailed feasibility study. These creeks are mainly being used for minor fishing while some are being used for major shipping. The mangroves around the mud flats bordering these creeks are considered breeding places for shrimps.

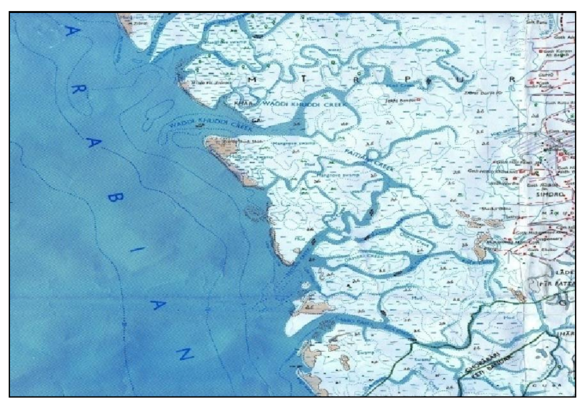

Figure 1. Potential sites for Tidal Power in Sindh, Pakistan (Khan, Nasim A, 2010).

The National Institute of Oceanography conducted preliminary study during the period between 1984- 86 "*the Estimation of Power from different Creeks of Indus River*" that indicated total tidal potential of these creeks based on barrages and dams as 875 MW. Out of this the Korangi/ Gharo Creek having a potential of 174 MW cannot be exploited due to shipping to Port Qasim leaving an exploitable potential of around 700 MW. The maximum power potential from the largest creek is 280 MW where as minimum potential from a single creek is around 2 MW.

3. Theory

The knowledge of predictable nature of ocean tides and their ebbing and flooding nature due to gravitational contribution of sun and moon is attributed to Aristotle's Cosmology (384-322 BC), Ptolemy's Astronomy (AD 90-168) and many others, and ever since was put to use in ancient Grain and Saw Mills, until replaced due to advent of electrical power in the early 19th century (Jonsson, Bjarni M, 2010 and Jack Hardisty, 2009 and Fargal O Rourke, 2011).

As early as 1921 Maximum Tidal Ranges possible at Severn (UK, 42ft, 12.8M), St. Malo near La Rance (France, 36 ft. 10.97M),and Bay of Fundy (Canada,45ft, 13.7M) designated as likely locations of Tidal Barrage Power stations. Also Mean Spring Range on English Coast was mentioned as 16.4ft (4.99M), and mean neap range of 8.4 ft. (2.56M). All this published in the interest of creating cheap electricity, as it was emphasized even at that time, it was believed that 'modern' turbines can operate under heads as low as 3ft.(0.91M) (Lienhard, John H, 1988-2001).

After 25 years research, and 6 years of construction work, La Rance TPP was made operational in 1967 on the river of this name located between towns of St.malo and Dinard in Brittany, France. Incorporating an Impoundment type barrage, this full scale experimental plant has 24 10MW low-head bulb-type turbines, yielding 240 MW, contributing 0.012% of France's total necessary energy. Each turbine weighs 470 tons with a blade diameter of more than 17 feet. At 13.5M, La Rance estuary has one of the largest range in the world (Clark, Peter, Klossner, Rebecca., & Kologe, Lauren, 2003 and Dr. Zhao Yong, Dr.Su Xiaohui, 2010 and Junqiang Xia, Roger A. Falconer, Binliang Lin, and Guangming Tan, 2012).

The Kislogubskaya TPP was constructed near Murmansk (Russia) between 1964-68. It used 3.3 meters running diameter bulb unit turbines, harnessing the ocean's potential energy generated by the tides. This has been a small experimental plant, generating only 0.4MW. This plant, however, replaced its turbines in 2004 with a new design referred to as the orthogonal hydropower units or orthogonal turbine. The turbine is simple in design and is a modification of an older rotor called the Darrieus rotor. In fact the latest version of these has been developed in the shape of double and triple helix turbine by Gorlov. That design is now included in all future Russian tidal schemes (Sveinsson, Niels, 2011).

The Helical Gorlov turbine which is an adaptation of Darrieus design is shown in Fig 2 (a) & 2 (b). The turbine has a number of straight or curved or helical hydrofoil blades installed in a barrel, which can produce high torque even in slow flow with a large water passage area.

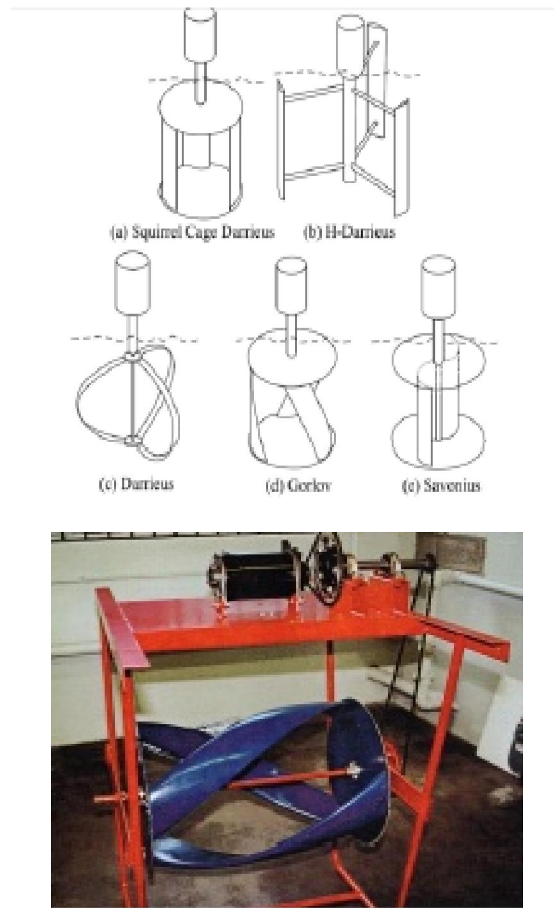

Figure 2(a) & (b). Adaptations of Darrieus Turbine Design.(Dr. Zhao Yong, Dr. Su Xiaohui, 2010)

4. Tidal Power Option

Thanks to National Electric Power Regulatory Authority (NEPRA), the tariff which is revised from time to time on regular basis, and allowed by the thermal power projects, has risen to more than 12-14 cents per kilowatt-hour has created a new market for environmentally free power that needs to be en-cashed on the first available opportunity. The policies set by the Government of Pakistan are very conducive to large scale investment in alternative renewable energy resources and tidal power is one such area that needs to be studied in details to attract investment. Tidal energy is appealing as it can provide reliable base load electricity either through low head barrage or by using tidal stream that is quite suitable in some creeks.

Theoretical power potentials of 8,000 MW, and 2000MW at Waddi Khuddi Creek and Pataini Creek sites respectively are located quite near to load center for the size of theoretical power they offer. The area is scarcely inhibited and is a place to earn livelihood by fishermen, who can be made more prosperous by involvement in these environmentally friendly projects that will be able to sell power to the national grid. An investor based in USA has proposed to initiate tidal power project with 50 MW of power. Waddi Khuddi Creek and Sonmiani/Dhab have been earmarked to initiate this project as both these areas have load centers in the near vicinity and transmission and consumption of 50 MW is considered suitable. (Khan, Nasim.A).

5. Calculation Of Tidal Power Generation

The energy available from a barrage is dependent on the volume of water. The potential energy contained in a volume of water is:

$$E = \frac{1}{2} A\rho g h^2 \quad ,,,,,,,,,,,,,,,, (1)$$

where:

- h is the vertical **tidal range**,
- A is the horizontal area of the barrage basin,
- ρ is the **density** of water = 1025 kg per cubic meter (seawater varies between 1021 and 1030 kg per cubic meter) and
- g is the acceleration due to the **Earth's gravity** = 9.81 meters per second squared.

The factor half is due to the fact, that as the basin flows empty through the turbines, the **hydraulic head** over the dam reduces. The maximum head is only available at the moment of low water, assuming the high water level is still present in the basin.

6. Assumptions:

- Let us assume that the average tidal range of tide at a particular place is 32 feet = 10 m (approx)
- The surface of the tidal energy harnessing plant is 9 km² (3 km × 3 km)= 3000 m × 3000 m = 9 × 10^6 m^2
- Density of sea water = 1025.18 kg/m^3

Mass of the sea water = volume of sea water × density of sea water

= (area × tidal range) of water × mass density

= (9 × 10^6 m^2 × 10 m) × 1025.18 kg/m^3

= 92 × 10^9 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 m^2 × 1025 kg/m^3 × 9.81 m/s^2 × (10 m)^2 =4.5 × 10^{12} J (approx)

Now we have 2 high tides and 2 low tides every day. At low tide the potential energy is zero.

Therefore the total energy potential per day = Energy for a single high tide × 2

=4.5 × 10^{12} J × 2 = 9 × 10^{12} J

Therefore, the mean power generation potential = Energy generation potential / time in 1 day

= 9 × 10^{12} J / 86400 s= 104 MW

Assuming the power conversion efficiency to be 30%: The daily-average power generated

= 104 MW * 30% / 100% = 31 MW (approx) [7]

7. Results and Discussion

The availability of creek in Pakistan specially the Indus delta which covers the area of 170 Km. The observations was collected on this area and found that tidal water flows in these creeks with high velocity. In the time of flood and ebb tides this velocity increase more, which is very favorable requirement for the extraction of energy from tidal currents. We can easily utilize the power resource potential of the Indus Deltaic Creek System energy to the Sindh, Pakistan. This is the great asset for us in the future. National Institute of Oceanography (NIO) and Pakistan Navy Hydrographic department is playing an important role and did so many surveys to the Indus deltaic region where seawater inundates up to 80 km inland at some places due to the tidal fluctuation. These surveys and investigations show encouraging results. These creeks extend from Korangi Creek near Karachi to Kajhar Creek near the Pak India border. The current velocity in these Creeks averaged ranged from 4-5 knots but values as high as 8-9 knots were also recorded.

The difference between tidal heights along the Pakistan coast varies between 2 to 5 meters. The tidal heights along the Sindh coast vary between 2-5 meters (Karachi) to over 5.0 meters (Sir Creek) in the Indus delta (Amjad, 2003, personal communication). It is estimated that about 1100 KW power can be produced from these creeks altogether. Development of indigenous capabilities for harnessing tidal energy from Pakistan coast, could bring uplift of socio-economic conditions of coastal population of Pakistan and consequently would also promote minimize environmental pollution.

8. Conclusion

In this study an effort is made to collect the detailed information from different sources to analyze and can give the suitable view to establish a complete system of power generation through tidal energy by using creeks of Pakistan. We can also consider the Sonmiani Hor and the Kalmat Khor for the development of Tidal Power in the Balochistan coastal belt. After thorough study we conclude that the tidal power generation has some con and prone as well. Costly project but plant can last 100 years, high efficiency, predictable output, could potentially provide a storm surge barrier. It can also restrict access to open water, can change tidal level of surrounding area, impact on fish, marine mammals and birds, disrupts regular tidal cycles, and decreases salinity in tidal basins. Generation of tidal energy has potential to become a viable option for large scale.

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