TO STUDY AND ANALYZE THE GENERATION OF ELECTRICITY THROUGH OCEAN TIDAL POWER AT PAKISTAN COASTAL WATERS

(**communication**)

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ABSTRACT: *In this communication we have studied ocean power is set to provide an exciting new source of clean renewable energy and one which can contribute to global energy needs on a sustainable basis. There are three basic energy resources available in the ocean to generate electricity including tidal power, wave power and ocean thermal energy conversion. For centuries human harnessed tides to produce power. Most modern tidal-power units generate electricity. In this paper we have considered the tidal power deriving the electrical power from the ocean especially at Pakistan Coastal Waters. Actually the tidal energy schemes capture the water at high tide and release it at low tide. The physical properties and environmental conditions in the southern regions of Pakistan also give the positive contribution in the generation of reasonable tide to work on the tidal-power.*

Keywords: tidal power, circulation of air, fluctuating dynamics

INTRODUCTION:

Tides are long waves much longer than ordinary wind waves that cause sea level to rise and fall with extraordinary regularity. In fact, the tide is the most uniformly varying phenomenon of the ocean. The daily rise and fall of the tide influences all life along the seashore. This is the fascinating aspects of the ocean is the tide, the slow, up-and-down movement of the sea level that occurs each day. Tidal fluctuations that is the periodic rise and fall of the sea surface is due to the gravitational attraction of the moon and the sun which operate daily and bimonthly, systematically raising and lowering the ocean surface.

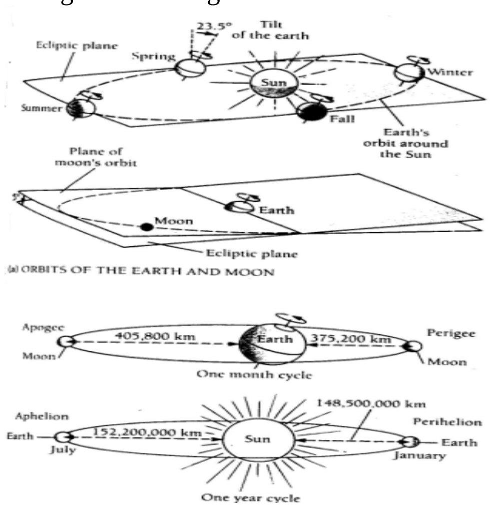

FIG. 1. Effects of lunar declination and orbital variations[1].

The main hindrance to limit tidal-power is the high construction costs and power transmissions. If earth was smoothed and water-covered, and ocean basins had simple shapes, tides could easily be predicted. After thorough analysis it is concluded that large tidal differences occur which, in the U.S., occur only in Maine and Alaska.

THEORY:

Tide produced by two ways on the rotating earth: centrifugal force and gravitational attraction. In the centrifugal force method, the effect of the distance separating the masses is greater than simple gravitational force indicates and varies as follows:

$$\text{Tide-generating forces} \propto 1/r^3$$

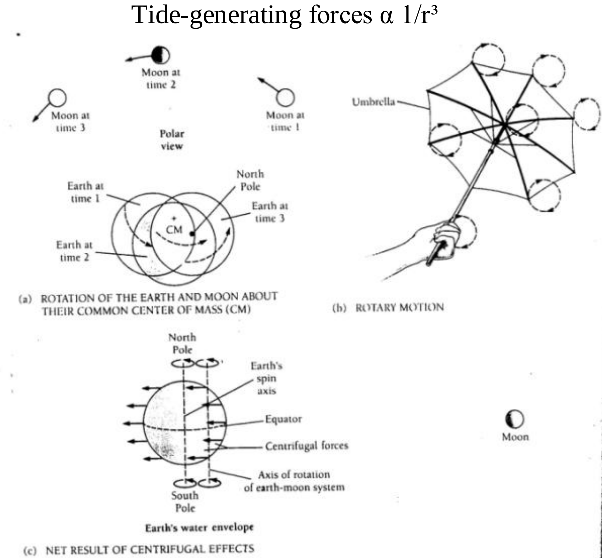

FIG. 2. The effect of centrifugal forces on the earth.

This proportionality indicates that tide-generating forces vary inversely with the cube of the distance that separates the centre of two interacting masses. Actually doubling the distance separating the two masses reduces tide-generating forces by a factor of $2^3 = 8$; tripling the distance, by a factor of $3^3 = 27$. It is just because the moon is closer to the earth; it has more than twice the gravitational attraction. Gravitational forces on the earth caused by the positions of the sun and the moon vary according to Newton's Law:

$$F = G\, m1m2 / r^2$$

Where G is the gravitational constant, m1 and m2 are the masses of the interacting bodies and r is the distance separating the centre of the two masses. The formula clearly indicates that masses of the bodies and distance between them to increase and decrease the gravitational force.

Tidal can be measured quite simply by driving a stake with centimeter markings into the shallow sea bottom and making hourly observations of the water level. The wave height of the tide varies from region to region. Oceanographers classify coastal settings according to their tidal range.[1]

Tides in ocean basins respond to few rules:

1. If the characteristic period of the standing wave in a basin is short relative to the period of the tide-generating forces, there is ample time for water levels to be displaced in step with the tide-generating forces. Such a basin has an equilibrium tide.

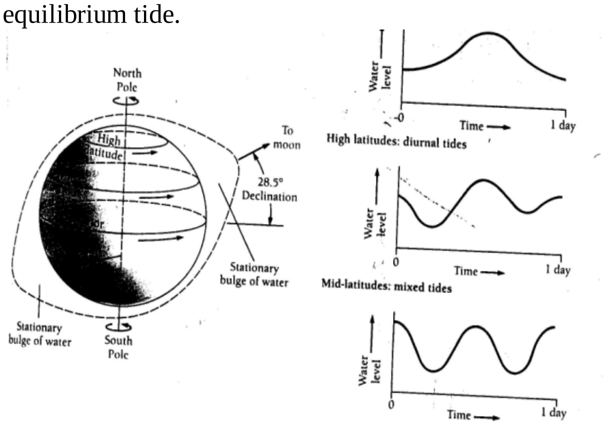

FIG. 3. Fixed points on the earth's surface rotate into and out of the "stationary tide" tidal bulges creating tidal fluctuations each day.

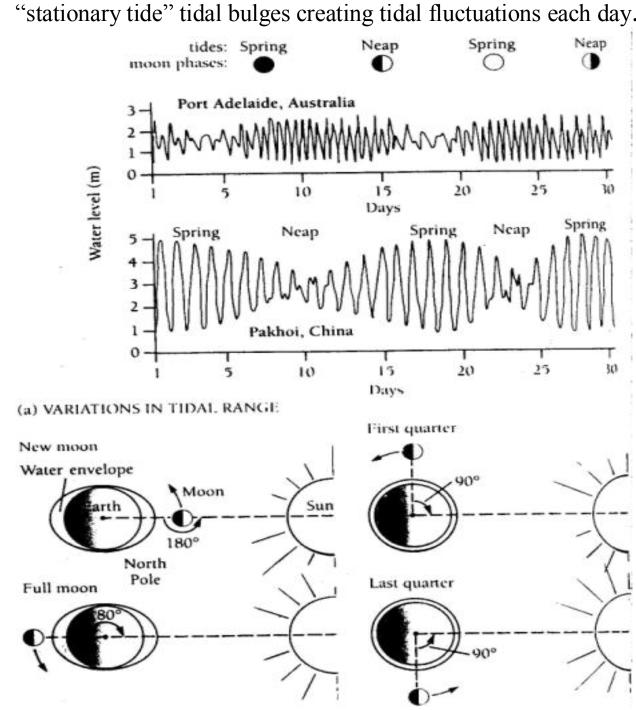

FIG. 4. Month long records of tides with during new moon and full moons.

2. If the characteristic period of the standing wave is very long relative to the period of the tide-generating forces, there is not enough time for water levels to keep step with the tide-generating forces. In this case the tides are small and reversed. In other words low tide occurs when we would have predicted high tide and vise versa, based on equilibrium tide theory.

3. When the characteristic period of a standing wave in a basin is nearly the same as the tide-generating forces, high and low tides occur nearly as we would have predicted, but tidal heights are much greater than predicted.

We can demoralize the tidal power into two ways; (1) By building semi-permeable barrages across estuaries with a high tidal range, and (2) By harnessing offshore tidal streams. Barrages allow tidal waters to fill an estuary via sluices and to empty through turbines. Most tidal-power plants involve one or more dams closing off a bay from the ocean. If the opening is larger and wider, it will increase the cost of construction. Most potential tidal-power sites are in higher latitudes, where glaciers have cut deep, narrow embayment and scoured landscapes down to bedrock [2, 3].

ENERGY OF TIDES:

There are two basic components involve in the energy of the tide wave. One is the potential and the other is the kinetic. The work done during the lifting of the mass above the ocean surface is known as potential energy. This energy can be calculated as:

$$E = g\rho A \int z dz = 0.5 g\rho A h^2.$$

Where E is the energy, g is acceleration of gravity, ρ is the seawater density, which equals its mass per unit volume, A is the sea area under consideration, z is a vertical coordinate of the ocean surface and h is the tide amplitude. Taking an average $g\rho = 10.15 kNm^{-3}$ for seawater, one can obtain for a tide cycle per square meter of ocean surface:

$$E = 1.4h^2, \text{ watt-hour}$$

or

$$E = 5.04h^2, \text{ kilojoule}$$

The kinetic energy T of the water mass m is its capacity to do work by virtue of its velocity V. It is defined by $T = 0.5mV^2$. The total tide energy equals the sum of its potential and kinetic energy components. Knowledge of the potential energy of the tide is important for designing conventional tidal power plants using water dams for creating artificial upstream water heads. Such power plants exploit the potential energy of vertical rise and fall of the water. In contrast, the kinetic energy of the tide has to be known in order to design floating or other types of tidal power plants which harness energy from tidal currents or horizontal water Sows induced by tides. They do not involve installation of water dams.

Following Mathematical Model will be employed for computation of annual power yield per year, in the study [4]:

Let E=ηmgR/2
= η(ρAR)gR/2
=1397ηR2A kWh per tidal cycle

Where R=Range (height) of tide in m
A=area of the Tidal Pool (in Km2)
m=mass of of water = ρV
g= 9.81 m/s2 = gravitational constant.
ρ= 1025 Kg/m3 =density of sea water
η ≈ 0.33 = Capacity Factor (20-35%)

Assuming 706 Tidal Cycles per year

Eyr= 0.997x106ηR2.A kWh.

MATERIALS AND METHODS:

In this study four different locations data are analyzed with different scenario to see the better location to generate tidal power energy. Government of Pakistan, with a view of benefiting from research in oceanography related with coastal & offshore areas of Pakistan established National Institute of Oceanography (NIO). The Institute has been collecting essential data on various aspects of oceanography despite budgetary constraints. Several tidal sites have been identified by NIO, while tidal stream velocities on the creeks have also been ascertained. However there was no feasibility study available in the country to undertake this route of power generation. Potential tidal power sites are shown in Figure-5 on the coast of Pakistan [5, 6].

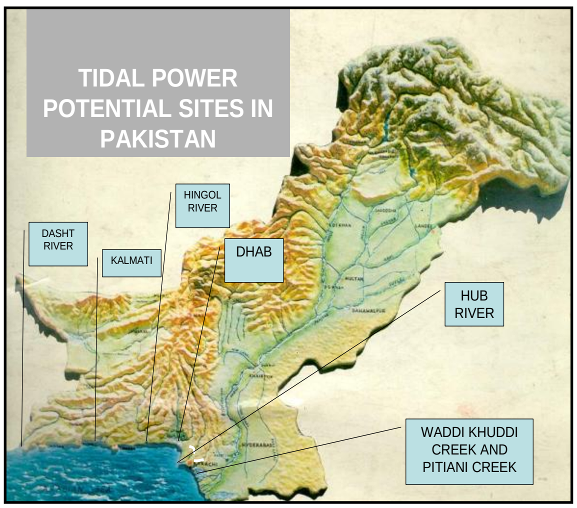

FIG. 5. Potential sites for tidal power along the coast of Pakistan.

Several potential sites at the coast of Baluchistan need to have a detailed feasibility study. One of these is on the River Dasht near Iranian border. Power of this site can be linked with electrical grid that connects Gawadar with Iran. The load area is located nearby, and this can significantly help promote development of the area.

Other two potential sites along the coast line are closely located at Kalmati and Ras Basol, and both can provide electricity to near by towns of Ormara and Jiwani. Another attractive tidal pwer plant site is the Hingol river junction with the ocean.

Near Sonmiani Bay is a comparatively large site, where tidal water fills a very large lake that can be effectively harnessed to supply power to national grid passing close-by which connects Karachi with Quetta. Hub River confluence with the ocean also offers a good site for tidal power plant and power generated can be fed in to national grid passing from Hub[7,8,9,10].

RESULTS AND DISCUSSION:

The plan to establish a model barrage type power station at Pakistan coastal waters is workable, provided data required as mentioned above can be accumulated for the detailed study, so that type of turbine best suited for this location can be decided. For this, and for fabrication of turbine models, and acquisition of prototype, as well as acquisition of equipment, and civil works needs proper planning and thorough study of the area. It is confirmed that the model barrage power station in Pakistan coastal waters will be a reality, as the first of its kind in Pakistan.

CONCLUSION

In this study an effort is made to clear the mind by observing the analysis result that the tidal power generation has some advantages and disadvantages as well. Requires no fuel, emission free, reliable, a plant can last 100 years, high efficiency, predictable output, could potentially provide a storm surge barrier, environmental impacts are local, not global but expensive to build, non-continuous, storage or grid-backup required, locations are often remote, barrages may restrict access to open water, can change tidal level of surrounding area, impact on fish, marine mammals and birds, disrupts regular tidal cycles, decreases salinity in tidal basins, mud flats (where many birds feed) adversely impacted, captures dirt, waste and pollution near the coast, reduces kinetic energy in the ocean.

Generation of tidal energy has potential to become a viable option for large scale. The base load generation in Scotland is one of the reference for us Tidal Streams are the most attractive method, having reduced environmental and ecological impacts and being cheaper and quicker installed. The proposed Stingray project is important to demonstrate the potential for the tidal energy industry in Scotland.

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