

TIDAL ENERGY AS A POTENTIAL RENEWABLE ENERGY RESOURCE

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ABSTRACT

Energy is the basic requirement for human life. At present most of the energy needs are met through fossil fuels and oil. But these are exhaustible resources. Therefore there is an urgent need all over world to tap renewable energy sources. Tides are a substantial potential source of clean renewable energy for future human generations and small communities or even individual households located near continental shorelines, straits or on remote islands with strong tidal currents. Taking an average $(g\rho) = 10.15\text{kJNm}^{-3}$ for seawater, energy can be obtained for a tide cycle, per square meter of ocean surface: $E = 1.4\text{h}^2$, watt-hour (5.04h^2 , kilojoules). The energy source estimated potential of tidal power is 10,000MW. This paper deals with the origin of tides, the energy associated with the tides and various technologies used for production of electricity using tidal energy.

INTRODUCTION

The increased power demand, depleting fossil fuel resources and growing environmental pollution have led the world to think seriously for other alternative sources of energy. Basic concept of alternative energy relates to issues of sustainability, renewability and pollution reduction. In reality alternative energy means anything other than deriving energy via fossil fuel combustion (Alias, 2005).

Tidal Energy in India

Since India is surrounded by sea on three sides, its potential to harness tidal energy has been recognised by the Government of India. Potential sites for tidal power development have already been located. The most attractive locations are the Gulf of Cambay and

the Gulf of Kachchh on the west coast where the maximum tidal range is 11 m and 8 m with average tidal range of 6.77 m and 5.23 m respectively. The Ganges Delta in the Sunderbans in West Bengal also has good locations for small scale tidal power development. The maximum tidal range in Sunderbans is approximately 5 m with an average tidal range of 2.97 m. The identified economic tidal power potential in India is of the order of 8000-9000 MW with about 7000 MW in the Gulf of Cambay about 1200 MW in the Gulf of Kachchh and less than 100 MW in Sunderbans. The Kachchh Tidal Power Project with an installed capacity of about 900 MW is estimated to cost about Rs. 1460/- crore generating electricity at about 90 paise per unit. The techno economic feasibility report is now being examined.

Although many wave energy devices have been

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invented, only a small proportion have been tested and evaluated. Only a few of these have been tested at sea, in ocean waves, rather than in artificial wave tanks.

- Oscillating Water Columns (OWC) These devices generate electricity from the wave-driven rise and fall of water in a cylindrical shaft.
- Floats or Pitching Devices These devices generate electricity from the bobbing or pitching action of a floating object.
- Wave Surge or Focusing Devices These shoreline devices, also called “tapered channel” systems are sizable barriers that channel large waves to increase wave height for redirection into elevated reservoirs.

Energy of Tides

The energy of the tide wave contains two components, namely, potential and kinetic. The potential energy is the work done in lifting the mass of water above the ocean surface. This energy can be calculated as:

E = gρA ∫ zdz = 0.5gρAh²

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 (gρ)= 10.15kNm⁻³ for seawater, tide cycle per square meter of ocean surface can be obtained as:

E = 1.4h², watt-hour Or E = 5.04h², kilojoules

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 = 0.5mV². The total tide energy equals the sum of its potential and kinetic energy components. (Gorlov, 2001)

Table 1. Ocean Energy System Characteristics [Ebbesmeyer *et al.* 1998]

S.No.	System	Developer	Configuration	Rotor Diameter (m)	Units Rating (kW)	Plant Capacity (MW)
1.	Aquantis	Dehlsen Associates, LLC,Santa Barbara, CA	Multi Blade, horizontal axis turbine	30	750	6.75
2.	Underwater Electric Kite	Abacus Controls, Inc.,Somerville,NJ	Dual unit shroude horizontal axis hydroturbine	Approx .3	90	5.4
3.	Electric Power from Ocean Currents	GCK Technologies, San Antonio,TX	Unknown	-	-	-
4.	Blue Energy	Blue Energy Ltd.	Ducted vertical axis turbine	Approx. 7	250kW, 31dual units	7.75

Requirements for power generation

The main requirements for their exploitation for power generation are:

- Sufficient depth of water to allow large enough turbines to be installed
- With such conditions extending over as wide an area as possible to allow the installation of enough turbines to make the project cost effective
- Fast flowing water
- A relatively uniform seabed to minimize turbulence
- Free from shipping constraints and
- Near enough to a shore-based electricity supply network capable of taking the power delivered [(IET) 2007].

Applicable Technologies

A variety of tidal energy conversion devices have been designed and prototypes built and tested. Characteristics of various ocean energy systems are shown in Table 1.

Energy Production Estimates

There are important issues to be addressed in the configuration of the tidal energy conversion system. First, the Colvos Passage must remain navigable so it is assumed that tidal energy converter may not extend beyond mid-channel, meaning turbines from 50 to 400m from shore. Also there are limits to the amount of energy that can be extracted from an open flow channel. If too many turbines are placed in the passage, the device will appear as a dam to the flowing water, which will simply stop moving or it will bypass the turbines and there will be no

Table 2. Resource and Technology Characteristics of Tidal Power Plant (Ebbesmeyer *et al.* 1998).

S.No	Parameters	Values	Assumption
1.	Tidal Induced Current	0 to 1.5 m/s	Estimate from tidal current charts-Diurnal hourly measurements are needed
2.	Average Daily Flow	14,000m3	Discharge in Northern direction from half of Passage-assuming half is reserved for navigation
3.	Turbine	750kW 30 m diameter	Estimate for Aquantis, LLC turbine would need to be optimized for the low flow
4.	Annual Energy Production	13 million kWh/year	9 turbines
5.	Total Rated Capacity	6.75 MW	20% capacity factor-could be increased by a factor of 1.5 or more by properly optimizing the turbine design
6.	Operation &Maintenance	Rs.0.9114 to Rs.1.3671kWh	Including labor, parts, periodic overhaul, insurance and taxes

energy capture. To avoid this problem, the turbines in the conceptual design were placed in two rows, 5 turbines in top (near surface) row with 2 rotor diameter (2d) spacing and 4 in row at 3d depth (U.S. Department of Energy, 2002).

- Reduce oil needs by one-half
- Save 3 million barrels of oil
- Save 330,000 tons of coal
- Save 90.8 tons of uranium

Environmental impacts

Tidal barrage schemes have a large impact on an estuary. With a reduced tidal range above the barrage there are potential changes to the land drainage, fish migration, navigation of ships, wading bird activities plus the possible increased sedimentation due to altered channel turbulence and flow in the estuary. Several advantages follow from the building a barrage, however, through the provision of the route for road traffic across an estuary and with the reduced tidal range comes increased opportunities for recreational sailing and water sports.

ECONOMICS

The benefits derived from inclusion of a tidal power plant are due to the cost of the fuel saved. Primary role of tidal power that would make it economically feasible:

- Replace fossil fuel
- Replace nuclear generated energy

CONCLUSION

Tidal energy is one of the best candidates for this approaching revolution. Development of new, efficient, low-cost and environmentally friendly hydraulic energy converters suited to free-flow waters, such as triple-helix turbines, can make tidal energy available worldwide. Wave energy is promising holds huge potential to reduce reliance on fossil fuels.

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