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Tidal Energy: An Overview of Indian Scenario

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ABSTRACT

Tidal Energy is one of the future energy generation sources for India as it could result in economic green progress of the country with minimal carbon emission. The Tidal energy technology is at nascent stage if current status of renewable energy generation in India is taken into account. In case of India, there is tremendous scope for the tidal energy as India has a very vast coastline and numerous islands in Bay of Bengal and Arabian Sea. Also few tidal energy power generation techniques have been discussed in brief. This paper presents a basic review of the current scenario of tidal energy technology and discusses its barriers & way forward for tidal energy development in India.

Keywords: *Ocean Energy; Tidal Energy Converters; Power Generation; Tidal Energy Plants.*

1.0 Introduction

Oceans occupy more than 70% of earth's surface and are an inexhaustible source of renewable energy. Ocean energy is the energy harnessed from ocean waves, tidal range (rise and fall) & tidal streams, temperature gradients and salinity gradients. Only few commercial ocean energy power plants have been commissioned till date. around 536 MW of installed ocean energy capacity is in operation at the end of 2016, with major share of two large scale tidal barrage plants i.e. the 254 MW Sihwa plant in the South Korea (completed in 2011) and the 240 MW La Rance tidal power station in France (completed in 1966). [1] Apart from tidal barrage plants which use established tidal turbine technology, other ocean energy technologies are still largely in pre-commercial development stages.

Tidal energy is one of the different ways of extracting energy from movement of water in the oceans. Tides are generated through gravitational forces/pull exerted by the Sun and Moon, which occur twice a day along the coast. Flow of water in and out of estuaries carries energy.

The exploitable potential of this energy depends on the speed of the flowing stream and the amount of area which is being intercepted, similar to wind power generation.

As water is denser than air, more amount of power can be generated over small areas and even at slow stream velocities. Even with its non-polluting, reliable and predictable electricity generation, tidal power still has a share of only a fraction of a percent in the world's total renewable electricity generation as shown in figure 1

India has a very long coastline of over 7500 km with 336 small & big islands in the Bay of Bengal and Arabian Sea. Keeping in view the immense potential of ocean energy in the country, it is now time that tidal energy may be harnessed as a future source of renewable energy [5].

2.0 Tidal Energy Technologies

Tidal energy is the energy contained in movement of ocean water in tides/current. The tides contain both potential and kinetic energy. Potential energy is the energy stored when water is available at a higher elevation than normal. The tidal stream turbines immersed in sea make use of the kinetic energy of the water stream which in turn spins the turbine and drives the turbine to produce electricity.

Potential and Kinetic energy of the tides can be harnessed by major approaches i.e. Tidal Barrage technology and Tidal current technology respectively. [4]

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3.0 Tidal Barrage Technology

Tidal barrage is the most successful technology so far in ocean energy conversion technologies. It has been deployed in most of the operational MW scale tidal energy projects Worldwide. This technique involves construction of dam like structure at mouth of bay/estuary having sufficient tidal range of at least 5m. Barrage allows ocean water to enter estuary through sluices/gates and flow through bulb turbines, hence generating power in this process as shown in figure given below. Tidal power can be generated at the time of ebb tide (receding), flood tide or combination of both. Depending on the potential of the site, power can be generated twice a day or more on highly predictable basis. The energy available from a barrage depends on the area of the water surface impounded by the barrage and the corresponding magnitude of the tidal range at the site. However, high capital cost involved in civil construction and possible adverse environmental impacts have restricted the deployment to only few plants worldwide.

Fig 1: Share of Ocean Energy in Global Renewable Energy Mix (Source: REN 21 Report)

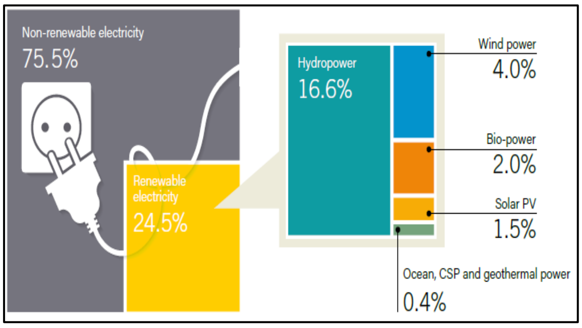
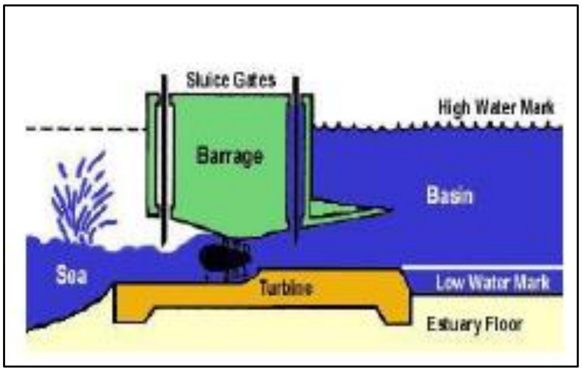


Fig 2: Tidal Barrage



4.0 Tidal Current Technology

On the other side, tidal current technology seems to be technology still at early stages of maturity/commercialization. Instead of constructing barrage, horizontal/vertical axis tidal stream turbines are directly placed in stream and power is generated by harnessing flow of ocean water in tidal currents as shown in figure given below. Tidal turbines are placed at potential sites having ocean depth of 35 m or more for optimum performance. Less installation time-frame is one of the benefits offered by tidal current technology.

Fig 3: Tidal Current Turbine

Some researches have also been conducted in other techniques including tidal lagoon and tidal fence. But, Most of these new technologies in tidal are still under testing or pre-commercial phase.

3.1 World scenario

Currently, South Korea, France, Canada, The United Kingdom, United States of America, etc. are the most active countries in terms of developing tidal energy conversion technologies. Details of the few major operational/under construction tidal energy plants with location, year of commissioning, capital cost, tariff, annual generation expected are shown in following table:- 240 MW La Rance Tidal Barrage in France was commissioned in 1966 and is the oldest plant under operation. The plant consists of 24 bulb type turbine generators 5.35 metres in diameter, 470 tonnes in weight, and rated at 10 MW each which generate electricity whether the tide is going in or out.

Table 1: Major Operational/Under Construction Tidal Energy Plants

Name	Country	Capacity (MW)	Year of Commissioning	Capital Cost	Feed-in-Tariff	Annual KWh expected
Shiwa Lake Tidal Plant	South Korea	254	2011	$ 560 millions (Rs 14.3 Cr/MW)	NA	553 GWh
La Rance Tidal Power plant	France	240	1966	95 Million Euros	$ 22 Cents per unit	500 GWh
Annapolis Royal tidal Plant	Canada	20	1984	NA	$ 56 Cents per unit (Rs 36/KWh)	50 GWh
Swansea Bay Tidal lagoon	United Kingdom	240	2018 (under construction)	850 Million Euros (Rs 24 Cr/MW)	Euros 25.78/MWh (Rs 17 per Kwh)	400 GWh

The average power generated is 68 MW for an annual output of around 600 million kWh units of electricity, at a capacity factor of around 26%. Sihwa Lake Tidal power plant in South Korea is the largest tidal power plant and was commissioned in 2011. The name plate capacity of turbines utilized is 254 MW.

3.2 Indian scenario

The Ministry of New and Renewable energy (MNRE) made a preliminary assessment of the potential of tidal energy in the country. The indicated potential was estimated at around 8000 MW i.e. 7000 MW in the Gulf of Kambhat & 1200 MW in the Gulf of Kutch in Gujarat and around 100 MW in Sunder bans delta in West Bengal.

As assessment of potential of any renewable energy technology depends largely on the technology and methodology used, therefore these figures can be updated continuously based on the recent advancements in technology and methodology being used. Indian Institute of Technology- Madras (IIT-M) in collaboration with CRISIL Risk and Infrastructure Solutions Limited conducted a study named Study on Tidal & Wave Energy in India: Survey on the potential & proposition of a roadmap. This report re-assessed the potential of tidal energy at around 12455 MW.

The earlier assessment of tidal potential was revised by IIT Madras through national hydro-graphic charts, Wx tide, etc. The tidal range at various locations along the Indian coastline was identified using the National Institute of Oceanography (NIO) tide tables and performing harmonic analysis by the IIT Madras. The tidal range, spring tide and neap tide range has been estimated for 46 sites along the coastline.

These tidal levels were validated by deploying sea level gauges at these locations along the Indian coast. Tidal currents were also estimated using hydro-dynamics modelling.

The spring tidal range along Indian coast is shown in the following figure [2]:-

Fig 4: Spring Tidal Range along Indian Coastline (Source: IIT Madras Report)

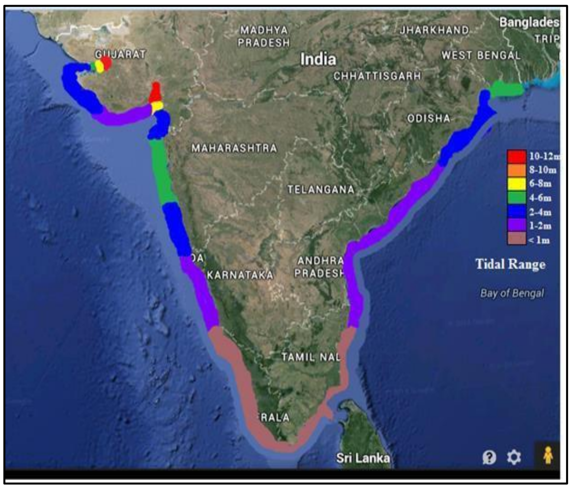
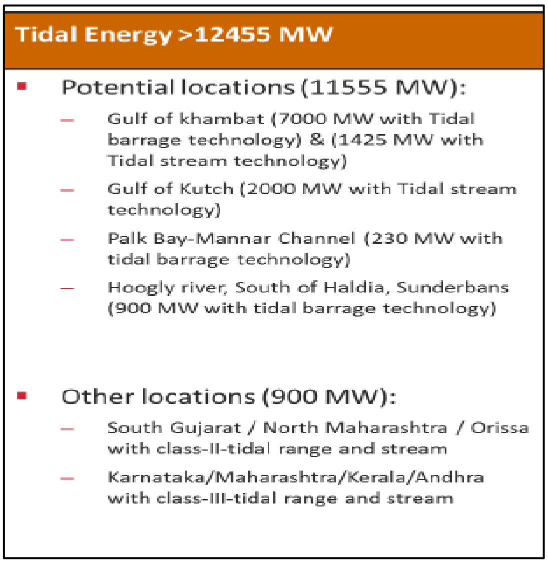


Fig 5: Potential locations for Tidal Energy Generation (Source: IIT Madras Report)



Power generation from tidal energy has not yet taken off in India due to relatively high capital cost, technology not maturing to commercial stage; unsustainable project specific tariff as compared to record low tariffs discovered in solar and wind energy recently and limited availability of sites with sufficient potential. However, with recent technological advancements in tidal energy technologies, it is now expected that it would now result in low levelised costs for harnessing tidal energy. Current Status of earlier tidal energy's project taken up in India is as [3]:-

3.3 MW tidal power project in West Bengal

A tidal energy demonstration project of 3.75 MW capacity was proposed to be installed at Durgaduani creek in sunderbans region in West Bengal. National Hydro Power Corporation (NHPC) signed MoU with West Bengal Renewable Energy Development Agency (WBREDA) in 2007 for preparation of DPR and implementation of 3.75 MW Tidal Power project in Sunderbans, West Bengal. However, due to high capital cost invloved (Rs 50-60 cr /MW); it was decided that project may not be taken up.

3.4 50 MW tidal power project in Gujarat

In 2011, the Government of Gujarat signed MoU with Atlantis Resources Pvt limited for carrying out further studies and implementing a 50 MW Pilot Tidal power project at Gulf of Kutch at Mandvi. The levelized tariff estimated came around at Rs 13/kWh. Therefore, the project was not taken further due to high capital cost invloved (Rs 35 Cr per MW) and unsustainable project specific tariff.

4.0 Barriers & Way Forward for Tidal Energy Development

Tidal energy is easy to operate and maintain, no fuel is required and generates no harmful waste by-product. However, its potential depends on the intensity of the tidal range/current and best suited for a site where tidal range/current is consistently strong. The possible benefits for the Indian society offered by harnessing tidal energy are as follows:-

1) Providing an environmentally friendly, non-polluting and highly predictable grid connected energy source for meeting regional/local power requirements of islands and remote areas along the coastline where main source of electricity generation is diesel based captive power plants with cost of generation of around Rs 20 to 25 per KWh.
2) reducing dependence on imported energy supplies & increasing national energy security
3) Possibility of local job creation and also attracts tourists, therefore overall economic development of the region
4) Higher energy density, as water is 800 times denser than air, for given electrical output tidal turbines can be much smaller than wind turbines.

Major barriers in deployment of Tidal Energy in India are technology being at pre commercial /deployment stage, lack of detailed resource mapping, lack of long term roadmap for ocean energy technologies, high capital cost along with lack of finance for tidal energy projects, requirement of too many administrative/environmental approvals, lack of evacuation facility at remote locations such as mangroves & islands, etc. Therefore, various Central/State government agencies may work together with academics & research institutions, private sector for promotion of research, design, development & demonstration of tidal energy in the country. Though this technology may take years before first plant is commissioned in India, tidal energy is an option worth pursuing as India has a very long coastline of over 7500 km with 336 small & big islands in the Bay of Bengal and Arabian Sea.

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