India Endeavours to Tap into Ocean Energy

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Oceans which occupy more than 70% of the earth's surface are unlimited sources of renewable energy. It is estimated that ocean energy can provide upto 1,000,000 EJ of renewable energy per year; second only to solar energy has a resource availability of 3,900,000 EJ per year. However, out of this annual energy flow, only a small fraction can be harnessed and the technical potential of ocean energy is estimated at 3,240-10,500 EJ per year, while that for solar energy is 62,000-280,000 EJ per year. To put these numbers in perspective the total energy consumed in the entire world in 2015 was approximately 500 EJ. It is therefore evident that oceans are an inexhaustible source of energy.

India has three distinct energy challenges: to meet it's ever increasing energy demand, to lower GHG emissions and to provide clean energy at low cost. These three seemingly contradicting end goals are to be met by 2030 in order to meet the Sustainable Development Goal 7 (SDG 7) on energy viz. 'Ensure access to affordable, reliable, sustainable and modern energy for all'.

Realizing the potential of ocean energy and its relevance for India, the Union Cabinet gave its approval for India to become a member country of the Ocean Energy Systems (OES) by signing the Implementing Agreement (IA) on 13 Jan 2016. The OES

Energy Technology Initiative is an intergovernmental collaboration between countries which operate under the aegis of International Energy Agency (IEA) and currently has 23 member countries including China, US, UK and other EU countries. This process of induction was formally completed on 27 April 2016 when India joined the Technology Collaboration Programme of the OES. The Earth System Science Organisation at the National Institute of Ocean Technology (ESSO-NIOT) under the Ministry of Earth Sciences is the nodal agency which will lead the Indian initiatives.
Ocean energy is primarily of six different types:

- Wave energy: Based on wind-wave interaction
- Tidal energy: Based on rise and fall of water level due to gravitational pull of sun and the moon
- Tidal stream: Water flow in channels located on coast due to tidal effects
- Ocean Thermal Energy Conversion (OTEC): Due to differential in temperature between different depths in the ocean
- Salinity gradients: Due to difference in osmotic pressure between fresh water and salty water found in the region where the river meets the sea.
- Ocean currents: Which are wind-driven or based on thermohaline circulation

In addition there are other potential sources of oceanic energy such as extraction of biofuel from seaweed algae and geothermal energy from submarine vents, but these technologies are relatively unproven.

While tidal energy is a well-established technology and a 240 MW tidal plant has been operating since 1966 at La Rance in France. The largest and the latest addition to tidal energy is the deployment of 254 MW plant at Sihwa Lake, South Korea in 2011. As there has to be a minimum difference of 7 mts between the low and the high tide, there are limited regions in the world which are suited for setting up tidal plants. In India, the total identified potential of tidal energy is about 9,000 MW which is distributed in three regions: Gulf of Cambay (7000 MW), Gulf of Kutch (1200 MW) and the Ganges Delta in the Sunderbans (100 MW). A 3.65 MW plant is functional in the Sunderbans and a 50MW plant is planned in the gulf of Khambhat and Kutch. The upfront investment cost for the plant is around 4,500-5,000 US $/KW and with a lifetime of 40 years, the levelised cost of electricity (LCOE) is around 17-25 cents/kWh. While this LCOE makes tidal energy as one of the cheapest form of ocean energy the cost is still higher than electricity generated from fossil fuels as well as clean energy sources such as wind and solar, which is a big barrier for adoption of the technology.

Wave energy is most potent in latitudes between 30-60 degrees and has reached full scale prototype demonstration. There are various existing technologies such as wave attenuators, point absorbers, oscillating waves surge converters, oscillating water column, overtopping devices etc. which are deployed throughout the world. The investment cost is relatively steep and ranges from 6,200-16,000 US $/KW, and the technologies have a lifetime of approximately 20 years. The total installed capacity of wave energy generators was 12 MW in 2014.

Tidal stream has also been deployed in single array and consists of horizontal axis turbines which are similar to wind turbines as well as vertical axis/cross flow devices which are installed underwater. These require a minimum flow of 1.5-2 m/s of water and require an investment of 5,400-14,300 US $/KW. The total installed capacity for tidal stream in 2014 was around 14 MW.

OTEC plants are most suitable for deployment in 0-35 degree latitudes as a temperature differential of 22 degree C is required for its operation. This is available in tropical waters where the surface temperature can go upward of 26 degree and cold water at 4-8 degree C can be extracted from depths of 800-1000 m. OTEC plants having a capacity of 10-100 KW have been deployed in India, US, and Japan. This technology is also preferred for deployment close to islands as it produces fresh water as a byproduct which can be used for drinking. NIOT had deployed an OTEC closed cycle plant of size 1 MW on a floating platform, ‘Sagar Shakti’ in 2000 off the coast of Tuticorin which was the largest plant ever tested at that time. The Indian Navy is also exploring setting up a

20 MW OTEC plant off the coast of Andaman & Nicobar Islands, pre-feasibility study for which have already been conducted by DCNS, France.

The other two technologies based on harnessing salinity gradients and ocean currents are relatively at an early stage of development. Although there are lab scale models, there is no scaled prototype for commercial generation of electricity from these technologies and it is anticipated that these will have to be substantially developed before deployment at sea.

There are many challenges such as the harsh corrosive environment of the sea, technological limitations such as daily and seasonal variability of waves and currents, requirement of power conditioning and output smoothing due to a power cycle of the order of seconds and low energy density of ocean energy. Other infrastructural issues such as power evacuation using submersible electricity carrying cables, distance of the plant from the shore, provisioning of offshore platform for plant installation also increases the overall cost of electricity generation.

Ocean energy is abundant, is emission free and forms a key component of the 'Blue Economy'. India's efforts to advance research, development and demonstration of ocean energy technologies in collaboration with the OES is laudable and it is likely that India will now have access to advanced technologies. Personnel will additionally have the opportunity to partner with other leading agencies and to join R&D teams across the world to develop cutting edge solutions to overcome the existing challenges and limitations. India will also benefit from being a part of developing test protocols and testing of Indian prototypes can now be undertaken based on international standards. What now remain to be seen is how the technology is scaled up and how fast the costs are brought down so that ocean energy can become a significant part of the global energy mix.

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