

## Energy from the oceans

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Energy is pivotal for prosperity. Economy prospered whenever a civilization could garner new energy sources. The discovery of fire was indeed an significant step in the human history - it marked the dawn of civilization - what marked humans distinct from animals. Subsequently human harnessing the animal power by domesticating them unleashed spur of activities. Discovery of coal and petroleum during the 18<sup>th</sup> century led to industrial revolution and emergence of modern world. Today we are also harnessing energy by breaking atoms - nuclear reaction.

However the extensive use of petroleum and coal has resulted in twofold problems. Both petroleum and coal are limited resources. As the rates in which we consume them keep on increasing, availability of these fuels for future is under threat. Estimates indicate that coal and petroleum reserves would be completely dry in another 50 - 60 years. Further as we burn these fossil fuels we release more and more carbon-dioxide into the air. As the concentration of carbon dioxide keeps on increasing in earth's atmosphere, Earth is facing the threat of global warming.

Scientists have been looking for ways of generating clean energy - say from solar, wind and so on. One such effort has been to harness power from the mighty oceans. They attempt to generate energy by utilizing the temperature difference between the sea surface and deep ocean.

### **Ocean as a source of energy:**

Just as land is heated by the sunlight, sea surface is also heated by the sun. While the average sea surface temperature is 17 degree, at temperate places it is usually as high as 23 - 24 degrees. Sunlight cannot penetrate much of deep sea water. It can heat up only the upper 200 meters or so. Below this depth the sea water becomes cooler and cooler. At about a depth of 500 meters the sea water is only about 12 degrees and at the depth below 1000 meters it is just 4-5 degrees. Much below this, the temperature drops to freezing 4 degrees or less. Thus the temperature difference which exists between the warm surface sea water (28° ~ 30° C) and deep sea cold water (7° ~ 15° C) could be effectively utilized for generation of power. This is called Ocean Thermal Energy Conversation (OTEC).

Before we understand how scientists are proposing to harness this temperature differential, let us understand how they conventionally generate electricity from burning coal. In coal based thermal plant or even in steam engine the technology of generating energy from coal is by burning it and generating steam. Called boiler technology, the idea is burning coal and generating heat energy. The heat energy is used to boil water in a boiler. As the water heats up and boils it generates steam. The steam is collected in the boiler at high pressure. The steam flows through a pipe and rotates a turbine. The turbine is connected to a dynamo. Dynamo is same mechanism that one may find in bicycles to generate light in the headlamp. As the bicycle is peddled, the dynamo also rotates due to

friction and light is generated. In like manner when the turbine rotates it in turn rotates the dynamo and electricity is produced in the thermal power plants.

In OTEC design, first, warm surface water heats a fluid with a low boiling point, such as ammonia or a mixture of ammonia and water. When this "working fluid" boils, the resulting gas creates enough pressure to drive a turbine that generates power. The gas is then cooled by passing it through cold water pumped up from the ocean depths via massive fibreglass tubes, perhaps 1000 metres long and 27 metres in diameter, that suck up cold water at a rate of 1000 tonnes per second. Alternatively the vapour can be taken by a pipe to depth of ocean where the temperature is only 4-5 degrees. At that lower temperature the vapour will condense and again become liquid. This can again be injected into the boiler and reused. While the gas condenses back into a liquid that can be used again, the water is returned to the deep ocean. Thus using the temperature differential of the sea surface and depth one can generate electricity.

Water usually boils at 100 degrees. However there are liquids that have lower boiling point. Acetaldehyde boils at just 20.8 degrees. Ammonia boils at -35.5 degrees. One of the key elements in OTEC is to identify a suitable "working fluid" that would become supersaturated at desired temperature. Another hitch is designing the plumbing works. You will have to inject a pipe of about 20-30 meter diameter and about 1000-3000 meters length into the ocean. The pipe has to withstand the stress and strain of the ocean currents. Also the material used, say ammonia and such chemicals should not corrode the pipe.

The idea of tapping the ocean's different thermal layers to generate electricity was first proposed in 1881 by French physicist Jacques d'Arsonval but did not receive much attention until recently when the urgency for clean energy has become acute. In 1979, off coast of Hawaii, an OTEC pilot plant was established generating 50 kilowatts of electricity. In 1981 Japanese group built a pilot plant off the South Pacific island of Nauru capable of generating 120 kilowatts. Difficulties in barge mooring and ocean plumbing resulted in shut down of these pilot plants. However, the Indian effort was ambitious "to scale up to generate ultimately 100 MW of power.

OTEC plants could be floating or land-based. Floating plants have the advantage that they are closer to the deep cold water and the cost of the piping and pumping will be less. However, floating plants are vulnerable to storms and the electricity which is generated has to be brought ashore. A land-based OTEC system will not require the long power transmission cable, but instead the warm and cold water will have to be brought onshore. There is the possibility that the cold water will warm up so reducing the efficiency of the power generation.

The amount of ocean thermal energy is vast, none of the other alternatives to fossil fuel can even come close to the magnitude of the OTEC resource. And, unlike wind or wave power, OTEC offers energy in constant supply, available day and night regardless of the weather and with only a small seasonal variation. For an OTEC plant to work efficiently there must be a temperature difference of more than 20°C between the surface water and the cool deep water and this is only found within tropical and sub-tropical oceans. However, in this zone are the southern states of the USA and parts of Australia, as well as many developing nations including **India** which is increasingly

using more fossil fuel to generate electricity. Tropical islands would particularly benefit from OTEC, because oil-fired power is expensive and there is usually a need for desalinated water.

Unlike other clean energy technologies, OTEC has some useful by-products. OTEC plants can be used to produce fresh water from seawater. In the open-cycle system, warm water is vaporised when it is subjected to a low pressure. The salt is left behind and the condensed steam is almost pure water. The desalination produced by OTEC in this way is effectively free.

### **Indian efforts:**

In India Dr. Subramaniam Kathirolu and his team at National Institute of Ocean Technology (NIOT) tried to set up an experimental plant for generation of electricity using the ocean thermal energy at the Bay of Bengal in 2003. Alas the pipes, about 800 meters long were washed by the ocean currents. Again they tried next year, yet again failure. Tight budget and lack of sufficient infrastructure the task became difficult. Bad weather compounded the problems. Two attempts of deploying the 800 m long and 1 m diameter cold water pipe in 1100 meter water depths failed. Mooring of the barrage in severe weather condition was also proving to be critical. Even when the power was generated transfer of the same to shore was yet another design difficulty.

Failures did not deter them. Rather they started to think laterally. Difficulties in transfer of power to shore and economics led to rethinking. Why not use the energy by-passing the electric power conversion? Many coastal places and islands are in need of drinking water and natural sources are either absent or inadequate. Trend towards desalination of sea water is seen. Kathirolu and others also thought of designing Low Temperature Thermal Desalination plant. The energy produced by OTEC could be used; and it need not be converted into electricity and sent to shore. Rather the energy could be directly used to purify sea water and potable water could be sent offshore.

NIOT under Kathirolu constructed a Barge Mounted LTTD plant off Tuticorin. The plant had a capacity of 100 m<sup>3</sup> per day. The project successfully demonstrated continuous production of good quality fresh water. Impelled by the success, one lakh litre LTTD was commissioned successfully at Kavaratti. NIOT's recently unveiled barge-mounted desalination plant, produces one million litres a day at about 6 paise per litre. The team is confident that they would be able to scale up and establish a plant with 25 million litres per day capacity and should be able to produce water at just 3 paise per litre.

World over total electricity generation is about 125 GW. Estimated OTEC energy potential within Indian EEZ through OTEC is alone 200 GW. Thus indeed OTEC could become a significant contribution for meeting the energy needs of future. Though recent success of OTEC has been in establishment of LTTD, electricity generation is not off the burner. World's leading aerospace engineers are involved in designing suitable fibreglass pipes that could be practically used in ocean. Even if some power could be generate using the ocean energy then one could at least reduce that much dependence on the coal and petroleum.

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