Geo-Thermal and Ocean Energy Technologies

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Keeping in view the commitment for a healthy planet and as per India's Nationally Determined Contributions made in the Paris Accord on Climate Change, India has made a pledge that by 2030, 40 per cent of installed power generation capacity shall be based on clean energy sources. Accordingly, an ambitious target has been set of installing 175 GW of renewable energy capacity by 2022. This includes 100 GW from solar, 60 GW from wind, 10 GW from bio-power and 5 GW from small hydro power. As on date, around 77 GW of renewable energy capacity has been installed in the country with major share coming from solar and wind power technologies. The possibility of venturing into new emerging renewable energy technologies, such as Floating Solar, Offshore wind, solar wind hybrid, energy storage, etc is also being explored. However, renewable energy technologies such as geo-thermal and ocean energy still remain at a nascent stage in India.

Ocean Energy

Oceans occupy more than 70 per cent 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). Apart from tidal barrage plants which use established tidal turbine technology, other ocean energy technologies are still largely in pre-commercial development stages.

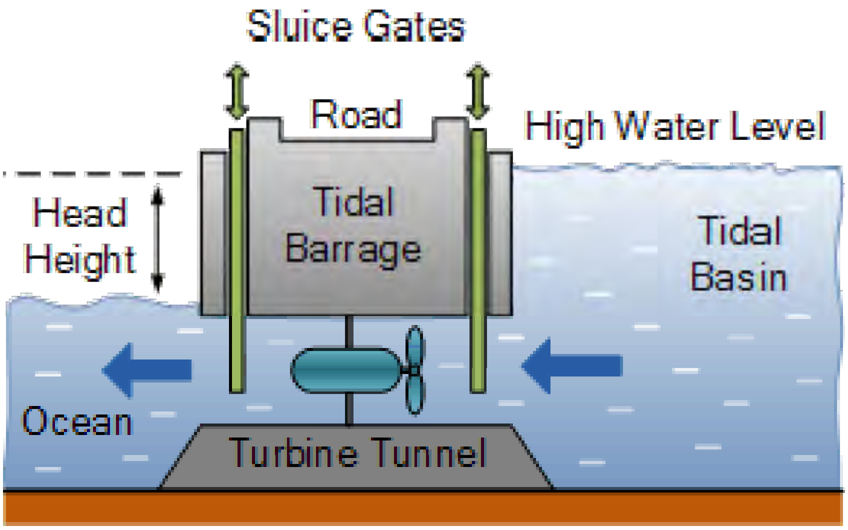
World Scenario

Leading countries in Ocean Energy technology are UK, USA, Sweden, Canada, France, South Korea. Examples of few large scale Tidal (Barrage) Plants are 254 MW at South Korea (2011), 240 MW at France (1966), 20 MW at Canada, etc. Ocean Technology, such as Tidal (Current), Wave, Ocean Thermal Energy Conversion (OTEC) are still at pre R&D stage/Kilo Watt level.

> **Geothermal Energy has experienced modest growth worldwide in recent times as compared to other Renewable Energy sources especially wind or solar due to its site specific nature, risk/uncertainty involved with resource exploration and high capital cost.**

Indian Scenario

As per study conducted by IIT Madras, Theoretical Potential for tidal Energy in India is 12500 MW, Promising locations are Gulf of Khambhat & Gulf of Kutch (GJ), Sunderbans (WB), Western Ghats (MH), etc. Theoretical Potential for Wave Energy in India is 41,000 MW, Promising locations are



Tidal Energy

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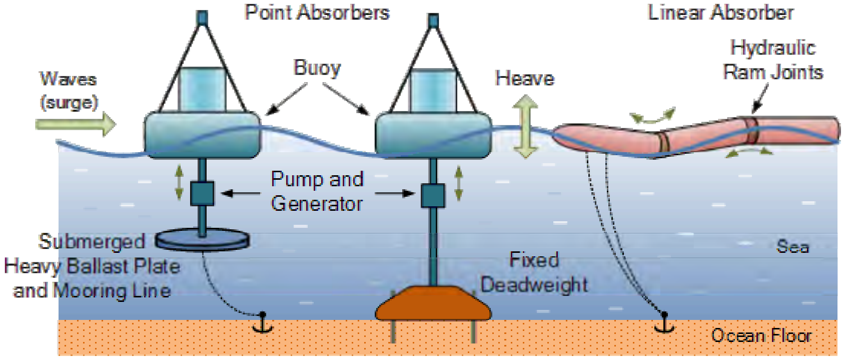
Western Coast of Maharashtra, Goa, Karnataka, Kerala, Kanyakumari, Southern tip of India, etc. However, resource survey at target locations i.e. Western Ghats, Eastern Ghats, etc. may be undertaken to assess/validate actual potential. These technologies are more suitable for off grid electricity generation in remote coastal areas/mangroves/islands where Tariff is very high @ Rs 25/Kwh for diesel based captive power generation. Major bottlenecks for deployment are high upfront cost i.e. Rs 60 Crore for 1.125 MW wave energy plant at A&N islands and Rs 2000 Crore for 8 MW plant by Indian Navy, high tariff @ Rs 15.69/KWh with 50 per cent grant for A&N wave energy plant.

Technology

a) Tidal Energy

The tidal cycle occurs every 12 hours due to the gravitational pull of the moon. The difference in water level from low tide and high tide is potential energy that can be harnessed. Similar to hydropower generated from dams, tidal water is captured in a barrage across an estuary during high tide and forced through a turbine during low tide.

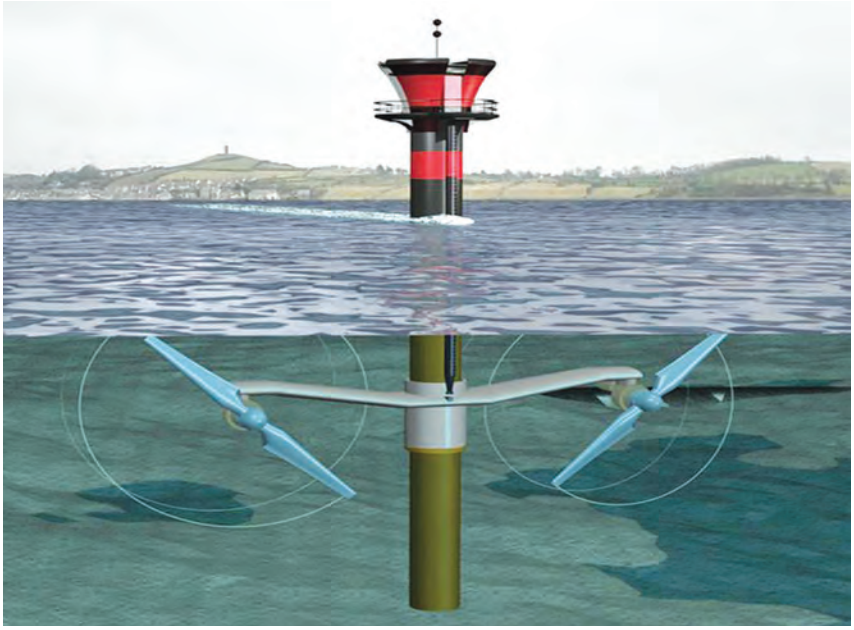


Wave Energy Converters

The capital cost for tidal energy power plants is very high due to high civil construction that results in high power tariff. In order to harness power from the tidal energy, the height of high tide must be at least five meters (16 feet) greater than low tide.

b) Wave Energy

Wave energy is generated by the movement of a device either floating on the surface of the ocean or moored to the ocean floor by the force generated by the ocean waves. Many different techniques for converting wave energy to electric power have been developed. Wave conversion devices floats on the surface have joints hinged together that moves with the waves. The kinetic energy pumps fluid through turbines and generates electric power. Moored wave energy conversion devices use pressure fluctuations produced in long tubes from the waves moving up and down. This wave motion drives a turbine.


Ocean current turbine

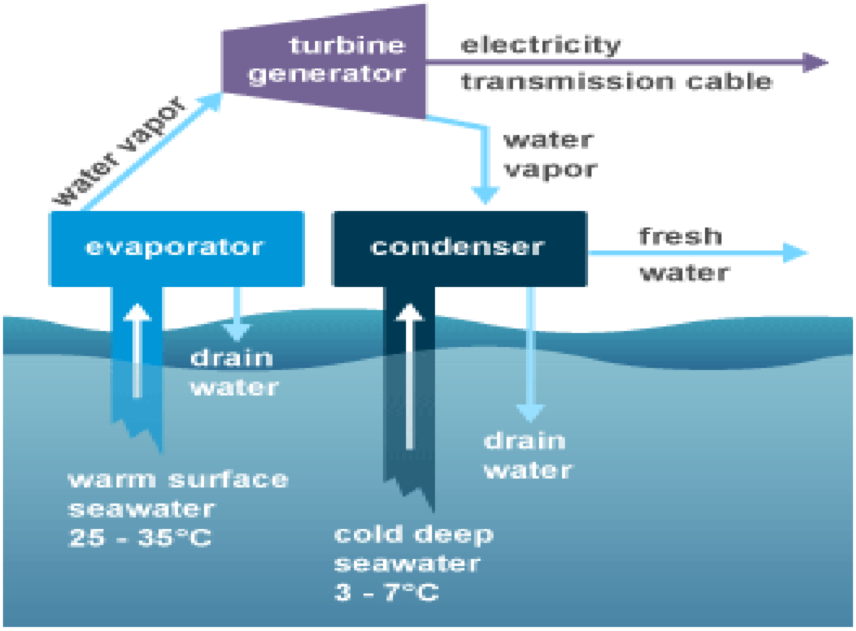
c) Current Energy

Ocean current is ocean water moving in one direction. This ocean current is also known as the Gulf Stream. Kinetic energy can be captured from the Gulf Stream and other tidal currents with submerged turbines that are very similar in appearance to miniature wind turbines. Similar to wind turbines, the movement of the marine current moves the rotor blades to generate electric power.

d) Ocean Thermal Energy Conversion (OTEC)

Ocean thermal energy conversion, or OTEC, uses ocean temperature differences from the surface to depths lower than 1,000 meters, to harness energy. A temperature difference of even 20°C can yield energy efficiently. Research focuses are on two types of OTEC technologies to extract thermal energy and convert it to electric power: closed cycle and open cycle.

In the closed cycle method, a working fluid, such as ammonia, is pumped through a heat exchanger and vaporized. This vaporized steam runs a turbine. The cold water found



Ocean Thermal Energy Converter

at the depths of the ocean condenses the vapor back to a fluid where it returns to the heat exchanger. In the open cycle system, the warm surface water is pressurized in a vacuum chamber and converted to steam to run the turbine. The steam is then condensed using cold ocean water from lower depths.

Future Road Map

Most Ocean Technologies are still at Pre R&D/commercialization stage worldwide. Therefore, technologies need validation from leading research institutes before demonstration. It is necessary to plan to develop Demonstration projects initially for each ocean energy technology at feasible sites before going for commercial plants as also to undertake resource assessment with support from leading countries as ocean energy expert.

Geothermal Energy

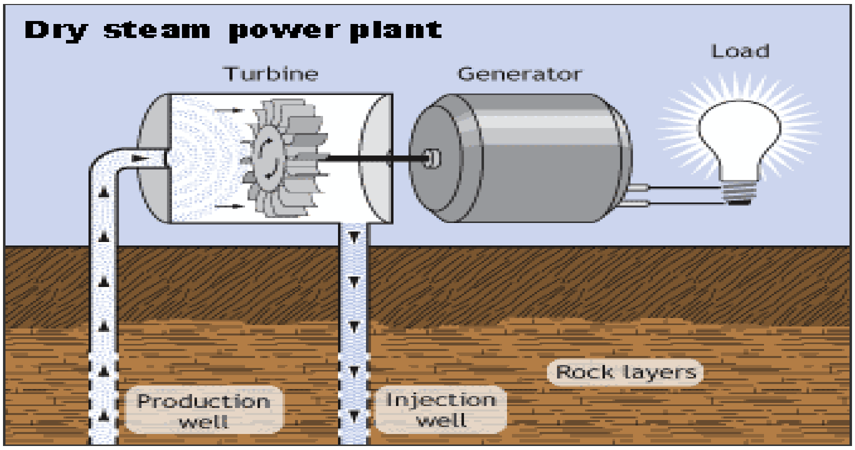
Geothermal Energy is a mature renewable energy technology that has a potential to provide clean and reliable energy for power generation and direct heating/cooling. Geothermal Energy can be utilized for both electric power production and direct heat applications including Ground Source Heat Pump (GSHP) for space or district heating, generating hot water for domestic/industrial use, running cold storages and greenhouse, horticulture, etc. However, Geothermal Energy has experienced modest growth worldwide in recent times as compared to other RE sources especially wind or solar due to its site specific nature, risk/uncertainty involved with resource exploration and high capital cost.

World Scenario

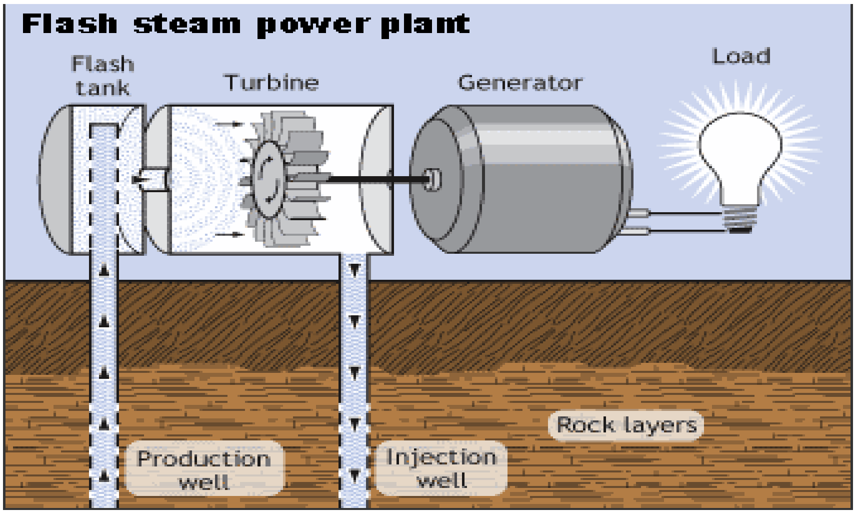
Total Installed Capacity for Geothermal Power is around 13.5 GW. Leading countries in geothermal power generation capacity are USA (3600 MW), Philippines (1900 MW), Indonesia (1600 MW), New Zealand (1000 MW), Mexico (900 MW), Italy (800 MW), Turkey (800 MW), Iceland (700 MW), Kenya (600 MW) & Japan (500 MW). Total installed capacity for geothermal direct heat utilization for heating/cooling (excluding heat pumps) is around 23 GWth. Leading countries in geothermal direct heat use are China (6.1 GWth), Turkey (2.9 GWth), Japan (2.1 GWth), Iceland (2.0 GWth) & Italy (1.4 GWth). Total installed capacity for Ground Source Heat Pump (GSHP) is around 50.3 GWth with leading markets as USA, China & Europe (France, Germany, Italy & Sweden).

Indian Scenario

India is still at nascent stage of geothermal energy utilization with no geothermal power plant set up in the country so far due to high upfront cost of Rs 30 Cr/MW & indicative Tariff in range of Rs 10 per KWh, site specific deployment, lack of load center and power evacuation facility nearby, high risk involved in exploration, etc. Geological Survey of India (GSI) with CSIR - National Geophysical Research Institute (NGRI) carried out preliminary resource assessment for the exploration and utilization of geothermal resources in 1970s & 1980s in the country.



Dry steam geothermal power plant (Source: US Department of Energy)



Flash steam geothermal power plant (Source: US Department of Energy)

As per preliminary investigations undertaken by the GSI, there are around 300 geothermal hot springs in India. Most of these geothermal hot springs are in medium potential (100 C to 200 C) and low potential (<100 C) zones. The promising geothermal sites for electric power generation are Puga Valley & Chummathang in Jammu & Kashmir, Cambay in Gujarat, Tattapani in Chattisgarh, Khammam in Telangana & Ratnagiri in Maharasthra. The promising geothermal sites for direct heat use applications are Rajgir in Bihar, Manikaran in Himachal Pradesh, Surajkund in Jharkhand, , Tapoban in Uttarakhand & Sohana region in Haryana.

Technology

Power Generation: Hot water and steam from deep underground can be piped up through underground wells and used to generate electricity in a power plant. There are three types of geothermal power plants:

i) **Dry Steam Plants** which use geothermal steam directly. Dry steam power plants use very hot (>235 °C) steam from the geothermal reservoir. The steam goes directly through a pipe to a turbine to spin a generator that produces electricity.

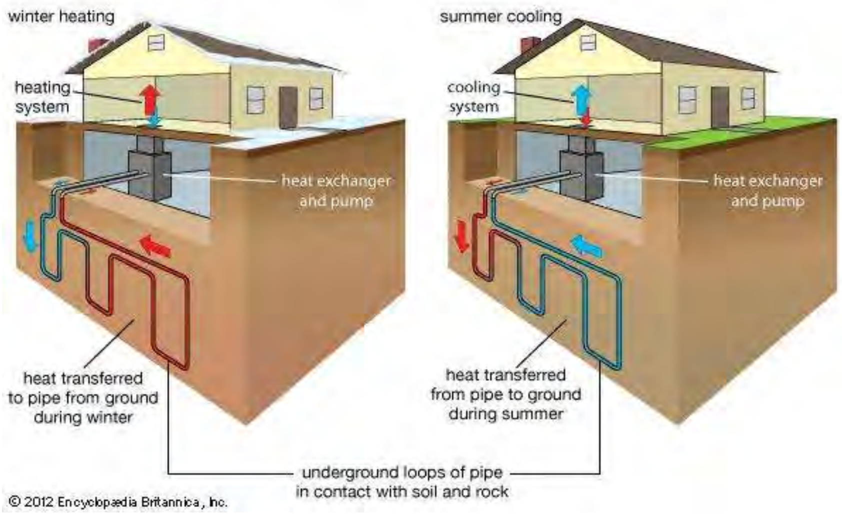
ii) **Flash Steam Plants** which use high pressure hot water to produce steam. Flash steam power plants use hot water (>182 ºC) from the geothermal reservoir. When the water is pumped to the generator, it is released from the pressure of the deep reservoir. The sudden drop in pressure causes some of the water to vaporize to steam, which spins a turbine to generate electricity. Hot water not flashed into steam is returned to the geothermal reservoir through injection wells.

iii) **Binary Cycle Plants** which use moderate-temperature water (107 to 182 ºC) from the geothermal reservoir. In binary systems, hot geothermal fluids are passed through one side of a heat exchanger to heat a working fluid in a separate adjacent pipe. The working fluid, usually an organic compound with a low boiling point such as Iso-butane or Iso-pentane, is vaporized and passed through a turbine to generate electricity.

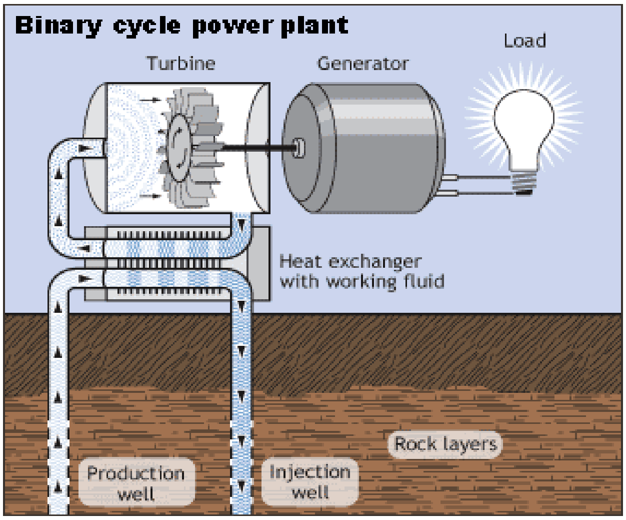
Other thermal applications: Apart from geothermal power generation, this renewable source can be utilized directly for thermal applications through these technologies:-

i) **Space/District Heating**: In areas where hot springs or geothermal reservoirs are near the Earth's surface, hot water can be piped in directly to heat homes or office buildings. Geothermal water is pumped through a heat exchanger, which transfers the heat from the water into the building's heating system. The used water is injected back down a well into the reservoir to be reheated and used again.

ii) **Geothermal Heat Pump/ Ground Source Heat Pumps**: A few feet under the ground, the soil or water remain a constant



Geothermal Heat Pump (Source: Encyclopaedia Britannica)



Binary cycle geothermal power plant
(Source: US Department of Energy)

50 to 60 degrees Fahrenheit (10-15 degrees Celsius) year-round. In this method, geothermal heat pumps use a system of buried pipes linked to a heat exchanger and ductwork into buildings. In winter the relatively warm earth transfers heat into the buildings and in summer the buildings transfer heat to the ground or uses some of it to heat water. These heat pumps function as both air-conditioning and heating systems. Fluid circulates through a series of pipes under the ground or beneath the water of a pond or lake and into a building. An electric compressor and heat exchanger pull the heat from the pipes and send it via a duct system throughout the building. In the summer the process is reversed. The pipes draw heat away from the house and carry it to the ground or water outside, where it is absorbed.

Future Roadmap

Industry led, applied R&D proposals to harness geothermal energy under Research, Design, Development & Demonstration (RDD&D) policy are necessary for this renewable energy source to become operational.. Plans should be made to develop Demonstration projects initially each for geothermal electricity production & direct heat use applications. PSUs may undertake resource assessment with support from leading countries as geothermal expert. Projects for space cooling and industrial process heating using GSHP technology may be supported through subsidy, preferential tariff from power companies as technology is energy/ water efficient. ❑

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