## Introduction:

Energy is required in almost all aspect of everyday life including agricultural, drinking water, lighting health care, telecommunication, and industrial activities. Use of fossil fuel also made a side effect. Their combustion product will make pollution, such as global warming, acid rain and so on. Conversion to clean and environment friendly energy sources such as solar energy would enable the world to improve the quality of life throughout the planet Earth, not only for humans, but also for its flora and fauna as well. Renewable energy sources, such as biomass, solar, ocean thermal, wind, currents, tides, waves, geothermal etc., are being considered as possible sources of energy to meet these challenges.

The ocean can produce two types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves. Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors. The sun's heat warms the surface water a lot more than the deep ocean water, and this temperature difference creates thermal energy. Just a small portion of the heat trapped in the ocean could power the world. Ocean thermal energy is used for many applications, including electricity generation.

Ocean mechanical energy is quite different from ocean thermal energy. Even though the sun affects all ocean activity, tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. As a result, tides and waves are intermittent sources of energy, while ocean thermal energy is fairly constant. Also, unlike thermal energy, the electricity conversion of both tidal and wave energy usually involves mechanical devices.

## Forms of Ocean Energy:

There are three basic types that allow us to use ocean for its energy.

1. wave energy, wave power
2. Ocean tidal power (ocean high and low tides),
3. Ocean Thermal Energy Conversion, OTEC). Also sometimes referred to as ocean energy or ocean power)

The term marine energy encompasses both wave power — power from surface waves, and tidal power — obtained from the kinetic energy of large bodies of moving water. Offshore wind power is not a form of marine energy, as wind power is derived from the wind, even if the wind turbines are placed over water. The oceans have a tremendous amount of energy and are close to many if not most concentrated populations. Ocean energy has the potential of providing a substantial amount of new renewable energy around the world. The oceans represent a vast and largely untapped source of energy in the form of surface waves, fluid flow, salinity gradients, and thermal.

## Wave Energy, Wave power:

Ocean wave energy is form of the kinetic energy that exists in the moving waves of the ocean since waves are caused by blowing winds over the surface of the ocean. This energy can be used to power a turbine and there are many areas in the world where wind blows with sufficient consistency to provide continues waves. There is tremendous energy in wave power which gives this energy source gigantic energy potential. Wave energy is captured directly from surface waves or from different pressure fluctuations between the surfaces. This energy can then be used to power a turbine and the simple and mostly used working principle of this procedure would be as follows: First the wave raises into a chamber and then the rising water forces the air out of the chamber and the moving air spins a turbine which then turns a generator.

The main problem with wave energy is the fact that this energy source isn't the same in all parts of the world, since it varies significantly from place to place. This is the reason why wave energy can't be exploited in all parts of the world but there are many researches that work on solutions of how to solve this variability problem. However, there are still many rich wave power areas in the world like the western coasts of Scotland, northern Canada, southern Africa, Australia, and the northwestern coasts of the United States, all with high potential for wave power exploitation. There are many different technologies to capture wave power but very few of these technologies is commercial enough to be fully used. Wave technologies are not only installed near shore and offshore but already also in far offshore locations and the emphasis of new research projects such as “The OCS Alternative Energy Programmatic EIS” is particularly on offshore and far offshore wave technologies where offshore systems are located in deep water, on depths passing even 40 meters.

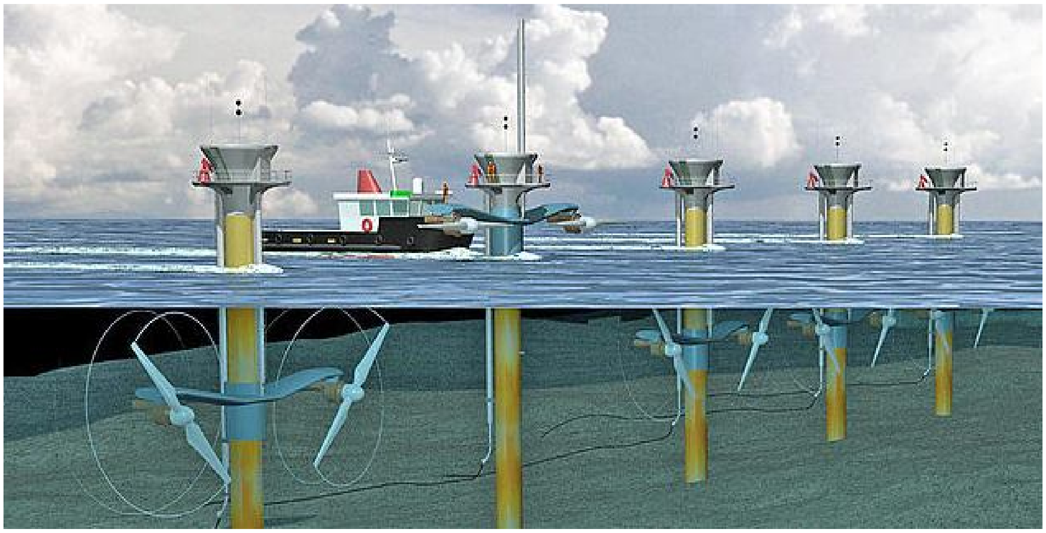
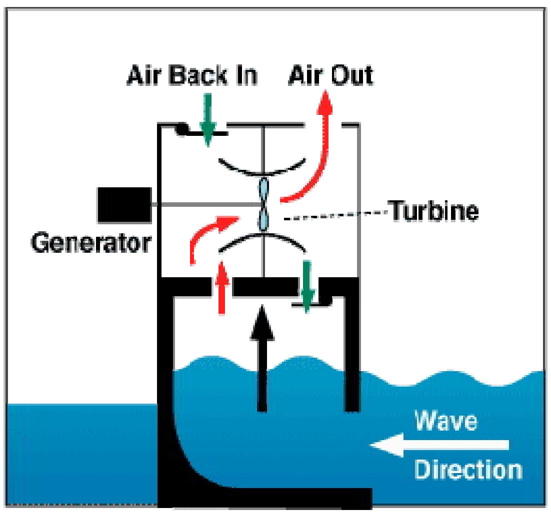


*Figure: Schematic diagram of wave power station.*

The wave energy sector is reaching a significant milestone in the development of the industry, with positive steps towards commercial viability being taken. The more advanced device developers are now progressing beyond single unit demonstration devices and are proceeding to array development and multi-megawatt projects. The backing of major utility companies is now manifesting itself through partnerships within the development process, unlocking further investment and, in some cases, international co-operation.

Kinetic energy (movement) exists in the moving waves of the ocean. That energy can be used to power a turbine. In this simple example, to the right, the wave rises into a chamber. The rising water forces the air out of the chamber. The moving air spins a turbine which can turn a generator. When the wave goes down, air flows through the turbine and back into the chamber through doors that are normally closed.

At a simplified level, wave energy technology can be located near-shore and offshore. Wave energy converters can also be designed for operation in specific water depth conditions: deep water, intermediate water or shallow water. The fundamental device design will be dependent on the location of the device and the intended resource characteristics.



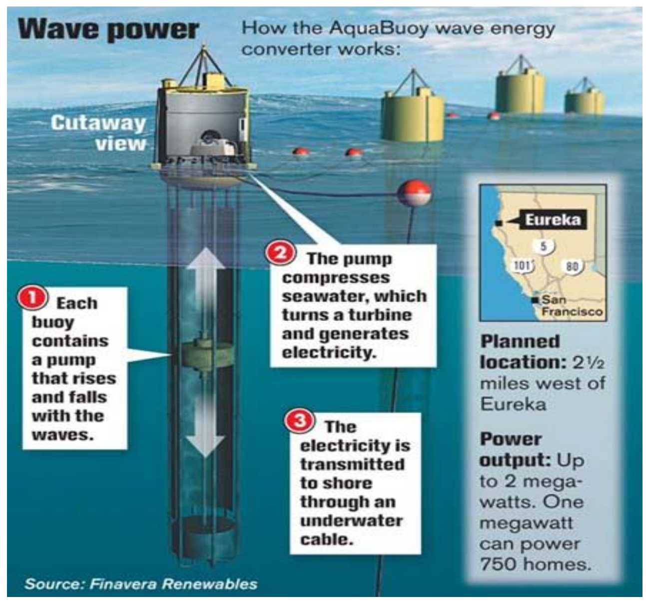




*Figure: Alternative form of Wave energy generation.*

This is only one type of wave-energy system. Others actually use the up and down motion of the wave to power a piston that moves up and down inside a cylinder. That piston can also turn a generator. Most wave-energy systems are very small. But, they can be used to power a warning buoy or a small light house.

Wave-power generation is not currently a widely employed commercial technology, although there have been attempts to use it since at least 1890. In 2008, the first experimental wave farm was opened in Portugal, at the Aguçadoura Wave Park. Energy output is determined by wave height, wave speed, wavelength, and water density. To date there are only a handful of experimental wave generator plants in operation around the world.

## Tidal power:

Also called tidal energy, is a form of hydropower that converts the energy of tides into useful forms of power - mainly electricity. The operating principle behind tidal energy converters is that the energy contained within the moving current is harnessed by a device that extracts kinetic energy from the flow and imparts this into a mechanical motion of a rotor or foil. The device then converts the mechanical motion of the structure into electrical energy by means of a power take-off system. Before connection to the electricity grid, the electrical power output from the device will need to be conditioned in order to make it compliant with grid code regulations. In essence, tidal device operation is synonymous to that of a wind turbine, albeit operating within a different fluid medium.

The energy from moving masses of water — a popular form of hydroelectric power generation. Tidal power generation comprises three main forms, namely**: tidal stream power, tidal barrage power, and** power. Tidal power, also called tidal energy, is a form of hydropower that converts the energy of tides into useful forms of power, mainly electricity. Although not yet widely used, tidal power has potential for future electricity generation.

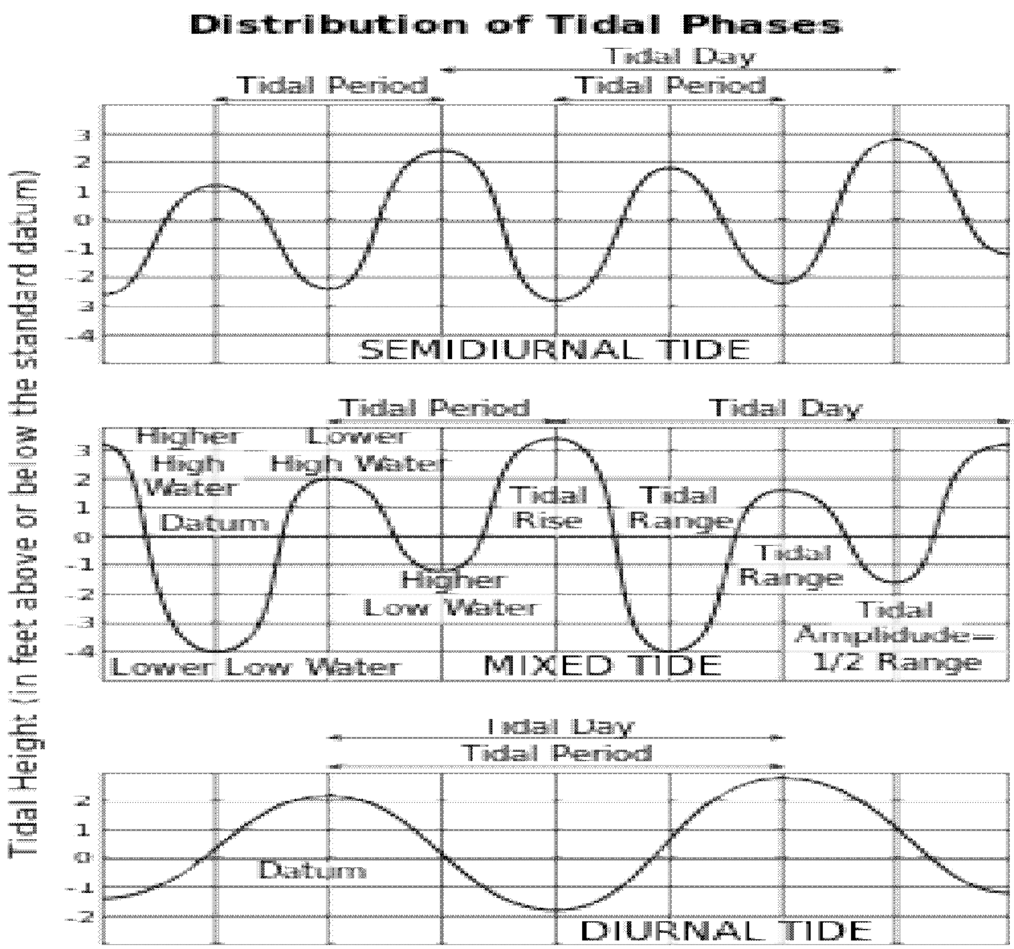



*Figure: Tidal Frequency.*

Tides are more predictable than wind energy and solar power. Among sources of renewable energy, tidal power has traditionally suffered from relatively high cost and limited availability of sites with sufficiently high tidal ranges or flow velocities, thus constricting its total availability. However, many recent technological developments and improvements, both in design (e.g. dynamic tidal power, tidal lagoons) and turbine technology (e.g. new turbines, cross), indicate that the total availability of tidal power may be much higher than previously assumed, and that economic and environmental costs may be brought down to competitive levels.

Historically, tide mills have been used, both in Europe and on the Atlantic coast of North America. The incoming water was contained in large storage ponds, and as the tide went out, it turned waterwheels that used the mechanical power it produced to mill grain. The earliest occurrences date from the Middle Ages, or even from Roman times. It was only in the 19th century that the process of using falling water and spinning turbines to create electricity was introduced in the U.S. and Europe.

Another form of ocean energy is called tidal energy. When tides come into the shore, they can be trapped in reservoirs behind dams. Then when the tide drops, the water behind the dam can be let out just like in a regular hydroelectric power plant.

Tidal energy has been used since about the 11th Century, when small dams were built along ocean estuaries and small streams. The tidal water behind these dams was used to turn water wheels to mill grains. In order for tidal energy to work well, you need large increases in tides. An increase of at least 16 feet between low tide to high tide is needed. There are only a few places where this tide change occurs around the earth. Some power plants are already operating using this idea. One plant in France makes enough energy from tides (240 megawatts) to power 240,000 homes.

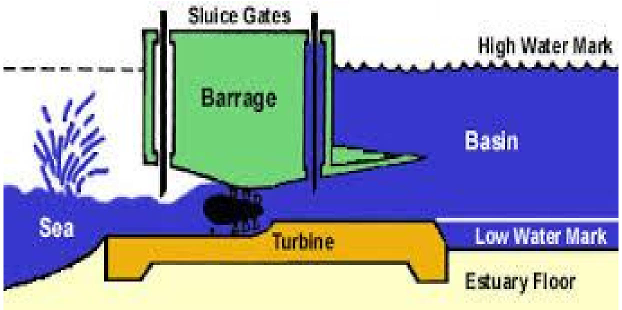



*Figure: Tidal barrage power in LA RANCE, France.*

This facility is called the La Rance Station in France. It began making electricity in 1966. It produces about one fifth of a regular nuclear or coal-fired power plant. It is more than 10 times the power of the next largest tidal station in the world, the 17 megawatt Canadian Annapolis station.

**Generation of Tidal Power**

Tidal power is taken from the Earth's oceanic tides; tidal forces are periodic variations in gravitational attraction exerted by celestial bodies. These forces create corresponding motions or currents in the world's oceans. Due to the strong attraction to the oceans, a bulge in the water level is created, causing a temporary increase in sea level. When the sea level is raised, water from the middle of the ocean is forced to move toward the shorelines, creating a tide. This occurrence takes place in an unfailing manner, due to the consistent pattern of the moon's orbit around the earth. The magnitude and character of this motion reflects the changing positions of the Moon and Sun relative to the Earth, the effects of Earth's rotation, and local geography of the sea floor and coastlines.

Tidal power is the only technology that draws on energy inherent in the orbital characteristics of the Earth–Moon system, and to a lesser extent in the Earth–Sun system. Other natural energies exploited by human technology originate directly or indirectly with the Sun, including fossil fuel, conventional hydroelectric, wind, bio-fuel, wave and solar energy. Nuclear energy makes use of Earth's mineral deposits of fissionable elements, while geothermal power taps the Earth's internal heat, which comes from a combination of residual (about 20%) and heat produced through radioactive decay (80%).

*Figure: The world's first commercial-scale and grid-connected tidal stream generator – SeaGen – in Strangford Lough. The strong wake shows the power in the tidal current.*

A tidal generator converts the energy of tidal flows into electricity. Greater tidal variation and higher tidal current velocities can dramatically increase the potential of a site for tidal electricity generation. Because the Earth's tides are ultimately due to gravitational interaction with the Moon and Sun and the Earth's rotation, tidal power is practically inexhaustible and classified as a renewable energy resource. Movement of tides causes a loss of mechanical energy in the Earth–Moon system: this is a result of pumping of water through natural restrictions around coastlines and consequent viscous dissipation at the seabed and in turbulence. This loss of energy has caused the rotation of the Earth to slow in the 4.5 billion years since its formation. During the last 620 million years the period of rotation of the earth (length of a day) has increased from 21.9 hours to 24 hours; in this period the Earth has lost 17% of its rotational energy. While tidal power will take additional energy from the system, the effect is negligible and would only be noticed over millions of years.

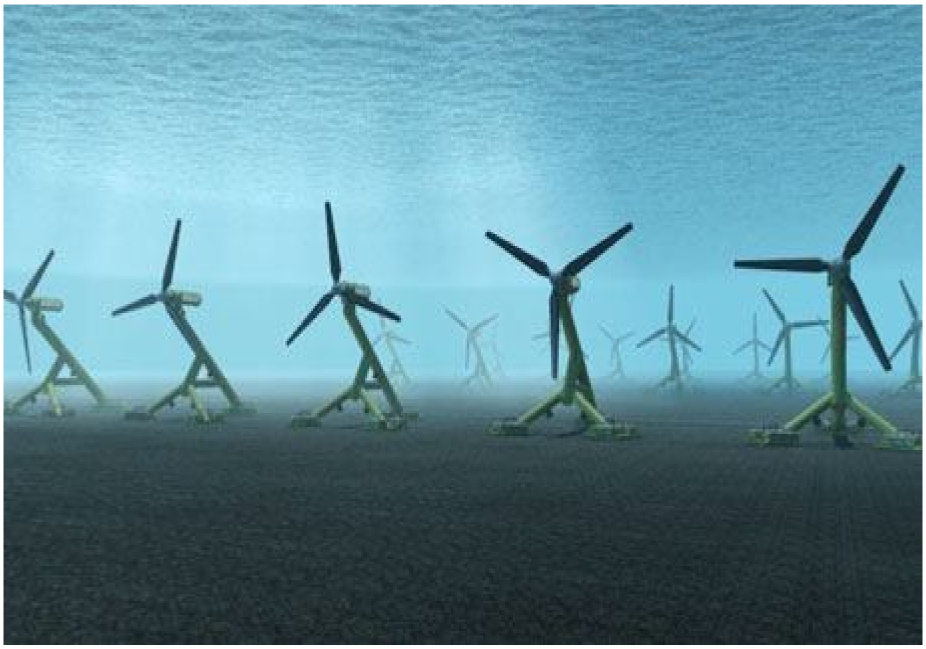


*Figure: Underwater 10 megawatt tidal stream project in the Sound of Islay between the Hebridean islands of Islay and Jura.*

## Ocean thermal energy:

Ocean thermal energy refers to the power from temperature differences at varying depths. Ocean thermal energy conversion (OTEC) uses the temperature difference between cooler deep and warmer shallow or surface ocean waters to run a heat engine and produce useful work, usually in the form of electricity. OTEC is a base load electricity generation system, i.e. 24hrs/day all year long. However, the temperature differential is small and this impacts the economic feasibility of ocean thermal energy for electricity generation.

The idea is not new. Using the temperature of water to make energy actually dates back to 1881 when a French Engineer by the name of Jacques D'Arsonval first thought of OTEC. The final ocean energy idea uses temperature differences in the ocean. If you ever went swimming in the ocean and dove deep below the surface, you would have noticed that the water gets colder the deeper you go. It's warmer on the surface because sunlight warms the water. But below the surface, the ocean gets very cold. That's why scuba divers wear wet suits when they dive down deep. Their wet suits trapped their body heat to keep them warm.

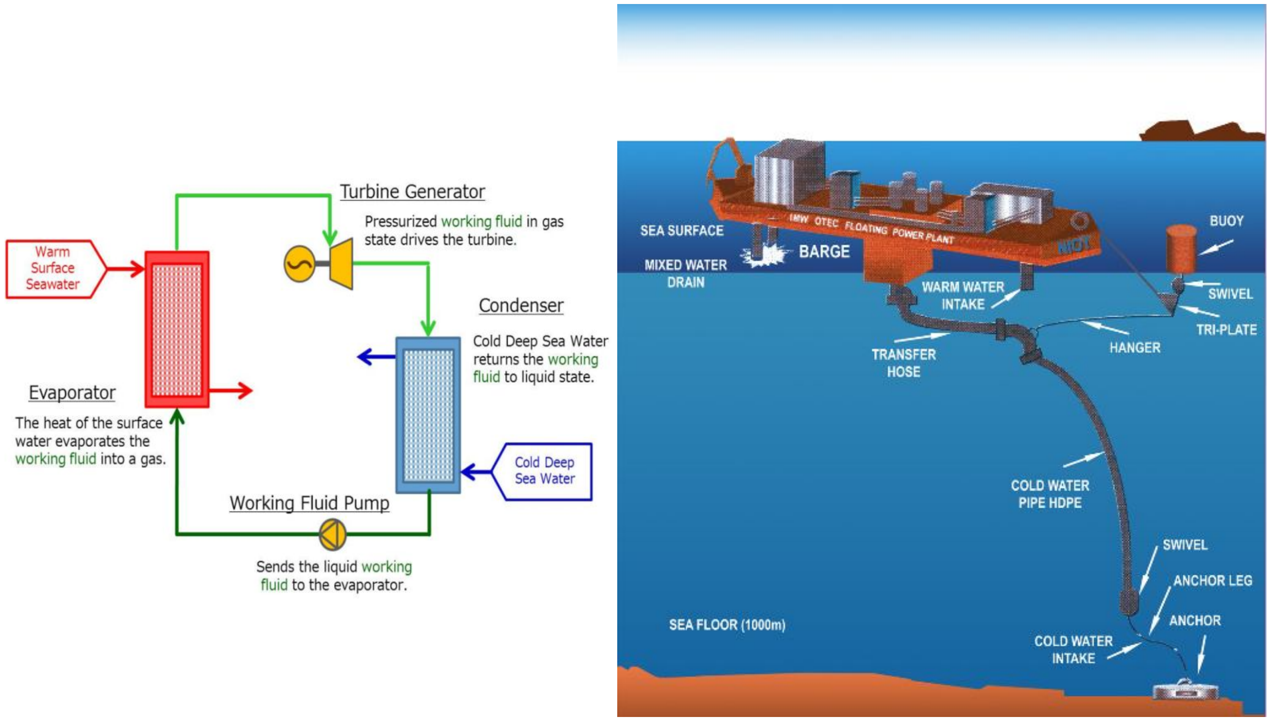
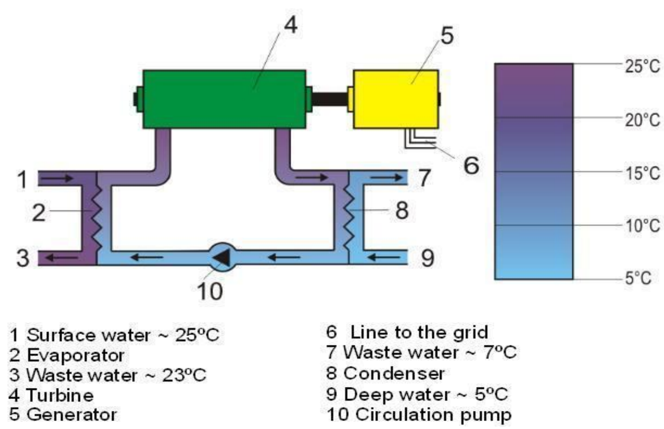



*Figure: OTEC basic working procedure.*

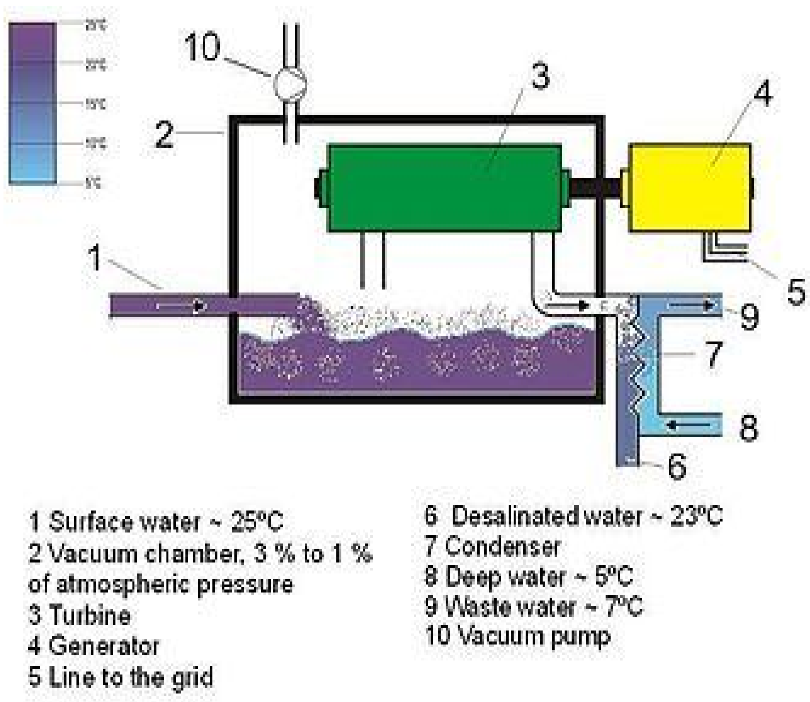
Power plants can be built that use this difference in temperature to make energy. A difference of at least 38 degrees Fahrenheit is needed between the warmer surface water and the colder deep ocean water.

## Closed Cycle:




Systems may be either closed-cycle or open-cycle. Closed-cycle engines use working fluids that are typically thought of as refrigerants such as ammonia or R-134a. These fluids have low boiling points, and are therefore suitable for powering the system's generator to generate electricity. The most commonly used heat cycle for OTEC to date is the Rankine cycle using a low-pressure turbine. Open-cycle engines use vapor from the seawater itself as the working fluid. TEC can also supply quantities of cold water as a by-product. This can be used for air conditioning and refrigeration and the nutrient-rich deep ocean water can feed biological technologies. Another by-product is fresh water distilled from the sea. OTEC theory was first developed in the 1880s and the first bench size demonstration model was constructed in 1926. Currently the world's only operating OTEC plant is in Japan, overseen by Saga University.

## Open Cycle:




## Thermodynamic Efficiency of OTEC:

A heat engine gives greater efficiency when run with a large temperature difference. In the oceans the temperature difference between surface and deep water is greatest in the tropics, although still a modest 20 to 25 °C. It is therefore in the tropics that OTEC offers the greatest possibilities. OTEC has the potential to offer global amounts of energy that are 10 to 100 times greater than other ocean energy options such as wave power. OTEC plants can operate continuously providing a base load supply for an electrical power generation system.

The main technical challenge of OTEC is to generate significant amounts of power efficiently from small temperature differences. It is still considered an emerging technology. Early OTEC systems were 1 to 3 percent thermally efficient, well below the theoretical maximum 6 and 7 percent for this temperature difference.[21] Modern designs allow performance approaching the theoretical maximum Carnot efficiency and the largest built in 1999 by the USA generated 250 kW.

## Ocean Energy on Bangladesh Perspective:

Bangladesh has got 710 km long coastal belt along the Bay of Bengal. If the marine RETs become viable option in the future, then the country may harness energy from marine RETs. The main marine RETs are –

1. Tidal
2. Wave and
3. Oceanic Thermal Energy Conversion

***Tidal***

Tidal power utilizes the twice daily variation in sea level caused primarily by the gravitational effect of the Moon and, to a lesser extent the Sun on the world's oceans. The Earth's rotation is also a factor in the production of tides. The normal tidal head rise and fall in the coastal region of Bangladeshi is between 2 and 8 meters as shown in the following table. This tidal range can easily be converted to pollution free clean renewable energy busing the simple low-cost technology of a “tidal wheel” in the sluice gates.

*Figure: One of many sluice gates in Sandwip that could be utilized for tidal power plant [Refocus 2001].*

The real benefits of this technology however are that it can be applied in a way that simultaneously enables the development of local infrastructure and various resource producing activities such as agriculture and aquaculture along with improved living conditions for the local people [Salequzzaman et. al. 2001]. A demonstration tidal power project is being planned in Sandwip, one of the coastal island of Bangladesh, by ISTP of Murdoch University, Australia. ISTP has developed a feasibility plan for rebuilding a recently damaged sluice gate with a trial paddle wheel [REFOCUS March 2001]. If become successful, the tidal project of Sandwip can be replicated in the other coastal areas and which will usher new light in the region.

Tidal levels in Coastal Bangladesh [BIWTA, 1999]

| STATION | LAT | MLWS | MLWN | ML | MHWN | MHWS | HAT | TD(AT) |
|---|---|---|---|---|---|---|---|---|
| Hiron Points | -0.256 | 0.225 | 0.905 | 1.700 | 2.495 | 3.175 | 3.656 | 3.912 |
| Sundarikota | -0.553 | 0.036 | 0.636 | 1.829 | 3.022 | 3.694 | 4.211 | 4.764 |
| Mongla | -0.261 | 0.325 | 1.194 | 2.310 | 3.427 | 4.296 | 4.882 | 5.143 |
| Khal no. 10 | -0.444 | 0.261 | 1.231 | 2.664 | 4.097 | 5.067 | 5.772 | 6.216 |
| Sadarghat | -0.423 | 0.239 | 1.100 | 2.481 | 3.861 | 4.722 | 5.385 | 5.808 |
| Cox's Bazar | -0.339 | 0.205 | 1.023 | 1.995 | 2.967 | 3.785 | 4.329 | 4.668 |
| S. Island | -0.348 | 0.191 | 1.045 | 1.874 | 2.703 | 3.557 | 4.096 | 4.444 |
| Sandwip | -0.583 | 0.238 | 1.634 | 3.243 | 4.851 | 6.248 | 7.070 | 7.653 |
| Char Changa | -0.375 | 0.256 | 1.060 | 2.037 | 3.014 | 3.818 | 4.449 | 4.824 |
| Khepupara | -0.323 | 0.195 | 1.025 | 2.060 | 3.096 | 3.925 | 4.445 | 4.768 |
| C.Ramdaspur | -0.261 | 0.189 | 0.763 | 2.036 | 3.309 | 3.883 | 4.333 | 4.594 |
| Barisal | +0.134 | 0.434 | 0.692 | 1.539 | 2.386 | 2.644 | 2.944 | 2.810 |
| Chandpur | +0.019 | 0.256 | 0.493 | 2.172 | 3.852 | 4.088 | 4.326 | 4.307 |
| Nalmuri | +0.078 | 0.370 | 0.722 | 2.195 | 3.669 | 4.021 | 4.313 | 4.235 |
| Narayanganj | +0.458 | 0.585 | 0.697 | 2.770 | 4.844 | 4.956 | 5.083 | 4.625 |
| Galachipa | -0.159 | 0.283 | 0.937 | 1.764 | 2.592 | 3.245 | 3.689 | 3.848 |
| Patuakhali | -0.143 | 0.242 | 0.740 | 1.575 | 2.409 | 2.907 | 3.293 | 3.436 |

**Explanation:**
MLWS = Mean Low Water Spring, MHWS = Mean High Water Spring, MHWN = Mean High Water Neap, MLWN = Mean Low Water Neap, ML = Mean Level, AT = Astronomical Tide, LAT = Lowest Astronomical Tide, HAT = Highest Astronomical Tide, TR =Difference between lowest and highest tidal height in "m".

Tidal Electric Inc. (TE) is one of the major global players in the field of tidal power projects around the world. TE is active in the two neighboring countries of Bangladesh – India and Myanmar in the Bay of Bengal. TE is carrying out feasibility study of a 1000 megawatt tidal power plant in Gujarat, India and target site in Myanmar. Wave Ocean waves represent a considerable renewable energy resource. Waves are generated by the wind as it blows across the ocean surface. They travel great distances without significant losses and so act as an efficient energy transport mechanism across thousands of kilometers. Energy can be taken from waves almost everywhere but if the waves are to small expenses will be to high. Wave energy is stronger around the poles and around the equator the water contains lesser potential.

Any site in the world with an average wave power level of over 15kW per meter has the potential to generate wave energy at competitive prices [OPD Ltd 2001]. From the atlas shown in Figure 7.2, it can be seen that for Bay of Bengal the value is 8 kW per meter of crest width. So, at present Wave power is not a viable option for Bangladesh.

**Oceanic Thermal Energy Conversion (OTEC)**

Ocean Thermal Energy Conversion (OTEC) utilizes the temperature difference between the warm surface sea water and cold deep ocean water to generate electricity. For OTEC to produce a net output of energy, the temperature difference between the surface water and water at a depth of 1000m needs to be about20°C [Australian RE Website]. From the atlas it can be seen that for Bay of Bengal the temperature difference between surface and subsurface (1000m) sea water is between 20 to 22°C.So, OTEC project is expected to be feasible in the Bay of Bengal in the future when the technology will be mature and cost of the system will go down.

## Conclusion:

Recently, an initiative has been taken to explore the scope of integrated tidal power plants in the island of Sandwip. If the pilot project becomes successful, similar projects can be replicated to other coastal islands of the country. Wave energy is stronger around the poles and around the equator the water contains lesser potential. Any site in the world with an average wave power level of over 15kW per meter has the potential to generate wave energy at competitive prices [OPD Ltd 2001]. From the atlas, it can be seen that for Bay of Bengal the value is 8 kW per meter of crest width. So, at present Wave power is not a viable option for Bangladesh. For OTEC to produce a net output of energy, the temperature difference between the surface water and water at a depth of 1000m needs to be about20°C [Australian RE Website]. From the atlas shown in Figure, it can be seen that for Bay of Bengal the temperature difference between surface and subsurface (1000m) sea water is between 20 to 22°C.So, OTEC project is expected to be feasible in the Bay of Bengal in the future when the technology will be mature and cost of the system will go down.

**References:**

[1] http://www.renewableenergyworld.com at 3:07PM on 29th April, 2014.

[2] http://en.wikipedia.org at 4:00 PM on 29th April, 2014.

[3] www.renewableenergyworld.com at 9:15PM on 19th April, 2014.

[4] www.oceanenergy.ie at 10:02PM on 19th April, 2014.

[5] www.awsocean.com at 11:26PM on 19th April, 2014.

[6] www.cyberjournals.com at 12:49PM on 19th April, 2014.