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Ocean Energy

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ABSTRACT: The world is in a great need for a resource that is reliable, clean, safe, largely abundant, predictable renewable resource and that produces a significant amount of electricity. Most recent energy resources like biofuel, wind and solar have developed to great extent but they all have few major unsolved issues like predictability, safety and availability of fuel for generation of power. Solving these issues to improve their efficiency is very important but finding new ways to generate power using an abundant fuel which is predictable is also necessary.

On earth, almost 70% or more is water, in which 96% is saline water in oceans that **cannot** be used for human needs. Oceans of the earth represent a vast source of renewable energy that is abundantly available. The aim of this review is to provide a simple and complete overview of why? How? Where? By when? Ocean energy could be used to produce clean electricity.

I. INTRODUCTION

The ocean water is always moving and there are efficient ways to predict its movement, current etc. This movement is mainly due to the moon's gravitation and also due to the fact that earth is elliptical in shape. We all know that the moon revolves around the earth and earth also rotates on its axis. The area that is facing the moon will have higher gravitational pull and hence higher tides. These changes to low tide in approximately 6 hours depending on the location and other factors. This makes the tidal force predictable. There are 4 tides every 24 hours, 2 of them high and the other 2 are low that alternate respectively.

In general, ocean energy can be divided into five types of different origin and characteristics: Salinity gradient- chemical pressure differential in the ionic concentration between freshwater and seawater, Ocean thermal energy conversion- tapping on to the temperature difference between hot surface water and deep cold water of the ocean, Tidal range- height difference between high tide and low tide, Tidal current- The periodic movement of water driven by a head difference created by out-of-phase ocean tides, and Ocean wave- motion of water molecules in the surface of the ocean

The kinetic energy present in tidal currents and Marine Ocean can be converted to electricity using relatively efficient turbine technology. But harnessing the kinetic energy within the waves has a different set of technical challenges that are being worked on and a wide variety of designs have been suggested to improve different problems faced. Ocean thermal energy can be converted to electricity using a heat engine that operates on a high temperature difference in the ocean. Salinity gradients, where the percentage of salt differs between two tappable areas, can be exploited for energy extraction through the osmotic process.

It was 1966 in La Rance, France when Sir. M. Jannaschii discovered that the movement of ocean water can be converted into usable energy like electricity. As of now, all sea vitality innovations with the exception of tidal range can be considered at a beginning period of improvement from its calculated plan to an exhibit stage. Some have even come up to the stage proving its profitability like the Sihwa Lake Tidal Power Station that is a 400-meter long tidal barrage power plant and has a maximum output of 254 MW .

Ocean wave and tidal current energy are the two types of ocean energy which are the most advanced and are expected to contribute significantly to the supply of power in future. Existing challenges include development of the technology to prove reliability, serviceability, toughness and reduce costs for installation.

II. OCEAN ENERGY TYPES

A) SALINITY GRADIENTsimply refers to **Osmotic Power** or the pressure generated as a result of pure water diffusion through a semi permeable membrane, which is placed in between saline water and freshwater. This semi permeable membrane only allows water to diffuse through it, which primarily collects salinity from the flowing water. In theory, The diffusion of water proceeds until the concentration of salt is neutralized on both sides of the water. Whereas practically, the water will continue to diffuse until a differential head of 240 m on the salt side which generates the required pressure to prevent further diffuse of water. According to this principle, it should be possible to completely utilize this osmotic pressure to generate electric power. This is the working behind the osmotic power plant, first proposed by Sidney Loeb during the 1970s. There are two main processes to generate electricity using osmotic power which works on the principle of osmosis with ion specific membranes - they are:

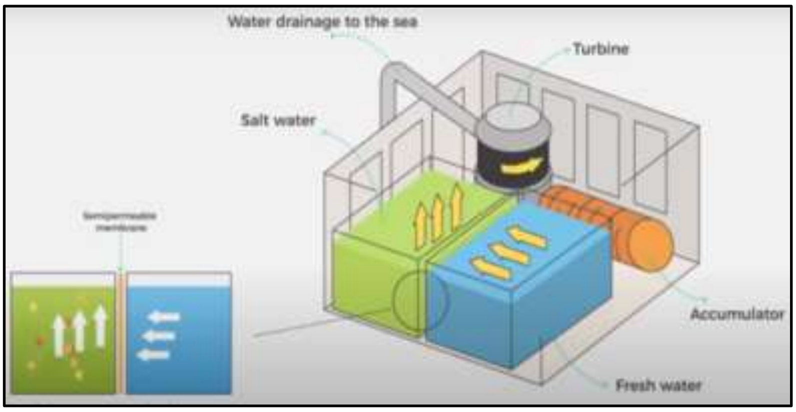
- Pressure Restart Osmosis (PRO)

This osmotic power plant contains pressurized seawater which is sent to a semi-permeable membrane leading to fresh water on the other side. A pressurized chamber is used to increase the pressure further by diffuse of freshwater into it by osmosis. The excess pressure discharges a portion of the salt water to a turbine, generating electricity.

The Norwegian utility Stat raft developed a prototype plant that began operations in 2009 and generated power of 2–4 kW capacity. They claimed that this can be raised to 10 kW by using more efficient membranes. Be that as it may, in the long run they shut down the plant because of high working expenses.

- **Reverse Electro dialysis (RED)**

This was observed by R. Platte in 1954 where fresh and salt water can be used as two electrodes of a battery to
semi permeable membrane. For this situation, one membrane will just permit dissolved sodium particles of the



water to pass through it while the other permits dissolved chloride particles. Saltwater and freshwater contain these cells with a semi permeable membrane between them. Then, the Sodium ions will diffuse from the salt water on one side into each fresh water cell, while chloride ions will diffuse from the opposite side creating a voltage separation between the saltwater cells on either side of the freshwater cell which is used for electricity generation.

In 2014, a company in the Netherlands opened a new station using the process of RED where water does not have to physically pass through these membranes, increasing its life span. This plant is still under initial stages and isn't open for commercial purposes.

Another recent method based on nanotechnology where few scientists used nano particles in the membrane such that only salt ions could pass through from one side to another creating a nano-pool like structure. It is said that 1 sq. meter of this cell can produce 1MW. Additionally, , the pores of these membranes are at an atomic scale that prevents it from blocking.

The ecological issues are related to the area where the plant is to be located and the fact that this plant has to be installed in places like estuaries (points where freshwater and seawater meet). Electricity production through salinity gradient is still in its conceptual and prototype stage. It is too expensive when compared to other means of generating electricity today which will eventually become cheaper, due to increase in fuel cost for other methods of power generation.However, on the off chance that all the estuaries can be tapped under a more secure, effective and economically feasible strategy, we could produce almost 70% of the needed energy for the world.

B) OCEAN THERMAL ENERGY CONVERSION:-Uses the thermal temperature gradient of the ocean to generate electricity. Deep under the ocean where little sunlight passes, the water is less hot or colder than the water at the surface of the ocean due to sunlight. This temperature difference powers the OTEC plant. A pipe is run down to the area where cold water is pumped up and connected to a condenser whereas

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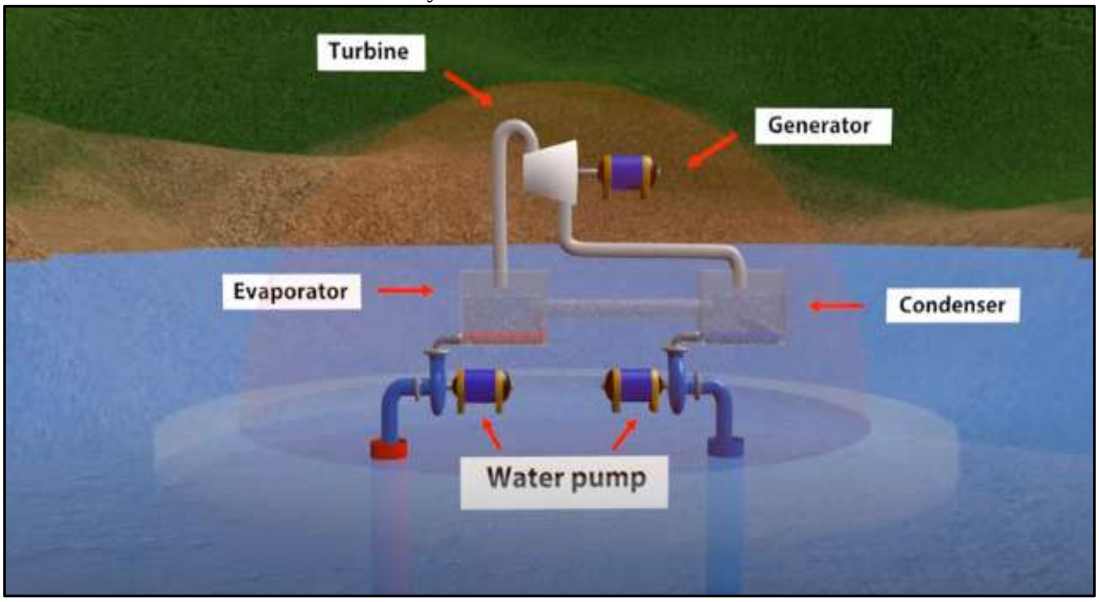
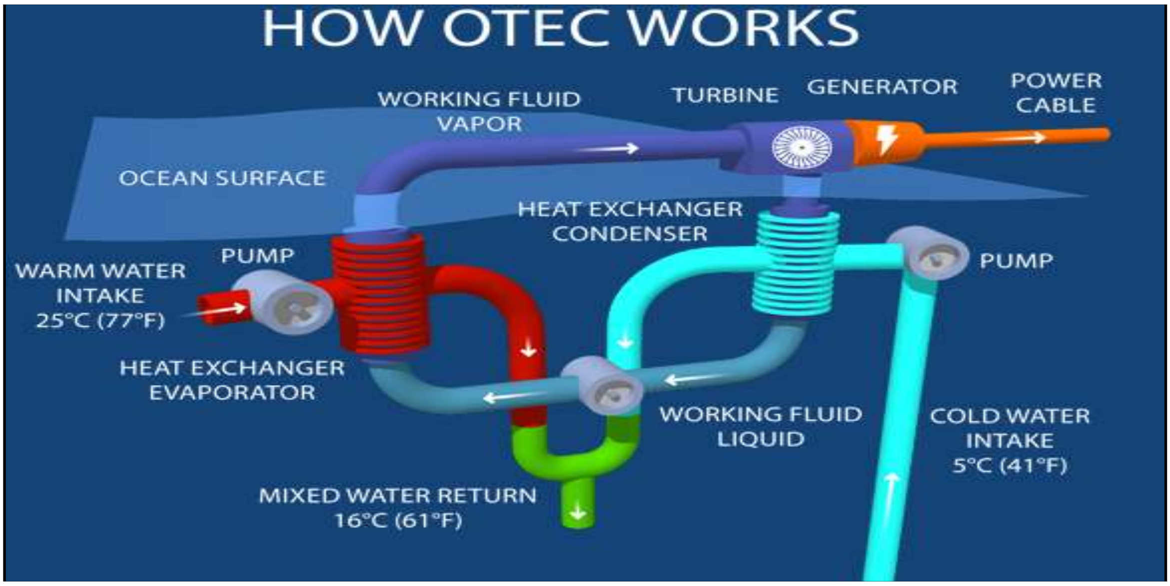
the surface hot water is connected to an evaporator. These are connected to turbine in a closed cycle as shown in the figure,



Liquid Ammonia is the working fluid used in the closed loop of an evaporator and condenser. When the hot surface water flows near the evaporator comes in contact with liquid ammonia, the ammonia converts to vapors and is accelerated towards the turbines. The turbines turn rigorously, absorbing most of the energy. And enters the condenser. Here the cold water is pumped out from the bottom of the sea and is used as a coolant that condenses and cools the ammonia back to a complete liquid form. Thus a closed cycle is formed that operates on the abundantly available temperature difference in the ocean itself. It is a steady source of power as it is utility grade electricity that does not require an inverter, filter and mainly the fuel is free.

The most important component in this plant is the heat exchanger. It is a completely insulated huge cylinder which has two different pipes running in them, one carrying ammonia and the other is the water. The heat from the water and ammonia is exchanged without these fluids mixing which enables us to keep the plant environmentally safe and reuse the refrigerant or ammonia for multiple times.



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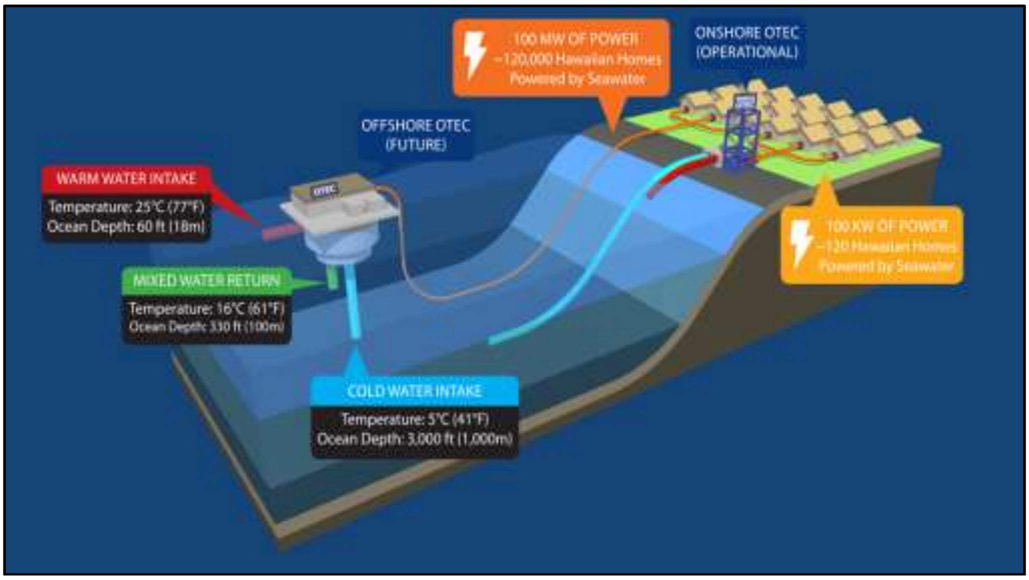
OTEC is one of the persistently accessible sustainable power source assets that could add to base-load power flexibly. The resource potential for OTEC is much larger than other forms of ocean energy as the differential temperature gradient will never cease to exist.

Makai Ocean Engineering, Inc. is a creative sea innovation and designing firm situated in Hawaii, providing engineering products and administrations worldwide since 1973. And in 2015 they generated almost 100KW of electricity becoming the world's largest OTEC plant and also the first to connect to the US electricity grid directly.



But huge monetary capital is required for construction of a commercial plant and is not feasible for low temperature difference i.e. below 20 degrees of difference. The working fluids(ammonia) used are supposed to boil and condense at a lower temperature compared to water. The fluids used in closed cycle are very expensive. The efficiency is relatively low and cost per KW hour is expensive today.

C) TIDAL RANGE is the vertical difference between high and low tide and we know that tides are generated from the gravitational forces exerted by the rotation of Earth around the sun and rotation of the moon around the earth. The potential for utilizing tidal range to produce power was proposed for the Severn Estuary in Victorian times, and La Rance (Brittany). The world's first tidal barrage plant has been creating power since 1966.[9]

Tidal range power plants can also be called dams that are constructed where the tidal range is sufficient to generate electricity economically.They are based on the principle of creating an artificial tidal phase difference by collecting water and then controlling the flow through turbines that generate electricity. The power generated is relative to the result of the appropriated wetted surface zone of the turbine and the square of the water level difference between the gathered water body and the flowing water stream. The two main methods of generating electricity using tidal range are tidal lagoons and tidal barrages.

Tidal Barrage consists of four major components, they are, **Embankments** is the main artificial containment of flowing water which are designed to have a minimal width and high enclosed surface area that run for long stretches from one land piece to another like a bridge. The key factor while designing the embankments is to minimize disturbance produced by the natural tidal flow.

Openings or Control gates are situated in a predesigned spot on the other side of the contained water that releases or opens the gate controlling the flow of the contained water per unit time. The shape, size of the opening depends on the pressure developed in the contained water, the type of turbine the water is to rotate.

Turbines are located in precisely designed places such that the water that passes from the control gates hits the turbine with least obstruction and turbulence possible making it spin and converts the potential energy created by the head difference into rotational energy, and subsequently into electricity via generators.

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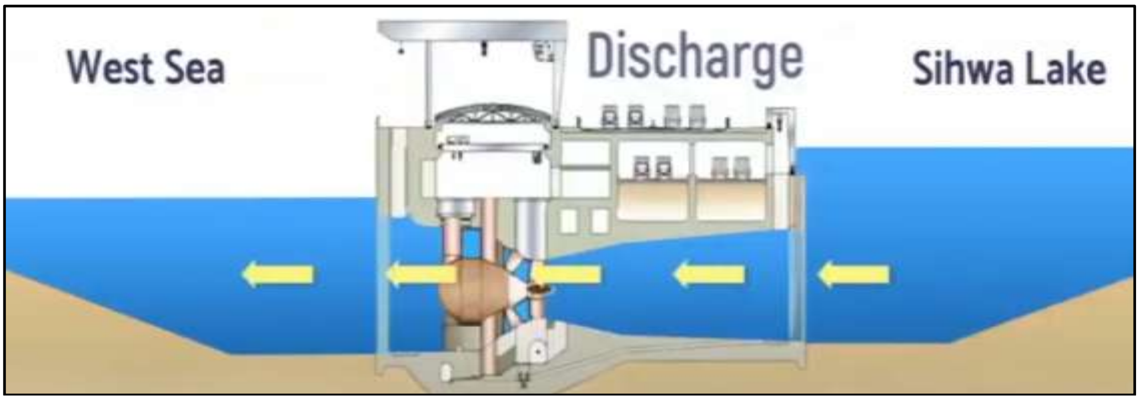
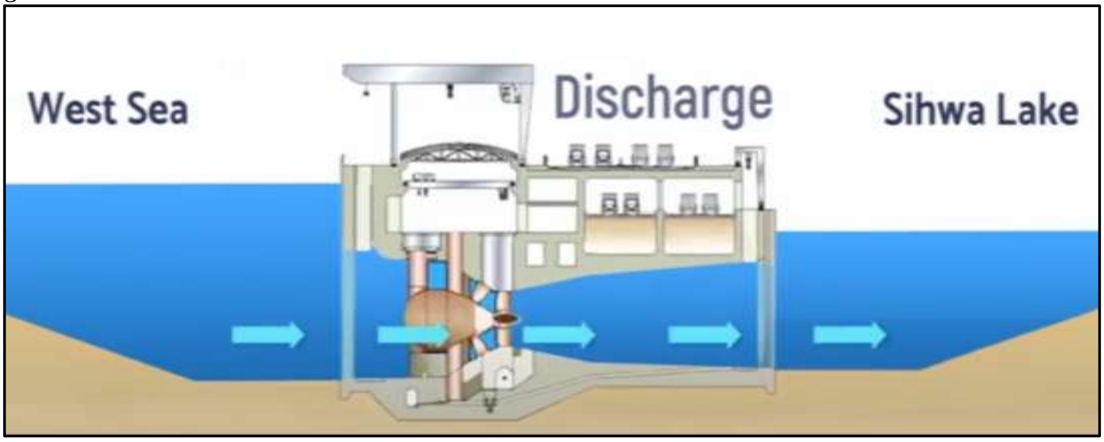
Sometimes, **Locks** are incorporated along the structure such that they allow vessels and ships to safely pass through embankment.

At low tide



At high tide



Sihwa Lake Tidal Power Station was built between Sihwalake and West sea in South Korea in 2011.It is a 400-meter long tidal power plant and has a maximum output of 254 MW. It has 16 such control gates and is designed for the Yellow Sea's high tides

At the time of construction there was a drastic change in marine life of the lake until the gates were open due to embankment of water. The COD chemical oxygen demand of the lake while construction was about 17.4ppm and after 5 years of successful operation, the COD level has come down to 2 ppm which is almost the same as the west sea. Regardless, other than the environmental use, it is equipped with ten bulb-type generator units, each making 552.7 GWh per annum.

But huge capital is needed for construction and they cause a significant change in tidal flow, which will change the geology of the sea bed and marine life migration. They may also result in shrinking or eliminating tidal flats. Tidal barrages have an exceptionally negative impact on the estuary's frameworks since they extend the period of high and low tide and abbreviate the tidal range. The other method is

Tidal lagoons are structures which utilize the same turbine technology but are smaller and capture a large volume of water behind a man-made structure which is then released to turn the turbines and generate electricity. They avoid impacts on the environment or sea as they use less marine space.Tidal lagoon schemes can be land-connected, with a ring-shaped harbor wall housing a section of hydro turbines and can also be located entirely offshore.

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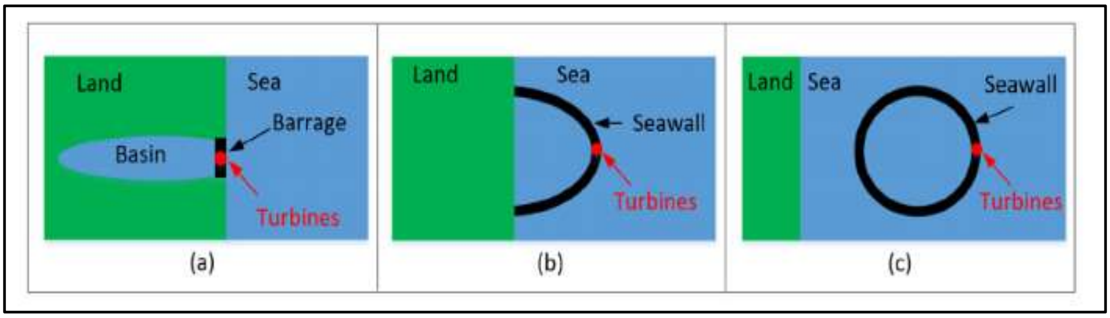
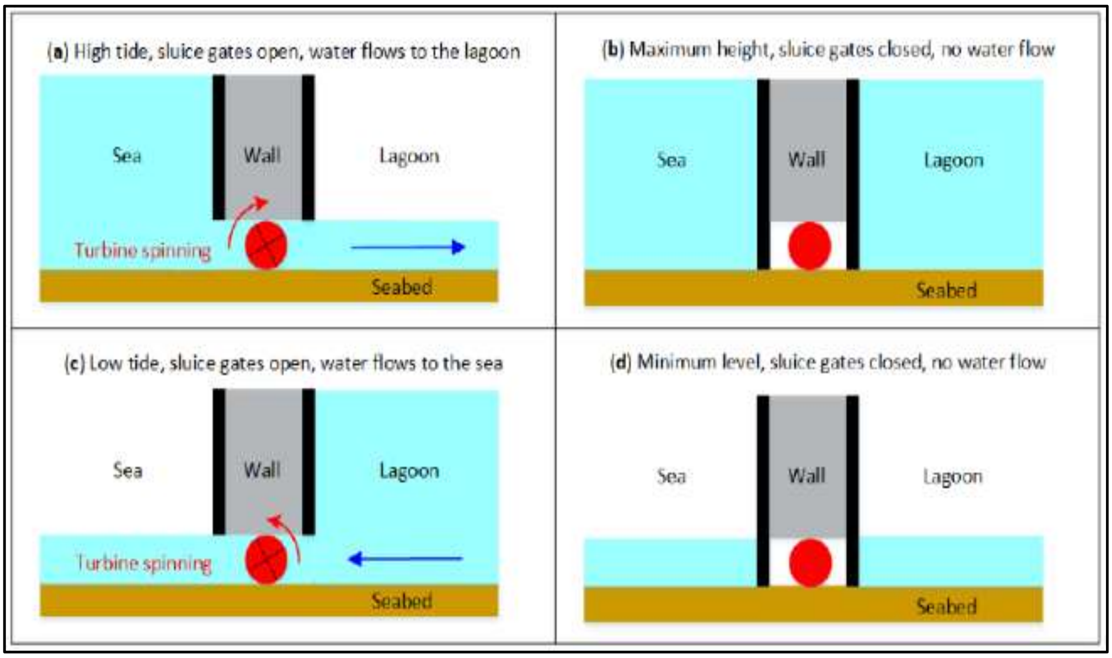


Tidal lagoons consist of a single basin that is created by a seawall.The turbines are located in water passages and are designed to convert the potential energy of the water into rotational energy using the blades of a turbine and then into electric energy by the help of generators. The turbines are located in openings within the seawall, which are fitted with control gates that are used to regulate the flow of water in and out of the lagoon.



Figure(a): At high tide, the gates are open and water is allowed to flow inside the lagoon, thus spinning the turbines clockwise and generating electric power.
Figure (b): When the maximum water level inside the lagoon is reached, the sluice gates are closed and water flow is stopped.
Figure(c): At low tide, the entry gates are open, and water is permitted to flow outside the tidal pond, accordingly turning the turbines counterclockwise, and producing power.
Figure (d): At the point when the base water level inside the lagoon pond is reached, the entry gates are shut, until the following tide, which will cause the generation cycle to begin once more.

Swansea Bay Tidal Lagoon is the world's first tidal lagoon power plant. It is a 'U' shaped breakwater, built out from the coast which has a lot of hydro turbines inside the embankment itself. Water tops off and exhausts the man-made tidal pond as the tides rise and fall creating power on both the approaching and leaving tides, four times each day. By keeping the turbine gates shut for just three hours, there will be a 4m height difference in water between the inside and the outside of the lagoon due to the strong tides on the West Coast of Britain. Water rushes through 60m long draft tubes, rotating the 7.2m diameter hydro turbines generating 0.52 TW or 520,000MW per annum.

The major issues with tidal lagoons are that - they are the most expensive because of their size and maintenance. The costs are so high that the company was trying to raise £1.2m to start work on

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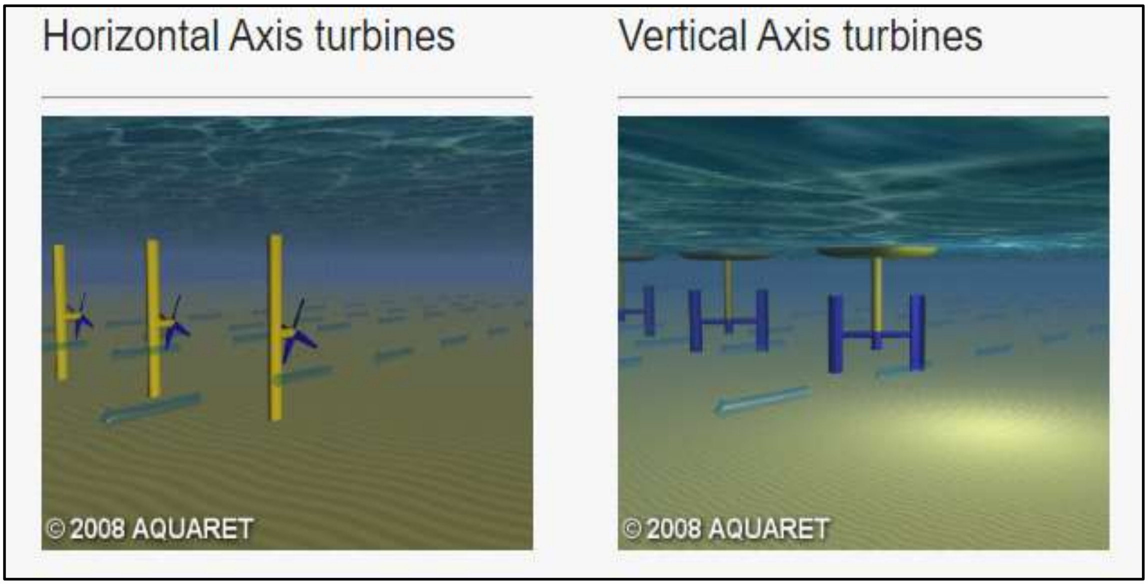
land. Tidal Power plc's chief executive Mark Shorrock said the five-year planning consent awarded by the government in 2015 expires in June 2020 "unless material works have commenced"[10]. A few people additionally revealed that the organization won't have the option to begin work in the ocean since it lacks a marine permit from Natural Resources Wales (NRW). Indeed, even the conservative government said that the undertaking has its value for money only if they start generating before 2020 because of its billions of dollars of speculation.

D) TIDAL CURRENT can be defined as the periodic movement of water that is usually driven by a head difference created by out-of-phase ocean tides at two ends of containment. External non-periodic forces are applied to tidal currents which depend on the local weather patterns, ocean characteristics like internal tides and geography. The rotation of the Earth and thecarioles forces modify the flow of water away from the equator. The flow characteristics are also dependent on the local topography and the shape of the surface of the seafloor at any particular location, as these will affect energy losses induced by the friction of the fluid on the rough sea/river bed as well as the intensity of turbulent mixing. Tidal stream devices are correctly in use utilize the energy of flowing water in tidal currents to generate electricity directly.

Tidal current frequencies and amplitudes can be analyzed and predicted using the same techniques as tidal range. The process of obtaining the initial data from tidal currents was more difficult than that of reading tidal range, but the introduction of advanced sea digital electronics has made it possible to extract high-quality energy from tidal current in a relatively straightforward and inexpensive method. Different mechanical techniques like horizontal and vertical axis turbines,venturi effect devices, Archimedes screws, tidal kites and even windmill like structure on the sea bed.



In a horizontal axis turbine the blades face the flow energy of water same as windmills facing wind energy and electricity is generated. But unlike the blades of a windmill that rotates for the wind hitting only in one direction, these water blades are designed to rotate in irrespective of which direction the water is flowing.

In a vertical axis turbine, the weights are situated in the circumferential ends of the vertical axis which rotate upon impact with water currents about this vertical axis and remember water is almost 800 times denser than air and can generate more power to rotate heavy weights that in turn rotates generators.

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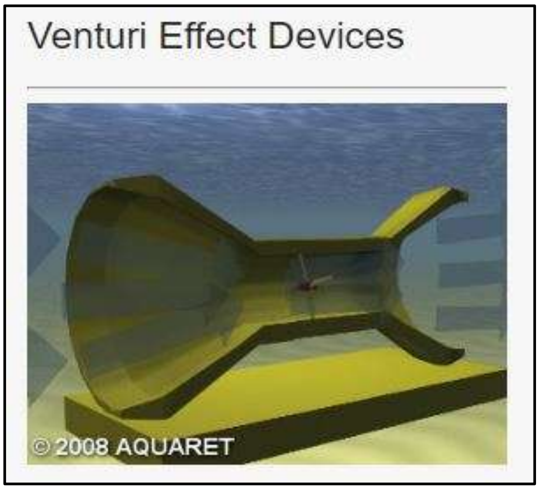

In a venturi effect device, the turbine is situated in the center with the least diameter such that the water flowing through that area has a higher flow rate. This happens due to increased pressure at that area as per venturi effect.

Archimedes' screw or the water screw, prevalently known as the screw pump, was a machine utilized for moving water from a low-lying waterway into an irrigation water system trench. Today, the same design is replaced with an expensive turbine system to rotate on its own axis irrespective of the direction of flow of water. This device draws power from the tidal stream as the water moves up/through the spiral, allowing the turbine to rotate.Rotating the turbines.

Semi Atlantis was the pioneer to start an underwater turbine which is very similar to a normal wind turbine but can be smaller in size due to water's higher density than air.

They started a project called SeaGen in Stanford Laugh, Ireland installing two 60m diameter turbines with a capacity of 0.6MW each at full capacity making a total of 77 GWh of power. But it only generated 11.6GWh because of a very low capacity factor of about 15%. This was because it was only a prototype and was removed frequently from the waters for service and surveillance. Highest recorded power production was about 522MWh in a month and claimed that it could be produced year round with a capacity factor of 59%. There is a short time gap between the peak power generation (at high tide) and low power generation(at low tide) which can be solved using basic power storage devices. This project was decommissioned in 2016 and main concerns were the environmental changes in the near surrounding and whether the turbine could be effectively removed from the deep ocean bed and SeaGen proved successful in both of these issues as no environmental changes.

Upon this success they started another project called MeyGen in Stroma, Scotland with a lease agreement of 400MW and have passed through the initial testing phase with 4 turbines and also completely satisfied the environmental norms. In SeaGen, they had actuators to lift the turbine up for service but MeyGen is designed such that both the turbines and generators can be removed and placed from a ship within 30 minutes making installation and maintenance easier and cost effective. But for marine mammals like dolphins and seals sound is a major censer and hence the nearby seals avoid that area by about 38m - 160m and dolphins avoid by about 100m radius from the turbines which isolates certain parts of the sea but does not block or cause severe ecological damages like tidal barrages in time of construction. This avoidance of marine life near the turbines because of sound acts as a fail proof for the turbine and also saves the animals from hurting themselves swimming too close to it.

E)Ocean Wave Energy is the kinetic energy present in the motion of water on the surface of the ocean**.** Extracting this energy from ocean waves is not a recent phenomenon as researchers have been studying different concepts or solutions since the 1970s. But now, the technology has evolved to a phase where different concepts are being tested at a full scale, pre-demonstration phase. There is a wide range of wave energy technologies, each using different solutions to absorb energy from waves. Adaptability of these technologies depends on the water depth and the location (shoreline, near shore, off shore) of the plant.

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All the mathematical modeling and designing using fluid dynamics of how waves respond with sea structures was done so as to not absorb this wave energy. While constructing an offshore structure like ship, boat etc, the main designing aspect is to nullify the forces exerted by the waves in order to prevent sea sickness. But now, the challenge is that the entire design of the floating structure absorbs this energy and produces electricity. The conversion of wave energy into usable energy is complex due to the hydrodynamic processes present in the diffraction and radiation of the waves as they propagate to shore. This means that the conversion to electrical power is subjected to varying energy fluxes and time scales.

Wave energy technologies consist of a number of components like

Prime mover which is the moving object that captures the energy of the wave,

Structureof the system, which could be fixed, floating or submerged,

Foundationwhich holds both the mover and structure at an accurate position changes depending on the structure,

Power take-off (PTO) system which converts the mechanical energy of the mover into electrical energy could be a air turbine, hydraulic motor or hydraulic turbine,

Control systems to safeguard the system and optimize performance in operating conditions.

Today different operating techniques like a piston pump are used which works like a single cylinder reciprocating engine that sucks air/water from Right intake in the Right cylinder when the floating weight pushes the piston upwards in the Left cylinder with a Left outlet . Once the piston reaches its final position, the floating weight also starts to move downwards, sucking in water/air from the left intake in the Left cylinder and pushing it out through the Right outlet of the Right cylinder.

The number/type of cylinders can be calculative used depending on the environment in which the system is to perform. Here is an example where four alternating piston pumps are used to pump the water up to the storage tank that controls the flow rate of the water to the turbine.

Using such combined water piston pumps collectively would result in higher efficiency due to the sinusoidal rise and fall of ocean waves. When the first piston drops down, the second automatically moves upward and so on. Assuming that the low tide isn't strong enough to pump more water, the stored water in the tank is released at a calculated rate such that continuous electricity is generated.

VoithHydrowavegen is one of the pioneers to generate electricity using an air turbine. This is a continuous process wherein a concrete block with a passage for moving ocean water on one side, causing the air to flow on the other side. This movement of air turns the air turbine generating electricity. It is a straightforward

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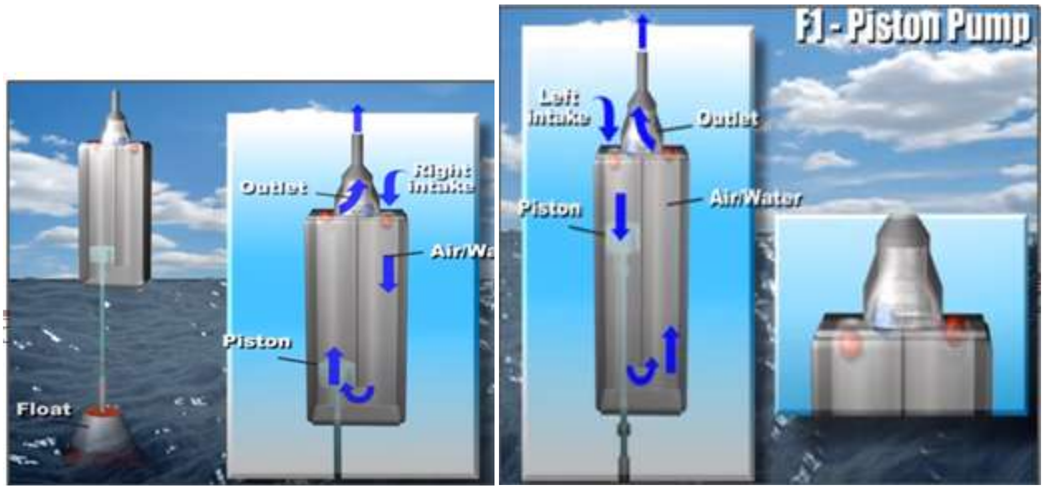
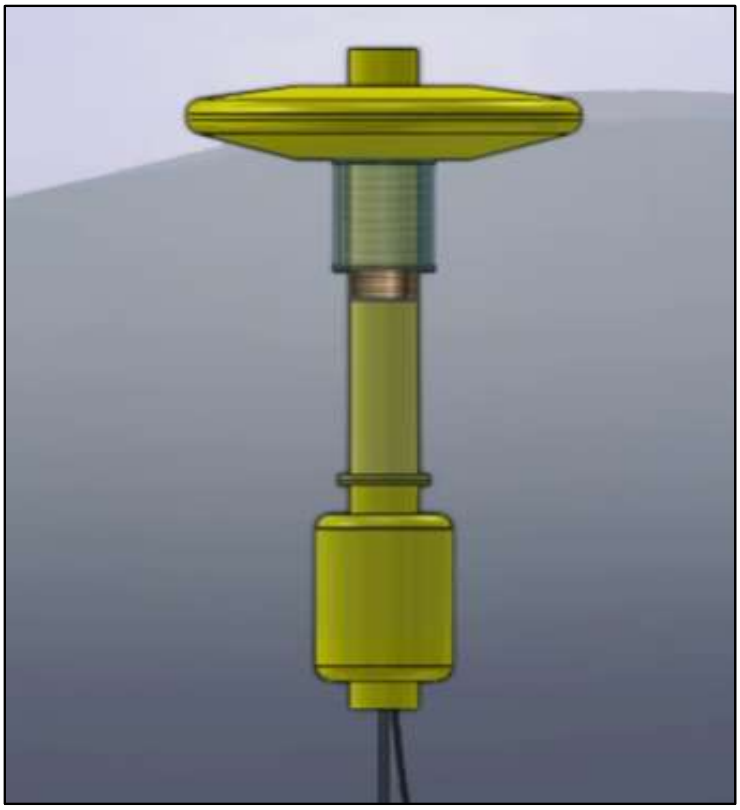
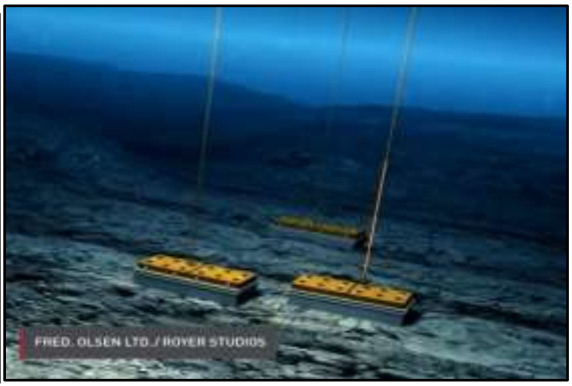


strategy which utilizes a Well turbine that is designed to such an extent that it rotates unidirectional regardless of the wind current's course. As this plant was for experimental purposes, it eventually shut down. But even a relatively slow motion of the wave could produce a significant amount of electricity.

A device called Azura, a 45 tonne steel device that pushes hydraulic motors generating electricity is installed at the Wave Energy Testing Site off the Marine Corps Base Hawaii, which is a joint venture by private companies, US military, US department of energy and University of Hawaii,.

Lifesaver,another device which is mainly funded by the US defense hoping it would generate power for ships and bases in remote islands. It gets the name because of its shape. This device consists of three pulleys on the circumferential edges with coils clamped to the sea bed. On motion of the lifesaver, the coil in the pulleys travels back and forth in order to balance the device in its equilibrium position generating electricity.





a) Top View of the LifeSaverb) Clamps attached to the sea-bed

In Oregon state university, a research team came up with an idea to use fibreglass and electronics instead of pumps and gears against the corrosive salt water. A simple float moves up and down, containing a magnet around an inner module with a coil. When there is relative motion between the magnet and the coils, there is a change in magnetic field inducing voltage directly.It was tested in 2008 and the system survived generating a substantial amount of electricity but not enough to power cities.

Later on using computer modeling and simulation, different designs and prototypes were made and tested in the Tsunami Wave Basin, Oregon State University generating a noticeable amount of power.

The universal need to move from fossil fuel based energy sources to renewables grow, it is imperative that all renewable sources should be examined thoroughly. A team from West coast wave initiative, University of Victoria In British Columbia, has installed more than four Buoys which assess and it sends hourly information to the base computer about the energy present in those waves.

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This team aims to develop an industry leading wave energy resource assessment techniques, numerical simulation tools for Wave Energy Converters (WEC) and numerical grid integration toolboxes, by creating an accurate mode of assessment for the feasibility of wave energy conversion in British Columbia.

It is important to understand that Ocean is a vast part of the fierce nature and this equipment is to stay in the same environment for a long time. Corrosion, leakage, serviceability are major factors to consider while designing them which leads to a higher capital cost. The area chosen for the plant must be close to an electricity grid for efficient usage of the energy but one must ensure that they do not alter or block the trading routes of the ships and vessels. Power generated is directly proportional to the speed of the wave making it impossible to generate stable electricity for human needs and hence efficient storage devices are to be found. Some claim that these large floating machines destroy the beauty of the ocean but if not for these devices, all the kinetic energy present in the flowing molecules of water would be wasted.

III. OCEAN ENERGY IN INDIA

The requirement for improvement of sustainable marine power sources is significantly increasing especially due to the increase in population of India. India has a long coastline of about 7000 km with a bounty of regular, clean sea vitality that relies upon innovation for gathering the enormous energy present in these oceans.

India was a trailblazer and a prototype was built at Vizhinjam, a fishing harbor off the coast of Thiruvananthapuram, Kerala during the late 1980s it was the first wave energy plant operating on oscillating water column was established in Vizhinjam, Kerala in India. It remains the main pilot study in India without significant breakthroughs in terms of structural optimization and power take-off (PTO) arrangements.

The Chief Economic Advisor of India identified the importance of OTEC in the Gulf of Kutch, India and started investigation of the ocean sites around 1982.

By the late 1990s electricity generation and grid connectivity was demonstrated and the feasibility study of techno-economic advancement was made.

Horizontal axis turbine based technology was proposed by National Institute of Ocean Technology NIOT and a hydrodynamic performance of a floating oscillating water column OWC was constructed on a scale of 1:13 to the prototype designed by Yoshio Masuda by japan and tested in late 2000s.

A demo of the Backward Bent Duct Buoy BBDB was successfully given by NIOT in the late 2010s while the team at IIT Madras evolved and optimized to double chamber OWC.

Classifications of tidal potential in terms of tidal range are,

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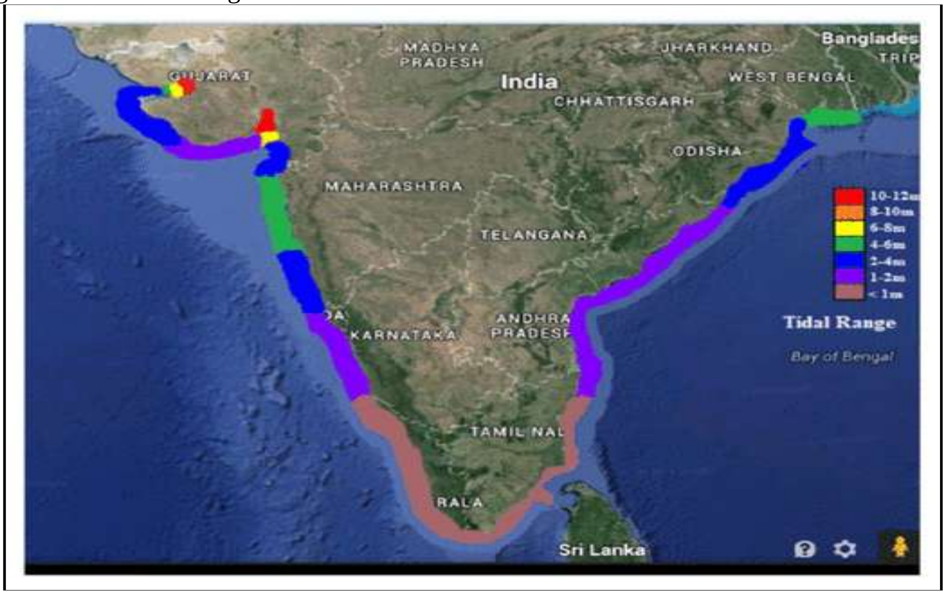
CLASS I -The range is above 5m of height like the Gulf of Kutch and Gulf of Khambhat regions with a range of 10–11m and the Sundarbans zone with about 5.5m range

CLASS II - The range varies between 2m - 5m like the regions south of Gujarat and West Bengal experiencing a moderate tidal range of 3–5 m

CLASS III -The range below 2m in region of southern states where the 1 m tide that is available can be stored in large backwater areas and micro tidal plants which need a critical evaluation.

In the below figure, the Indian coastline is colored according to the tidal range



Classification based on the tidal Current speed

CLASS I -Above 3m/s velocity of tidal current in The Gulf of Kutch, Gulf of Khambhat, and Sundarbans regions.

CLASS II -Between 3m/s - 2m/s in South of West Bengal and Khambhat regions.

CLASS III -Between 2m/s - 1.5m/s in locations along Karnataka/Maharashtra coast on the west and along the Coromandel Coast on the east including the north of Tamil Nadu, Kerala.

CLASS IV -Lesser than 1.5m/s velocity of tidal current which has very weak tidal velocities.

Potential sites and its Energy Generation Method

In the Class I Tidal Range regions like the Gulf of Kutch, Gulf of Khambhat and Suburbonswith more than 5m of range have excellent potential for tidal barrages as the tidal range height is so high that even with lesser area of water containment, enormous amounts of energy can be generated with less capital investment. At the Gulf Of Kutch due to its ocean depth around 15-20m, they are a potential site for tidal stream turbines as they also fall under Class I Tidal current regions with an ocean current speed more than 3m/s.

In Class II Tidal Range regions like the coast of west bengal and Khambhat, medium scale power generation is possible through tidal barrages or tidal stream turbines. Deciding between these two depends on the particular region's vessel traffic and the sea bed depth available for installation.

As several countries are committed to moving away from carbon emission, India with such an enormous population density and high energy demand should also take drastic steps in order to reduce its carbon usage. As of 2018 more than 60% of electricity produced is by fossil fuels and this has to reduce as there is an increase in global warming effects. Relying on such a predictable, abundant and continuously available resource like Ocean energy is a considerable option to satisfy that high energy demand.

IV. WAY FORWARD

The capital required to establish a ocean energy power plant is very high today in comparison with other means of generating electricity that consumes fossil fuels. This is because efficient means of extraction, generation and storage of the required fuel for generation of electricity have been found in course of time. But we should remember that fossil fuels are not renewable sources and eventually their prices will hit the roof for not being able to satisfy the increasing energy demand. At such a point in time, generating electricity using the ocean's energy as a free, reliable, safe fuel would be really profitable as by then technological advancement would have led to more efficient methods of power generation.

Another important aspect called the capacity factor which is the measure of how often a power plant runs for a specific period of time. Today, it is very low as almost all devices are under research and advancement for which they need to be brought back to the shore or made to stop generating electricity. But eventually there will surely be devices installed and even sold that run at full capacity. Such a phenomenon was seen even for the windmills when wind powered plants were under prototype stages.

Standardization of design will also play an important role in today's scenario because the whole world is trying to solve the difficulties faced in ocean energy and standardization could give out faster and more efficient answers. But the major problem is that all these devices are to be individually designed for the geographical location it is to be used in and each geographical location has its unique issues. Hence standardizing the design for ocean energy devices is a difficult task laid upon us.

The country's respective government also plays an important role in improvement of ocean energy production. Its services like subsidiary, compensation, tax returns, allowances etc should be imposed for ocean energy power plants. For example, The USA has an extra tax return policy for its citizens using an electric hybrid vehicle which is really expensive today in their market. But due to its high efficiency and tax returns, the capital investment will eventually pay off and would be more profitable in comparison with other vehicles. Similarly, the government compensating the construction, providing allowances for construction equipment or even subsidizing the entire power plant would curtaining increase the production of electricity from ocean energy.

The only unsafe part of this puzzle today is the investors. Their capital is not certain due to harsh ocean conditions, engineering difficulties etc. Hence very few organizations and countries are ready to take this chance. However we should remember that all methods of electricity production had been at its developmental stages and eventually reached its breakeven point and turned profitable. These methods are still dependent on capital to buy the fuel these power plants operate on, but note that the energy stored in the ocean is freely available everywhere and hence it would reach its breakeven point faster than other methods and will definitely turn out to be profitable and safe for the investors.

V. CONCLUSION

There is no one best method of ocean energy extraction; it is Geological dependent to where the device is to be situated. Major problems of ocean energy extraction are its cost effectiveness which has to be solved by more research and development. The safety of the oceans is a concern that has already been solved by few companies like Semic Atlantis. The most important factor to consider is that two thirds of the earth is ocean which provides a free, uninterrupted, predictable source of fuel unlike any other resources which could revolutionize energy production. Now, how much of this everlasting resource can be converted to electricity is dependent on our further research and technological advancement.

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