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OCEAN ENERGY AND ITS HARVESTING

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Abstract
Ocean energy is one of these renewable sources comprising a vast amount of the renewable energy source as it covers 70% of the earth. This paper focuses on the idea of getting benefitted by one of the largest sources of renewable energy source by absorbing its energy in the form of marine and tidal current energy, thermal energy, wave energy etc. This paper will also give us a perspective of how harvesting of the ocean energy would change the traditional energy production business with respect to economy, efficiency and its effect on nature.
Keyword: Ocean energy, Thermal energy Harvesting, Tidal energy harvesting

1. Introduction

The main forms of ocean energy are tidal energy, wave energy, thermal energy, ocean currents. Over 70% of the earth surface is covered with ocean, and within it lies vast amount of renewable energy. It can be harvested to assist energy requirements of the world. Ocean energy is in the form of kinetic energy and thermal energy. As the waves of the ocean are continuously in motion, kinetic energy is always getting developed which is very strong. That is why we need to construct breakwaters, to absorb the kinetic energy of the waves so that it wont affect the shores to a great extent. Thermal energy is produced due to heat stored on the surface water. The difference in temperature, between the top surface and deep surface water is used to generate electricity from thermal energy. Since these waves and huge temperature difference are produced due to gravitational pull of the sun, moon on the earth and due to suns heat respectively, ocean energy is termed as renewable energy, as it will never cease to exist.

As time passes more and more people are depending on fossil fuels to satisfy their daily needs of energy, which is leading to a not so healthy environment. CO_2 levels are increasing at alarming rate resulting into increase in global temperature which eventually would lead to disastrous future. It is assumed by the year 2021 the world could lock in 1.5^0C of warming at the current rates of green house gas emissions. Also these fuels are not going to satisfy our energy requirement for ever as they wont last forever. Alternative for energy production from the means of renewable sources is in much need today. Besides adopting common renewable sources like wind energy, solar energy and hydro energy for energy production It is time to adopt new techniques to satisfy our daily growing hunger of energy. Ocean energy is such a source of renewable energy which if used to procure energy it will solve many problems. It would carry a series of chain of events like reduction of energy production from fossil fuels which would in turn lead to reduction of CO_2 emission which would decrease the warming of earth by a huge extent. This is only one of the ways it will benefit human kind.

Reference [1] shows that there are many techniques used to procure energy from ocean which includes

- Harvesting energy from tidal currents
- Harvesting thermal energy from the ocean
- Harvesting energy from salinity gradients by process like osmosis
- Using biomass from the ocean to harvest energy

This paper focuses on harvesting energy from tides and on harvesting thermal energy from the ocean.

The kinetic energy from the tidal currents can be harvested by deploying machines or structures in the ocean so as to convert it to electricity. Most popular methods are

- Float or buoy system
- Oscillating water column
- Turbine On shore

For harvesting thermal energy which is much abundant in nature, some systems have been developed, which include

- Open cycle
- Closed Cycle
- Hybrid Cycle

Each system having its own use, own condition, own efficiency of operation.

2. Literature Review

After the oil crisis of 1973, scientist started to find alternate energy providing resources. The concept and possibility of harvesting ocean energy came into existence around middle of 1970s. The basic idea was to harvest the kinetic energy the waves carry, by turbines. After that many researchers concluded that there lies huge potential in harvesting of energy from the ocean since it showed possibility to generate of electricity in Europe which would satisfy 19% of their electricity requirement in the year 1990 [1]. Europe is still the number 1 country in terms of investment which is 50% of the amount needed for ocean energy harvesting research and projects. Some of the other countries investing in ocean energy and its harvesting are Canada, Norway, Japan, France, Australia.

America, in a study carried out in the year 2005-2006, estimated that the potential of harvesting electricity from the ocean energy is of 25GW. This study was based on 7 sites picked near Florida. Some other sites near south and north America showed the energy capacity of 21TWH/year [2].

2.1 Technological Advancements

Reference [3] shows Sweden, with its research has contributed majorly in accelerating the movement of harvesting ocean energy. Before Sweden, japan already had its 2.5MW KAMEI, which used wave energy to drive turbine in 1978. Sweden came with Sweden hose pump buoy system, on which most of the new technological investment relating to ocean energy harvesting is based. Depending upon the motion of the wave, and its utilisation, to generate electricity, the machines are characterised as,

- Wave activated bodies
- Overtopping devices
- Oscillating water column

Pelamis, which is considered to be the worlds best energy wave converter is a wave activated type of body. It is made up many section, which uses the motion of the wave to generate electricity. It is based on Sweden hose pump and pump buoy system which was first tested in 2004.

Wave dragon is an overtopping device, which came into existence in 2003 as far as large projects are considered. It was invented by Erik Friis Madsen. This test unit has supplied electricity to the grid in more than 20,000 hours – a world record. A 7 MW demonstration project is currently being applied for in Wales, and preparations are underway for a 50 MW array in Portugal.

The KAIMEI designed by Japan for wave to energy conversion, is based on the same principle as that of the oscillating water column. It is equipped with wells turbine, which rotates un the same direction irrespective of the air current. It was developed in the year 1970 by Alan Arthur Wells. This is widely used today to generate electricity.

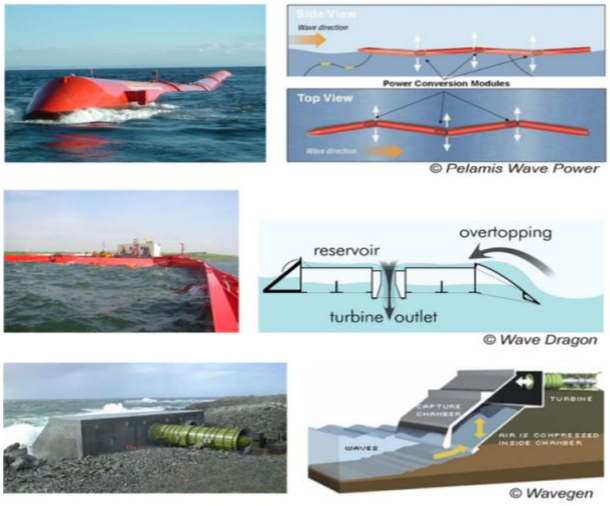

Fig.1. Top: Pelamis Device. Middle: Wave Dragon. Bottom: Oscillating water. column

Today we have numerous ongoing project all around the world having an aim to harvest and successfully use the energy. Some of the projects have reached commercialisation or are very close to being commercial. Japan being surrounded by ocean is planning to harvest its ocean energy by installing windmill type structures, which will not only generate electricity, but will also dissipate the energy, so as to decrease its impact on shores.

3. Methodology

3.1 Tidal energy

Tidal energy is formed due to experiencing gravitational force from the sun and the moon. The magnitude of velocity, does depend on the wind speed, and hence the amount of energy potential change from place to place on earth.

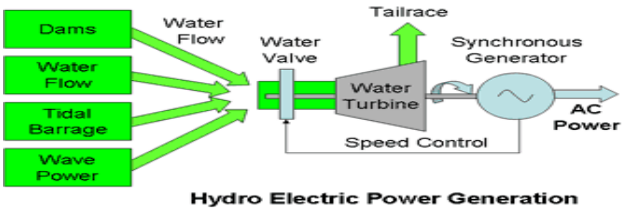

Fig.2.Block Diagram of wave to energy conversion

The basic concept, used for harvesting tidal energy, which is in the form of kinetic energy, is to use the motion of the waves to rotate a turbine. This turbine which is attached to a generator, will develop electricity from it and supply us through cables. Large waves in shallow water cause extreme velocity fluctuations which can damage the blade of the turbine to a great extent. For this purpose, installation of systems between islands or in estuaries is recommended since the wave are generally low. The factors affecting the energy output from tides are

- Grid connections and transmission
- Wave height
- Wave velocity
- Period of the waves
- Variation between spring and neap flows

3.2 Thermal energy

Thermal energy is formed due to heat stored in the surface of the ocean. It is converted into electricity by using the temperature difference between the deep cold ocean water and relatively hot surface ocean water.

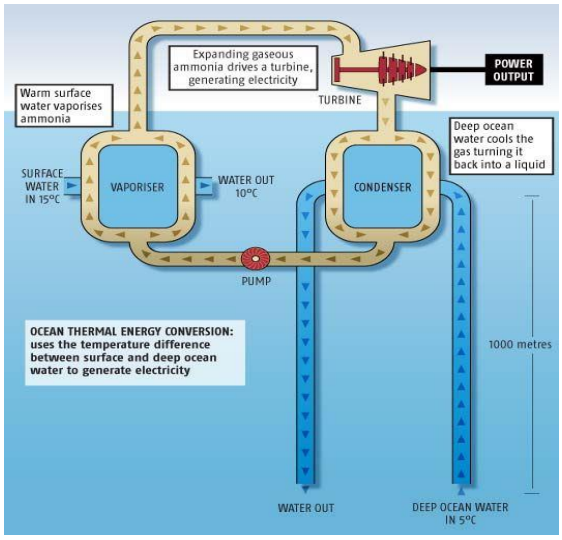

Fig.3. Diagram depicting the process of conversion of ocean thermal energy to electricity

The vapour formed in this process, drives the turbine which is connected to the generator to generate electricity. In this process, we may get fresh water as by-product and hence can assist us in the growing water shortage problem. However, this process is very expensive and hence is not practices largely throughout the world, even after having many positive outcomes. The energy produced by this system is supplied to the grid by underwater cables.

4. Precautions to be undertaken

As ocean contains many corrosion causing agents including salt, it may lead to breakdown of the machines which are used for energy conversion. Also there is always the possibility of the machines being exposed to many natural disastrous conditions like typhoons which would damage the machine to a great extent. Factors like these should be taken into consideration while designing of these structures which would add to additional cost. Site selection should be done in such a manner that it wont sacrifice the profitability, and be secure at the site.

Machines used for the energy conversion operation, should be designed in such a way that they wont prove harmful to the marine life and aquatic life. Trapping of seaweeds and collision of them on the machines can lead to acceleration of degradation of the machines and reduce its efficiency [4]. Proper maintenance to avoid the above problems as well as to avoid cavitation, marine growth should be done.

During construction of wave to energy conversion systems, that is during dredging, drilling and other activities care should be taken that it wont harm marine life by unbalancing their natural habitat or due to any other reasons.

5. Governments Support

Governments are in much need to divert some of their attention from generating electricity from non renewable to much more profitable and healthier generation of electricity from renewable sources. European government has already adopted this approach, by investing 50% of global RD&D investment in ocean energy.

Reference [5] shows, India is also on the same path of funding research to find ways of harvesting new and profitable energy sources effectively. There is a need to promote awareness related to upcoming technological advancement and methods for harvesting ocean energy in order to cultivate interest in private organization, so as to increase investment in cultivation of energy from these sources. Many countries including India, has introduces supportive policies and initiatives to promote development of energy sector. Some of the policies are as given below.

Fig.4. Current government incentives

Gujrat government has already stated to develop India's first tidal project, by investing 25 crore INR in the project.

6. Case study

India, which is the 2nd most populated country in the world, is lagging in production of electricity for its people. The gap of amount of electricity needed and the amount of electricity produced is increasing each and every year due to urbanization. Reference [5] shows, the total percentage of Indian domestic energy consumption has grown from 16.9% to 24% due to urbanization and rise in service sector. Demand for electricity in India far outstripped availability even in 2011 when the base load requirement was 861,591MU against availability of 788,355MU, 8.5% deficit. During peak loads, the demand was 122GW against availability of 110GW, a 9.8% shortfall.

Primary estimates indicate that the annual wave energy potential along the Indian coast is between 5 MW to 15 MW per meter. Hence theoretical potential for a coast line of nearly 6000 Km works out to 60000 MW approximately [6]. However, the realistic and economical potential is likely to be considerably less and 47 kW/m is available off Bombay during Southwest monsoon period. India has a tidal power potential of about 8000-9000 MW" [5]. considerably less. OTEC has a potential installed capacity of 180,000 MW in India [5].

Based on the wave statistics for the southern tip of India, a mean monthly wave power of 4 - 25 kW/m is estimated. The average wave potential along the Indian coast is around 5-10 kW/m. India has a coastline of approximately 6500 km. Even 10% utilization would mean a resource of 3750 – 7500 MW [6].

7. Advantages and Disadvantages

7.1 Advantages

- Process of harvesting of mechanical energy is non polluting and environmentally friendly. Process of procurement of electricity from thermal energy developed in the ocean produces carbon dioxide but is comparatively less to existing electricity extraction from fossil fuel process.
- Easy to operate and maintain.
- Emit greenhouse gas in low percentage as compared to other existing energy sources.
- Provides a non-exhaustible energy source to mankind.
- Acts as barrier to cost line from strong dangerous waves.
- Power generation is 24X7.

7.2 Disadvantages

- Although there are many devices which can be used, advancement is much needed in the machine design.
- There is desperate need in cost reduction as it is limiting the frequency in which it can be used.
- Environmental impact and marine life impact is in desperate need to be studied.
- Social factors and issues are in need to be considered before start of any these processes.

8. Need of harvesting ocean energy

Energy potential of wind is generally given in GW, while the energy potential from waves is found out to be in TWh/year. With the study carried in America, the total wave energy potential along the outer continental shelf is 2640TWh/year [7]. Even harvesting of only 1TWh/year of energy, would result into providing of annual year energy requirement of 93,850 houses [7]. The amount of recoverable energy is 1170TWh/year, which will approximately satisfy one third of the America energy requirement. 30% of America is powered by electricity generated through coal [8], which totally can be replaced by ocean energy, which comparatively has little to none green house gas emission. This will not only assist us to meet the growing energy hunger, but also to decrease green house gasses. If such system is adopted through out the world, it would assist us immensely in the mission of the decreasing green house gas emission.

Waves may be seasonal, but are more constant—and more predictable than wind or sunlight. Constancy and predictability enable a more straightforward and reliable integration into the electric utility grid. Wave energy also offers much higher energy densities, so devices can extract more power from a smaller volume at consequently lower costs. Harvesting of this ocean energy would be more as compared to harvesting of energy from wind. The density of the ocean water is 850 times that of air. Hence the energy produced from wind of 18m/s would be relatively close to the energy produced by just a current of 2m/s.

9. Discussions and Conclusions

It is true that oceans have huge energy within it, and if harvested could satisfy current demand of electricity of the world. However, it is also true that, with the existing technologies, recoverable energy from the ocean is comparatively less. Still the

amount of recoverable energy will solve some of the issues of scarcity of electricity and it will be a step toward harnessing the total energy potential of the ocean.

The biggest hurdle in adopting ocean energy from the ocean is the cost required to be invested to harvest electricity from it. Also the technologies are not that developed, that they can withstand the brutal waves of the ocean when at full power. Currently we have to invest nearly 7.5cents/KWh for procuring energy from ocean. This amount is huge if we compare it with amount required to harvest electricity from coal which is only 2.6KWh. Also harvesting of electricity from wind, which is another renewable source, is relatively cheap at 4.5cents/KWh. This raises doubt in the industry of the need of harvesting ocean energy and investing amount in it. This problem can only be solved with blinding support from the government towards research and technological improvement.

It is now time to focus more on researching on new and better output giving renewable source of energy rather than working increasing number of traditional devices to procure energy. If power renewable sources are studied further, I believe that at certain point the biggest disadvantage of the ocean energy conversion system, which is the huge cost will decrease by large extent. Also this won't only give us a new and better source of energy to mankind, but also as a boon to reduce the global warming issue and extend our earths life span.

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