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OCEAN ENERGY IN THE INDIAN CONTEXT

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ABSTRACT

India has got a very high potential for the renewable ocean energy, the most promising forms being Thermal (OTE), wave (forming part of a multi-benefit system) and tidal energies. For each case the potential, principles of extraction, technological developments, work in progress at global level and the activities in India are briefly presented.

Key-words: Oceann thermal energy, wave energy, tidal energy, India.

Ocean energy as alternative energy source

Solar radiation which sustains life on earth is continuous and inexhaustible. It has been estimated that about 10^{16} Watts of solar energy reaches the earth. The ocean which covers about 71% of earth's surface acts as a natural collector of this energy. Thus, the ocean has an enormous potential to supply energy in many different ways. The major advantages of ocean energy are that it is renewable and continuous through out the year, pollution free and has minimum health hazards. For remote islands, ocean energy will be the most important form of alternative energy since it comes from the immediate vicinity.

Various forms of ocean energy

The forms in which the ocean energy could be tapped are:

Ocean Thermal Energy, Wave energy, Tidal energy, Salinity gradient energy, Offshore wind energy, energy from marine currents and energy from marine bio-mass.

While R & D activity is going on concerning all the above energy aspects around the world, the forms of energy that have already achieved/could achieve, technical feasibility in the near future are:

Ocean Thermal Energy Conversion (OTEC), Wave Energy and Tidal Energy.

OCEAN THERMAL ENERGY CONVERSION

Principles & Systems

Ocean thermal energy is the most important form of ocean energy for a country like India having a long coast of tropical waters. The principle behind OTEC is quite simple. It utilises the temperature-difference existing between warm surface sea water of around 28°C and the cold deep sea water of around 5 to 7°C, which is available at a depth of 800 to 1000 m in tropical waters.

Two Alternative OTEC Systems

First is the *open cycle system* which uses sea water as the working fluid. In this system the warm surface water is flash-evaporated in a chamber maintained under high vacuum and the generated vapour is utilised to drive a low pressure turbine connected with the generator. The exhaust steam is condensed using cold sea water.

The *closed cycle system* utilises a low boiling point liquid like Freon or Ammonia as the working fluid. The fluid is evaporated using the warm surface sea water. After the vapour drives the turbine, it is condensed by cold sea water. This condensate is pumped back to the evaporator.

Location of OTEC System

Depending upon the availabilitly of deep sea near the coast, the OTEC system could be installed in three possible types of locations.

1. Where the distance of deep sea from coast is large, OTEC plant could be placed on a floating platform with a cold water pipe suspended from it. An underwater cable is needed for power transfer to shore. Alternately, the energy generated may be utilised to produce energy intensive materials like Ammonia or Hydrogen from the sea water. The products have to be transported to the main land by ships.

2. If the distance is around 10 km, the OTEC plant could be floating in the near shore area and the generated power can be transmitted to the main land by underwater cables.

3. If the deep water conditions are available within 2 to 3 kms of the coast, the entire plant could be situated on land with the cold water pipe line running along the ocean bed to a depth of 800 to 1000 metres.

Advantages of OTEC Systems

1. Power from an OTEC system is continuous, renewable and pollution free.

2. The cold deep sea water is rich in nutrients and can be utilised for aqua-culture.

3. An open cycle OTEC system provides fresh water as a by-product. The closed cycle system can also be combined with a desalination plant to get fresh water.

4. OTEC is an important alternative source of power for remote islands.

5. A floating OTEC plant could generate power even at mid-sea, and can be used to provide power for operations like offshore mining and processing of manganese nodules.

Global OTEC potential and development

The world wide area with annual average temperature difference of about 22° C is approximately 60 million sq. kilometers. It is estimated that an OTEC plant with a grazing area of about 200 sq. kilometres can have a continuous output of around 325 MW. Based on this, estimated global power potential from OTEC alone is about 10 million MW. This is approximately 10 times the total world electric power production today. This indicates the enormous opportunities offered by OTEC and the necessity to develop adequate technology for tapping Ocean Thermal Energy. Active work including sea trials on pilot plants and design of commercial plants is in progress in U.S.A., Japan, France, Sweden and Netherlands.

OTEC potential in India

India is geographically very well placed as far as the OTEC potential is concerned. Around 3000 kms of coast length along the south Indian coast down from Bombay on the west coast, upto Visakhapatnam on the east coast, a temperature difference of 20° C throughout the year is available. Thus we have more than 3 lakh sq. kilometres of tropical waters in the exclusive economic zone around India where sufficient temperature gradient exists throughout the year. Apart from this we have attractive OTEC plant locations around the Lakshadweep, Andaman and Nicober islands. The total OTEC potential around India is estimated to be more than 50,000 MW. This potential is about 150% of our total installed power generating capacity. This points out the urgent need to develop OTEC technology indivenously.

The national OTEC programme envisages building a 1 MW OTEC pilot plant at Kavaratti, capital of Lakshadweep group of islands. A co-ordinating OTEC project cell of Department of Non-Conventional Energy Sources at Ocean Engineering Centre, IIT Madras, in collaboration with several national organisations has campleted the feasibility study.

WAVE ENERGY

General

The incessant motion of sea surface in the form of wind-waves constitutes a source of energy which is continually being replenished. About 1.5 percent of the incoming energy from sun is converted to wind-energy. Part of the energy from the winds is transferred to sea surface resulting in the generation of waves. This energy is carried to coastlines throughout the world where it is dissipated as the waves break. If this energy can be tapped and used economically it can provide a sizeable portion of world energy needs.

Extraction of energy from waves is more efficient than direct collection of energy from the wind, since wave energy is concentrated through the interaction of the wind and the free ocean surface. In this respect, the sea behaves like an immense energy collector whereby the wind energy, transferred to large seasurface is stored as mechanical energy in waves. The inertia of the waves provided this short time storage and also tends to smooth out part of the high variability in time and space that is characteristic of the wind.

The wave energy potential varies from place to place depending upon its geographic location. Even at a given place, the energy availability varies during the different parts of the day, for different months and from season to season.

Estimation of Wave Energy Potential (Global & Indian)

It is estimated that the global wave energy potential is of the order of 45×10^{15} W. A wave power potential of about 60 to 80 kw/m have been reported in the North Atlantic and North Sea areas. Available informations, based on visual observations, indicate that annual average wave height along the Indian Coast is of the order of 1.5 m with the wave period of about 6 seconds. But some scientific wave data collected off Kalpakkam and near Kakinada on the east coast using wave rider buoys, indicate wave heights of more than 2.5 to 3 m, even during nonmonsoon periods. This suggests that the annual average wave power potential along the Indian coast may lie any where between 5 kw/m and 15 kw/m. For the Indian coast of around 6000 km in length the wave energy potential is approximately 60,000 MW.

Global Technology Development

United Kingdom and Japan are the pioneers in the wave energy development, while Sweden, Norway and the USA also have started serious R & D activities. Few hundreds of patents have been registered on different types of wave energy devices. The United Kingdom has spent about 4 million pounds on this research activity till 1980. The major projects that were supported by this funding are Salter's Duck, Cockerell Raft and oscillating water column systems. Commander Masuda of Japan Marine Science & Technology Centre was the first to develop the oscillating water column system with air turbine to light navigational buoys. This concept was extended for large scale power generation and later this development became a joint effort between UK and Japan.

The oscillating water column system consists of a chamber in the sea exposed to wave action through an entrance at the bottom or in the side. The air inside the chamber gets pressurised or expanded due to wave action. Air movement through a small opening from or into the chamber depending on the pressure inside, is utilised to drive an air turbine.

The oscillating water column (OWC) system with the air turbine was subjected to sea trial in the sea of Japan in October 1979. These systems were tested on a barge with vertical openings, named 'Kaimei' which was moored in the deep seas. It was 80 m long, 12 m wide and about 6 m in depth and weighed 800 tonnes.

The conventional axial flow air turbine for power generation requires four valves for rectifying the flow. Prof. Wells of Belfast University, U.K. has developed a turbine which will rotate in the same direction with pulsating air flow in and out of the system. This is a unique turbine and does not require any valves. However, it requires detailed study before final deployment in the sea.

Wave Energy Related Activity at IIT Madras

Wave energy potential along the Indian coasts is not as high as in the northern latitude countries. Therefore a wave energy system purely to generate electricity from the waves may not be commercially viable in the near future. However, there are many other utilities that may arise by regulating the waves. A multi-purpose wave regulator system can be used.

1. To absorb the energy of the waves by providing a long wave barrier and to convert the energy into electricity.
2. The long barrier results in a calm pool of water between the barrier and shore and this pool could be used as:
    i. a natural harbour
    ii. space for aqua-culture
    iii. space for coastal transport with lighter crafts
3. This wave absorber system also provides shore protection against erosion by the waves.

Because of the multi-functional aspects of the Wave Regulator System (WRS), such a system should be situated not very far from the shores. It is being proposed to place the system in a water depth of about 10 metres, which exists at a distance of about 500 metres from the shore. Such locations exist off Madras and at many places along the Indian coast.

A project entitled 'Scientific investigation of wave climate, wave regulation and power' sanctioned by the Department of Ocean Development, Government of India, is under advanced stage of implementation at the Ocean Engineering Centre, IIT Madras.

The major aims of this project are:

1. to gather systematic data on the wave climate off Indian coast;
2. to study various possible designs of wave energy devices, and

3. finally to select the most suitable system for Indian conditions and suggest a suitable design for installation at a specific site off Indian coast.

TIDAL ENERGY

Global potential and development

Tidal power development has gone through long stages of development and two tidal power stations have been in operation for more than a decade. The first one to go into commercial production is the Rance plant in France. It is operational since 1966 and the installed capacity is 240 MW. The second is an experimental plant at Kislaya Cuba in Russia.

In spite of the fact that two tidal plants are in operation for more than 10 years, more plants have not been built because plant construction is highly capital intensive. But the world oil price hike has drawn greater attention towards tidal power development. The important points in favour of tidal power are :

1) The life of plant is of the order of 75 to 100 years and is high compared to 25 to 35 years for a nuclear or thermal power plant.

2) The technology of power development in tidal power plants is simple as in hydro-electric power stations.

3) Improved construction technology like prefabricated plants being sunk at site and development of straflow turbines (with generator mounted on the rim of the wheel) have considerably reduced the construction cost.

A tidal range of 3 to 4 m is considered viable for installing a tidal power plant. But there are hundreds of sites around the world having a tidal range of more than 10 m. Several estuary projects in UK and Bay of Fundy projects in Canada are under very serious consideration.

Tidal Power Potential in India

There are quite a few sites in India suitable for tidal power development but all these sites are clustered in two or three areas only. The Gulf of Kutch and the Gulf of Cambay on the west coast of India have maximum tidal ranges of around 11 m and annual average of around 6 m. In the Sunderbans area of West Bengal, the annual average is around 3.5 m. A study conducted in 1975 by an U.N. expert, Mr. E. Wilson indicated a theoretical possibility of installing very large tidal power station in the Gulf of Cambay and Kutch but smaller power stations in Sunderbans area. Installed capacities of about 7300 MW, 1000 MW and 15 MW in the Gulf of Cambay, Gulf of Kutch and in Sunderban areas respectively are possible. The corresponding estimated costs (1975) are Rs. 1925 crores, Rs. 600 crores and Rs. 15 crores respectively. The Gulf of Cambay scheme may require a barrage of 40 m height and about 30 km long.

The 7300 MW plant at Gulf of Cambay, if installed, will be able to contribute about 20% of India's installed power capacity power today. Realising the great potential, Gujarat State Electricity Board and Department of Energy, Government of India have jointly taken up a detailed project study in collaboration with Electricity de France, the pioneer who built the Rance Plant.

CONCLUSIONS

Ocean has immense energy resources. In the Indian context, Ocean Thermal Energy Conversion (OTEC) with other benefits like aqua-culture and desalination can be a continuous source of power throughout the year. Wave energy combined with aspects of shore protection and aqua-culture has a very high potential all along the Indian coast. The third form of ocean energy that could be exploited in India is the tidal energy. The estimated potential of these three in India are as follows:

Ocean Thermal Energy (OTEC)	:	50,000 MW
Wave Energy	:	60,000 MW
Tidal Energy	:	8,000 MW

Considerable developmental work is going on around the world in tapping these energy sources and some preliminary work has already been carried out within our country. In view of the enormous power potential from our own country, a major thrust in this area appears to be justified.

The eastern coast of India and islands of Lakshadweep and Andaman offer immediate possibility of exploiting OTEC. Possibilities for Wave Energy utilisation are available all along the Indian coast. Gulf of Kutch, Cambay on the west and Sundarbans area on east offer excellent sites for tidal power development.