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The Present Situation of the Wave Energy in Some Different Countries of the World

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Abstract—Development of renewable energy technology (RET) was started primarily as a response to the energy crisis of the 1970s world over. This early experience helped in identifying wave energy source which have been developed to a great extent [1]. In this paper, a discussion has been presented wave energy for electrification, giving emphasis on the existing systems in some countries of the world. Different projects are reviewed, along with early implementation experience. Bangladesh has an energy crisis [2]. To keep this in mind this work has been studied. Bangladesh is a watered by rivers country and harnessing a huge potential of wave energy that may be the vital source of electricity and can face the energy crisis of Bangladesh. This work will help to develop the research on wave energy for practical utilization in Bangladesh.

Index Terms—Renewable Energy, non-renewable energy, Pelamis, Oscillating Water Column, Power Buoys, navigation buoys, Submarine Cable, Harbour, shoreline, megawatts, kW, MW, TW, prototype, hydro-electric, Volt, Local Time, High Tide, Compartment, PKL, Load Current etc.

1 INTRODUCTION

MANY countries of the world research in renewable energy because modern people knows that the limitations of non-renewable energy. That's why modern scientists worked hard for more utilization of renewable energy. Ocean waves represent a major resource, estimated by the world energy council to be in encases of 2 Trillion Watt worldwide. Wave power harnesses the energy of waves and converts it into electricity. Wave power devices harness directly from surface wave motion or from pressure fluctuations below the surface. Wave-power rich areas of the world include the western costs of Europe, northern Canada, southern Africa, Australia, and the northeastern and northwestern coasts of the United States [28]. Wave power could supply 10% of the world's electricity current supply levels. Several methods of extracting energy from waves are being researched. One of the most effective ways is using the rise and fall of wave action to compress air in a chamber. The compression and release of air pressure is used to drive a turbine and a generator. Its benefits are ones installed, wave systems should not be expensive to operate or maintain and offshore locations are unobtrusive and the environmental and social impact should below. Wave energy is reliable which needs appropriate site with consistently strong wave action. Equipment must be durable enough to withstand rough conditions and salt water. Wave energy systems could significantly alter flow patterns of sediment on the ocean floor. According to the U.S. Department of energy, renewable energy analysts believe there is enough energy in the ocean waves to provide up to two terawatts of electricity.
[3],[4],[8],[11],[13],[14],[15],[16],[17],[19],[20],[30],[31],[32]

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2 WAVE ENERGY IN UNITED STATES OF AMERICA (U.S.A)

2.1 Background

The State of Oregon Taps the Brakes on Commercial-scale Wave Energy development on March 7, 2008, Ocean Power Technologies Ins. (OPT)- 52 days after a major public meeting in coast country to discuss a 20-buoy wave energy pilot project-announced they had been submitted to the Federal Energy Regulatory Commission (FERC) a Notice of Inter and Preliminary Application Document (NOI-PAD) to do a 200-buoa commercial-scale wave energy park off coasts country. Since March 7, 2008, there's been a swift reaction from the State of Oregon and FERC. In the State of Oregon's MOU with FERC, the parties recognize it's in their mutual interest to coordinate their activities, and, to hold off approving commercial scale projects until modest sized pilot projects have had time to develop further information. In the MOU, the parties also recognize the State of Oregon intends to prepare a comprehensive plan for the sitting of wave energy developments and marine reserves in the Territorial sea. Preparing a state plan for wave energy / marine reserves is something many people on the Oregon coast have called for since wave energies companies and two coastal countries began filing for Preliminary Permits in the Territorial seas. Here's the bottom line. Members of the Coastal Caucus that OCZMA Director Onno Husing has talked to support developing placeholder budgets for the 2009 Legislative Session with generic information. They agree it's premature (plus unnecessary and counterproductive) to press for a full-blown marine reserve nominations process at this time. State agencies also develop placeholder

POPs (policy option packages) in the Governor's proposed

Fig. 1. Buyae of Oregon, U.S.A. [10]

budget of the 2009 session. To do any or all of these things will require substantial resources. Because of the present situation of the economy, getting any money from the Oregon Legislative session to support a marine reserves/wave energy planning process will be tough. [5],[10],[12],[19].

Fig. 2. The first stage of deployment and testing of the new Pelamis P2 generator. [34]

2.2 Wave Energy in United Kingdom (U.K.)

The British coast line is 11,072 miles long and has some of the highest tidal ranges in the world. The tidal range in the Severn Estuary that creates the Severn Bore can be as much as 50 feet (15.4 metres), the second highest in the world. Despite these natural advantages marine renewables are only just developing towards the point where they can be deployed commercially. After testing at the European Marine Energy Centre (EMEC) in Orkney, Pelamis Wave Power's P1 wave generators have been used to establish a 2.5MW wave farm off the Portuguese coast. Pelamis have several projects around Europe, and are currently in the first stage of deployment and testing of the new Pelamis P2 generator.

European Marine Energy Centre (EMEC) was established to help the evolution of marine energy devices from the prototype stage into the commercial market place and has established full scale testing sites for wave energy systems at Billia Croo and a testing facility for tidal generators off the island of EBay. To date, Government and other public sector organizations invested around £15 million in the creation of the centre and its two marine laboratories.

In Scotland funding is also available from Scottish Enterprise's Marine Energy Collaboration Fund. The United Kingdom (U.K.) government has recently set up the £50 million Marine Renewables Deployment Fund to support the continued development of the marine renewables sector. [4],[18],[22],[32]

2.3 Wave Energy in France

The largest tidal power station in the world (and the only one in Europe) is in the Rance Estuary in northern France has been generating 240MW since 1966. This barrage works like a hydro-electric scheme using the huge volumes of water flowing through the tidal estuary to drive turbines built into the barrage. Particularly on an high tide the barrage traps water behind it releasing it slowly as it generates electricity. [4],[26]

Fig. 3. The largest tidal power station in the world (and the only one in Europe) is in the Rance Estuary in northern France.

2.4 Wave Energy in Germany

Germany's first wave power generation plant will be installed by Energie baden-Württemberg Ag (EnBW) in cooperation with Voith Siemens Hydro Power Generation GmbH & EnBW sees potential for wave power on the North Sea coast. The German pilot plant will rely on the only technology producing wave power in practical today. The Limpet power plant installed by Wavegen (a UK based subsidiary of Voith Siemens) currently feeds a nameplate 500kW into the network. The technology uses the "Oscillating Water Column" (OWC) principle to convert wave energy into compressed air which drives turbines. The plans for a German pilot plant target a 250kW capacity, enough to power about 120 households. A small start, but nonetheless a step towards

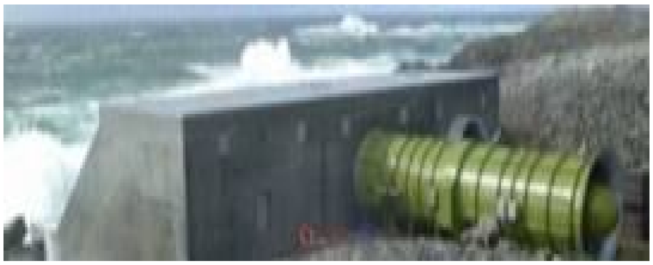

Fig. 4. Wave energy convertor device in Germany. [27]

providing the technology for more ambitious projects. Advantages of the Wavegen power plantinclude its low profile so that visual disturbances from coastal energy projects are minimized. EnBW envision implementing energy projects in cooperation with coastal conservation projects or port construction, which should further minimize the loss of natural beauty on the coastline while optimizing the energy creation potential. [19],[27]

2.5 Wave Energy in Italy

The participation of the WavEC in European projects has given us the opportunity to work in collaboration with universities receiving students from different countries of WavEC's team. [36]

2.6 Wave Energy in Spain

Iberdrola Renewables has begun the testing of a wave energy pilot plant in Santoña, Cantabria, Spain which became the first of this kind to be installed in Europe. The company has begun on-shore testing of the operation of the internal components of the first PowerBuoys from Ocean Power Technologies (OPT). OPT's PowerBuoy wave generation system uses the rise and fall of waves to move a piston-like structure inside the buoy column to pump hydraulic fluid that drives a generator anchored on the ocean floor. Generated power is transmitted ashore via an underwater power cable. The tests consist of the inspection of the components, evaluation of the individual functions of each of the systems and a final resistance test, in which the units are interconnected and the real operating conditions the buoy had to face in the sea were simulated, at varying surge intensities. The installation was located four kilometers from the coast of Santoña and comprised 10 buoys. In a first phase a 10-meter, 40 kW buoy were anchored to the seabed some 50 meters down. The remaining 9 buoys, planned for a later phase, had an initial capacity of 125 kW. When all 10 buoys were in operation, the electricity produced the approximate equivalent to the domestic consumption of some 2,500 homes. The joint company that is developing the plant, named Iberdrola Energias de Cantabria, S.A., is owned by the Iberdrola Renewables (60%), TOTAL (10%), OPT (10%), the IDEA Institute for Energy Diversification and saving (10%), and the Sodercan Cantabria Development Society (10%). The budget for the first phase, which included the marine electrical infrastructure, which includes the marine electrical infrastructure, comes to some €3 million (US$4.6 million). In addition to the Santoña Wave Energy Project, Iberdrola is developing a wave energy plant off the Orkney Islands in the North of Scotland, which will become the world's largest by installed capacity (3 MW). This complex will comprise four floating Pelamis generators with a capacity of 750 kW each. [4],[9].

2.7 Wave Energy in Portugal

It is the modest quantity, but it is the first stage of "the first power plant in the world to use waves as a source of renewable energy," engineer Rui Barros explained to IPS. In the renewable energy field Portuguese company vast experience in the use of wave energy. The Portuguese wave farm was planned and built offshore, eight kilometers from the beach at agucadoura, by Ocean Power Delivery (OPD), a Scottish firm which, Barros said, "has operated in this market since 1997, and has achieved a level of know-how that is unrivalled in the world." [4],[21],[23],[24],[25]

Fig. 6. The front of the Pelamis machine bursting through a wave at the Agucadoura Wave Park of Portugal. [33]

The first assembly phase was carried out in naval shipyards at Peniche, 120 kilometers north of Lisbon. Three enormous "Pelamis" tubes were assembled, 142 metres long and 3.5 metres in diameter, which have been installed eight kilometers from the coast to capture wave energy, to transmitted to the mainland via submarine cables. The hydraulic action starts the three generators, each of which can produce 750 kilowatts of electrical energy when operating optimally. This is first accumulated, and then transmitted by submarine cables to mainland, where it is fed into the EDP grid. Arguments in favor of developing wave energy are based on Portugal's geographical location and conditions.

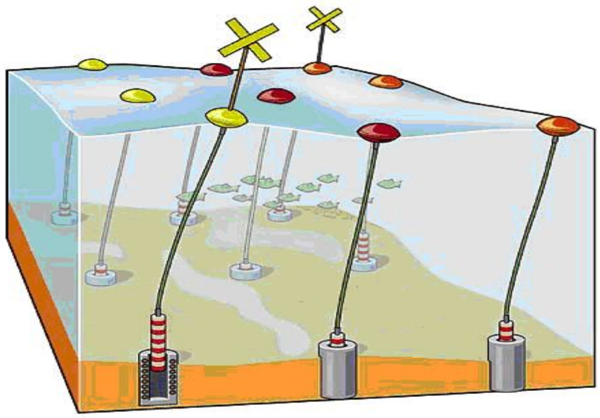

Fig. 7. Point Absorber Wave Energy Farm. [5]

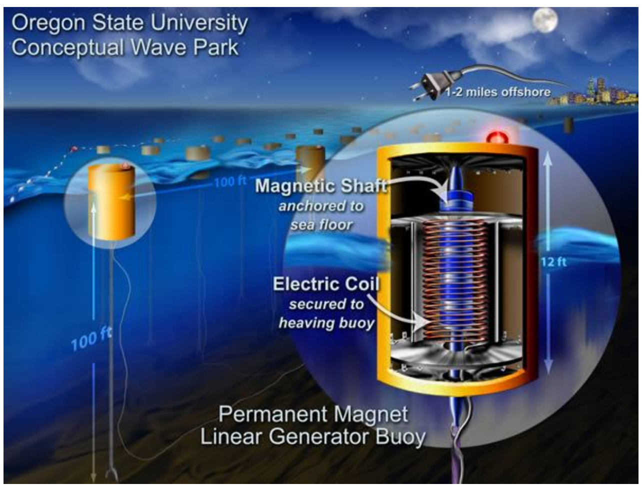

Fig. 8. Rendition of a Wave Farm Made Up of Permanent Magnet Linear Generator Buoys [5]

2.8 Wave Energy in Russia

Dr. Rob Carver has done a detailed analysis of the remarkable Russian heat in his latest post, The Great Russian Heat wave of July 2010. A persistent jet stream pattern has set up over Europe, thanks to phenomena known as blocking. A ridge of high pressure has remained anchored over Russia, and the hot and dry conditions have created helped intensify this ridge in a positive feedback loop. [6]

2.9 Wave Energy in Canada

BC Hydro is investigating the potential of wave power on Canada's west coast. [35]

2.10 Wave Energy in Australia

While Australia is home to world-class wave energy resources, there are no commercial scale ocean energy projects at an advanced stage of development. Australia rides the waves EcoGeneration, Rachel Purchase, 4 August 2010 water covers over 70 percent of the Earth, and Australia is particularly lucky to be surrounded by a lot of it. However, the ocean power available down under remains a largely unharnessed resource. Australia is home to world-class wave energy resource, there are no commercial scale wave energy projects at an advanced stage of development. Industry experts Michael Ottaviano of Carnegie Wave Energy, Colin Parbery of Oceanlinx, and Gilbert Geotge of Ocean Power Technologies Australia agree that ocean technology requires a stable policy and regulatory environment to encourage large-scale investment in new technology. [4],[29]

2.11 Wave Energy in China

The main body funding comes from the State Science and Technology Committee which is aiming to develop offshore wave power stations. Fundamental research on wave power is continually supported by the Natural Science Fund of China and the Chinese Academy of Sciences.

A shoreline is OWC. This is being undertaken by Gunagzhou Institute of Energy Conversion of the Chinese Academy of Sciences. After problems encountered in considering the device device for Nanao Island, the latest planes are for it to be built at Shanwei city in Guangdong province and will be a two chambered device with total width of 20m and rated at 100 kW. A shoreline pivoting flap device (Pendular) is being developed by Tanjin Institute of Ocean Technology of the State Oceanic Administration. An Experimental 3 kW shoreline OWC was installed on Dawanshan Island in the Pearl river estuary. This supplied electricity to the Island community and, following its good performance, it is being upgraded with a 20 kW turbine. China also produces mini-wave power devices for navigation buoys with a rating of 60 W. Over 650 units have been deployed in the past 17 years, mainly among Chinese coast with a few exported to Japan. [4]

2.12 Wave Energy in India

The Indian wave energy program started in1983 at the Institute of Technology, Madras and has concentrated almost exclusively on the OWC with harbor walls was built onto the breakwater of the Vizhinjam Fisheries Harbor, near Trivandrum in India in 1991 (Ravindran et al, 1995). This scheme has functioned well, producing data that have been used to design and build an improved demonstration scheme at the same site. This will have the following new features-

The squirrel cage induction generator will be superseded by a slip ring, variable speed induction generator with an improved performance under fluctuating load conditions. The previous device suffered from losses of 15 kW, which had to be supplied from the grid under low wave energy conditions. The new scheme will comprise two power modules, only one of which will run under low power conditions.

The fixed chord blade turbine will be replaced by one where the blade chord varies along its length for improved efficiency.

Following the successful testing of this, it is proposed to build a commercial scheme of 10 caissons, each 21m wide, at Thangassery, on the west coast of India. Each caisson will have two power modules, both with a 55 kW rating, leading to an overall rating of 1.1 MW. These caissons will be spaced at an optimum distance apart, in order to increase their overall capture efficiency to above that of a single caisson. [4]

2.13 Wave Energy in Japan

Japan is surrounded by the sea. The average wave power level around Japan is 6-7 kW/m of coastline. The total wave energy around Japan is estimate to be 31,000 MW-36,000 MW. The open-sea test of the 'Mighty whale' concept completed in 1987 at JAMSTEC was last in the series of experiments with wave energy devices in Japan. Most of wave energy devices in Japan were shoreline concepts. These concepts were intended for incorporation to breakwaters. Most of the concepts operated on the Oscillating Water Column principal. The sizes of generated output of these devices were relatively small and were in the range 10-100 kW. [4],[19]

2.14 Wave Energy in Indonesia

A feasibility study has been carried out by Groner AS (Norway) on deploying a TAPCHAN scheme at Baron on the Island of Java. Discussions have since taken place between interested parties, but the demonstration has not yet been taken forward despite the project's technical feasibility. [4]

2.15 Wave Energy in South Africa

Scottish company Ocean Power Delivery, which develops technology to generate power from waves, is considering a R7-billion development off the coast of Mossel Bay that could generate 700 megawatts of electricity, according to business Report. The company is talking to the South African Department of Minerals and Energy and a potential local partner, Port Elizabeth-based Genesis Eco-Energy, about developing a pilot plant at Mossel Bay, 400 kilometers east of Cape Town. South Africa currently has the capacity to generate about 40,000 megawatts of power, but is looking to cut its dependence on coal and rely more on renewable energy sources. Ocean Power Delivery is an Edinburgh-based company set up in January 1998 to develop the Pelamis wave energy converter, which is then transferred to the shore through a cable. [7]

2.16 Wave Energy in Bangladesh

The vast energy potential of the wave energy from the Bay-of-Bengal has not yet been harnessed significantly. Jagannath University and NOAMI (National Oceanographic and Maritine Institute) jointly have been tested and the results of the tests are encouraging. Both Jagannath University and NOAMI jointly will be designed and fabricated a wave energy converter for increased realization of the energy potential of the wave considering the variation of the wave formation. For this reason I (author1) as a representative of "NOAMI" first servey the wave nature and other necessary opportunities for utilizing the wave energy power of Bangladeshi sea-costal area on the 23rd April,2011 at the Kolatoli, New Kolatoli and Sugondha seabeatch in Cox'sbazar using speed-boat. My 2nd training trip was arranged by Bangladeshi Naval largest Hydro Servey ship "ONUSHONDHAN" at 2nd and 3rd June, 2011 in the deep sea of the "Bay –of-Bengol". From 4th to 7th June, 2011including the previous beaches I also servey the land erosion, sea-cost uprising, shallow depth wave nature and the natural desusture management syste at the Inani seabeach and Himsory seabeach in the Cox'sbazar. According all kinds of situation finaly I decided New Kolatoli seabeach for my research. In my 1st research trip I used some PKL (Pathore Kuchi Leaf) module of 4 & 6 compounds. At 23rd April, 2011 I took some data after taking the modules into the speed-boat and crossed some sea-waves.

TABLE 1

DATA SHOWING AFTER CROSSING SEA-WAVE AT SHUGONDHA NEAR LABONI POINT

Local time	Voc (V)	Isc (A)	Compartment	Load Voltage(V)	Load Current I (A)
11:44am	2.96	0.09mA	4	2.33	.02mA

We saw that into the speedboat after crossing the sea-waves the voltage of the modules increases. According to the time of High Tide the calculations of the height of the coming 4 waves were: 14.5cm, 15.5cm, 20.5cm & 25.5cm.

TABLE 2

DATA SHOWING AFTER CROSSING SEA-WAVE AT SHUGONDHA NEAR LABONI POINT

Local Time	Voc (V)	Isc(A)	Compound
01:28pm	4.95		6
01:35pm	5.04	.12mA	6
01:42pm	4.74	.21mA	6

TABLE 3

DATA SHOWING AFTER CROSSING SEA-WAVE AT SHUGONDHA NEAR LABONI POINT IN THE SERIES COMBINATION BETWEEN 6 & 4 COMPARTMENT

Local Time	Voc (Volt)	Isc (A)
01:44pm	8.38	0.50mA

TABLE 4

DATA SHOWING AFTER CROSSING SEA-WAVE AT SHUGONDHA NEAR LABONI POINT IN THE PARALLAL COMBINATION BETWEEN 6 & 4 COMPARTMENT

Local Time	Voc (V)	Isc (A)
2:10pm	3.54	0.12mA

TABLE 5

MEANINGS OF THE SCITIFIC SYMBLES

Symbol	Meanings
pm	Ante meridiem
am	Ante meridium
Voc	Voltage for open circuit
V	Voltage
Isc	Current in the circuit
A	Ampier
mA	Mili Ampier

3 Results

The table no.1, 2, 3 & 4 shows that if we cross sea-wave the voltage will be increase. So that we can come to the dission that it is possible to produce energy as electricity from the wave energy of the Bay-of-Bengol in Bangladesh.

4 RECOMMENDATION

The above discussion lead to the recommendation for the improvement of wave energy technology worldwide. Governments and organizations should give more financial incentives in this sector.

5 CONCLUSION

To resolve the environmental problem facing us today and to live in the next century, we must build a global renewable power generating system using wave energy. For utilization such energy, a strong dissemination program is needed. Wave formation is always available in good quality and quantity in the networks of concerned rivers originated from the Bay of Bengal. Numbers of Islands are formed due to the rivers networks. The Potential energy of waves may be utilized as alternate source of energy in these areas. A very few numbers of wave power plant projects are in experimental stage.

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