AN ASSESSMENT OF WAVE POWER POTENTIAL ALONG RATNAGIRI COAST MAHARASHTRA

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ABSTRACT

Day by day along with population, Electric Power demand is increasing with consumption rate in all sectors. Electric Energy is of acute importance in the entire process of development and growth of all human beings and it plays a major role in the social and economic development of a country. Electric Energy is extremely important and any uncertainty about its supply may hamper the developing economies. In India, most of the power generation is carried out by conventional energy sources i.e. Coal and mineral oil-based power plants and suffers a supply shortage. This paper presents a hybrid use of renewable energy resources. A 5 year wave data of Ratnagiri, Maharashtra is statistically analyzed. The wave climate required for power generation and availability duration was assessed. This research paper will certainly be motivational in further design and development of a small capacity Wave Power harnessing unit.

KEYWORDS: *Renewable energy sources, Electric power, Wave Power, Wave data, WEC, efficacy*

I. INTRODUCTION

Electric power plays vital role in our lives. We need electricity for Industry, Agriculture, Transport, communication etc. The fundamental relationship in energy economics is more people with more income, means rise in production and hence more consumption of energy. Electric power demand is increasing day by day in all sectors along with population. Population and income growth have been the most powerful driving forces behind Electric power demand. India's working-age population ranges between the ages of 15 to 64 which is around 54% of total population on 2011, which represents the engine for its economic growth and hence rise in energy demand.

After independence, India's population has grown from 220 million to 1400 million; and so simultaneously electricity demand has increased from 4182GWh/year to Presently 852903 GWh/year [1] which is satisfied by the current installed capacity of the conventional and non-conventional power plants. Power generation in India is mainly Hydro-Electric and Thermal Power Plants. This electric power is supplied by National grid (south, west north, north east, east). But still there is vast deficit of 12218 MWh/year in electric power supply [2].

Table 1. All India LOAD GENERATION BALANCE REPORT (LGBR) (2013-14) [2]

Power Supply Position	LGBR	Actual	Deviation (%)
Energy Requirement(MU)	1048533	1002257	-4.4
Energy Availability(MU)	978301	959829	-1.8
Peak Demand (MW)	144225	135918	-5.7
Peak Demand Met (MW)	140964	129815	-7.9

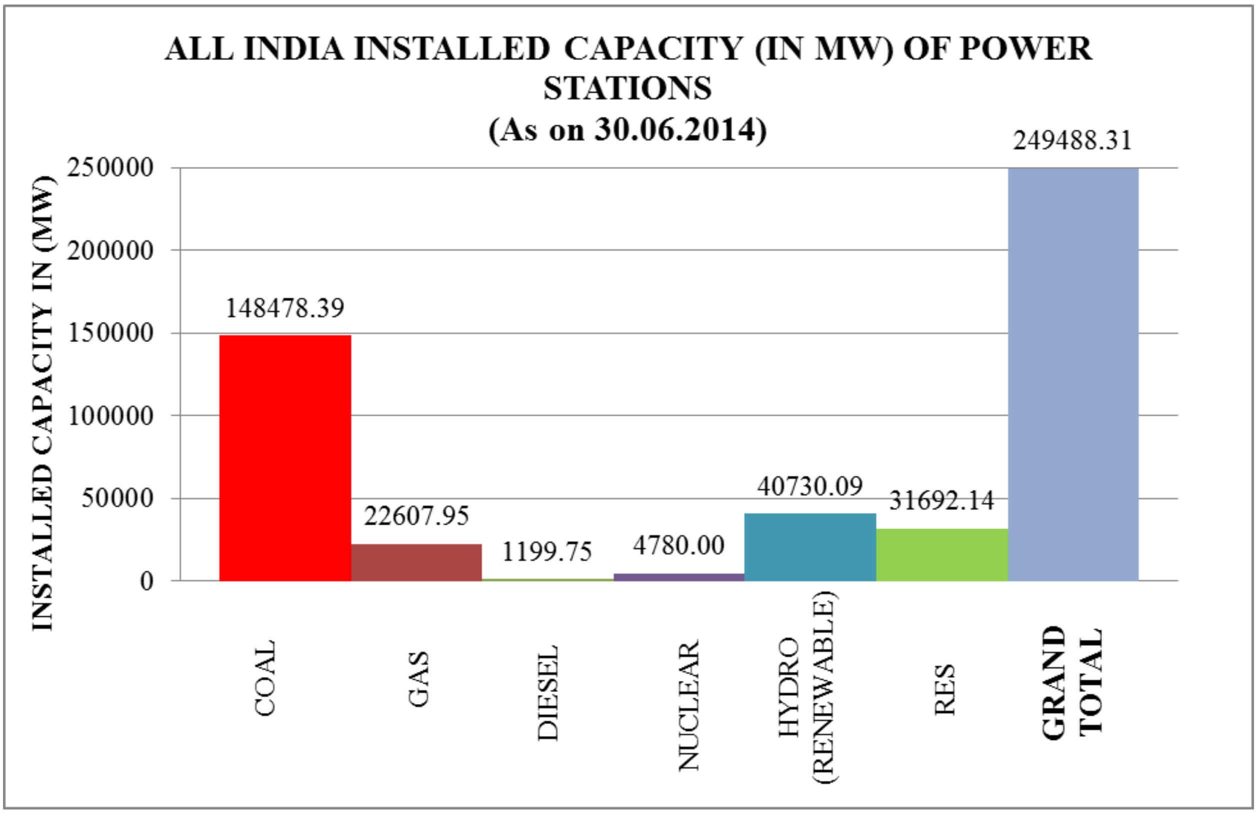

Figure 1. All India Installed Capacity (MW) as on 30-06-2014 [3]

These 'future Energy- Supply projections' suggest that there will be problems in matching supply and demand early in next century. Setting up of new conventional resource power plants will inevitably reduce the ability of natural carbon sinks such as forests to absorb Green House Gases emissions. The subsequent decline of fossil fuels, uncertainty of Rainfall & Oil crisis leads to inventions of alternate sustainable renewable energy resource.

Thus, tackling the energy crisis by identifying substitute sources of energy, which are abundantly available and renewable also. The types of renewable resources are Solar Energy, Wind Energy, Hydropower, Ocean Energy, Geothermal Energy and Biomass etc. There are plenty of renewable resources around the country and these sources can be exploited to their extremes without fearing about their depletion.

In the event of shortage of 'Grid connected power supply', less importance is given for supplying electricity to the remote area localities which don't have industrialisation. Thus, the remote/ coastal areas away from the national grid starve for their domestic electricity demand. In these remote/coastal areas, during pre-monsoon summer period (Feb-June) power is available only few hours per day.

India has more than 7500 km of coast on East and West side, having 30% of country's population [4]. The coastal areas in Maharashtra are remote from the grid due to presence of Sahyadri mountain hilly areas in NW direction close to shore. As such, it is expensive to extend the grid in this remote part for supply of electricity even in the periods of low demand and fair supply (Aug to January). Hence isolated power plants should be maximized.

Amongst all renewable sources, about the Ocean Energy (Tidal, Wave, OTP), in Tidal energy has a limitation due to useful tide range which is maximum at Kutch and Gulf of Cambay of Gujarat wherein a grid connecting 250MW tidal power plant is being installed by Govt. of India[5]. Ocean Thermal Power (OTP) requires minimum temperature difference of 20 degrees, which is available in deep Ocean, is located far away from the coast. Only Wave energy is offered, more or less throughout the vast coast line of India.

Waves in ocean are available and predictable also and the wave scatter diagram provides an effective representation that helps a wave energy conversion (WEC) device's performance to be estimated for a given site's wave conditions. If a WEC power matrix is available we can assure the suitability of that wave power unit or the number of multiple requirements of the units.

II. WAVE CLIMATE ALONG WEST AND EAST COASTS OF INDIA IN BRIEF

The phenomenon of Ocean waves is the motion in the ocean. Waves are caused by a number of forces, wind, and gravitational pull by the moon, sun, atmospheric pressure changes, and earthquakes. Waves that are created by wind are the most common ocean waves.

West and east coasts of India differ in their topographic and bathymetric features and prevailing climate conditions. The east coast of India is categorized by narrow continental shelf width as compared to the west coast of India. Wave characteristics along the west and east coast of India are influenced by the three different seasons: pre-monsoon (February – May), southwest monsoon (June – September) and northeast monsoon (October - January).

The Bay of Bengal experiences three different weather conditions as follows fair weather, south west monsoon and north east monsoon. In fair climate season, the sea surface is usually calm and the coastal region is dominated by swells and to a smaller extent by the locally produced waves. Extreme events of weather are common during NE monsoon (October to December) season. During extreme events, due to the sudden decrease in water depth, the waves surge further and create severe coastal hazards.

Tropical storms/cyclones occurring in the Bay of Bengal and in the Arabian Sea have considerable impact on the wave characteristics along the Indian coast. The most powerful in the Arabian Sea is SW monsoon, which has considerable impact along the west coast. During pre-monsoon and NE monsoon-season, global winds are usually weak, and the local winds play the major role of controlling the dynamics along the west coast of India. Along the west coast of India, wave heights are usually higher during SW monsoon and low during NE monsoon and pre-monsoon seasons. Storms occur frequently in the Bay of Bengal than in the Arabian Sea.

Thus along west coast of Maharashtra, at a selected location Ratnagiri, an attempt has been made here to assess wave power potential by re- analyzing the interpolated statistical wave data.

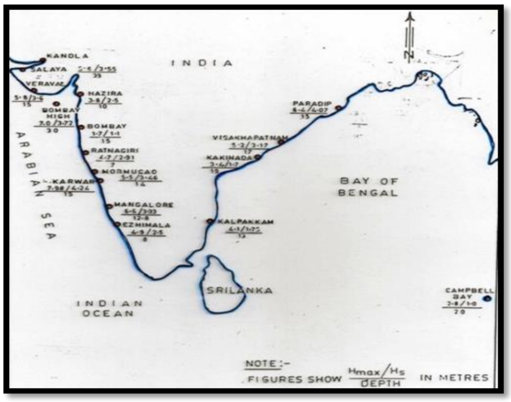

Figure 2 India's wave conditions of different sites [6]

III. Data Collection

The Indian government website "Ocean Data and Information System(ODIS)" provides the required wave parametric data for the selected location for the period of about 5years (2010 -2014).[7]

Buoy Id	Longitude	Latitude
Ratnagiri	73.263	16.977

IV. Study Area

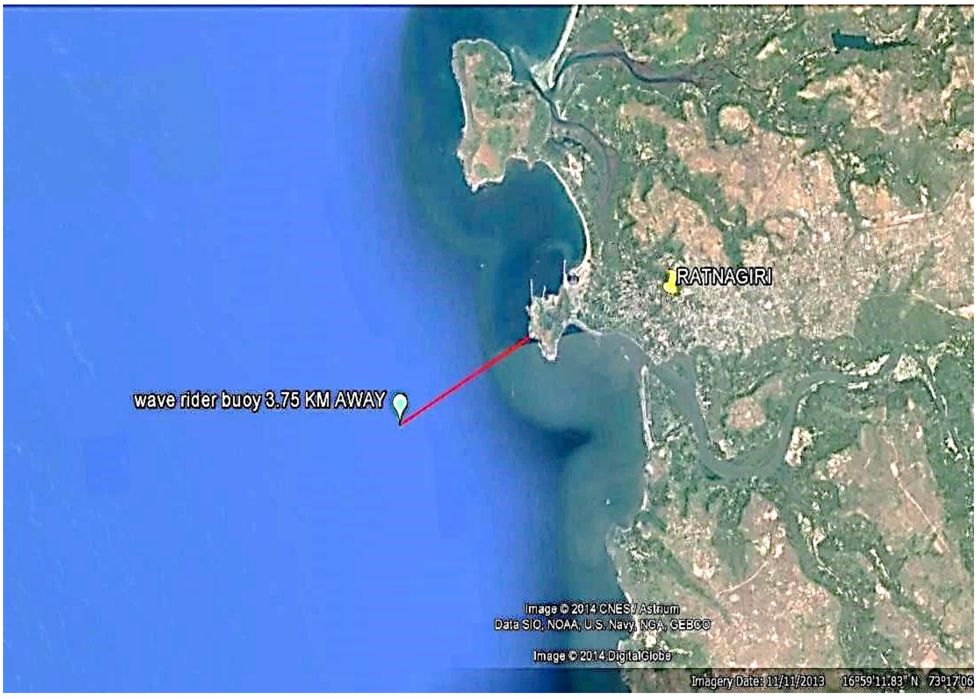

Figure 3. Geographical Buoy Location at Ratnagiri

1. Data on website from Wave Rider Buoy, in graphical format as shown below: [7]

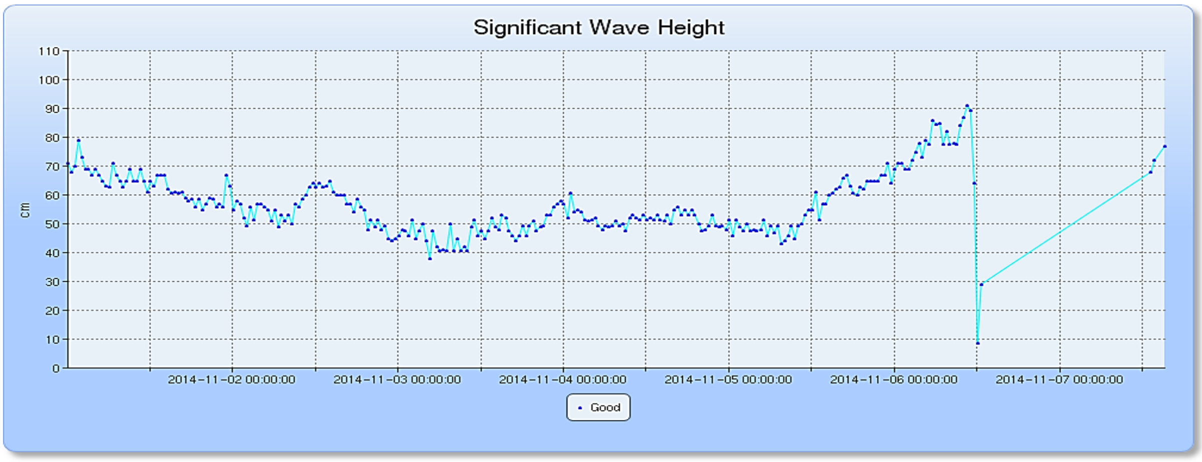

Figure 4. showing significant waves height

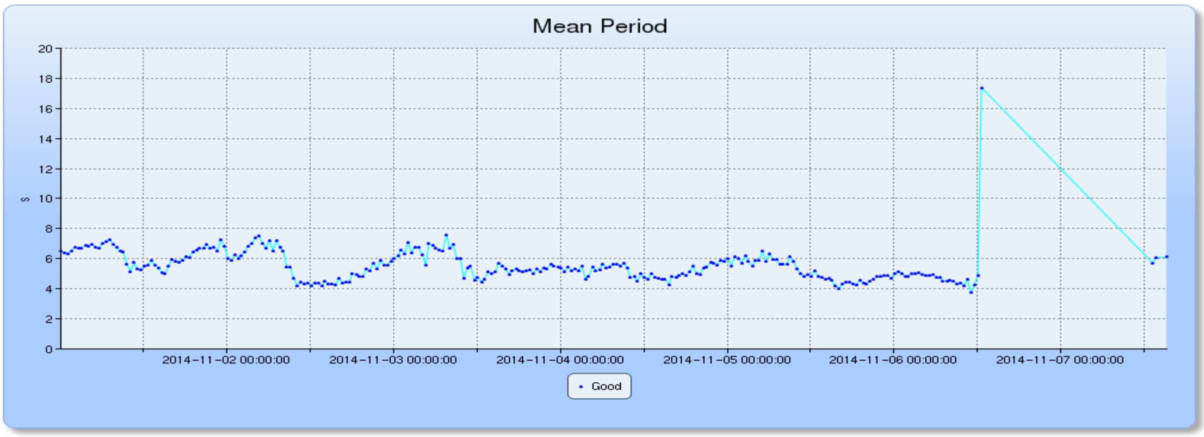

Figure5 showing significant mean wave period

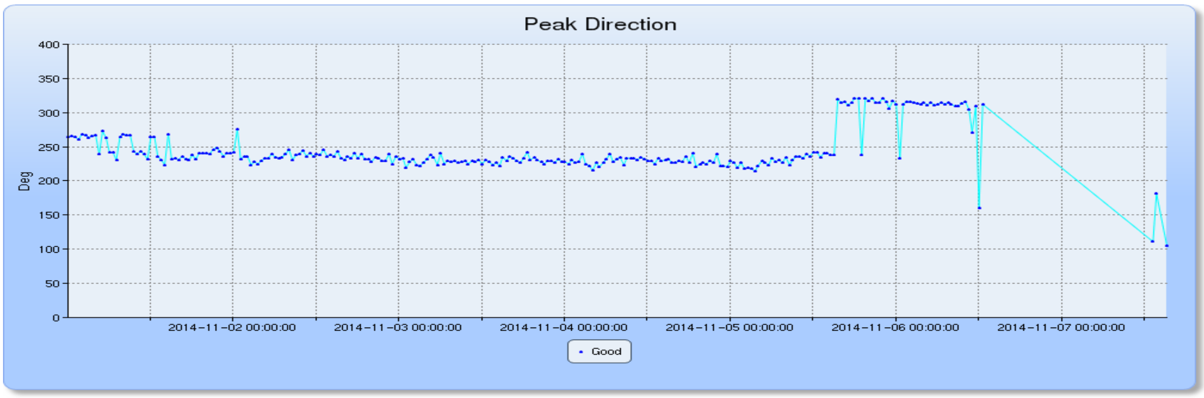

Figure 6 peak direction

2. study of wave climate:

Wave rider buoy sends digital data for the wave parameters is being analysed by computer program and final significant height is given for that interval of time.

Table 2 Significant Height (SH) % Distribution

Sr. No.	Significant Wave Heights	Occurrence %
1	Up to 0.50 m is less than	4 %
2	0.50 m to 1.0 m is more than	57 %
3	1.0 m to 1.50 m is about	7 %
4	1.5 m to 2.00 m is about	16 %
5	2.0 m to 2.50 m is about	11 %
6	2.5 m to 3.00 m is about	5 %
7	3.0 m to 3.50 m is less than	1 %

Table 3 Yearly Variations of Significant Wave Height and Wave Average Period

From 5 years (2010-2014) data		
Year	Average Wave Period in Seconds	Average Wave Height in meters
2010	6.6	1.48
2011	5.71	1.13
2012	5.57	1.07
2013	5.74	1.18
2014	5.74	1.35

In case of availability of numerical wave data of all the wave parameters, it could have been possible to adopt Tucker method analysis for computation of significant wave height (Hs) etc. Since we have data available in the graphical format directly for Significant wave heights, Mean Wave Periods and Peak Directions of waves, the graphical weekly data is interpolated for 5 years. From the wave data for 5 years (2010-2014) for Ratnagiri region, it is observed that Ratnagiri wave climate is as follows: From above wave data of 5 years monthly variation of average wave period and average Significant wave height (Hs) derived as follows.

Table 4 Monthly Variation of SH and Average Period for period of 5 years

From 5 years (2010-2014) data			
	AVERAGE WAVE PERIOD in sec	**AVERAGE WAVE HEIGHT in meters**	
MARCH	4.75	0.75	PRE-MONSOON PERIOD
APRIL	4.80	0.77	
MAY	6.98	1.22	
JUNE	9.29	2.68	
JULY	9.33	3.08	MONSOON PERIOD
AUG	8.53	2.5	
SEP	8.32	1.98	
OCT	5.9	0.69	
NOV	6.35	0.61	POST-MONSOON PERIOD
DEC	6.42	0.71	
JAN	4.53	0.63	
FEB	4.63	0.7	

Following average wave power conditions persists at Ratnagiri coastal region.

TABLE 5. Available Average Wave Power

Average Wave Power 'P' (KW/m)=500*Hs^2 * Tz								
From (2010-2014) wave data								
PRE-MONSOON			MONSOON			POST-MONSOON		
Month	KW/m	Average KW/m	Month	KW/m	Average KW/m	Month	KW/m	Average KW/m
MAR	1.09	**5.69**	JUL	21.45	**10.88**	NOV	0.78	**0.80**
APR	1.15		AUG	14.66		DEC	0.76	
MAY	2.30		SEP	6.16		JAN	0.73	
JUN	18.24		OCT	1.28		FEB	0.93	

Average efficacy of the wave power units available is around 30% of available wave power therefore if a WEC using 20 meter Wave front of efficacy 25% would harness power as follows
Harnessed Power supply from WEC would be of the order of

1. In Pre-monsoon season (1.09*0.25*20) **5.45 KW** to (18.24*0.25*20) **91.20 KW**
   Average Power supply would be (5.69*0.25*20) **34.14 KW**
2. In Monsoon season (21.45*0.25*20)**107.25 KW** to (1.28*0.25*20**) 6.40 KW**
   Average Power supply would be (10.88*0.25*20) **54.40 KW**
3. In Post-Monsoon season (0.78*0.25*20) **3.90 KW** to (0.93*0.25*20) **4.65 KW**
   Average Power supply would be (0.80*0.25*20) **4.00 KW**

Electricity Consumption per House varies significantly due in part to differences in demographics, house size and characteristics, and weather. The average number of houses benefited by power supply for a given area location is simply the quotient of the average performance power supplied by wave power unit and the average annual house consumption. Due to differences in WEC unit's performances and average energy consumption per house, the number of houses powered by a WEC power unit can vary considerably from one location to another.

On review of requirement of wave climate from experimental / commercial work executed by researchers and industries, it can be said that, if a WEC unit utilizing waves ranging from 0.5 m to 1.0 m is used, then the WEC can harness wave power for maximum number of days in a year avoiding seasonal wave height variations and limitations of higher wave heights range.

V. CONCLUSIONS

1. An attempt has been made to assess wave power potential by re- analyzing the interpolated statistical wave data available at Ratnagiri, along west coast of Maharashtra,. As such, efforts have been made to access the feasibility of available Wave Power based on five years field wave data analysis.
2. Review of studies stated in table 4 indicates that during pre-monsoon period (March–June), it is indicated that adequate wave potential power is available which can be harnessed for domestic supply purpose.
3. Table no 2 and 3 indicate that the waves of about 0.5m to 1.0 m height are available for almost all the time throughout the year. Thus for consistent harnessing wave power is necessary to be consider this concept of "Every day waves" in WEC design.
4. A near shore wave power plant in the wave breaking zone i.e. within 50 meters of reach from the beach should be provided which will reduce the cost of installation, cabling and maintenance in operational conditions.
5. Considering the huge expenditure on investment for the wave power harnessing system it is suggested that the wind turbines and solar panels along with wave power could be coupled to make the net power available for more number of days per year. Since it would be a hybrid power plant, it will give more consistency of power supply.

VI. FUTURE SCOPE OF STUDY

1. After knowing the prevailing wave climate and wave power availability at Ratnagiri, it is also necessary to provide other suitable renewable energy sources such as wind, solar etc.
2. A detailed investigation needs to be carried out for power from other renewable sources such as wind and solar for providing domestic power in post-monsoon season where wave climate is weak.
3. Efficacy of the WEC units should be improved to harness maximum percentage of wave power available to reduce capital cost per KW of power supply.
4. Further research in this direction certainly helps in accurate design of a small Hybrid Power Harnessing unit which will work out to be economically viable in long run.

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Vilas B. Joshi has graduated in Civil Engineering from University of Pune in 1970 and joined CWPRS in 1972. Since 1980 he joined the Coastal Group as Research Officer. He has obtained Masters of Science Degree in Ocean Engineering from University of Hawaii at Honolulu, USA during 1984-85 under UNDP Fellowship program. He was working as Chief Research Officer at CWPRS Pune, heading the Ports & Harbours Division II when he retired in November 2007.His area of specialization includes random wave models for the port layouts, field wave data collection and analysis, design of sand trap and beach nourishment, coastal Protection works and radioactive tracer studies for disposal of dredged material in deep sea. He was selected as Indian representative to attend International Field Training workshop for Tracer studies at Bangkok arranged by International Atomic Energy Association (IAEA) He has published about 28 papers in National and International Conferences and Journals. Since January 2008, he has been delivering lectures as Visiting Faculty for the elective subject "Coastal Engineering "for B. Tech/M. Tech. course at College of Engineering Pune [COEP], Bharati Vidyapeeth, Sinhgad Technical Education Society Pune. At present, he is working as Professor of Civil Engineering at BV-COE for M. Tech students for their Research & Academic activities He is also working as Project Advisor for feasibility studies for coastal projects for development of Ports & Offshore Structure in the private sector.