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Research Article

Study on wave power regarding Bangladesh

Mohammad Asadul Haque*, Tasibana Chowdhury and Mamunur Rashid

Department of Physics, University of Chittagong, Chittagong, Bangladesh

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ABSTRACT

Wave Energy is a type of renewable energy that uses the power of waves to generate electricity, and it is the largest estimated global resource form of ocean energy. This study deals with various techniques of wave power and focuses on the present scenario in the world and its potentiality in Bangladesh. The analysis of parameters of wave height, wavelength, and wave period; indicates the bright prospects of wave power in Bangladesh.

Introduction

The economic development of a state depends on the power sector. Bangladesh can be enriched in the power sector by using wave energy to alleviate poverty and fight environmental degradation, such as desertification, bio-diversity depletion and climate change. The state is trying to overcome the problem of costly rental power plants and looking for long-term nuclear power that is unsuitable for the state (Salimullah et al., 2014). It has been estimated that if less than one percent of the total capacity of tidal electricity is generated, it will cover five times the total global requirements (WEC, 2022). Wave power converts the periodic up-and-down movement of the ocean waves into electricity by setting up equipment on the surface of the oceans that captures the energy produced by the wave movement. The world energy council has estimated that approximately 2 terawatts of power could be produced from the ocean via wave power (Siddique, 2013). Bangladesh has a huge ocean area with various power resources such as wave energy, Ocean Thermal Energy (OTE) and tidal energy. In the Bay of Bengal, the wave height varies from 0.5 m to 3.5 m, and the wave period from 3 to 12 sec indicates the potentiality of wave power generation in Bangladesh (Haque et al., 2010). The state can easily meet its huge power demand by proper utilization of the above mentioned energies, where wave power can play a vital role in integrating as a new source of renewable energy to the off-grid power connection in isolated coastal areas, namely Sandwip, Saint Martin, Koakata, Kutubdia, dublar char, Cox's bazar tourist zone, etc. and improve the social, environmental and economic perspective of Bangladesh (Anam and Bustam, 2011; Rahman and Khan, 2014). This study aims to concentrate on the progress of wave power world wide and its prospects in Bangladesh.

Wave energy in details

When the wave travels through a medium, it will experience some local oscillations, but the particles do not travel with the wave. Water waves are surface waves with circular particle movement directions involving longitudinal and transverse wave movements. Waves are generated by the wind blowing over large ocean areas and once generated, travel immense distances with only small energy losses. Waves travel vast distances across oceans at great speed. The longer and stronger the wind blows over the sea surface, the

*Corresponding author: <asad.physics@cu.ac.bd>

higher, longer, faster, and more powerful the sea is. The energy within a wave is proportional to the square of the wave height, so a two-meter-high wave has four times the power of a one-meter high wave. The amount of energy transferred depends mainly on the wind speed, period, and distance over the surface on which it blows. In 2008, the first experimental wave farm was opened in Portugal at the Agucadoura Wave Park (World's first commercial wave power station, 2018). The standard formula for wave power calculation (Salimullah et al., 2014):

Where, P is the power of a wave in deep water,

$$P = \frac{\rho g^2 T H^2 L}{32\pi} \quad \text{..........(1)}$$

measured in watts; ρ is the density of seawater (1,025 kg/m^3); g is the acceleration due to gravity (9.81 m/s^2); T is the wave period in seconds; H is the wave height in meters; L is the length of the wave front (perpendicular to the direction of travel, across), in meters; π is the mathematical constant 3.1416 (Calisal, 1983; Tucker and Pitt, 2001).

Fig. 1. Images of wave power technologies

Image of power buoy point absorber

Image of surface attenuator

Image of oyster wave surge converter device

Image of AWS pressure differential device

Image of wave dragon overtopping device

Image of oscillating water column

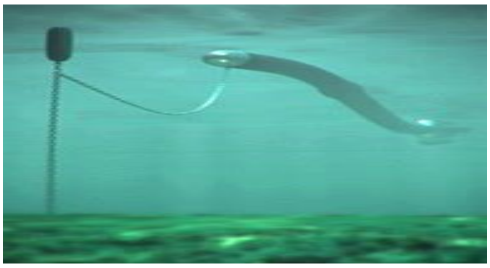

Image of the anaconda bulge wave power device

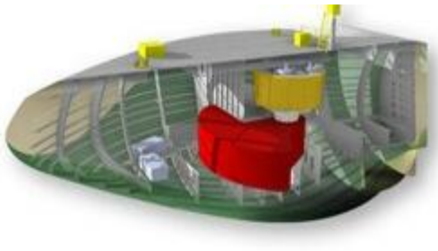

Image of the rotating mass device

Wave power devices are generally categorized by the method used to capture the energy of the waves by location, and by the power take-off system. Generic wave energy concepts are shown through several images of Fig.1 (McCormick and Ertekin, 2009; Kurniawan et al., 2014; Shareslide. net, 2022).

Present scenario of wave power in the world

The current status of wave power stations in the world as of 2022 is listed below: (Rahman and Khan, 2011; Vicinanza et al., 2011; Joao and Babcock, 2015; You et al., 2012; WEC, 2022).

Country	Details
United Kingdom	Islay Limpet, Scotland (the world's first commercial Wave Power plant) 250 kW; 2000 [Decommissioned in 2018]
	Pelamis P2 generator (wave farm off the Portuguese coast) Orkney wave power station; Estimated 120 GW.
Portugal	Aguçadoura Wave Park 2.25 MW (22.5 MW Planned); 2008
Germany	North sea coast; 250 kW; 2000
France	France’s Brittany (largest tidal 240 MW); 10 MW; 2021
Sweden	Sotenas Wave Power Project; 10 MW; 2015
Greece	SINN power (Island of Halki in Greece); 1 MW; 2015
Finland	Penguin; 1 MW; 2020
Canada	25 GWh wave power plants are investigated at five locations on Canada's Pacific coast; 2017
Italy	1 MW; 2018
U S A	2.64 trillion kilowatt hours has been estimated theoretically; 2021
India	Total potential comes to around 40,000 MW; 2010
China	Ten regions of China, the energy. Estimated near shore wave energy of 249.7 TWh/year; Practicing wave energy since 1980
Myanmar	Has 1,930 Km of coastline on the Indian Ocean; Wave energy theoretical potentials (Twh/year): 211 Wave energy applicable potentials (Twh/year): 11; 2016
Ireland	Wave energy conversion project located 4-6 km offshore Co. Clare, Starting with 5MW capacity. [Estimated 1875 TW]; 2021
South Korea	The average 30 kW power could be increased in the Korean Peninsula, which is surrounded by the Yellow Sea, East China Sea, and East Sea.
Bangladesh	The vast energy potential of the wave energy from the Bay of Bengal has yet to be harnessed significantly.

Methodology, Results, and Discussion

For experimental data, wave parameters such as wave height, wavelength, and wave period are measured using a direct measurement system. A new shape iron frame that is scaled in centimeters has been constructed to measure the wave height vertically and wavelength horizontally. A stopwatch has been used to record the time and a floating boat from where the data have been taken.

Bangladesh’s large and long coastal area can be used for electricity generation to minimize the energy crisis. The scope of wave power in Bangladesh has been assessed by calculating wave power production in the ocean area. Most of the recent research indicates that the wave height produces in the coastal regions of the Bay of Bengal lies between (0.5-3.5) m, which is very much suitable for wave power (Haque et al., 2010). In the Bay of Bengal, the wave height remains the same in all general day conditions. For these reasons, it has been considered four spots in the Bay of Bengal at Chittagong and Cox’s Bazar districts as Station-one: Potenga Sea shore area at Chittagong; Station-two: Anowara Sea shore area at Chittagong; Station three: Cox’s Bazar Sea shore area and Station four: Saint Martin Island at Cox’s Bazar as shown in Fig. 2 (Southern part map of Bangladesh) from where the primary data have been collected.

Fig. 2. The study area is shown in the map of Bangladesh (Southern part)

In this research, the average wave height is from 0. 45 m to 3.42 m, and the wave period is about (3 to 11) sec in the above survey area. The recorded data have been analyzed for power production and presented through several graphs. The wave height, wave period, and the possibilities of power production with time in other months have been presented below:

The wave height has been recorded from 9 am to 6 pm from 2 to 14th April-2018, after every 30 minutes at station-1; from 9 am to 6 pm from 4 to 13th May-2018 after every 30 minutes at station-2; from 9 am to 6 pm from 4 to 11th June-2018 after every 30 minutes at station-3 and from 9 am to 6 pm during 12 to 19th June-2018 after every 30 minutes.

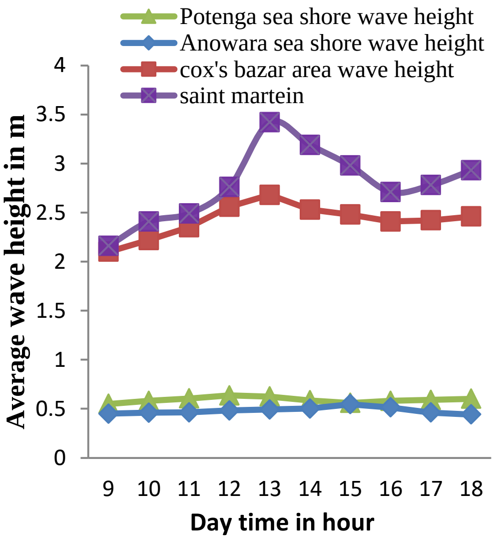

Fig. 3. Average wave height versus day time of the survey area.

The average wave height has been found to be from 0. 55 m to 0.63 m and the wave period is about (3 to 4) sec at station-1; from 0. 45 m to 0.55 m and the wave period is about (3 to 4) sec at station-2; from 2.1 m to 2.68 m and the wave period is about (8 to 10) sec at station-3 and from 2.2 m to 3.42 m and the wave period is about (9 to 11) sec at station-4.

The average wave height versus daytime of the survey areas at a glance is shown in Fig. 3:

Fig. 3 indicates that the wave height continuously has an increasing and decreasing tendency with the variation of the tides. It follows six hours rotation, after six hours, it goes maximum and then tells to a minimum. The wave height and time are also related to wind speed, and vast space (free front side and back side) is required for more wind speed.

Due to the high wave height Fig. 4 indicates the wave takes more time at Saint Martin than at the other three places.

Fig. 5 shows more wave height produces more power which is clear that the wave height is maximum at Saint Martin and minimum at the Anwara Seashore area. The reason is that at Potenga and Anwara seashores, the front side has huge free

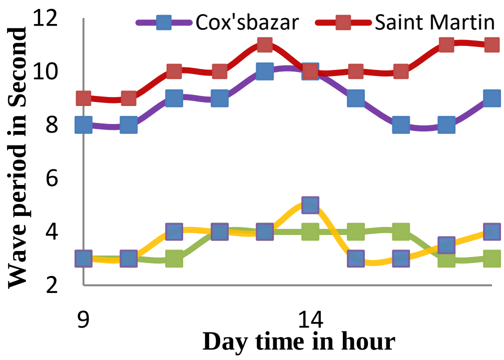

Fig. 4. Average wave period versus daytime of the survey areas

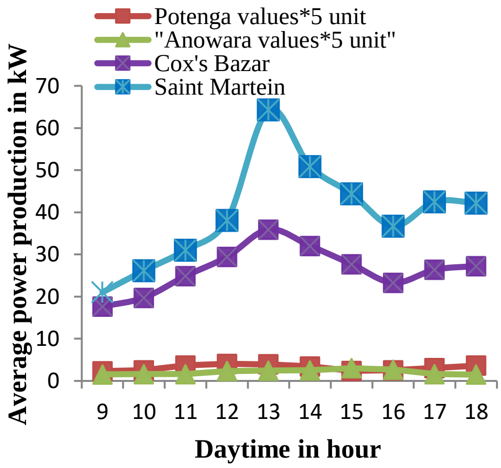

Fig. 5. Possible power production with daytime in survey areas

space for incoming wind, but the back side is blocked by human habitation, so the incoming wind can't pass properly. Since urbanization and human habitation are not so much developed in Cox's Bazar long Seashore area, the place is much better than Chittagong. The island of Saint Martin is the best place for wave power production because of the maximum wind speed. Fig. 5 shows that getting an average of 27 kW power from a single wave device could be possible. Available space in the Bay of Bengal indicates a chance to set up several wave machines quickly. Finally, wave power could be a new renewable energy source that can play an essential role in solving the present energy crisis in Bangladesh.

Conclusion

The summary of this study shows that there is a considerable opportunity for Bangladesh to meet its future power demand and thus, economic growth through wave power. It can help the state produce more power to reduce the Load-shedding problem. The time has come to look forward and work with wave energy to produce electricity rather than depending wholly on conventional methods. Therefore, the Government and the private sector should work hand in hand to emphasize wave energy more to produce electricity to solve our power crisis.

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