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A Review on Wave Energy Harvester

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***Abstract*: Generating electricity from wave power has to overcome the electricity need in coastal areas. The consumption rate of conventional energy resources is much higher than the replenishing rate. The depletion of fossil fuels has created a great desire in searching for alternative energy sources. Harvesting of alternative energy is a quite difficult and challenging task, most importantly for harvesting wave energy. This review explained Wave Energy Converter (WEC) and the different methods used in the Wave Energy Harvesting process. Buoyancy force and wave power calculation are identified. This method of energy harvesting can rectify the energy shortage in coastal areas. Our intention is to give an Eco-friendly and low-cost method to harvest energy from nature.**

***Keywords*: Buoyancy Force, Energy Depletion Wave Energy Harvesting, WEC.**

1. Introduction

The energy demand is continuously increasing worldwide and conventional methods for power generation are causing many Environmental issues such as global warming, acid rain, and air pollution. Thus, the method of harvesting energy from renewable energy sources such as waves can reduce the harmful impact of such issues on the environment. The wave energy harvester is basically an energy harvesting device, which is used to harvest the energy from the waves. The kinetic energy present in the waves caused due to air is converted into electric energy. The conversion of electrical energy is done by using WEC. In 1977 there was first wave power patent are filled. Around 23 million people live in coastal areas due to the arid interior of Australia. The large potential marine energy resources are available in Australia due to high coastal lines.

Richard Manasseh et. al. [20] gives details about coastal protection and energy expert in Australia. The ocean energy conversion occurs due to seawater the temperature in the tropical northeast of Australia. That's the reason Australia an ideal location for technology development.

In Adelaide, the wave rider company produces 500KW of power using the Heaving buoy(array)device. Marine renewable energy technologies are highly developed in Australia because of the more coastal area. In Future the cost of electricity from marine sources is higher than the present wind cost. More companies are focused on testing and development of energy from the ocean in Australia.

2. Energy harvesting

It's the method of producing energy from solar, wind and other conventional methods. By using conventional it will harmful to the environment but wave energy is a vest and it not harmful to the environment.

Shahrukh Adnan Khan et. al [1] have been reviewing the four Energy harvesting technologies and gives the details of small-scale Energy harvesting. Triboelectric Nano generator network used on a large scale with estimated power output 1.15Mv from 1Km^2 water surface.

In Solar Energy Harvesting, the Lithium battery is used to produce 53% and 83% of efficiency with 20Mv to 30Mv of power. Super Capacitor based hybrid control system is used for wind energy harvesting .it can charge 6v to 12v battery at low wind speed.

Piezoelectric Energy harvesting uses Poly Zirconate Titanate (PZT) and Poly Vinydene Flourideand (PVDF) to produce electric power. PZT able to produce 150v with 80 MW of power and PVDF able to produce 60v with 20 MW of power.

Andreas Uihlein and DavideMagagna [2] have been addressed the future cost of ocean energy for operation and maintenance. Ocean energy is the future research and the economic and social impacts were focused.

A. Benefits

Advantages of using wave energy over other methods as follows:

1. By Comparing all renewable energy source Ocean waves give the highest energy density [3]. Waves are formed due to Temperature Gradient on the surface of the Ocean. the solar energy intensity value of the vertical plane (2–3kW/m^2) is generated from 0.1–0.3kW/m^2 intensity of Horizontal turbine below the water surface [4].
2. With less energy loss waves can travel large distances. The Kinetic energy of the wave is converted into electrical energy.
3. Comparing wind and solar energy devices, wave energy converter produces up to 90% of power on the time [5].

B. Types of wave energy converters

1) Point absorber

It's the type of WEC that harvest incoming wave energy using up and down motion. The electricity generated from this method by using vertical position floater.it can absorb wave energy and converts electrical energy through linear

generator.it can produce power up to 252MW.

Fuat Kara [6] use the latching control method to improve the efficiency of WEC. By using the latching control, the point absorber heaving high power from ocean waves through the vertical cylinder.

Fig. 1. Point absorber device: Power buoy [23]

Latching control is a separate time control process. The amplitude of wave power can be increased by using this method.

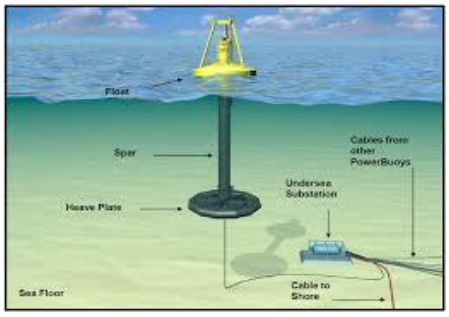

Fig. 2. Point absorber: Structure [24]

According to Athanasios Koliosa et. al. [7] the WEC floater is prone to experience fatigue before the end of their nominal service life.

Elie Al Shami et. al. [8] focused the one body and two body absorbers. In one body point absorber, the distance between floater and the bed is high. So, it will not give more efficiency. the two-body point absorber can overcome this problem.

2) Attenuator

Attenuator lies on the surface of the ocean and parallel to wave direction. Hydraulic pumps are used to generate electricity through flexing motion. This flexing motion is created by swells.

Fig. 3. Attenuator [25]

3) Oscillating water column

It's one of the oldest methods of wave energy harvesting. Due to the action of waves, the column gets oscillate inside the chamber. Waves act like a piston to forces the column and it moves up and down, due this electricity gets generated.

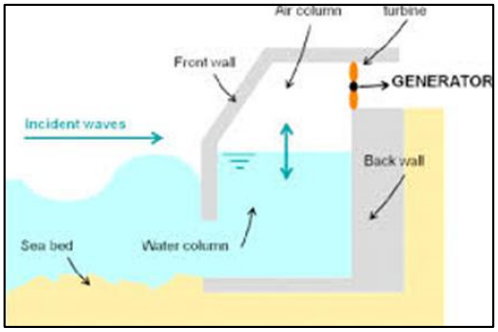

Fig. 4. Oscillating water column [26]

J.C.C. Henriques et. al. [9] resulted in self-powered sensor buoys are suited to long term condition in OWC compare to point absorber. The conditions of the long-term monitor and minimum maintenance of these sensors are well suited. For large scale wave energy harvesting, OWC devices are used.

Marco Torresi et. al. [10] discuss these OWC devices are used for harvesting the wave energy under the resonant condition in the ocean.

4) Oscillating Wave Surge

It's also known as Oyster Wave Energy Converter is a hydro-electric wave energy device that uses the motion of ocean waves to generate electricity.

As the wave hits the PCU and it creates a movement of back and front, it will drive the by a hydraulic piston.

Due to the flow of this high-pressure water hydroelectric turbine gets rotated and electricity produced.

Fouzi K.M. Rahuma, and O. Yaakob [11] developed a cost-effective power for coastal areas through nearshore OWSC. The average efficiency of OWSC is 37% and the efficiency of this method improved by increasing the width of the device.

Matt Folley et. al. [12] discuss and compare shoreline and pendulor OWC with OWSC. Resulted in the OSWC method is more productive and construction cost is minimum.

Fig. 5. Oscillating Wave Surge [27]

5) Over Topping Device

In this device, the electricity is produced using a hydro-electric turbine. The high-velocity waves come on the top of the device. It will go to the turbine with a high velocity. Finally, the water comes to the reservoir.

Vidura et. al. [13] mentioned using overtopping device produce 20KW of power in Pari island and power density ranges of this island is 30-80 W/m^3.

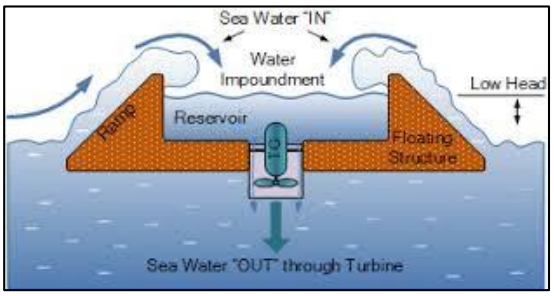

Fig. 6. Over Topping Device [28]

3. Wave power and efficiency

Wave power is a type of energy that is used to reduce electrical energy from the kinetic energy of waves. CYJ. Chen[14] gives the evaluation of the potential of wave power and economic valuation of wave energy conversion facilities for theoretically assessing the feasibility of energy from the waves in the Ocean.

$$P_w = 0.0625\rho g\, H^2\, C_v\, (T_p, h_d) \quad (1)$$

Where P_w is the wave power (kW M^{-1}), ρ is the density of water (1028 kg M^{-3}), g is the acceleration due to gravity (9.8 m s^{-2}), H is the certain wave height, T_p is wave energy is tellurium period (second), h_d is the water depth, and wave C g is the group velocity (M S^{-1}).

And it will use to assessing the demand for energy feasible from waves in the oceans.

Zhongyue Lu et. al. [15] uses a reversing wave energy generating device. It will be used to achieve continuous rotary motion through the irregular motion of wave energy for the generator. The low time period of the wave can give more output voltage. That can learn from his experiment.

Table 1
The output voltage for corresponding period of time [14]

S. No.	Time Period (s)	Voltage (V)
1	2	9
2	2.5	6
3	3	4
4	3.5	3
5	4	2

4. Rack and pinion mechanism

According to Srinivasan Chandrasekaran et. al. [16] wave energy converters focus on using hydraulic and pneumatic devices is very expensive and requires high maintenance. So, using a mechanical component is an easy and simple construction. Rack and Pinion mechanism is using to converting the up and down motion into the rotary motion. the floating buoy is connecting to the bottom end of the rack support shaft, during the wave motion it will go up and down. It will be connected to the pinion gear so; the electricity gets generated and resulted in the absorbed power of buoy for 4.4m diameter is 42 KW. The efficiency of the buoy is 21%.

5. Pawl and rachet mechanism

The purpose of this mechanism is to allow shaft rotation in one direction and another direction is free rotation. The pawl is a metal part, it will stop another direction of the rotating shaft.

Akash S. Ambavale et. al. [17] gives the pawl and ratchet mechanism to the front axle wheel of the vehicle. It used to prevent reverse motion.

Fig. 7. Pawl and Rachet Mechanism [29]

Lakshya Shrivastava et. al. [18] developed a mechanism of pawl and ratchet, it can stop the Vehicle rolling back from hills areas.

6. Gear train

A system of gears that transmit power from one shaft to another.

There are four types of gear train:

1) Simple gear train
2) Compound gear train
3) Riveted gear train
4) Epicyclic gear train
   - Simple gear has only one gear per shaft.
   - The Compound gear train has two gears per shaft.
   - In Reverted gear train the input and output gears are coaxial.
   - Epicyclic gear train has one with a relative motion of axes.

Radhakrishnan [19] gives the calculation for designing of various gear train arrangement used for lifting weights and loads.

7. Buoyancy force

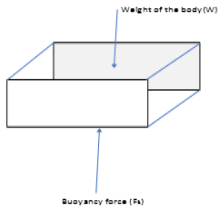

Fig. 3. Floating object

"According to Archimedes Principle, the magnitude of the buoyant force always equals the weight of the fluid displaced by the object"

Sivakumar kuri [21] explained the law of buoyancy based on the specific gravity of the body.

Law of buoyancy,

$$F_B \alpha\ 1/S_g \quad (2)$$

where, F_B - Buoyancy force
S_g – Specific gravity

In this experiment the specific gravity is less, the buoyancy force is high otherwise the specific gravity is high, the buoyancy force is less.

8. Locations to WEC placed

Table 2
Converter located three different regions [30]

Location	Depth of water	Wave length (λ) (h-water depth)
Off Shore (deep water)	>50 m	h > 0.5λ
Near Shore	10m to 25m	h < 0.05 λ
Shore line	Near land	0.05λ < h < 0.5 λ

9. Challenges

During harvesting energy from the wave, we would face some problems. The design model of one WEC is different from another. So the cost of design is high. Corrosion and Fatigue failure occurs in the type of material used for WEC. Environmental issues like turbine blades nares trucked by marine mammals and fishes.

The Following problems are existed in WEC

- Seasonal variations
- Survival ability
- Complex design
- Huge installation
- High maintenance cost

Angelica Felix [22] identified the challenges occurs during the use of energy from the ocean waves. So, some challenges are available in the wave energy conversion process. But compared to other energy harvesting process it's an easy one.

10. Conclusion

Wave Energy is an "Alternative Energy" that can also be called as a "Renewable energy source", as the Earth uses the gravitational forces of both the moon and the sun every day to move vast quantities of water around the oceans and seas producing waves. The conventional energy resources which we are consuming presently are replenishing at a much faster rate than expected. The depletion of fossil fuels has created a great desire in searching for alternative energy sources.

This review explained WEC and the different methods used in the Wave Energy Harvesting process. Buoyancy force and wave power calculation are identified. This method of energy harvesting can rectify the energy shortage in coastal areas.

By considering the economical view this method is cheap and best, it will not affect the environment. Conventional methods of energy resources produce a harmful effect on the environment and cost is high. By this depletion of energy resources people are searching for some new energy source. The Wave energy harvesting method will solve this problem and overcome the energy needs in various countries.

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