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Hybrid offshore wave energy platform.
Plataforma híbrida de energía undimotriz en alta mar

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ABSTRACT

Ocean waves are the greatest unexploited renewable energy resource which would reduce our reliance on fossil fuels. It can be harnessed throughout the year using a hybrid offshore platform. In this paper, hybrid offshore wave energy platform and its working principle, is explained explicitly. These devices when use independently are found to be not very efficient in terms of generating energy in a given time when compared to the resources used in establishing them. This in turn discourages the investments which can be made in them. This paper addresses the above issue and provides a solution with the use of hybrid offshore platforms as a step towards exploiting open seawater in a sustainable way to generate energy in a much more efficient way. Combining multiple renewable energy devices in such a manner could potentially offer stable electricity production, despite seasonal changes. The hybrid offshore platforms are conceptual and are undergoing R&D or are in the pre-commercial prototype and demonstration stage. This paper aims to discuss about one such innovative design for a hybrid offshore platform and assess the technical, economic and environmental feasibility of constructing such a platform.

Keywords -Hybrid Offshore Platform, oscillating water column, oscillating wave surge converters, modular wind and wave energy converter.

RESUMEN

Las olas del océano son el mayor recurso de energía renovable sin explotar que reduciría nuestra dependencia de los combustibles fósiles. Se puede aprovechar durante todo el año utilizando una plataforma marina híbrida. En este documento, se explica explícitamente la plataforma híbrida de energía de las olas en alta mar y su principio de funcionamiento. Estos dispositivos, cuando se utilizan de forma independiente, resultan poco eficientes en términos de generar energía en un tiempo determinado en comparación con los recursos utilizados para establecerlos. Esto, a su vez, desalienta las inversiones que se pueden realizar en ellos. Este documento aborda el problema anterior y proporciona una solución con el uso de plataformas marinas híbridas como un paso hacia la explotación del agua de mar abierta de una manera sostenible para generar energía de una manera mucho más eficiente. La combinación de múltiples dispositivos de energía renovable de esta manera podría ofrecer una producción de electricidad estable, a pesar de los cambios estacionales. Las plataformas marinas híbridas son conceptuales y están en proceso de I + D o se encuentran en la etapa de prototipo y demostración precomercial. Este documento tiene como objetivo discutir sobre uno de estos diseños innovadores para una plataforma marina híbrida y evaluar la viabilidad técnica, económica y ambiental de construir dicha plataforma.

Palabras clave -Plataforma Offshore Híbrida, columna de agua oscilante, convertidores de oleaje oscilante, convertidor modular de energía eólica y undimotriz.

INTRODUCTION

The major technical advancements made in the past decade were made, keeping in mind the energy requirements of the future. Economically generating power from renewable sources of energy is one of the most important objectives of our modern society. These renewable sources like wind, solar, hydroelectric, marine current and wave power, none of the technologies associated with these sources are developed completely to provide a solution to the current or for the same future energy needs. The power densities associated with these renewable sources are relatively low. Wind energy roughly supplies over 3 % of global electricity consumption which is expected to exceed 5 % by 2020. Unlike wind energy, wave power technologies have not yet reached a common conceptual design and its potential has not been harnessed to a great extent. There are many types of wave energy converters under development which can be used at nearshore and offshore locations as well as shallow or deep-water depths. Wave Energy Converters can be primarily classified as oscillating water columns, oscillating bodies, and overtopping devices as shown in Figure 01 and 02:

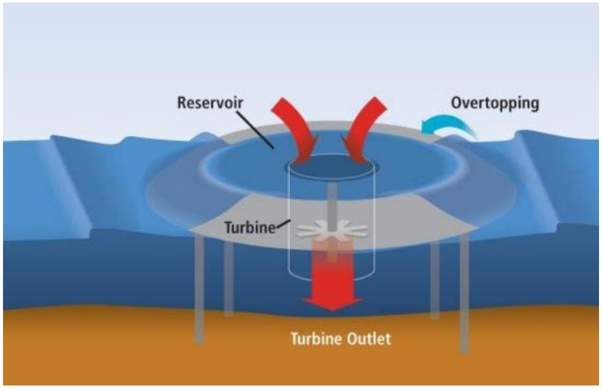

Fig1: Overtopping Device

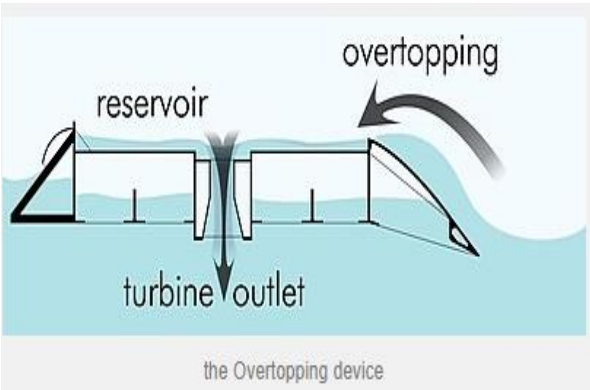

Fig 2: Overtopping Device

The two successful hybrid wind wave systems are: W2Power (Figure: 03) by Pelagic Power and the Poseidon Wave and Wind by Floating Power Plant. Both systems have reached testing phase ocean deployments.

A brief study of these existing technologies has been mentioned below:

SNo.	PARAMETER	W2Power	Poseidon80
01	Full scale power (MW)	9.2-10.2	4.9-7.6
02	WEC power (MW)	2-3	2.6
03	WEC type	Oscillating body	Oscillating body or oscillating water column

Fig3: Hybrid Wind and Wave Energy Converter

After the analysis of existing technologies, the detailed study of one such wave energy converter has been discussed in the next section.

OSCILLATING WAVE SURGE CONVERTER

The Oscillating Wave Surge Converter (OWSC) (Figure: 04) is made up of a paddle suspended from a hinge located above the water surface which allows it to rotate about an axis approximately parallel to the wave crests, together with an angled back-wall behind this paddle, as shown in the figure:

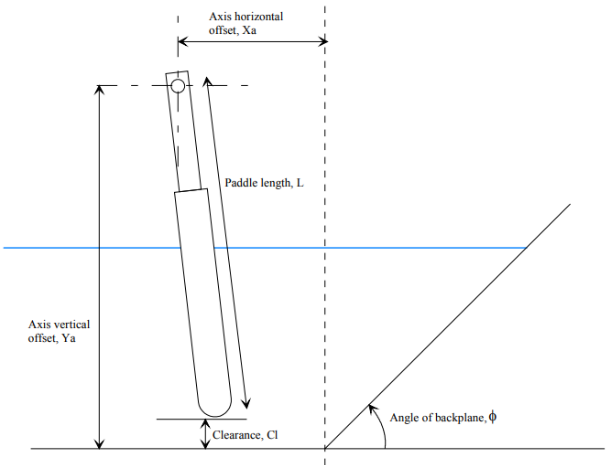

Fig 4: Oscillating Wave Surge Converter

Improvements to the above basic model could include the paddle oscillating about a non-vertical position and more complex profiles of the back-wall. An OWC in general consists of a box with an underwater opening so that a water column in the box rises and falls in response to the incoming waves. This movement of the water surface results in the air to be driven through an air-turbine. Because a water surface must remain approximately horizontal, the water surface must move orthogonally i.e., vertically, to change the air volume in the box. However, in the absence of any bodies, water particles in a wave move in an elliptical orbit, thus for it to work effectively, the horizontal motion of the water particles must be converted into vertical motion. This conversion was achieved in LIMPET by inclining the water column at an angle of 40 degrees to the horizontal, which helped in the transition from horizontal to vertical water particle motion. Land Installed Marine Power Energy Transmitter (LIMPET) was developed and operated by Wavegen which is a shoreline device using an Oscillating Water Column to move the air in and out of a pressure chamber through a Wells turbine. This kind of inclination has two disadvantages namely, diverting an amount of the water up the outside of the front wall of LIMPET and the other disadvantage is inducing transverse oscillations in the water column, which do not cause a change in the air volume. As the water becomes shallower, the motion of the water particles become more horizontal and though it is possible to design OWC's to minimize these side-effects, it does not appear to be possible to do this economically. To achieve largely the horizontal motion of the paddle, the paddle can be hinged at the top or bottom, utilize a multi-hinged "straight line" mechanism, or move on horizontally aligned slides. The horizontally aligned slides and "straight-line" mechanisms are likely to be expensive and difficult to maintain. Hinging the paddle at the bottom would better for the motion of the water particles due to the exponential decay in water particle motion with its depth of submergence. The back-wall is necessary to shape this water column so that it is optimally tuned for the incident wave climate. The back-wall must also be shaped in such a way to minimize the generation of turbulence that reduces device performance. It will also allow the horizontal water particle motions being efficiently converted into elevation of the water column surface. The sloped back-wall can help to stabilize the OWSC. In the experimental setup the rotation of the axis is measured by a potentiometer and the torque on the shaft is measured using a torque transducer. a coulomb friction brake on the shaft is used to dampen the motion of the paddle. The force applied to the shaft via the friction brake can be adjusted to the level of applied damping. The friction brake also provides a near constant torque opposing the rotation of the paddle. Therefore, it has a similar characteristic to a constant pressure pump. The performance of the OWSC has been determined for the six sea-states and for a limited number of configurations. Optimum damping has been determined for each sea-state by testing at a range of braking loads. Then by plotting the root mean square (RMS) of the braking torque against the capture factor, the maximum capture factor is determined. A typical plot is shown in the figure:

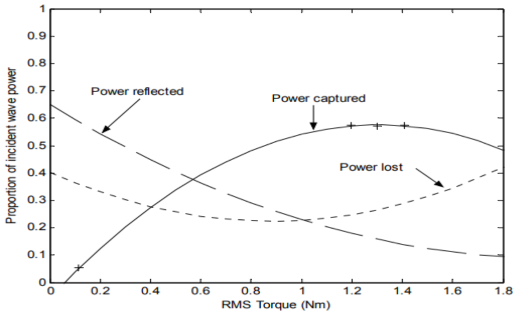

Fig 5: RMS Torque Vs Proportion Incident Wave Power

The amount of reflected wave power increases with the increasing energy period of the incident wave climate (Fig. 05), which indicates that the OWSC is tuned to shorter period waves. The oscillating wave surge converter is a promising offshore wave energy converter whose potential can be maximized with its usage in a hybrid offshore wave energy platform.

WIND TURBINES

Wind turbines are huge mechanical devices that make use of wind to generate electricity. A wind turbine consists of propeller-like blades around a rotor, which are rotated by the wind, which in turn spins a generator, thereby generating electricity (Fig. 6).

Fig 6: Offshore wind turbines

Offshore wind turbines are massive structures and they face different transportation challenges than the land-based wind installations. The large components of the wind turbine can only be transported on ships. These off shore wind turbines are able to generate vast amounts of energy by capturing powerful ocean. The wind speeds available offshore are much higher as compared to on land. Therefore, the energy

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generated by these offshore structures is much greater as compared to land-based structures. A wind turbine converts wind energy into electricity using the aerodynamic force from the rotor blades. The blades work like an airplane wing or helicopter rotor blade. The air pressure on one side of the blade decreases when wind flows across the blade. This difference in air pressure creates both lift and drag. As the force of the lift is stronger than the drag, it causes the rotor to spin. The rotor is connected to the generator, either directly or through a shaft and a gearbox. The gearbox speeds up the rotation and makes the generator physically smaller.

ADVANTAGES

Such hybrid platforms produce energies from waves, which is an ideal renewable energy source for the future. The large scale and unified production of such hybrid platforms can increase the amount of power generated by manifolds. The optimal use of space and connection to a grid need to be emphasized on while designing such platforms. Combining the energy output of multiple hybrid platforms can even lead us to fulfill higher energy demands of the future.

Motion suppression of hybrid platforms: Wave energy can be used to significantly reduce the motion of such hybrid platforms as the wave converters use up the wave energy by absorbing them and therefore dampen the wave strengths (FIGURE 07). This creates a condition where the motion of the offshore platform is suppressed naturally. The decreased motion of hybrid wave energy platforms is important as it helps to reduce system fatigue and increase the system lifetime. This aspect of motion reduction is still in the early stages of research; still it has a bright and promising future in our field of interest (Fig. 7).

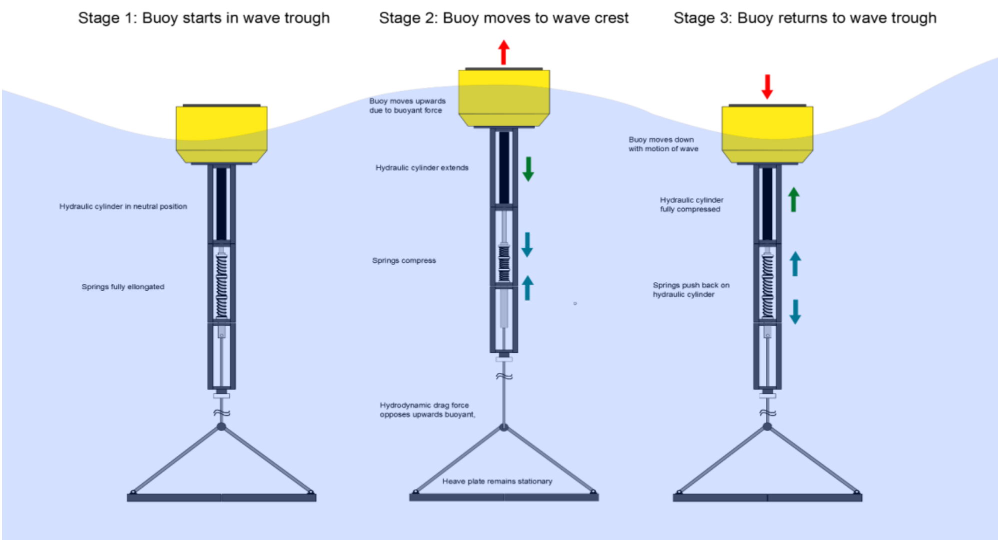

Fig 7: Oscillating Buoy Wave Energy Converter

CHALLENGES

The development of wave energy converters began in the late 20th century and dates to late 1960s. Even after 5 decades of research and development there are many variants of WECs yet no design convergence. Generating considerable amounts of power and withstanding the harsh sea states simultaneously is yet to be mastered by the researchers. The stability of such platforms in harsh sea states and stormy conditions is another design challenge for the designers as the vessel behavior changes in different conditions. The uniformity in design and connection to a centralized grid are some of the other problems that need to be addressed while producing such hybrid platforms in large scale.

Presently, with the modernization and the growing technical knowledge it is now possible to determine numerous factors that can be used in our favor to produce energy and meet the growing demand. Tidal energy is a very reliable source of power and its seasonal and unseasonal variations are very predictable for many years ahead. That will make the production of energy using the hybrid wave energy platform very predictable and plan the consumption cycles.

SOLUTION AND APPROACH

In order to drive the full potential of the individual energy producing devices in the Hybrid Platform it was necessary to make it modular making it convenient for assembling it in the desired water space based on various factors like distance from the nearest power storing house, sea state etc.

It's a modular maritime platform that will be able to generate wind and most importantly wave energy. Oscillating wave surge converters will be combined with wind turbines in order to generate energy by both wind and wave simultaneously. Also, by analyzing power output patterns, manufacturing companies can easily optimize a service plan for potential customers that are willing to meet their energy demands for a long-term using the hybrid wave energy platform. Judging by the growing demand for energy and the renewable sources of energy, it will be economically advantageous to use these platforms. Power output patterns will also allow the manufacturing companies to anticipate repairs before serious damage occurs.

As conclusion this paper is an effort to understand better the working and future scope of hybrid offshore wave energy platforms. Hybrid wave systems have a potential to be a sustainable source of energy for the future. The main benefit of wave energy is the platform motion suppression and local power needs. Wave Energy Converters (WECs) can suppress platform motion both passively and actively through WEC control. Existing hybrid wave energy converters have shown promising results and have reached demonstration stages. The Oscillating Wave Surge Converter is a feasible technology and has been discussed in detail in this paper. Hybrid wave systems may create a risk to offshore wave development, and extensive research is needed for considerable developments in this field. With advancement in technology and increasing innovative methods, WECs could be used to optimize power production and minimize structural loading of these systems.

REFERENCES

Floating Power Plant – Invest in future power: www.floatingpower.com

Overview and initial operational experience of the LIMPET: citeseerx.ist.psu.edu

The Oscillating Wave Surge Converter: onepetro.org

Pelgaic Power: W2 Power: www.pelgaicpower.no

Open Energy Information: openei.org

https://www.energy.gov/eere/wind/articles/top-10-things-you-didnt-know-about-offshore-wind-energy

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