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Wave energy convertor applications

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Abstract

The demand for renewable energy sources is increasing rapidly due to the fact that the fossil fuels tend to run out and the oil crisis in the 1970s, which is likely to be experienced in the following years, has affected the world economically due to the dependence on fossil fuels. Wave energy is a type of energy that stands out among renewable resources with its advantages such as having the potential to work 24 hours a day, not needing panel cleaning like solar energy, and not occupying space on fertile agricultural lands like solar energy. Studies on wave energy converters continues rapidly today. Wave energy converters reach a much more widespread usage rate in the world with the decrease in the initial investment cost, the decrease in the amortization period and the increase in the amount of power obtained from the unit. Today, the development of Computational Fluid Dynamics (CFD), Computer Aided Manufacturing (CAM) and computer aided kinematic analysis applications of mechanisms enables the design of prototypes on the waves by completing these studies in a computer environment, thus reducing research and development costs. In this study, studies on wave energy converters are stated.

Introduction

Countries need to use their own resources to reduce foreign dependency in energy. Not every country has a source of coal, oil or natural gas, and since fossil fuels are an exhaustible resource, the trend towards renewable energy alternatives is quite common. Here, the geographical location of the countries is of great importance.

Wave energy, one of the renewable energy sources, is a type of energy originating from the wind energy on the oceans and seas; contains potential and kinetic energy [1]. Ocean wave energy is developing technology and renewable energy source that still is almost unexploited [2].

The approximate wave power density in a sea can be estimated by multiplying the 0.49 constant of the apparent wave height squared, H_s^2, and its period, T_e which stated at formula (1) [3];

$$P(kW/m) = 0.49\, H_s^2\, T_e \tag{1}$$

As seen in Fig. 1., a maximum of 127.7 kW/m sea wave power can be obtained in the world.

As can be seen in Fig. 2, the rate of use of hydro energy and renewable energy resources in many countries such as Germany, Japan, Portugal, USA, UK is increasing every year. The studies carried out by researchers in many countries in this field are important to meet the increasing demand for energy and to prevent the energy crisis.

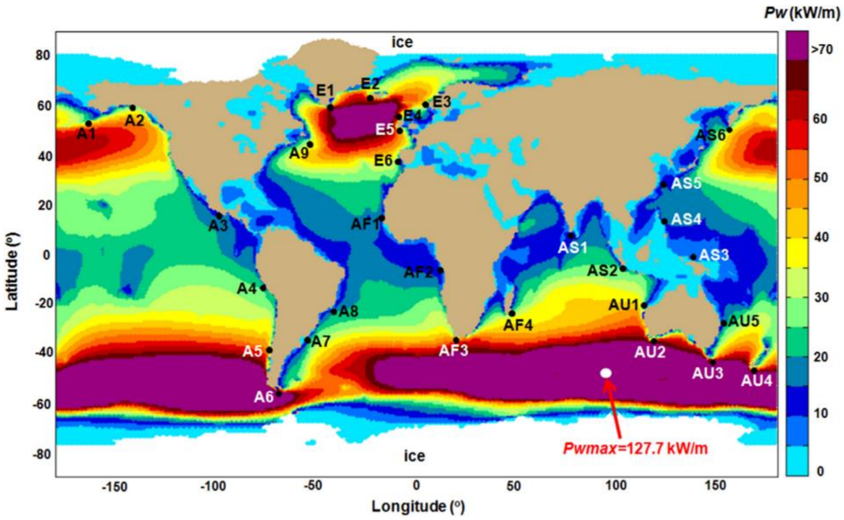

Figure 1. Map of the mean wave power density (in kW/m) corresponding to the 15-year interval from January 2000 to December 2014; the positions of 30 reference points, distributed along the coastal environments of: America (A1–A9), Europe (E1–E6), Africa (AF1–AF4), Asia (AS1–AS6) and Australia (AU1–AU5), are also indicated [4]

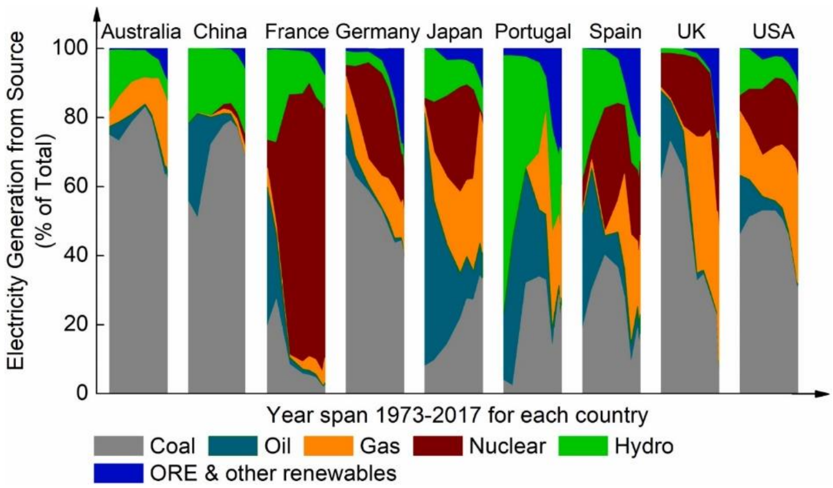

Figure 2. Evolution of the worldwide electricity generation by source between 1973 and 2017. The results are summarized from the data presented in the report of World Energy Balances 2018 by the International Energy Agency [5]

Material and Method

Experimental Studies

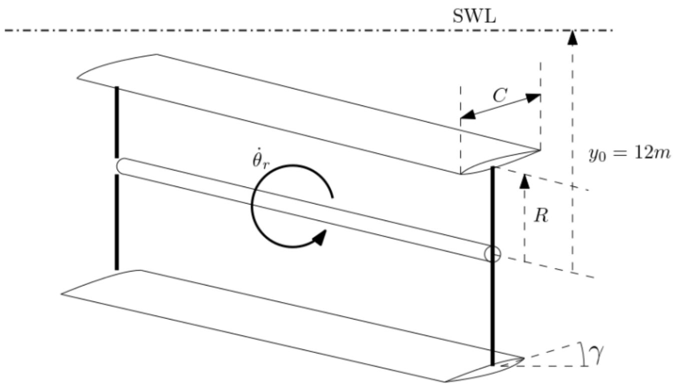

Figure 3. Cyclorotor-based wave energy device (SWL: Still water level) [6]

Ermakov et. al. [6] designed cyclorotor-based wave energy devices shown in Fig. 3. Their operational principle is based on the generation of lift forces on the rotating hydrofoils due to their interaction with wave-induced circulation of water particles. It is a design that can be said to be promising because it has a design produced at a low cost for generating energy.

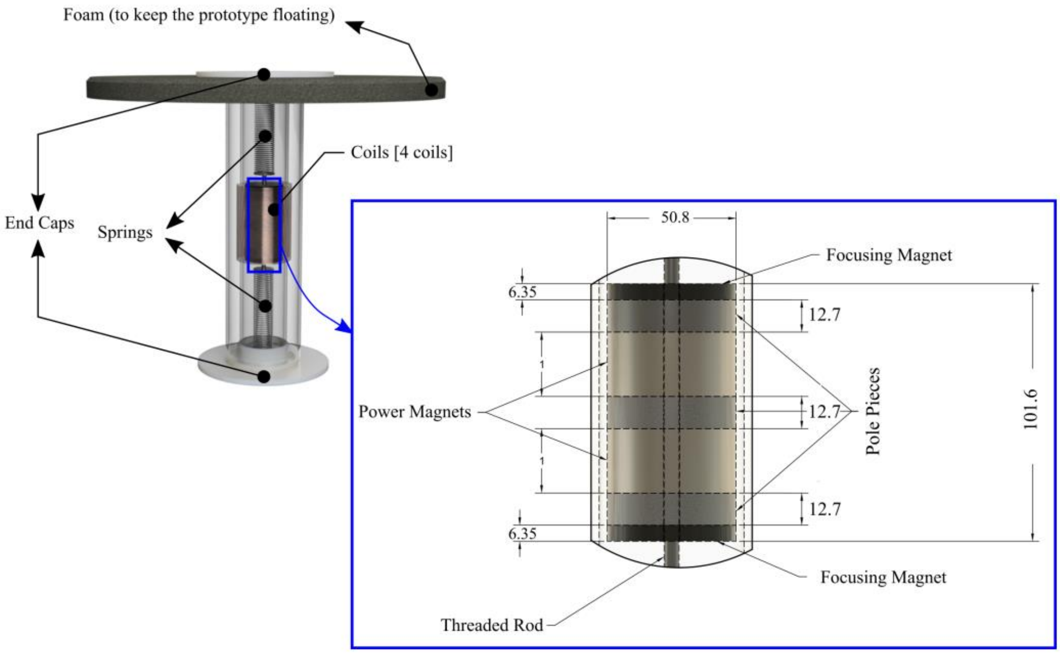

Figure 4. A Modular Wave Energy Converter for Observational and Navigational Buoys [7]

More than 80% of the ocean is not fully mapped or even observed. Observational and navigational buoys used in many countries and those buoys needs power to operate. Some buoys use solar panels, but solar panels not always ideal for every conditions. Vella et. al [7] designed WEC which shown in Fig. 4. for powering observational and navigational buoys. Experimental testing showed that device can get 81 milliwatts for waves with a wave period of 1 s, a wave height of 10 cm, and a water depth of 91 cm.

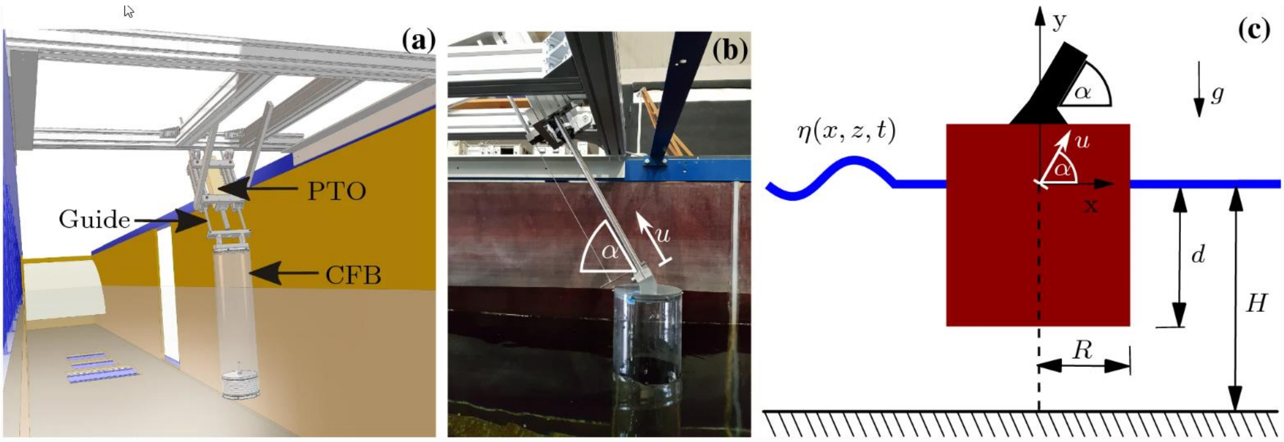

Figure 5. Experimental rig in the wave flume of the Institute of Mechanics and Ocean Engineering from two different perspectives (a, b) and a sketch of the resulting wave energy converter (c) [8]

Hollm et. al. [8] designed guided point absorber for harvesting wave energy shown in Fig. 5. Experimental and simulational tests shown that the inclination angle has a significant influence on the energy harvesting output.

Carandell et. al. [9] studied electromagnetic rolling mass energy harvester that uses kinetic energy of waves for the use of ocean monitoring systems sensor platforms. This Kinetic energy harvester system is based on a rolling mass resonator with permanent magnets that oscillate with respect to a frame which includes a coil system. Electromagnetic rolling mass energy harvester is shown in Fig. 6.

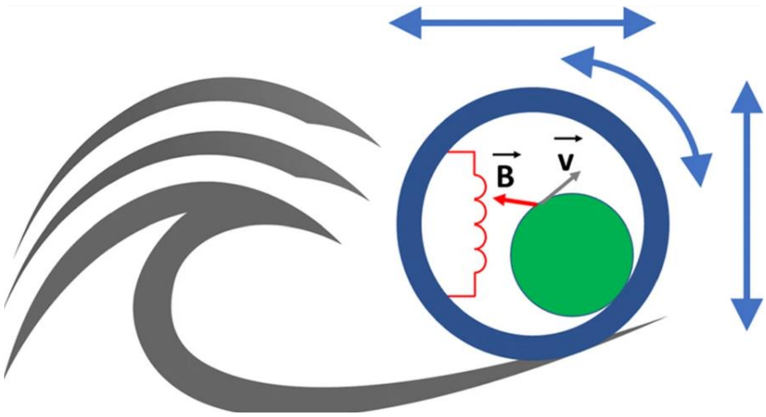

Figure 6. Electromagnetic rolling mass energy harvester [9]

Conclusion

It is estimated that almost 150 WEC projects (either conceptual or operational) have been reported at a global scale [4]. Most of projects are funding by governments. Wave energy converter designs and approaches differ. Factors such as wave frequency and height values of the country's coasts, the location of the wave energy converter device to the shore, and initial and maintenance costs are the main reasons for these differences. The location of the wave energy converter devices to the shore is more important with the inclusion of the cable installation costs stated in the table (Table 1).

Table 1. Cable installation costs [10]

Cable laying/ km trenched	€282000
Cable laying/ km untrenched	€282000
Cable coverage (rock coverage/ km	€282000

WEC devices is used for generating energy that alternative to fossil fuels. Additionally, WEC devices designing to use for powering observation devices of seas. There are too many promising theoretical and experimental studies in the world and wave energy convertor devices becoming widespread again nowadays.

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