

Harnessing Offshore Energy: Progress and Prospects

Aprovechamiento de Energía Offshore: Avances y Perspectivas

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Abstract— Growing global demand for energy is driving research related to taking advantage of non-conventional energy sources such as those found offshore. There are advantages and disadvantages associated with taking advantage of such sources depending on their locations and novelty factors. A review of progress made at harnessing offshore energy within the European and Latin American contexts is presented in this paper. It was found that offshore harnessing systems are being used in an increasingly efficient manner so as to meet energy needs while also weighing the associated economic challenges. In addition, hybrid systems are being developed.

Key words—Offshore, renewable energy, non-conventional deposits and offshore deposits.

Resumen— La creciente demanda energética mundial ha impulsado la investigación en el aprovechamiento de fuentes no convencionales como las fuentes energéticas offshore. El aprovechamiento de este grupo de alternativas energéticas tiene ventajas y desventajas propias de acuerdo con su nivel de novedad y localización. En este artículo se presenta el trabajo de revisión sobre el aprovechamiento y los avances de la energía offshore, dentro de los contextos europeo y latinoamericano. La revisión realizada registra que los sistemas offshore se están aprovechando de una

manera cada vez más eficiente, se destaca la tendencia de estructuras que satisfagan la necesidad de abastecimiento energético y a la vez contrarresten los retos económicos, así como el desarrollo de sistemas híbridos.

I. INTRODUCTION

Currently, the most exploited energy sources are non-renewable ones and this is expected to continue since energy demand is predicted to grow by 37% by the year 2040. During 2010, energy demand grew by 5.6% (the largest increase since 1973) and global consumption equaled 11.650 million tons of crude oil equivalent [1]. Given this increase in demand, research into unconventional energy sources has gained momentum, including into offshore energy sources seen as the mix of renewable energies obtained from natural sources imbued with high energy potential and a lower propensity for polluting than conventional sources in use.

II. OFFSHORE WIND POWER

Wind is harnessed as an offshore resource for generating electricity free of pollutant atmospheric emissions. Wind turbines are placed miles out to sea in order to harness the large amount of kinetic energy that wind possesses [2]. The blades rotate around a rotor connected to the main shaft thereby generating

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energy that is sent to a gearbox that increases the rotation speed thus propelling the high speed shaft which feeds the electricity generator. The electricity travels along cables strung down the tower until they reach the electricity storage cell [3].

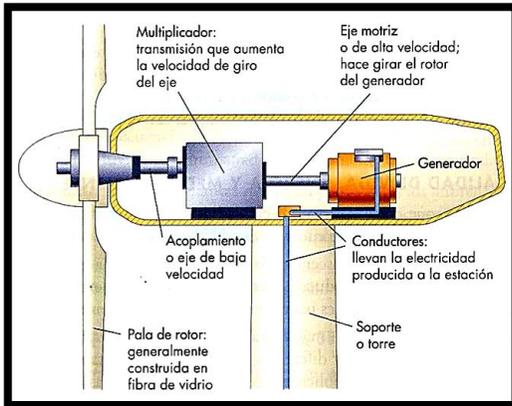


Fig. 1. Mechanical structure of a wind turbine.
Source: Modified from [4].

The structures used for harnessing offshore wind power can vary in order to exploit the resource in an optimal and effective way. The offshore structures are classified based on the depths at which they are placed: fixed structures are cemented to the marine floor using gravity, jacket, monopile, tripod, or tripile foundations; and floating structures found further out to sea [5]; as well as those anchored to mooring lines at even greater depths [6]. Figures 2 and 3 demonstrate fixed and floating offshore wind assemblies located respectively in Germany and Portugal.



Fig. 2. Fixed structure offshore wind turbine
Source: Modified from [7] [8].



Fig. 3. Floating structure offshore wind turbine.
Source: Modified from [7] [8]

Using connected load as the criterion, the United Kingdom is the leader in Europe with 1,014 wind turbines in operation equaling the generation of 3,611.45 MW, according to reported information from the last two years [9] [10]. Belgium has also made a significant contribution by installing 176 wind turbines (682.5 MW). In addition, Germany installed 249 wind turbines (620.3MW) followed by Denmark with 204 (607.43 MW), Sweden with 16 (48 MW) and finally Spain, Finland and Portugal with 1 wind turbine each, respectively representing an installed generation capacity of 5 MW, 2.3MW and 2 MW respectively. Given that South America is surrounded by the large expanses of water in the form of the Atlantic and Pacific oceans, it is surprising that, as yet, no large scale plants for harnessing wind power along the coasts can be mentioned.

III. WAVE OR TIDAL POWER

Waves are a renewable energy source for obtaining non-polluting electrical energy given their high kinetic energy content coming from tidal movements. The current structures or prototypes for harnessing tidal energy are classified according to their size and mechanisms. There are three major categories of wave energy converters (WEC): oscillating water columns (Eo bouy), oscillating wave surge converter (Oyster o Wave Roller) and prototypes of overtopping devices (wave dragon) [11]. Figures 4 and 5 show two prototypes for harnessing wave energy: oscillating water columns and oscillating waver surge converters. A number of countries have attempted to take advantage of this resource including Spain which installed a wave energy plant in 2011 with a total generating capacity of 296 kW, equaling 10% of electricity consumption for the Basque country. Great Britain has invested approximately 5 million sterling in harnessing wave energy over the past five years, and has approved another project worth 42 million pounds sterling. There are also proposals for 7.4 MW in England with the intention of reaching 23 MW installed [12] [13] in the future. With respect to Latin America, Ecuador, Peru, Chile and Brazil all have experience in this field with the largest development being the wave energy platform being installed in Ceará State, Brazil. The Wave Energy Center of Brazil is considered to be the pioneer in Latin America [14].

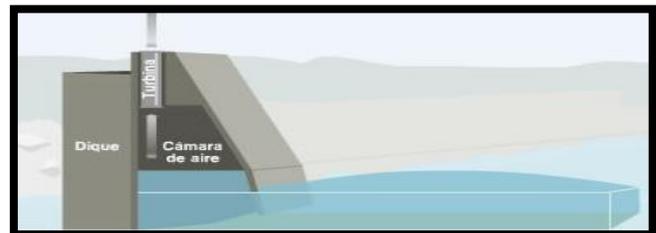


Fig. 4. Prototype of an oscillating column for harnessing wave energy.
Source: Modified from [15] [16]



Fig. 5. Prototype of oscilating wave surge converters for harnessing wave energy.

Source: Modified from [15] [16]

IV. OFFSHORE DEPOSITS

These are unconventional deep-sea energy deposits. Exploitation is achieved using two main types of structures: fixed structures cemented to the marine floor close to the coast, and floating rigs anchored to mooring lines at greater depths. Most of Europe's oil and gas production comes from offshore deposits. There are currently more than 1.000 platform rigs operating in European waters generating an effective source for meeting the increasing energy demand. Figures 6 and 7 show both types of structures for extracting offshore crude located in the Arabian Gulf and Colombian waters respectively.



Fig.5. Fixed platform rig

Source: Modified from [17] [18].



Fig.6. Floating rig

Source: Modified from [17] [18].

In Latin America, progress can be seen in Brazil with 18 rigs, seven drilling rigs, two production units and three conductor support systems [19]. In addition, Mexico inaugurated a platform that produces 100,000 barrels of petroleum and 200 million cubic feet of gas daily [20]. Recently, an offshore deposit was found in the Tayrona block located in the department of Guajira, Colombia, with an estimated capacity of 264 million barrels of crude and gas equivalent [21]. The Carina and Aries deposits are located in

the province of Tierra del Fuego, Argentina, representing the country's largest offshore natural gas production. The platforms are located at 30 km and 80 km from the province of Tierra del Fuego. An offshore deposit called Área Magallanes, located at the mouth of Magellan Strait into the Atlantic Ocean produces oil and gas that is transported along a network of submerged pipelines to the refinery in Magallanes.

V. CONCLUSIONS

Carrying out a literature review of the information related to harnessing different forms of offshore energy such as wind, wave and oil and gas deposits, it was possible to register progress on the issue in Europe and Latin America.

Europe is the continent where offshore wind power is most taken advantage of, while Latin America has not made any significant progress on this front despite wide expanses of offshore water.

With respect to wave energy, Latin America has recently seen the installation of a wave surge converter prototype in the state of Ceará, Brazil.

Europe's efforts are more focused on research and the prototypes in use for harnessing wave energy are designed on a small scale, with the exception of the prototype situated in the Basque Country.

With respect to exploiting offshore oil and gas deposits, both Latin America and Europe show progress. There are around 1000 oilrigs operating in Europe, and Brazil, Mexico and Colombia are the Latin American countries that have made the most notable gains in this area.

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