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Planning of the installation of offshore renewable energies: A GIS approach of the Portuguese roadmap

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ABSTRACT

The present paper presents the methodology and development of a planning tool for the installation of marine renewable energy systems, which enables the identification of suitable areas for this purpose. The marine spatial planning is one of the challenges of the offshore renewable energies. This is one of the reasons to write this paper, because there are areas where the energy potential is great but with real limitations for installing an offshore renewable energy farm. This methodology is based on the development of automated and interactive GIS tools in order to enable the user to change inputs according to his research objectives. The developed tools are applied to a case study referring to the Portuguese coast and the obtained results enable the identification of several areas, suitable for the development of marine renewable energies projects. The methodology and the developed tools intend to be a contribution for the Maritime Spatial Planning of the Portuguese coast and can be applied to other countries as well whenever the necessary information is available.

1. Introduction

1.1. Motivation

The marine spatial planning is one of the challenges of the offshore renewable energies (offshore wind and wave energy). This is one of the reasons to write this paper, because there are areas where the energy potential is great but with real limitations for installing an offshore renewable energy farm, such as navigation areas, environmental protected regions, fishing zones, etc.

1.2. Literature survey

In the latest years there has been a great concern in the implementation of maritime spatial planning measures in the EU countries, which has originated a great effort by the governments in the establishment of planning policies (for instance, the network planning [1,2]). Following the concerns of the EU (European Union) countries which are involved in maritime spatial planning, Portugal has also begun the work of implementing a Maritime Spatial Plan (MSP) followed by the publication of POEM. Also several research project works have been developed in this area together with the identification and suggestion for the development of maritime renewable energies. Examples are the work developed by Zaucha (2012) [3], where the MSP plans and developments are identified for a set of countries with coastal borders. Zaucha (2012) refers to the Portuguese case where the "The MSP is being implemented on the basis of the National Strategy for the Seas with all ministries concerned involved through an Inter-ministerial Commission for Maritime Affairs set up in 2007. A draft MSP has been formulated and it went through public consultation in 2011" [3]. Also Calado and Bentz (2013) have published work on this issue and describe with detail the National MSP [4]. The authors describe the national initiatives on this matter focusing in National regulations, maritime economic uses and barriers to the development of maritime renewable energies in order to minimize effects on other uses [5,6].

Researchers and planning experts were involved in this process and several research projects in this area have been funded in recent years. In this sequence, LNEG (Laboratório Nacional de Energia e Geologia) has assumed an active part in this procedures being partner in some research projects in this area, such as FP7 Seanergy – maritime spatial planning, and National funded FCT Roadmap WW – roadmap for the development of marine

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renewable energies (wind and wave) which led to the development of methodologies for the identification of suitable areas for the deployment of marine renewable energies based on Geographical Information Systems (GIS) techniques. GIS are nowadays powerful tools for planning methodologies due to the ability in dealing with large amounts of georeferenced information usually needed for this kind of studies (land use, seabed, resource parameters, and others) and have proved to be powerful tools for the assessment of renewable energies (REs) and identification of suitable areas for REs projects deployment, supporting policy makers, investors and planners. In this sequence, several GIS planning tools have been developed in recent years for assessing the sustainable potential of REs for several countries e.g., Spain [7] and US [8]. Also these planning methodologies were applied at regional scales Grassi et al. (2012) [9], taking into account various land uses, the wind resource - data from mesoscale modeling - and the environmental restrictions [10].

1.3. Contributions

The work here presented was part of the FCT Roadmap WW project and intends to establish a methodology for the identification of suitable offshore areas for the development of Wind and wave energy systems in the Portuguese coast. It comes in the line of previous planning methodologies developed by LNEG for the installation of wind farms [11–15] and intends to be a contribution for National Maritime Spatial Planning. The development of marine renewable energy systems faces several restrictions and conditions for the installation of the technologies. These are mainly related to environmental restrictions, policy measures and incentives (e.g. FIT (feed-in tariffs), economic issues, grid connection). In this context, the present paper will describe a method in order to obtain the selected offshore areas taking into account environmental and technical aspects.

1.4. Organization of the paper

The organization of the paper is: firstly, the state of the art of the offshore wind and wave energy is developed; secondly, the methodology has been described, considering the physical restrictions and the location settings, it considers the four tools developed; thirdly, the map results are shown; and, finally, the conclusions of the paper are exposed. A schematic overview of the whole paper is shown in Fig. 1.

2. State of the art

There are two types of offshore renewable energies: ocean energy and offshore wind. Ocean energy is directly obtained by the sea, considering waves, marine currents, tides, ocean thermal energy and salinity gradients [16].

Offshore wind is the energy produced from the wind at sea. In addition, offshore wind can be classified in floating or fixed offshore wind, depending on the depth of the sea where the platform had been installed. Fixed offshore wind platforms are installed in waters up to 50–60 m and floating offshore structures are located in areas with deep waters (more than 50–60 m) [17,18]. Some types of wind fixed structures are: GBS (Gravity-Based Structure) as the farms of Nysted or Thorntom Bank; monopile as the farms of Horns Rev I and II, London Array; the suction bucket, installed in Dogger Banck and Frederikshavn; jacket frames installed in Thorntom Bank; tripiles installed in Hooksiel, BARD Offshore and Veja Mate; and tripods, installed in Alpha Ventus. Nowadays, fixed offshore wind has a great development, mainly in the North Sea in Europe. However, floating offshore structures are still improving their technologies: spar floater as the Hywind in Norway, tensioned-leg platform (TLP)

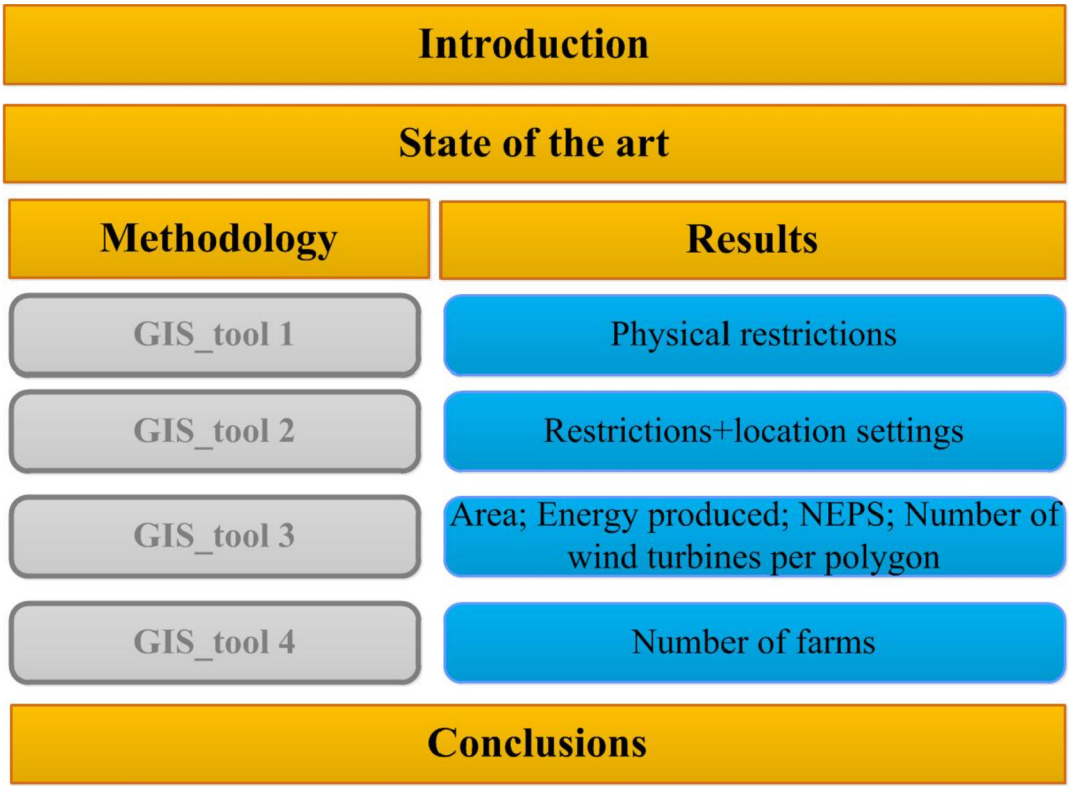

Fig. 1. Overview of the paper.