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Wave and tidal current energy – A review of the current state of research beyond technology

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ABSTRACT

The oceans of the earth offer vast amounts of renewable energy. Technologies to harness the power of the seas are at an early stage of development. Even the most advances technologies, namely tidal current and ocean wave still face considerable barriers and many obstacles remain. Research, development and innovation can help overcome those barriers. This review provides an overview over the current state of research in the field of ocean energy. In particular, the authors focus on research beyond technology or technological improvements. This article also highlights areas where research gaps exists and where future research efforts should be directed to.

Contents

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1. Introduction

The oceans of the earth represent a vast source of renewable energy. In general, ocean energy can be divided into six types of different origin and characteristics: ocean wave, tidal range, tidal current, ocean current, ocean thermal energy, and salinity gradient [1–3].

Currently, all ocean energy technologies except tidal range can be considered at an early stage of development from conceptual up to demonstration stage [2]. Ocean wave and tidal current energy are the two types of ocean energy which are most advanced and are expected to contribute significantly to the supply of energy in future [2]. Thus, the authors will focus on those two types ocean energy in this paper.

The ocean energy industry has made significant progress in recent years but is still at very early stage with some advanced prototypes that are currently being tested [4]. Existing challenges include further development of the technology to prove reliability and robustness and to reduce costs but also deployment and risk reduction. This is reflected in the current research themes funded e.g. by the EU with 68% of the funds being directed to technology development (Fig. 1). However, other not technology-related knowledge gaps and barriers exist [4].

The aim of this review is to provide an overview over the current state of research in the field of wave and tidal current energy. Further research and innovation in the area of technology is the prerequisite to tap the full potential of ocean energy. According to [5], technological barriers represent the most important issue that the ocean energy sector needs to address in the short-medium term. Priority topics include e.g. technology advancement, reliability demonstration, sub-system development and optimisation, pre-commercial array sea trial and demonstration, predictive maintenance systems, and array electrical systems [4].

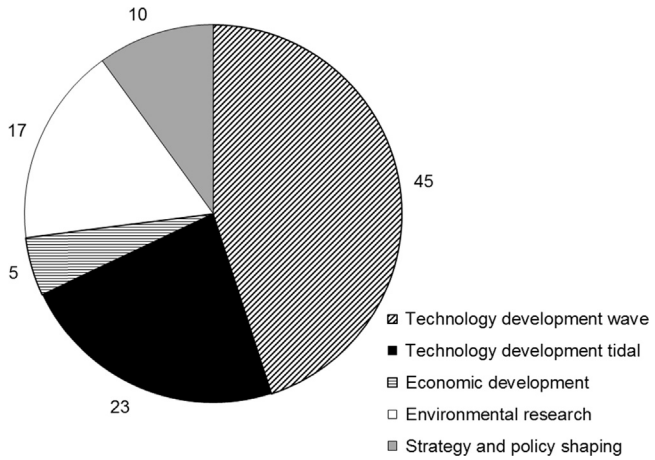

Fig. 1. Research themes financed by EU funding in 2011 according to [132].

However, also other areas require attention but they are tackled to a minor extend partly. This article will focus on research beyond technology or technological improvements (for those, the authors would like to refer to technology-oriented studies and reports such as [4,6–8]) and identify areas where research gaps exists and where future research efforts should be directed to. The review is based on a literature review and desk-based research. Areas that will be covered in greater detail have been identified according to [2,7,9].

The article is structured as follows: Section 2 presents the state-of-research of resource assessment and forecasting; Section 3 will present research on environmental impacts. Section 4 covers socio-economic impacts and Section 5 grid integration. Section 6 discusses the current literature on array configuration, installation, operation and maintenance while in Section 7; some relevant works on regulatory and legal affairs will be presented. Section 8 contains some conclusions.

2. Resource assessment and forecasting

An important initial step towards market deployment of ocean energy is the characterisation and mapping of ocean energy resources. The assessment of wave energy resources includes the identification of areas with high wave energy, the quantification of average energy resources (e.g. total annual wave energy) and the description of the resource by using parameters such as significant wave height, wave energy period and mean wave direction [10]. Precise estimates and description of available wave energy resources at high spatial and temporal resolution are needed for proper planning and the optimisation of the design of ocean energy converters [11,12]. This will help to optimise device performance in terms of power produced. For example, the power output of a Oscillating Water Column device at a certain location has been studied [13]. The current state of technology development will determine how much of the resource can be exploited with the main technical parameters to be improved being device efficiency and capacity factor [10,14] . Reducing uncertainties concerning the available resources will also increase the confidence of investors as it allows a better determination of the value of investments and minimising risks [15,16]. In the following sections, an overview of current state of wave and tidal current energy resource assessment and forecasting is presented.