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## Economic and socio-economic assessment methods for ocean renewable energy: Public and private perspectives

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## ABSTRACT

This paper provides a comprehensive review of the current state of the art of the economics and socio-economics of ocean renewable energy (ORE); the many ways in which the viability and impacts of an ORE project are assessed, and an analysis of the current weaknesses, issues or inappropriateness of the metrics and methodologies used in their definition and presentation. The outcomes of this paper are anticipated to benefit the ORE and wider renewable sector as a whole. The review revealed that, for the most part, the current study of economics and socio-economics of ORE remain separate and discrete areas of research. The economic methods utilised appear to be comprehensive but are limited to project (or private investor) level. The methods identified for socioeconomic assessment fall between traditional, and now routine, environmental assessment approaches and more novel holistic approaches such as ecosystem services and life cycle assessment. The novel section of the paper explored the connectivity between the economics and socio-economics of ORE in relation to project developments and policy/planning. A visualisation method was created of concentric rings intersected by related axis of economic, socio-economic and environment, and enabled the examination of the benefits arising from the connectivity between the two spheres. The concept of sustainable development process and the integration of environmental assessment for ORE was also explored and how it responds to differing stakeholder aspirations and interpretations. The analysis revealed that there was a divergence between public and private economic and socioeconomic assessments for ORE: environmental assessment is primarily a public responsibility but with significant inputs from the private developer involved while economic assessments are conducted primarily by the developer and/or investor at their own behest. However, the two spheres of economic and socio-economic for ORE are highly connected and synergistic and must be examined in a holistic manner.

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## 1. Introduction

This paper provides a review and analysis of the relationship between the methods and metrics used by different user groups and by different disciplines to assess the value of an ocean renewable energy (ORE) (defined in this paper as wave and tidal energy) project or farm. The concept for this paper stems from an European Energy Research Alliance (EERA) workshop [1], where it was proposed that a comprehensive review to be undertaken of the current state of the art of the economics and socio-economics of ORE. The identification of research needs relating to economics and socio-economics, along with their inherent synergies, is anticipated to further enable the sustainable development of the ORE sector as well as have transferable lessons for other renewable energy sectors.

In this paper ‘economic assessment’ refers to the appraisal of financial and economic performance of a project or technology. Such assessments are typically undertaken to inform developers, sponsors or policy makers about the financial viability of specific projects or technologies. In contrast ‘socio-economic’ assessment generally refers to the wider external impacts of development; for example, employment multipliers, ecosystem services, community benefits, and lifecycle analysis. These issues are still economic in nature, but they are experienced by wider society beyond the confines of the project.

Reviews of offshore wind economic and socio-economic analysis have already been conducted and published [2], and a gap in the literature remains for ocean renewables. This paper takes one novel step further, by analysing the perspective of the project funder or private investor (or a firm) and of a number of stakeholders. Sustainable development,<sup>3</sup> as conceptualised in ‘Our Common Future’ [3], requires a convergence between the three pillars of economic development, social equity, and environmental protection, as defined by the UN [4]. The objective of this study is to identify the metrics and methods used in each of these disciplines and to analyse the interconnections between evaluation methods used by investors and by the wider stakeholder community. The intention is to inform the development of approaches that will support the sustainable development of ocean energy projects.

Many thousands of offshore wind turbines have now been constructed and several tens of GWs of offshore wind turbines are currently at the planning stage in European waters alone [5]. Tidal stream and wave energy systems are at a much earlier stage of development but both could provide a significant contribution to European and global electricity supply [6]. Europe faces a

<sup>3</sup> Sustainable development is defined in this paper as the process that aims to achieve a future state of sustainability.

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