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Integrated methodologies of economics and socio-economics assessments in ocean renewable energy: Private and public perspectives

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ABSTRACT

This paper offers a holistic approach to the evaluation of an ocean renewable energy (ORE) technology type or specific project in order to provide a comprehensive assessment of both narrow economic and broader socio-economic performance. This assessment incorporates methods from three pillars areas: Economic – financial returns and efficient use of resources, Social – employment, social and community cohesion and identity, and Environmental – including the physical environment and pollution. These three pillars are then considered in the broader context of governance. In order to structure this evaluation, a novel parameter space model was created, defined by the three pillars and by the scale of the system under assessment. The scale of the system ranged from individual components of an ORE project; to projects comprising of a number of devices; through to a geographic regions in which multiple farms may be deployed. The parameter space consists of an inner circle representing the boundary of interest for a private investor, or a firm, developing an ORE project. The outer circle is characterised by assessment tools typically employed at the broader stakeholder level including economic, social, and environmental methods that can be employed at local, regional or national scale and which are typically employed to inform policy and decision making regarding ORE. Governance sets the stage within which management occurs. Wider impacts to the firm undertaking the project will take into account "externalities" of the project across the three fields. In this model, key methods identified are mapped onto this parameter space and the connectivity explored. The paper demonstrates that the three pillars are inter-connected and each

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must be considered in any meaningful assessment of ORE sustainability. An integrated assessment approach has the ability to address both the private and the public aspects of an ORE development, This analysis provides insights on existing best practice, but also reveals the potential for disconnect between an ORE project's commercial viability and its contribution to environmental and social goals.

1. Introduction

This paper provides a holistic approach to the evaluation of an ocean renewable energy (ORE) (defined in this paper as wave and tidal energy) technology type or specific project. This analysis takes the novel approach of considering economic and socio-economic (E&SE) analysis from the perspective of the project funder or private investor or a firm (called *Private*) and of a wider societal stakeholders (called *Public*). *Private* systems (considerations and aspects) can vary from the components of an ORE project, including a project comprising a number of devices installed at a particular location, through to a geographic or economic region in which multiple farms may be deployed on a national scale with clear associations to *Public* considerations. Such an assessment incorporates methods relevant to three pillar areas: Economic – financial returns and efficient use of resources, Social – variables such as employment, social and community cohesion and identity, and Environmental – including the physical environment and pollution. In addition the overarching governance system will also be discussed, to complete the assessment.

The methods and metrics used in *Public* and *Private* spheres, and by different pillars, to assess the performance of ORE projects are reviewed. The objective of this review is to catalogue the principal methods used and to identify any gaps and weaknesses in these.

The paper then progresses to integrate the assessment methodologies between the *Private* and *Public* by creating a novel parameter space model, defined by the three pillars and by the scale of the system under evaluation. The interconnectivity between pillars as well as the relationship between the broader macro-economic, social and environmental issues and those directly considered by private investors are assessed.

In context of this work '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 the macro-economic, social and environmental assessment generally refers to the wider external impacts of development; for example, employment multipliers, environmental impacts, ecosystem services, community benefits, and lifecycle analysis. These issues are still economic in consequence, but they are experienced by wider society beyond the confines of the project.

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 [1]. 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 [2]. Europe faces a renewable energy target of 20% [3] of electricity production from renewables by 2020 [4], with some countries, such as Ireland, setting even higher targets of 40% for 2040 [5]. A portfolio of electricity generating technologies with low carbon emissions that include nuclear, offshore wind, wave, tidal range and tidal stream are expected to be required to meet these targets. At present tidal stream systems are generally considered to be closer to technical viability, and a handful of prototype technologies are undergoing offshore testing. To-date no large-scale OE farms have been constructed [6]. Prior to the construction of any large farms, alternative designs must be compared and preferred design solutions identified.

Reviews of offshore wind economic and socio-economic analysis have already been conducted and published [7,8]. To assess the viability of any infrastructure project, a variety of assessment criteria or techniques may be employed. Seen through the lens of sustainable development these methods can be considered in three broad categories – economic, environmental and social. Sustainable development, as conceptualised in 'Our Common Future' [9], requires a convergence between the three pillars of economic development, social equity, and environmental protection, as defined by the UN [10]. There have been many studies of the cost of energy, and potential future cost of energy, from ocean energy systems [11,12]. Such values are a key input to corporate decision making and strategic energy system planning. Similarly there have been many studies of social acceptance, siting, environmental impact incorporating coastal processes, flora and fauna, and ecosystem services [13–16]. Environmental assessment is a legal requirement which seeks to ensure that the environmental implications of decisions on development planning are taken into account by decision-makers before they make their final decision. In the EU, the environmental assessment process is governed primarily by the Environmental Impact Assessment Directive (85/337/EC as amended). The Directive identifies the projects subject to mandatory EIA (Annex I) which list projects for which EIA is mandatory (Annex I), and those for which EIA can be requested at the discretion of the Member States (Annex II), whereby the national authorities have to decide whether an EIA is needed. Whilst ocean energy (wave and tidal) developments are not explicitly listed in Annex I, where an EIA is mandatory, they have nonetheless been subject to EIA arising from Annex II which lists "industrial installations for the production of electricity" as potentially requiring an EIA.

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