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Accelerating the development of marine energy: Exploring the prospects, benefits and challenges

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ABSTRACT

Energy system scenarios and modelling exercises may under-represent the learning potential of emerging technologies such as marine energy. The research described here was devised to represent this potential, and thereby explore the possible role of marine energy in future energy systems. The paper describes a scenario for the accelerated development of marine energy technology, and the incorporation of this scenario into wider scenarios of UK energy system decarbonisation from now to 2050. The scenarios suggest that the accelerated development of marine energy could contribute significantly to the decarbonisation of energy supply in the UK, especially over the medium to long term. However, this is predicated on sustained innovation, learning and cost reduction over time. Encouragingly, a number of recently established policy support programmes are now beginning to stimulate the development of marine energy in Scotland, the UK and beyond. As the paper discusses, building on these initiatives, and 'realising' the accelerated development of marine energy, present a number of challenges, and will increasingly require international efforts. However, the potential rewards are very substantial.

1. Introduction

The broad acceptance that greenhouse gas emissions such as carbon dioxide (CO_2) are responsible for climate change has made decarbonisation an energy policy priority in the UK and internationally (e.g. [1,2]). At the same time, energy security has also gained increasing attention in UK energy policy (e.g. [3]). With the UK and other countries setting ambitious targets for decarbonisation, and with rising concerns for security of supply there is now an urgent focus on energy system change, and, as part of this, finding ways to accelerate the development and deployment of secure sources of low carbon energy.

Responding to the climate change challenge, UK and Scottish governments have set out legally binding frameworks for the progressive decarbonisation of the UK economy from now to 2050, with ambitious interim targets for the decade to 2020 [2,4]. There are also highly ambitious Scottish, UK and European targets for renewable energy deployment [5–7]. In striving to meet such ambitious targets, there is a potentially important role for a number of emerging supply technologies, including marine energy.

In the short term, over the next decade, marine energy is expected to make some relatively minor contributions to energy system change in the UK and internationally. The British Wind Energy Association [8] has – perhaps rather ambitiously – suggested that 3 GW of marine capacity could be deployed in the UK by 2020 and at the European level, the European Ocean Energy Association has suggested that marine energy could reach 3.6 GW of installed capacity in the EU by 2020 [9].

However, over the medium to long term, there are indications that marine energy could make a much more significant contribution. The UK has a particular interest in marine energy, and the potential to sustain an internationally leading role in the

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marine energy industry. The Carbon Trust [10] estimated that around 15–20% of UK electricity demand could eventually be met by marine energy.

With a sense of increasing urgency for decarbonisation, there are strong interests in seeking to accelerate the pace of development of low carbon technologies such as marine energy. However, marine energy is still an emerging technology, and there is a need for substantial further research, development and demonstration efforts to allow for learning and cost reduction before it can make major contributions to energy supply.

This paper explores the opportunities and challenges associated with efforts to accelerate the development of marine energy technologies, and the potential impact of accelerated development on the decarbonisation of the UK energy system. A scenario of accelerated marine development is first devised, and then a series of wider scenarios of UK energy system change from now to 2050 are constructed which incorporate assumptions of the accelerated marine development. Consideration is also given to the wider institutional and policy challenges of accelerated marine technology development.

2. Overview of marine energy innovation

Marine Energy – also referred to as ocean energy – is defined here as wave and tidal current energy; tidal barrages and other ocean energy technologies are not considered in this paper. After the energy crisis of the 1970s there were a number of marine energy R&D programmes established internationally. In contrast to wind energy, these efforts were not sustained, and there was only very limited innovation in marine energy from the mid-1980s to the late-1990s. Over the last decade, however, drivers such as climate change and industrial development have renewed policy interest and public and private investment, prompting a resurgence in marine energy innovation. This has led, in turn, to the emergence of a variety of prototype device designs for both wave and tidal power. This resurgence was led by small and medium enterprises (SMEs) and university consortia. However, more recently, large power companies and large public-private programmes have become increasingly involved. For a more detailed overview of UK-based marine energy innovation, see Ref. [11].

Wave and tidal energy resources are quite distinct, and there are a number of design concepts in development for both. For wave energy, there is a wide variety of device concepts including oscillating water columns, overtopping devices, point absorbers, terminators, attenuators as well as flexible structures. Tidal current energy exhibits less design variety, with most prototype designs based on horizontal axis turbines, but vertical-axis rotors, reciprocating hydrofoils and Venturi-effect devices are also being developed. Two UK-based companies have recently installed full-scale marine devices: Pelamis Wave Power in Orkney, Scotland and Marine Current Turbines at Strangford Lough in Northern Ireland (Fig. 1).

At present, the UK has an internationally leading position in the emerging marine sector — reflecting a significant natural resource, research capacity, related skills in offshore engineering and a relatively strong funding and policy support framework. There has also been a growth in interest in the development of marine energy internationally, and now over a dozen countries have dedicated support policies for marine energy [12]. Even with this growing international interest, a significant proportion of all marine energy developer companies and support facilities is based in the UK. Internationally, the UK is seen as having an important leadership role by other countries entering the sector.

Research capacity in the UK has seen significant expansion recently from initiatives such as the SuperGen Marine programme, supported by the publicly-funded UK Engineering and Physical Sciences Research Council [11], and the involvement of organisations such as the UK Energy Technologies Institute, a major public-private initiative, as well as the Technology Strategy Board, a non-departmental government body. UK research groups also play a key role in a number of EU-funded marine energy consortia and research projects [11]. At the same time, many other countries' energy research programmes are now taking an active interest in marine technology, both in Europe and beyond, and future research and development efforts are likely to become increasingly international.

In addition, a number of marine energy test centres have been established in the UK and beyond, such as the full-scale test centres at the European Marine Energy Centre (EMEC) in Orkney, Scotland and Wave Hub in South West England, as well as drive-train test facilities at the National Renewable Energy Centre (NaREC) in England and others in continental Europe, such

Fig. 1. Full scale marine energy devices.
Sources: PWP, MCT.