



Original research article

A transformational paradigm for marine renewable energy development



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ARTICLE INFO

Article history:

Received 14 August 2016

Received in revised form 18 October 2016

Accepted 21 October 2016

Available online 27 October 2016

Keywords:

Community

Development paradigm

Economic development

Marine renewables

ABSTRACT

Marine Renewable Energy (MREs) holds extensive environmental, social, and economic potential for rural coastal areas across the globe, which are often resource-rich but capital-poor, often due to historic paradigm of economic (under) development. Focusing on the Highland and Islands region (HIR) of Scotland, we identify a conundrum which is currently limiting overall development of MREs and their positive effects, mainly due to the lack of access to sustained sectorial investments and a stable demand for electricity. From a historic perspective, we identify in the *Megalopolis* paradigm the reasons for this conundrum. Further, we develop a new policy and governance paradigm, DICEP, rooted in the concepts of diffusion of benefits, inclusive governance, community engagement, regional entrepreneurship, and a balancing top-down approaches with bottom up initiatives. The paradigm builds upon local strengths and policies for combining MREs and economic development policies for expanding non-residential electricity demand through the support of productive activities. Finally, we present two case studies where elements of Megalopolis and DICEP emerge, as well as propose potential localized uses of energy for manufacturing and agricultural practices. DICEP acts as an operationalization of the New Rural Paradigm, and a bridge between the initial diffusion of MREs and their future full deployment.

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1. Introduction

The development of the renewable energy sector (RES) has the potential to address multiple needs across the globe, including energy security and a transition from a sector which is driven by single policies to one which is able to accommodate a diverse range of needs [1]. Whether these needs are related to alleviating fuel and economic poverty [2], mitigating climate change and increasing national security [1,3], or establishing a new, often export-oriented industry capable of creating employment opportunities in peripheral regions of developed countries (see e.g. [4,5]), RES have to operate within a different, yet complex framework of governances, fulfilling multiple needs across their spatial extent [6]. Peripheral regions which previously relied on importing fuel and/or electricity have become pivotal for hosting (often) large-scale sites for RE technologies [7]. Whatever the framework utilized for conceptual-

izing the drivers, barriers, and institutional landscapes that guide the transformation of the energy landscape of a nation towards low-carbon and renewable technologies, the exploitation of RE resources in these peripheral regions does not and will not occur within an empty historic, social, economic and policy paradigm (see e.g. [8–11]). There is the possibility that these paradigms can result in outcomes similar to, although somewhat less risky than, than the ‘Dutch disease’ or the ‘resource curse’ [1,2,12], potentially creating barriers to the deployment of RE technologies.

In the present work, we argue that the Megalopolis paradigm has generated a *conundrum* for the development of MREs in Scotland. This *conundrum* is comprised of interlinking issues relating to disjointed energy policies and governance measures reaching from the EU to national government to local authorities [13,14], the centre-periphery layout of the national grid and island charging [15], financing the development of MREs, and finally the technology itself – where power take-off systems and survivability are still being developed [16]. We argue that this conundrum cannot be solved solely through replicating past evolutionary examples set since the 1970s, when the Orkney and Shetland Islands (S&O) were given the opportunity to manage part of benefits derived from the fossil resources extracted locally through the Zetland County Council Act 1974. As an answer to this *conundrum*, we propose the

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Diffused Inclusive Community Entrepreneurship Paradigm (DICEP). This new paradigm foresees implementation of stable institutional support for linking the supply of power to local demand of energy for sustainable economic and social development. Finally, we identify examples of policies and societal responses which could be institutionalized and replicated through DICEP, thus enabling an equitable and smooth transition towards a low-carbon electricity sector.

This work contributes to the literature on transition towards a low carbon future and to research on economic development of remote areas in two ways. Firstly, DICEP aims at filling the gap between top-down policies and bottom up, often fragmented initiatives in the MREs sector. The new paradigm addresses this gap by creating a top-down supported, bottom up, scale free paradigm for expanding the deployment of MREs in accordance with national priorities and local needs. Secondly, DICEP incorporates and operationalizes a new role for of renewable energy, making it more than a way to decarbonise electricity generation. The new paradigm frames marine renewable energy technologies (MREs) as tools for local and national economic development, whose major benefits can be collected indirectly, building on local strengths and community engagement.

1.1. Why Scotland: energy potential from the sea in a diverse policy landscape

We focus on a sub-region (Scotland) of the broader Northern Atlantic rural periphery,¹ presenting how an overarching, pre-existing economic and policy paradigm, Megalopolis, is hindering the deployment potential, and the achievement of the multiple objectives set at both local and national level for renewable energy. Within the coastal Northern Atlantic rural periphery, the RES potential rests in the development and deployment of MREs. This family of renewable energy is capable of creating ecologically sustainable and stable jobs [18–20], and countering decades-long demographic decline. Despite this potential, and the availability of significant offshore wind, tidal and wave resources in this vast region, the divide between local and national acceptance has yet to be bridged [17,21], while institutionalized support has to be fully developed [22] to better enable the generation of socioeconomic benefits to local communities using the electricity generated locally [20]. Among the nations with functioning institutions attempting to utilize the transition towards a low-carbon economy to achieve multiple goals, the devolved region of Scotland represents an example where regional objectives, local control of resources, historical economic patterns within and beyond the energy sector, and embedded within a multi-layered jurisdictional and political landscape have been affecting the deployment of MREs. In recent years the Scottish Government has promoted MRE technologies and small-scale onshore wind farms in rural communities, as a way to achieve energy security, economic development and environmental sustainability [23,24].² MREs play a pivotal role in the ambitious plan of the Scottish government to supply 100% of electricity demand from renewable resources by 2020 [24–27]. The vast majority of suitable resources for wind, wave and tidal technologies in Scotland are located off the shores of the Highlands and Islands region (HIR), reflected in the substantial plans for project development in these areas (Fig. 1³). Capturing sub-regional benefits, in addition to national economic contribution, is of major significance for policymakers and developers alike, particularly due to

the socioeconomic fragility of the HIR region [28,29]. In addition, the transformation of the HIR economy and landscape through the implementation of low-carbon energy generation would be in line with the concept of ‘New Rural Paradigm’, in that this process builds upon of local assets [30].

Despite recent efforts to establish best practices for community engagement, the Scottish and the UK governments currently implement a market-driven, top-down approach to planning the MRE sector [33–35]. From this perspective, deploying MREs across the HIR is dependent on large-scale transmission upgrades for reaching the final demand, which is mostly located in Scotland’s Central Belt, an area stretching between Glasgow and Edinburgh [34,36,37]. The current approach of the Scottish Government to MREs replicates the paradigm that has characterized the political and natural resources flows relationships between the HIR and the rest of Scotland for the past 250 years [38]. We name this paradigm *Megalopolis* after the work of von Glasow et al. [39]. *Megalopolis* thus encapsulates both the current paradigm governing the efforts of the Scottish government to expand MREs, and the area targeted to dictate the agenda for this expansion, that is, the Central Belt.

2. Towards the conundrum

2.1. Historical economic background of the HIR

For the past 250 years, the economy of the HIR has been characterized by a strong resource and export-oriented nature [38,40–43]. Although the nature of the exported resources has changed through the centuries, the flow of monetary benefits and the destination of these resources has remained England and the Central Belt region, as shown in Fig. 2.

Initially providing seafood and logging, the HIR soon became central in supplying the rest of the United Kingdom (UK) with other highly demanded resources, such as meat and wool, making the HIR a major supplier of domestic natural resources for the rest of the UK. The end of the 18th century set the bases for what later has become known as the *Highland Clearances*. With Glasgow on its way to become one of the most important industrial and trade hubs in the world, the constant flow of logs, food and other resources from the HIR was critical, and its implementation was made by feudal landowners forcing most of the HIR crofting population to abandon their farms and move to poorer quality land, or away from the area, often across the Atlantic to North America [38,43,44].

Towards the 1870s, the HIR underwent a first shift in its production base, reducing its role in the wood and cattle sectors, mostly due to the increased competition from animal farming in Australia and New Zealand. The region started re-investing in afforestation designed to supply outdoor recreation to southern elites [44]. Between the late 19th century, and the first half of the XX century, as a consequence of the expansion of the aluminium industry and the increased demand for power for industrial production during WWI and WWII, the flow of resources from the HIR towards the southern regions of Scotland and the UK surged. Along with the traditional agricultural products and timber, the mainland Highlands became a key supplier of electricity through vast developments in the hydropower sector [45], while the outer islands were used as strategic bases and as prison camps. The development of the aluminium industry in the region showed that the exploitation of natural resources could be paired with higher-value industries. Nonetheless, while requiring *in situ* refinement and some degree of skilled labour, the coupled aluminium/hydropower industry still suffered limitations: centralized management, focus on refining raw materials for exportation purposes [45], and dependence on an external entity for employment that at the same time crowded out indigenous industries. Closure of mature smelters during the

¹ See the EU Northern Periphery Programme (<http://www.northernperiphery.eu/en/home/>) for further information about the European portion of this region.

² Include coastal onshore and offshore wind, tidal, and wave energy technologies.

³ Based on [31,32].

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