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A transformational paradigm for marine renewable energy development

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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.

Keywords: marine renewables, community, paradigm, economic, policy, development

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 conceptualizing 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. [8,9,10,11]). 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 devolutionary 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 *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, through the expansion of MREs applications, 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 marine energy technologies (MREs). This family of renewable energy is capable of creating ecologically sustainable and stable jobs ([18,19,20]), 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 [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 developed nations 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

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.

of the Scottish government to supply 100% of electricity demand from renewable resources by 2020 [24,25,26,27]. 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 (Figure 1). 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].

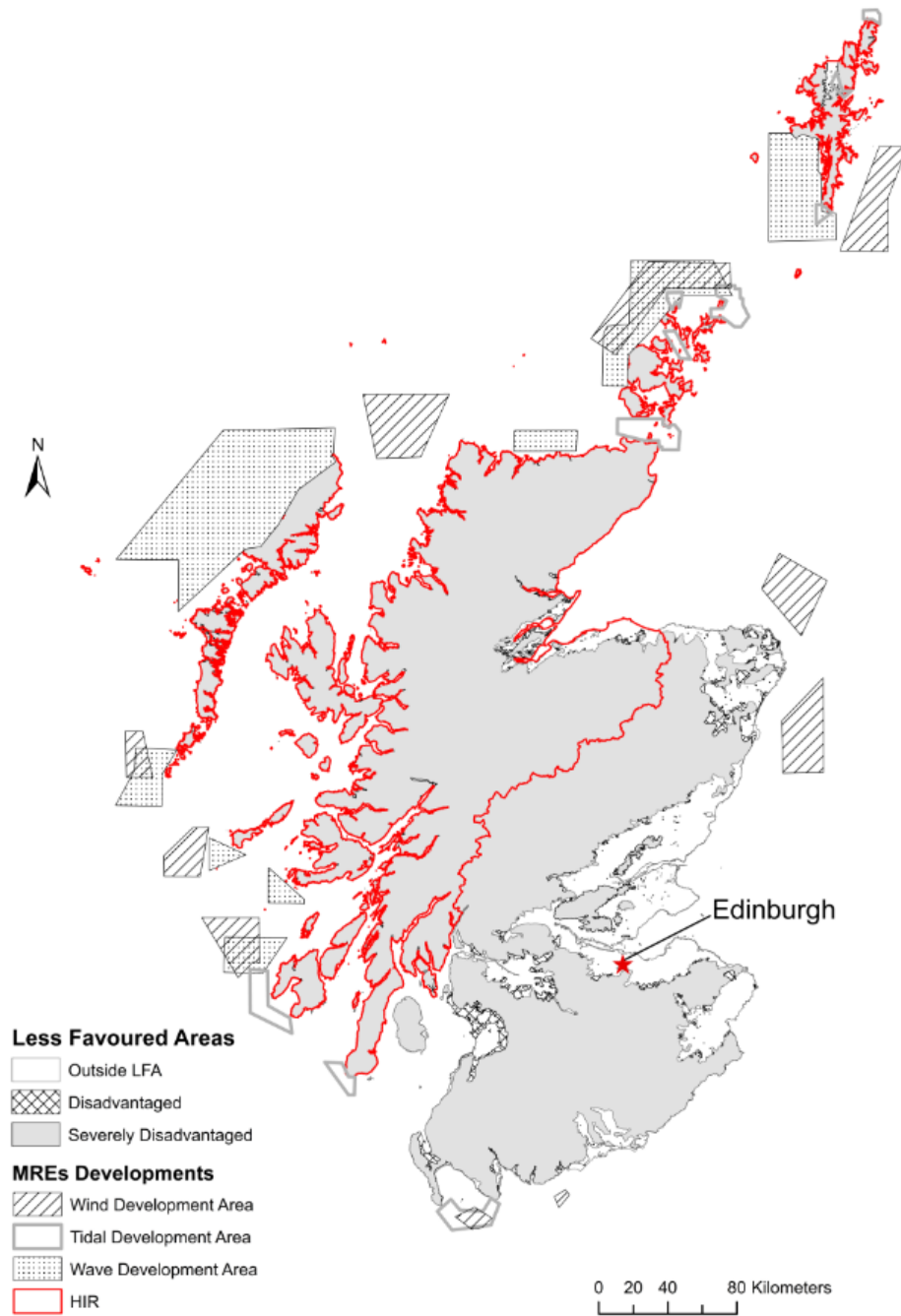


Figure 1 – Map of Scotland with Identified Potential Site for MREs, and economically Less Favoured Areas³

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 [33,34,35]. 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

³ Based on [31] and [32].

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 [38,40,41,42,43]. 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 Figure 2.

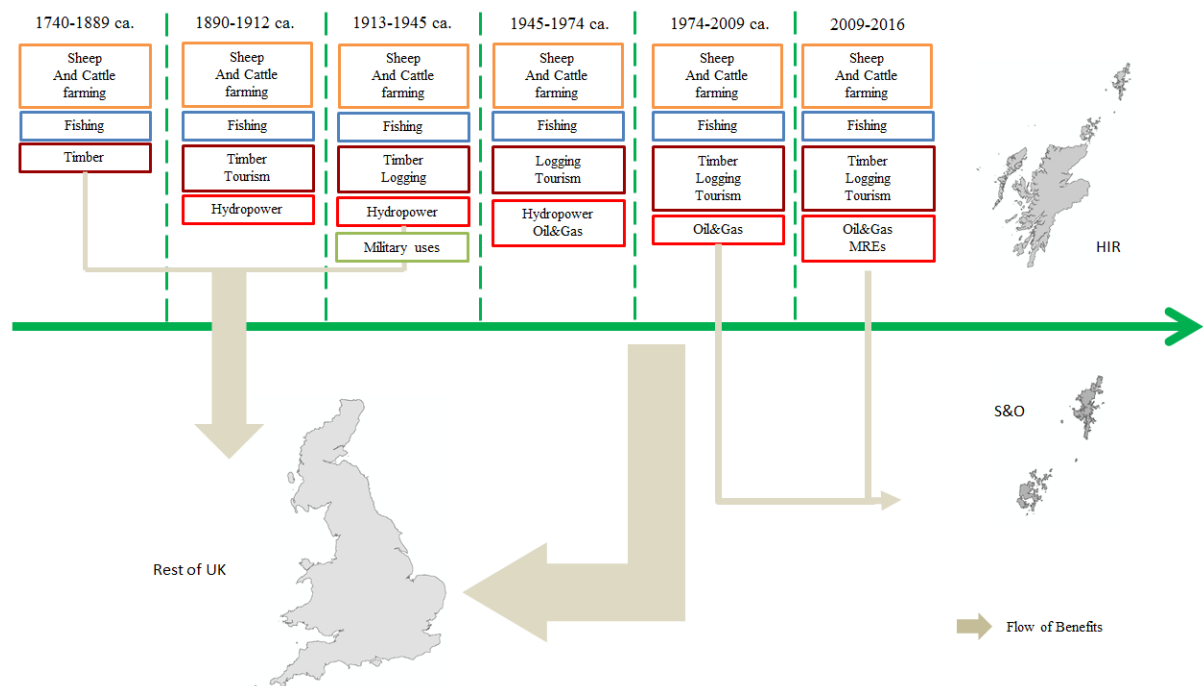


Figure 2. Timeline of major trade flows and benefits from HIR to the Rest of UK.

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 second half of the 20th century left communities with sudden unemployment as well as significant environmental and health externalities [46,47].

Starting the second half of the 19th century, and well up to the present, the HIR has been seen as a destination for shooting (grouse), stalking (deer) and wildlife tourism located relatively close to major urban centres in the UK [48,49]. Tourism in the HIR has been linked with the landscape of the region, traditionally perceived as wild and scenic by visitors, and has had major effects on management of the HIR, and especially its moorland and forested areas [43,49]. Over recent decades, the tourism sector and the associated branding of the region has inspired the growth of several light manufacturing processes, including whisky distilleries, contributing to increase in entrepreneurial ventures built upon

local skills. The fishing and aquaculture industries have recently also begun a new period of resurgence, as one of the fastest growing sectors in the region [50]. Seafood production is likely to interact with MREs, therefore demanding careful planning and siting of MRE projects [51].

Finally, development of the oil and gas industry since the second half of 1970s generated dramatic changes for the HIR and Scotland as a whole. We will consider this particular development in the next section, noting two particular major changes resulting from this new stream of wealth: increased devolved powers to local jurisdictions in the S&O; and the use of the increased revenues for enabling a major economic shift in these jurisdictions [52].

2.2 A Turning Point in the Energy Landscape of HIR

The arrival of the oil and gas industry, and the adoption of the *Orkney and Zetland County Council Acts* in 1974 represented the first successful attempt from any HIR local community to capture part of the wealth generated from local resources since the industrial revolution, although limited to the S&O sub-region [33,52]. Through the monies garnered from their oil terminals facilitated by the 1974 Acts, the local authorities responsible for these two archipelagos invested in the development of logistics and local entrepreneurship opportunities, with the aim of refining their economic structures, building upon natural resources and extending their infrastructure to be able to accommodate shipping, MREs and cruise tourism.

Recently, the devolved resources enabled establishment of the European Marine Energy Centre (EMEC) and the infrastructure to accommodate the expansion of MRE industry in Orkney. Orkney Council has invested in RE since the early 2000's, with their long-term strategy looking to supplement the money that they receive from Flotta Oil terminal through the County Council Acts with rents from MREs [53] in parallel with other economic developments. An example is the Haston dual purpose cruise ships and MRE pier, underwriting investment in MRE with another industry, which is rapidly expanding and already paying off [54].

Despite the widespread institutional support, MREs development in Orkney has not been without issues. These setbacks have come in the form of the disjointed governance - where decisions

about land based renewables have been made by the relevant local authorities (i.e. local councils) and the Scottish Government while decisions about leasing sites have been made by the UK-wide Crown Estate [52]. There are further complications from potential conflicts with other marine industries already operating in areas that have been leased. Scotland's National Marine Plan aims to address these issues by providing a 'one stop shop' for developers and policy-makers and by enabling more strategic planning through the integration of data from all marine industries and users [55]. Further devolution of marine leasing powers from the UK to the Scottish Government is planned, while S&O and the Western Isles Councils are still campaigning for further devolution of marine leasing powers, arguing that they are in the best position to make fair and positive decisions for their economies and their energy futures [56].

While the devolution of revenues to S&O demonstrates the possibility of energy developments generating substantial local socioeconomic benefits, this example cannot simply be replicated for MREs. These energy technologies are different from oil and gas in at least three ways. Firstly, they require logistics which are distributed and continuous, that is, different from the point-to-point of oil. This means that local authorities that do not host MREs are still directly impacted by their developments. Secondly, MREs have a lower return on investment than oil, and thus less potential to drive large cash-flows to benefit local communities. Finally, other than in S&O, local authorities across the HIR lack the financial and human capital to rapidly build or access the necessary skills to manage the development of large-scale energy developments in conjunction with other marine activities.

2.3 The 'Conundrum'

The word 'conundrum' has come to identify an intricate, difficult problem, usually one to be solved only through conjectures or a pun. In the case of HIR and MREs, the conundrum arises from the temporal and resource overlap required by both the deployment of MREs and the upgrade of the Scottish grid system under the current governmental objectives (job creation and low-carbon energy production), within the context of a megalopolis-oriented economic space (Figure 3).

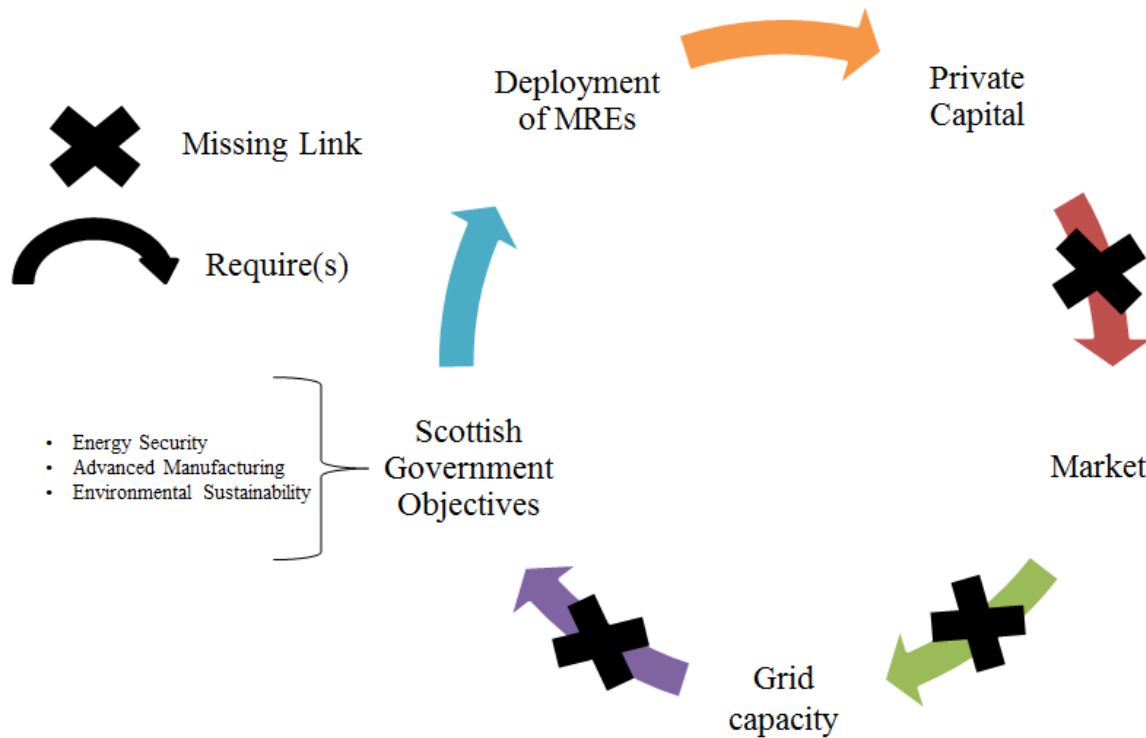


Figure 3. The Conundrum

The overall vision of a south-driven demand of MREs requires these technologies to be deployed in significant proportions relative to fossil-fuelled power stations for lowering the operational costs, and having a significant impact on the Scottish energy matrix [57,58]. Investments from private firms (with the partial support of the Scottish Government) are then required for research, development and deployment of MREs plants, especially for near-the-shelf technologies [36,52,59]. However, privately-supported MREs require a market where to sell the potentially vast amount of electricity produced, and stable support policies from the government. The uncertainty related to grid developments, the continuous changes in national and devolved support policies to MREs, and the lack of alternative, local demand due to the historically peripheral economic role of the region hampers investments in development of the grid [60]. In addition, even if the grid was to be upgraded, this requires a substantial time window, limiting the deployment ability of MREs developers in the near term. Finally, the reduced ability of deploying MREs will hamper the economic and sustainability objectives that the Scottish Government is currently pursuing, while limiting the ability for HIR communities to capitalize upon these resources. This delay between the development and implementation of new technologies has been previously described as the “Death Valley” of change –

where a technology is past the start-up phase, but has not yet reached commercial viability due to a complex mix of issues [61,62]. Although potentially an important factor, the higher-than-fossils leveled cost of electricity can be easily overcome through policy measures, especially when it comes to large-scale renewable technologies [63]. Further, in several parts of the world it either is cheaper to generate electricity by using renewables (e.g. wind power) than fossil fuels, and other factors, such as location-specific heterogeneity of the electrical output [64], business models-policy interactions [65], or county-specific characteristics, including length of the support measures [66] affect deployment of MREs in HIR, as recognized by Johnson et al. [52].

This conundrum has the potential to hold back the full transition of Scotland towards a low-carbon economy, while at the same time reducing the ability of developing a robust domestic industry in the sector. In addition, because of the overall north-south vision inherited through megalopolis even in the event of a massive, top-down public intervention for supporting the development of an enhanced grid, local communities in peripheral areas will still be unable to fully capture the benefits of MREs, mainly because of lack of skills, knowledge, and resources available to local authorities [67].

To overcome this self-feeding conundrum, the present work introduces a new paradigm for the deployment of MREs in the HIR, one that will require a shift from megalopolis, and that will build upon current existing policies and tools to re-draw the role of the devolved government and academia in the HIR.

3. Beyond the *Conundrum*: DICEP

We propose that the solution to unlock the conundrum rests in moving away from the megalopolis paradigm, conjugating the deployment of MREs with economic development policies and regional institutional integration. From its four major characters, the new paradigm is named *Diffused & Inclusive Community Entrepreneurship Paradigm*, or DICEP. DICEP builds upon several characteristics that have been identified and conceptualized in recent years (Table 1), linking them with the HIR context and the institutions necessary for the paradigm to be implemented. The paradigm is not ‘regionalist’ in the sense that it is not seen as unique to the HIR. Rather, DICEP can be applied in other

national and regional contexts, although each of the objects requires a regional contextualization to be implemented.

Table 1. DICEP characteristics and associated objectives

Characteristics	Objective	Contextual Reference
<i>Diffused</i>	Distribution of benefits	Martin et al. [68]
	Distribution of MREs	
	Distribution of experience	
<i>Inclusive</i>	Institutional framework	Acemoglu and Robinson [69]
<i>Community</i>	Local engagement	Johnson et al [70]
<i>Entrepreneurship</i>	Proactive communities - MREs for reducing socioeconomic fragility	Dees; Fuchs and Hinderer [71,72]

DICEP introduces three major changes within the current social-jurisdictional regime:

1. Expansion of local electricity demand through economic development;
2. Engagement of local communities, MRE developers, and entrepreneurs in energy-economic projects; and
3. A facilitating and *supporting role* rather than a *directing role* for the Scottish Government and the regional research institutions (devolved institutions).

The diffusion of benefits, whether in the form of new skills, jobs, monetary payments or reduced cost of energy is pivotal in DICEP. As of 2016, not only the HIR are affected by several of the imbalances previously introduced, but it operates within a national context of extreme economic agglomeration, which has created a spatially imbalanced economic landscape in the UK [68]. The elements of DICEP aim at reducing these imbalances, using MREs deployment, and at the same time unlocking future uses of Scottish renewable energy resources. In the remainder of this section we will discuss the key characteristics of DICEP in more detail. We start by discussing a proposed implementation of community entrepreneurship to move from electricity exports to an ‘electricity economy’. We then discuss the need for local diffusion not just of financial benefits but also of human capital to enable inclusivity. The final parts of this section discuss the broader dynamics of DICEP and how the paradigm compares to past approaches.

3.1 Diffused and Inclusive

Devolution of fiscal and regulatory powers is only a partial response. Local authorities and communities also require a diffusion of skills and experiences. The term ‘diffusion’ highlights a two-way relationship between local communities and the devolved and central governments for creating actual *inclusive* social and economic processes. Communities require development and access to the skills and resources necessary for taking informed decisions both locally and regionally (i.e. involving multiple local authorities). At the same time, this learning process would operate faster if peer communities shared their experiences. In DICEP, the Scottish Government enables local communities not just by target-setting but also in terms of financial and non-monetary resources and skills. Access to knowledge services is pivotal for local communities to implement complex tasks, including environmental impact analysis across neighbouring regions, marine spatial planning, and investment and development of associated economic activities. The HIR hosts several advanced research institutions, such as EMEC, the Scottish Association for Marine Science, the University of the Highlands and the Islands, Heriot-Watt University, as well as regional economic development agencies (Highlands and Islands Enterprise, LEADER programmes).

The principle of *inclusion* is seen as operationalized through an active community engagement, based on the *diffusion* of information and best practices. In other regions, a range of program-designs have shown their effectiveness at operationalising community-based movements through region-wide policies. For example, the US-based Solarize Program leverages community engagement with financial incentives for fostering the adoption of photovoltaic systems. Conceived and partly funded at federal level, planned at state level, and implemented by local authorities (e.g. towns, counties), Solarize is a community based programme that leverages social interactions to promote the adoption of solar power [72]. Although MREs require larger capital, acceptance from communities is fundamental for deploying this technology effectively, even leveraging on local knowledge of the local, often difficult, environments [14,52]. These best practices are vastly available throughout Scotland, thanks to the large number of community-owned energy initiatives [73], and they offer a starting point for the last element. The role of local and/or community agents for change in accelerating facilitating the diffusion of innovations is not new, and has been widely explored by literature in various fields (see for example

[74,75], including renewable energy [76]. Within this perspective, the role of the devolved government becomes pivotal not in terms of directly introducing a specific MREs in a specific location. Rather, the government is responsible for establishing flexible frameworks for pairing MREs projects with localized uses of energy. Once again, the concept of *inclusive institutions* comes in to play, thus creating a continuum within DICEP aimed at initiating a full sustainable transition process beyond electricity generation. The element of time in the diffusion process of innovations modifies the perception, role, and relationship between agents and the innovation itself [77]. The internal dynamics of DICEP, the collaboration between entrepreneurs within and outside the communities enables the adoption of MREs within the support of national and devolved institutions as planner and regulator, funder and facilitator.

3.2 Community Entrepreneurship: from electricity exports to electricity economy.

Recent literature suggests that local community and social entrepreneurial initiatives have significant potential in terms of facilitating the transition to a low-carbon economy (e.g. [71,78]). In DICEP, the entrepreneurial experiences are aimed at pairing increased local demand of electricity through economic activities with a faster deployment of MREs. The expansion of local demand will decrease the need for grid investments, while exploiting a local resource for local economic development. Because of the lack or limited access to the main grid, especially in the Western Isles, and relatively limited local demand for residential uses, most of the communities and projects in and across the HIR cannot rely upon sales of electricity as a source of revenue. Thus, DICEP aims at involving local communities and authorities in utilizing MRE outputs for new economic activities. These entrepreneurial efforts can either take the form of social entrepreneurship, or follow more profit-oriented approaches. Building upon an ongoing trend in literature for merging energy policy and economic development, DICEP aims to achieve a reduction in the uncertainty linked to the support for MREs, a suggestion previously advanced in the broader context of renewable energy by Carley et al [79].

Operatively, DICEP aims at reconfiguring the involvement of the Scottish Government to that of three roles: of planner/regulator, of funder and of facilitator. This new role envisages the Scottish

Government to set the long-term, national goals for energy use, but it also to facilitate (rather than ‘commanding’) a continuous dialogue among communities, local governments, developers, and entrepreneurs, providing know-how (with the involvement of universities) and redirecting existing funds towards paired MREs-economic projects. Through this combined support to both energy supply and demand, DICEP aims to initiate what Fuchs and Hinderer [71] define an *endogenous transition towards sustainability*. For example, remote communities could exploit the locally-produced electricity (at subsidised prices) for powering greenhouses for food production, providing lower-cost fresh produce locally and reducing reliance on subsidised deliveries whilst generating jobs, addressing some of the issues identified by Leat [80] in the sustainability of the Scottish food supply chain.

Localized uses of energy for food and manufacturing production represent a pivotal economic strategy in other countries, most notably Iceland. The country has invested in developing its domestic supply based on geothermal resources for fostering advanced uses of energy, such as tourism, carbon recycling, agricultural production, and smelting [84,85,86], though the latter not without significant negative environmental externalities and protests [47]. There are two main differences between the Icelandic case and HIR. At the detriment of the HIR case, geothermal power is currently cheaper than MREs and tidal and wave technologies require further testing. However, HIR is less isolated than Iceland in terms of market access, and the potential benefits (and initial capital costs) can be shared with a much larger population (and economy) based in the Central Belt and rest of the UK. The localized use of energy will not only expand demand for electricity, but it will directly link the sustainable production of electricity with economic activities aimed at diminishing the socioeconomic fragility of the HIR.

Additional potential energy applications in the HIR would include seaweed production for human and non-human consumption, including biofuels and fertilizers [86], and pharmaceutical applications. HIR already hosts several initiatives, privately and publicly funded, researching or manufacturing seaweed-based chemical products. BASF, one of the largest chemical manufacturers in the world, has an established plant in the Western Isles (BASF Pharma Callanish Limited). On the mainland, Argyll hosts the European Marine Science Park, and a small cluster of seaweed-focused start-

ups and companies, mostly established in the past five to ten years. This application of MREs electricity can be seen as a way to store the electricity in new, transportable ‘vectors’, whether these are energy products (e.g. biofuels), or other types of advanced chemicals and food products. Although potentially producing export-oriented, locally manufactured goods, this application of MREs would require higher initial capital and additional skills if seaweed is transformed into higher-value products [87]. Along with the entrepreneurial character of this setting, the central and proactive role of local communities in engaging with uses of energy and MREs projects beyond community ownership sustains the *community* character of DICEP.

After the MREs have been deployed along with their connected activities, the changes and spillovers emerging by this transition have to be governed by the same devolved institutions led by the Scottish Government. This last step links the internal and the external dynamics of DICEP. The paradigm is not an alternative point of arrival for low-carbon transition in Scotland. Rather, it serves as a step between the current situation and the further expansion of MRE-based electricity production in future years, especially once price grid-parity will be achieved across multiple technologies (Figure 4).

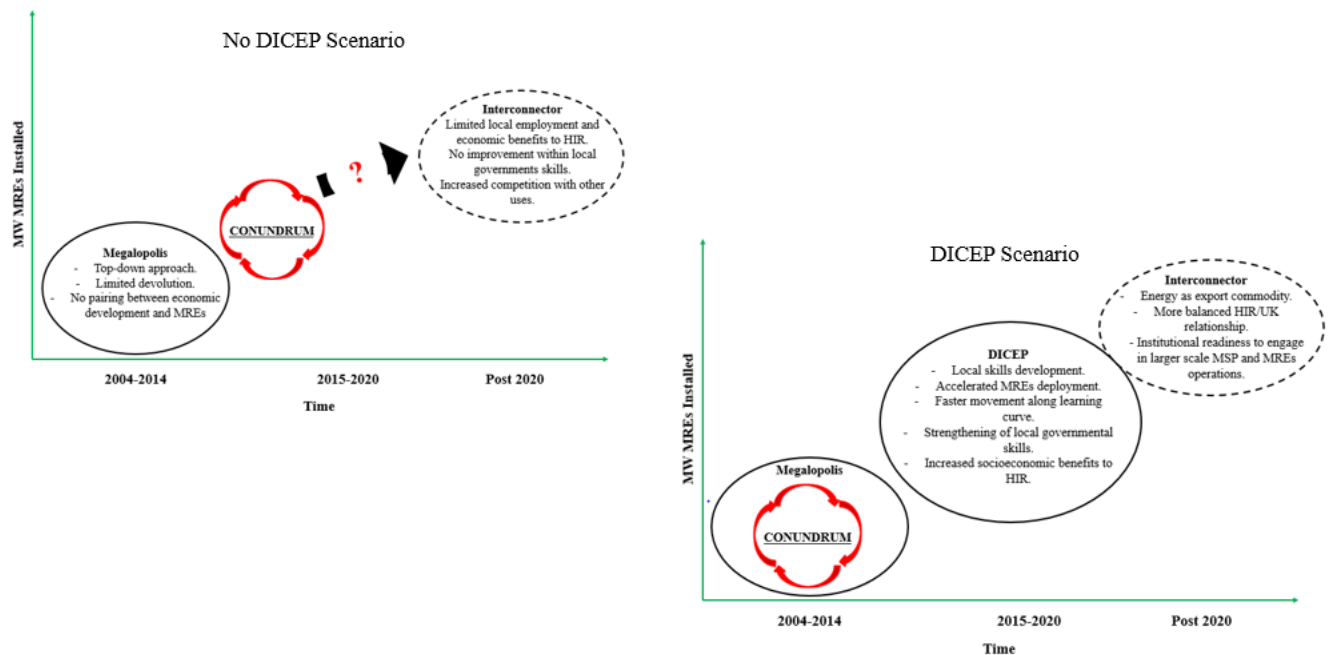


Figure 4. DICEP as a stepping-stone for building a stronger ‘Interconnected’ scenario.

3.3 DICEP vs previous devolution approaches

One element emerging from DICEP is the central role that communities across HIR will play. In recent years, local councils, wards, and smaller jurisdictions have been given increased responsibilities over more complicated matters, often with little increased resources. Within DICEP two elements enable local authorities and communities to cope with these increased responsibilities. DICEP focuses on local and external entrepreneurs for inspiring and leading the diffusion of MREs and the related economic activities. These entrepreneurs are not necessarily based within political institutions. Scotland has an established tradition of community-energy renewable energy projects in which local residents operate within new community and regional organisations and enterprises, reducing the stress on local public institutions [88, 89], which often act as a barrier to effective planning and monitoring [87]. Supporting local communities and governments to access the services of research institutions and universities with strong local knowledge can provide access to scientifically robust and non-affiliated scientific support. This access requires financial resources and the exploitation of existing and new fora for establishing a continuous dialogue among communities, developers, entrepreneurs (external/internal), and research institutions [90]. This increased collaboration, financed at devolved level, can create the social, technical, and institutional skills for enacting the additional devolvement of powers introduced by Johnson et al [52], such as the extension of planning and rent revenues to local authorities in S&O to include all MREs activities. In addition, this collaboration can generate create the conditions for developing the (social) enterprises envisioned by Okkonen and Lehtonen [20], which includes improved local infrastructures, investments in social services, and community business developments (e.g. heritage centres, community farming). In acting as a stepping-stone paradigm, DICEP aims at bridging towards an alternative scenario compared to one driven by Megalopolis (Figure 4), acting not only as a viable approach for easing the transition towards a low-carbon energy, but also to create the institutional, political, social and economic base for achieving a balance among local, regional, and national benefits once MREs are integrated into a national/international grid system, and strike-price is achieved.

4. Evidences of Community as Agency in the Pre-DICEP Age

Episodes of community action displaying some of the elements of DICEP have recently emerged in the HIR. We briefly present and compare two cases of implementation of renewable energy technologies: both are based on the Isle of Lewis, Outer Hebrides. These two cases refer to coastal onshore wind, rather than offshore technologies, as the former are more mature technologies. However, we believe that cross-contamination among sectors is possible, especially within the wind industry as a whole. The first case of the Galson Estate Trust embodies a DICEP community; the second, Lewis Wind Farm, represents an example of Megalopolis.

The Galson Estate Trust, a company limited by guarantee, was set up by the Galson Estate community in 2004 in order to guide the process of buying out their land (after 85% of a 72% turnout voted in favour of a buy-out), a 55,800-acre estate on the North West coast of Lewis, under the 2003 Scottish Land Reform Act [91]. Driven by the ambitions of several local actors for developing the area both socially and economically, the Galson Trust looked to wind energy as a means to provide the funds required to meet these goals including climate-change mitigation initiatives. In 2008 the Trust received planning permission to put up three 900kW turbines - totalling 2.7MW of installed capacity. The first one started producing electricity in November 2014 and the other two are constructed and expect to be producing electricity by the end of 2015. The first turbine was enabled by a bank loan from the Co-operative Bank and Triodos Bank. The second two were co-funded by a Triodos Bank loan, the revenue from the first turbine, and by a community share option, which brought in £705,800 by 168 members. Each turbine will generate £150,000 in revenue annually, which will be re-invested in the local community through the Community Investment Fund [76]. The shareholders are expected to earn 4-5% interest on their investment. The Galson Estate Trust predicts that it will buy back all shares with the aim of being the sole owners of the turbines and any associated revenues by 2035 [92].

In contrast, Lewis Wind Farm fitted in the megalopolis paradigm. It was a plan to build the largest, privately-owned, terrestrial wind development in Europe [93], on the protected peat moors of central Lewis. The plan was rejected after the government received 10,826 letters against the proposal [94]. We identify the major differences between the two projects in Table 2.

Table 2. Salient Characteristics of The Galson Estate Trust wind development and Lewis Wind Farm

Lewis wind farm (Megalopolis)	Galson Estate Trust wind development (Aspect of DICEP)
Privately owned	Community owned (D and C)
Large-scale	Small-scale (D)
Rejected by the local community	Accepted and owned by the local community (C&E)
Rejected in the planning process	Planning permitted (C&E)
Unknown local social and economic benefits (LWP,2004)⁴	Known local social and economic benefits (E)

Adding to the argument for the DICEP paradigm is the theory that Lewis Wind Farm was ahead of its time in terms of the scale of the development [14] evident through the lack of local policy and communications mechanisms needed to handle such a large renewable energy project [95] in a location where developments were previously small and incremental rather than large scale and immediate [94]. The (mis)management of the project by both the Local Authority and Lewis Wind Power Ltd [95] contributes to the argument for DICEP as the socio-economic benefits would have included a percentage of the revenue from the development [96], as well as the interconnector going in on schedule. The latter would have been likely to enable other renewable energy projects to go ahead – such as those planned by the wave energy industry. Aquamarine Power Ltd and Voith Hydro Wavegen Ltd. withdrew their plans for developing offshore wave arrays which were granted planning permission citing the lack of grid connection as a barrier they could not overcome [81,82]. Both these elements could be seen as progressive steps if the project was viewed from the narrow perspective of energy targets and economic indicators and excluding social and environmental factors. However, the social and environmental factors proved strong enough to prevent planning permission from being granted. This follows literature on the acceptance of wind farms which links success of wind developments in the planning process to community ownership and mitigation of environmental impacts [97,98,99]. It might be considered that, had the Lewis Wind Farm project gone ahead in its original form, it might have reduced the impetus for local communities to start up their own energy firms thus the energy landscape of Lewis and the greater

⁴ The socio-economic analysis conducted by Lewis Wind Power showed a decent amount of community benefits. However, the accuracy of the environmental statement was questioned enough by the RSPB that they commissioned an independent review [113].

Wester Isles might look significantly different to what it does today, where community scale energy projects are prevalent [76].

The incremental rate of change afforded by community developed renewable energy projects, such as that of the Galson Estate Trust, allows for more time for the mechanisms for regulating larger scale projects (if they are preferable in the future) to be developed and tested whilst supporting the Scottish Government's targets for renewable energy as well as addressing the social and economic needs of the locations which are host to renewable energy resources. Additionally, through the stronger, bottom-up and informed development process, locally generated revenues and energy can be paired with local uses, thus improving the medium-term socioeconomic impacts of RE projects and any future MRE projects in the HIR. With the implementation of DICEP, examples such as the one presented in this section could be strengthened and expanded within a context of continuous national support, thus creating a generalized favourable environment for MREs.

4.1 DICEP at Work: Challenges and Solutions

The implementation of DICEP faces several challenges, mainly from the current governance structure and MREs paradigm within Scotland and competitive uses of the marine space. Along with the top-down, Central-Belt driven policies implemented by the Scottish Government, local authorities have received an increasing amount of responsibilities, within a national context of shrinking public resources [87,100]. The Scottish governance context offers contrasting perspectives. Rural areas such as the HIR have been often targeted by unified policies [101], which often simplifies different needs among stakeholders, and it is driven by Megalopolis, thus replicating past paradigm of resource exploitation. At the same time, the HIR is today undergoing a fragmentation in the governance space of MREs through the implementation of Scotland's National Marine Plan, and further powers to be awarded to local councils, thus fragmenting the jurisdictional space within which MREs planning, support and integration with other marine uses and economic applications occur. On top of this conflicting governance framework, renewable energy policies at national level have often been unstable, with continuous changes in both the nature and financial value of subsidies and standards

[79,102,103]. To address these challenges, we suggest building upon existing experiences within the HIR, Scotland and Europe.

Establishing *fora for communities* to share experiences and institutional learning has the potential to spread acceptance, skills, and experience across the HIR. This solution is not a novelty in Scotland, thus lowering the burden on local governments. In 2004, Highland and Island Enterprise established the Community Energy Company, today known as Community Energy Scotland (CES). CES is a charity established to help communities to introduce renewable technologies into their economic portfolios [104]. As argued by Walker et al. [98], community-level initiatives had and have a central role within the UK renewable energy policy, as they magnify the effects of national and devolved level support policies. Sharing best practices across communities, and developing peer-based fora thus becomes a necessary step to further increase the reach of the initiatives undergone at local level both within and beyond CES, and with the inclusion of the public officials from local authorities, whose role is pivotal for the long-term success of MRE-energy use initiatives.

DICEP requires a high degree of local acceptance of MREs as well as integration of local and expert knowledge around potential social, economic and environmental impacts. A particularly useful deliberative-analytical approach to integrating local with expert knowledge is *participatory scenario development and evaluation*. Scenario development can be defined as a “systematic method for thinking creatively about dynamic, complex and uncertain futures, and identifying strategies to prepare for a range of possible outcomes” ([105], p.346). A participatory approach typically brings together stakeholders and experts to develop storylines and a set of criteria and indicators by which scenarios are subsequently modelled and evaluated. This can then lead to development of shared values around the social benefits and costs of different options, allowing development of synergies and reducing risk of potential conflict [106]. Participatory scenario development can be combined with marine spatial planning tools to make trade-offs between MRE and other sectors more transparent [51].

Marine Spatial Planning: In relation to MREs, MSP provides a number of opportunities to support transition to new approaches to resource exploitation outlined in this paper, including a potential framework for both the community dialogue and participatory exercises described above. Firstly, as noted in our discussion of energy developments in S&O, local planning and consenting powers can lead to greater local leadership and development of community-based energy initiatives, and this has parallels with the developing approach to MSP in Scotland, which will be taken forward by geographically distinct Regional Marine Planning Partnerships (eleven across the territorial waters of Scotland) rather than led by a central authority [106]. This provides the opportunity for empowerment of local communities to specifically influence local energy projects considering the linkages between different terrestrial and marine activities in their region. However, doubts remain in relation to the capability of these new sub-regional entities to address advanced, and spatially complex issues in times of increased fiscal austerity [91]. Secondly, as a cross-sectoral, multi-interest platform for engagement on a regional level, MSP provides a framework for addressing conflict and co-existence, whereby potential issues related to conflict for space or resources can be discussed, and solutions for more effective and optimised use of ocean space to be identified. A major principle of MSP is the participation of communities in influencing the development of their local marine area, a process of empowerment which is critical for achieving sustainable development ‘on the ground’. Large scale MSP is in its early stages in Scotland, but the emphasis on the participation of civil society and interest groups promises to expand the potential for citizen engagement beyond the traditional consultative exercises carried out to support Government-led initiatives. Participation at the local level in marine planning is critical to engendering understanding of industry development plans, to explore new forms of resource use, such as community-based off-grid renewable energy initiatives and co-location of multiple activities (e.g. [107,108]) and to engender greater sensitivity to local issues in project development (such as social acceptance of wind farms [89]).

5. Conclusions and Policy Implications

The transition towards a low-carbon economy has opened new opportunities for peripheral regions with abundant non-fossil resources. This transition, however, operates within pre-established economic and social paradigms, which often can generate conundrums capable of hindering the deployment of these technologies (e.g. MREs). These paradigms can also reduce the ability for these regions to address local social and demographic needs. Focussing on MREs in Scotland, our work attempts to develop a new approach to unlocking the energy and economic potential of the HIR in an ecologically sustainable and socially equitable way, which supports the transition of a remote, resource-rich, capital-poor region. Previous social research shows that one of the key elements for this successful transition is local acceptance of the technologies, often linked with ownership, tangible community benefits, and the right ‘fit’ of technology with culture [110,111,112].

In this work, we identified a conundrum hindering the deployment of MREs in the HIR region: this barrier partly replicates, at regional level, the North-South paradigm currently contributing to the social divide in the UK [68]. Specifically, we identified the lack of an updated grid and alternative local demand, combined with an uncertain support system for renewable energy technologies as elements that discourage investments in to the MREs system and hinder both economic development and the Scottish Government’s objectives for MRE. The new approach we introduce, DICEP, attempts at solving this conundrum by balancing national needs for secure, low-carbon electricity, with local social and economic development. Further, DICEP provides a bridge between the current MRE conundrum and future setting where MRE is a more prevalent electricity source by integrating policy, economic and technology settings within the historical, cultural and social context of HIR based on the findings of previous social research on community relationships with RE development.

Current policies and governance approaches do not include *phasing in* of MREs: DICEP, however, promotes a phasing in process, allowing MREs to become common-place or a societal norm rather than an object of opposition forced upon rural communities, or another element of resource extraction with limited local benefits. Through the change in the relationship between community and MREs projects, DICEP provides the link to a nation-wide transition towards renewable power generation, and economic development in a remote and resource-rich region such as the HIR. The

paradigm also promotes the use of MSP by sharing community and regional experiences, and utilizing participatory scenarios for selecting and implementing combined models where MRE generation supports productive uses of the electricity, thus creating stronger local support, and larger demand with greater impact on the regional economy. Although DICEP has focused on Scotland and, among renewable energies, the sub-family of MREs and coastal onshore wind power, this paradigm contains principles that can be applied in other remote, and resource-rich regions of the Northern Atlantic and other macro-developed regions with similar characteristics, where RE, regardless of the technologies, can be used to unlock economic development, and to reduce the effects of demographic decline and the need for ecological stewardship. Further, DICEP builds upon existing examples and tools within the local, (HIR), regional (Scotland), and national (UK) levels for operationalizing its principles, and calls for a re-organization of the devolved and national support strategies across multiple sectors, rather than an overall expansion of current support programs. Although other localities and regions can and will build upon different tools and policies because of their socio-economic and political landscapes and needs, DICEP introduces principles for socially equitably and environmentally sustainable support for resource-rich, capital-poor peripheral regions as they become pivotal in the global effort of reducing our dependency on fossil fuels. These general principles are:

- 1) *A centralized source of support, coupled with a diffusion of benefits and opportunities*, where devolution of powers is replaced by coordinated economic, ecological, and energy strategies – In the HIR, this principle translates into a new role for the Scottish Government for coupling MREs support with economic development support, beyond simply devolving more powers to often capital and skill-poor local authorities.
- 2) *An inclusive approach, capable of building upon local knowledge, and of incorporating local needs at the planning level* – In our example, this principle translates into strengthening the approval process through the implementation of the Scottish MSP.
- 3) *An overall understanding that energy resources can generate paradigmatic shifts beyond the energy sector, if combined with other economic activities* – In our work, this principle fuels the idea of ‘entrepreneurial’ communities, where energy (electricity) is directed at

local, traditional and advanced economic activities, such as seaweed farming and processing.

These principles, along with the DICEP's characteristics, are rooted in a few assumptions:

- 1) *That the region/locality is within a developed country, with technological, financial, social and human capital at its disposal* – in our example, the UK.
- 2) *That the RE technology is medium-to-large scale, or a technology whose best performance occurs when scaled-up* – in our example, MREs.

Major shocks, both within and outside the domain of energy markets (e.g. an independent Scotland) can change the very essence of the Megalopolis paradigm. However, DICEP is a paradigm which can aid transition to a low-carbon economy through incremental changes to the current cultural, ecological, institutional, and economic framework of the HIR, by using previous research, such as the findings of Okkonen and Lehtonen [20] on job multipliers, and that by Goldthau et al. [7] and Johnson et al [52], especially in the necessity of devolutionary processes to establish a secure legal framework for MREs deployment, or, more generally, the appropriate scale [7], without conflicting with the region's social and cultural landscapes, as previous projects did [85]. The DICEP strategy can underpin a shift in energy transitions policy that enables a more effective and socially inclusive approach to low carbon energy generation as well as contribute to the mitigation of the substantial economic and demographic challenges faced by the Northern Atlantic periphery and other (RE) resource-rich, capital-pool regions within developed countries.

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