Ocean & Coastal Management 117 (2015) 32–42

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

The power of the offshore (super-) grid in advancing marine regionalization

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ARTICLE INFO

Article history:
Received 7 October 2014
Received in revised form
31 July 2015
Accepted 6 August 2015
Available online 4 September 2015

Keywords:
Offshore grid
Supergrid
Marine regionalization
Europe

ABSTRACT

Large scale and transnational electricity grids facilitate balancing capacity across the areas that they serve and increase potential for energy trading. Offshore grids and the more ambitious notion of supergrids are beginning to play a significant part, especially in Europe, in the realization of improving security of domestic energy supply and expanding renewable energy production. As such, offshore (super-) grid development provides an excellent example of the move towards marine regionalization. Moreover, because of limited spatial claims and environmental impacts, marine electricity systems seem well-aligned with the rationale of ecosystem-based management, which is at the heart of European marine governance. By outlining their historical path and the envisioned outlook, in this article we show how offshore (super-) grid developments link up to marine regionalization and its related processes of integration and cooperation. It is argued that scaling-up grids to the level of regional seas is not un-problematic, but faces obstacles which depend on persistent practical and policy realities, and which may be relevant to other expressions of marine regionalization.

1. Introduction

One of the most striking examples of using sea space to integrate transnational (and sub-national) economies is the development of offshore electricity grid systems. Laying high-voltage electricity cables upon or within the seabed is a means of expanding and connecting land-based electricity supply systems around the peripheries of coastal nations and even across entire sea basins. This has allowed terrestrial electricity systems, including those of different nations, to be linked, allowing centres of production and demand to be inter-connected across longer distances and with greater opportunities for interchange. Offshore grids are now also being used to connect centres of offshore supply, in particular wind arrays, to terrestrial grids (Orths et al., 2013). The potency of this use of the seabed lies not just in the economic possibilities that it presents, but also in the makeup and presence of the infrastructure involved, namely networks of linear cables and other structures physically linking different jurisdictions, channelling electricity between them and embodying increasing energy interdependence (Watson, 2012).

European seas are a particularly clear focus of these trends. As described below, offshore links have been developing within them over several decades, and the offshore wind industry is now leading to further expansion and is acting as a catalyst for much more ambitious 'supergrid' plans. Moreover, many of these developments are at a regional (supranational) scale, and some of the grander aspirations have much of Europe, and even beyond, in their sights (Aguado, 2011; Elliott, 2013). In this article, we focus specifically on the grid dimension of this offshore infrastructure. It seems that they in particular are now displaying a regional scale of marine resource use, and may be, insofar as they are the product of active governance processes, one of the clearest examples of a new regional dimension to marine governance.

To illustrate the notion that offshore (super-) grid development is indeed an expression of regional governance within Europe, it is worthwhile to refer to recent European Union (EU) policy supporting their development. In 2006, the European Council (EC) adopted the Energy Community Treaty (2006/500/EC) which reinforced commitments to realize a common European market in general and an internal energy market in particular (EC, 2006, 2008). In the following years, commitments to work together on energy issues became more explicit, including the Energy Efficiency Directive and measures to enhance security of electricity supply and infrastructure investment. The promotion of renewable energy sources is of course

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http://dx.doi.org/10.1016/j.ocecoaman.2015.08.002
0964-5691/

a very important driver, given the EC's "20-20-20 targets", that is, to raise the energy share from renewable resources to 20% by 2020 (EC, 2009). Related to these ambitions are the more grid-specific targets to have energy storage facilities and strategic networks, often specifically referred to as supergrids, ready by 2020.

In order to make these ambitions more tangible, the EC has defined twelve Priority Corridors and, recently, 248 Projects of Common Interests (PCIs) (EC, 2011, 2013). Advantages for a project labelled as PCI will be a more efficient permit granting procedure, improved regulatory treatment, and access to financial support from the EU. Four of these Priority Corridors and 140 of the PCIs are in the field of electricity transmission and storage and a substantial part of the future network includes offshore connections (Fig. 1, Map A). Moreover, one Priority Corridor is named according to its large offshore contribution, the Northern Seas Offshore Grid (Fig. 1, Map B). Indeed, the increasingly transboundary character of European electricity transmission in general suggests that a regional approach is the (only) way forward towards securing European energy supply and fostering renewable energy use (among others: Patt et al., 2011; Woolley, 2013). In policy practice, working concepts such as Priority Corridors and PCIs illustrate the focus on the regional level. Offshore grid development appears to be set firmly within this wider context of regional energy systems, with the added dimension of being an example of regional marine governance.

Setting offshore grids and supergrids within the context of regional marine governance opens up several sets of questions. Firstly, to what extent does the offshore (super-) grid programme demonstrate the features identified as part of the marine governance framework such as integration and cooperation (Soma et al., 2015)? Does it suggest that other factors are at work in processes of marine regionalization? Conversely, does this example indicate whether there are challenges and limits to regionalization, and if so, what determines these limits? Secondly, if offshore grids and notions of supergrid do indeed represent wider process of regionalization, to what extent do they depend upon and reinforce other dimensions of this agenda, such as renewables and other economic activities, in a co-constitution of institutional and sectoral interests in favour of marine regionalization? Thirdly, an ecosystem-based management (EBM) approach, aiming to balance environmental concerns and economic interests, is now at the core of European marine governance. Since it appears that the environmental and spatial impact of cabling is limited when compared to other maritime activities, can it be assumed that applying EBM will be more easily achieved in offshore grid development?

In this article, we aim to assess offshore grid development from a marine governance perspective, and specifically in the light of marine regionalization as conceptualized in this special issue (Soma et al., 2015). We begin by addressing the evolution of electricity grids in Europe, including offshore, showing the trend towards marine regionalization. After outlining this evolutionary path of European offshore electricity grids, we assess the future trend of development, in particular the framing of offshore grid/supergrid. We analyse how processes of integration and cooperation work in the regionalization of grid developments and then discuss the added value of understanding offshore (super-) grid through a regional lens. We conclude with reflections on the implications of the offshore (super-) grid for regionalization of marine governance as a whole.

2. The evolution of offshore electricity grids

2.1. The development of electricity grids

Electricity grids are an integral part of electricity production and supply systems, taking power from points of generation to points of demand. Generation has conventionally been in large, centralized power stations (hydrocarbons, nuclear or large-scale hydro), whilst demand is much more dispersed, from major industrial users to a myriad of small-scale domestic users. Grids have two main components: transmission systems, transferring electricity at very high voltage from power stations over longer distances towards areas of demand, and distribution systems, transferring electricity at progressively lower voltages to customers. On land, power is routed along overhead lines suspended from towers (pylons) or via underground, insulated cables; overhead lines are generally preferred as the much cheaper option, although public protests (mostly related to visual concerns) may lead to replacement by underground alternatives (Hammons, 2003). Along the way, power is stepped down to lower voltages and divided along different routes at transformer stations, which form the main nodes in the network. Grids generally make use of alternating current (AC), though direct current (DC) is more efficient over long distances, and some transmission systems include high voltage DC lines.

Electricity systems have mostly been developed to serve national or sub-national needs, sometimes through the integration and expansion of earlier, more localized networks. They generally came under national ownership until recently, through 'vertically-integrated', monolithic state enterprises, which have managed the whole system of production and supply (Messing et al., 1979). However, in many countries, the industry has been progressively broken up over the last two decades, with 'unbundling' of component parts, some or all of which have been transferred to private ownership, in the interests of economic liberalization and competition (Geradin, 2001; Patterson, 1999). Transmission and distribution grids now generally operate as independent entities, with varying degrees of public and private ownership in different jurisdictions. Their 'natural monopoly' status has, however, been recognized, and grids competing in the same area have not come about.

Liberalization at the national level has been accompanied by moves to encourage electricity trading across borders, especially in Europe, where barriers to trade have been reduced and transnational, strategic energy routes (Priority Corridors) have been proposed. This is building upon some long-standing transnational arrangements; for example, there has been high-voltage interconnectors between neighbouring countries such as Denmark–Sweden and France–Italy since the 1960s (Table 1). The possibility is now opening up of much more significant export, import and balancing of demand across much larger geographical regions (EC, 2006, 2011, 2013).

In parallel to this institutional dis-integration and liberalization of the sector, new forms of electricity generation have grown in importance, especially from renewable sources of energy. These have posed challenges for grid systems, to which they need to connect: these generation plants are generally much smaller in scale and more dispersed than conventional power plants, and, especially in the case of wind power, less predictable and intermittent in their output. Grids are having to adapt to this changing pattern of generation; for example, a small, localized plant may connect directly to a distribution rather than a transmission network. Accommodating the variable input of renewables remains costly and technologically difficult (Schaber et al., 2012).

2.2. Grids reaching offshore

Comprehensive electricity networks now serve the great majority of populated areas in developed nations (Fig. 1, Map C). However, they are now extending their reach offshore. The manner in which marine regionalization is happening in relation to grid