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Values in the Smart Grid: The co-evolving political economy of smart distribution

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HIGHLIGHTS

- Smart grid investments can benefit municipal economic development.
- Drawing on urban political economy we describe these values.
- New values alter the smart grid investment problem.
- New integration of urban policy and DNOs are proposed by this research.
- Socio-technical approaches are enhanced by urban political economy and vice versa.

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ABSTRACT

Investing in smart grid infrastructure is a key enabler for the transition to low carbon energy systems. Recent work has characterised the costs and benefits of individual "smart" investments. The political economy of the UK electricity system, however, has co-evolved such that there is a mismatch between where benefits accrue and where costs are incurred, leading to a problem of value capture and redeployment. Further, some benefits of smart grids are less easy to price directly and can be classified as public goods, such as energy security and decarbonisation. This paper builds on systemic treatments of energy system transitions to characterise the co-evolution of value capture and structural incentives in the electricity distribution system, drawing on semi-structured interviews and focus groups undertaken with smart grid stakeholders in the UK. This leads to an identification of municipal scale values that may be important for business models for the delivery of smart infrastructure. Municipalities may thus pursue specific economic opportunities through smart grid investment. This supports recent practical interest in an expanded role for municipalities as partners and investors in smart grid infrastructures.

1. Introduction

"…..the inherent economic viability and wealth of a city is intrinsically linked to its capacity to supply heat and power and the infrastructure, whether that's roads, telecommunications or energy infrastructure…." (Interviewee, 2014).

Whilst there is no universal definition of what makes an electricity distribution grid "smart", Xenias et al. (2014) define the main features of a smart grid as an energy network that can: manage embedded suppliers, communicate between the producers and users of electricity, utilise ICT to respond to and manage demand, and ensure safe and secure electricity distribution. Current electricity distribution networks in the UK do not incorporate these features and so (save some demonstration projects) may still be regarded as forming "dumb" grids that are maintained to accommodate one way power flow and ensure security of supply (Balta-Ozkan et al., 2014).

Smart Grids form a key part of the transition to low carbon energy systems. The UK's energy regulator Ofgem has estimated

Abbreviations: DCPR, distribution price control review; DE/DH, distributed energy and district heat; DNO/DSO, distribution network/system operator; DSR, demand side response; DUoS, distribution use of system; ESCo, energy service company; GVA, gross value added; kV, kilovolts; LEP, local enterprise partnership; NUP, new urban politics; PPA, power purchase agreement; RE, renewable energy; RIIO, revenues incentives innovations outputs; RPI-X, retail prices index – "X"; SME, small to medium enterprise

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that meeting electricity system decarbonisation targets compatible with the UK's Climate Change Act (2008), would require up to £32bn of investment in distribution assets by 2020 (Ofgem, 2010a). Some recent scholarship has analysed the costs and benefits of individual "smart" investments (De Castro and Dutra, 2013; Faruqui et al., 2010; Jackson, 2011); yet many of these approaches analyse only those economic values that can be captured by the utility deploying the technology. As such the "benefit" element of the cost benefit analysis for smart grid investment, is bound to those revenues which accrue to the investing utility (Giordano et al., 2012). However, there are geographically specific values that accrue to non-traditional actors from smart grid deployment. In this paper, we argue these values could be captured under different business models for smart grid investment. We demonstrate the wider benefits of smart grid investments by examining the local economic development benefits that can accrue to city-regions. We draw on two literatures to describe the current mismatch between traditional and alternative valuations of the smart grid. These are socio-technical transitions literatures, and urban political economy. Bringing these two literatures together with empirical evidence from interviews and focus groups, we show how new business models for smart grid investment can be proposed with a greater role for municipal governance.

This paper is structured as follows: Section 1.1 describes the emergence of a co-evolutionary understanding of large system change. We link this to the need for an understanding of urban political economy to underpin our analysis, given a new interest in energy infrastructure at the city-regional scale. This leads to our research questions. Section 2 sets out the methodology for the study. Section 3 begins with a description of the traditional appropriation of value for UK smart grid investments, followed by substantive analysis of the economic values that smart grids confer on cities. We then propose a new reading of the smart grid investment problem, and utilise this analysis to extend our understandings of value in the smart grid. We conclude with policy implications and by arguing that urban economic development resources may find smart grid infrastructures productive avenues for investment.

1.1. Co-evolution of technical and social elements in the UK's distribution infrastructure

The liberalisation and privatisation of the UK energy system led to competitive markets being created for generation and supply whilst transmission and distribution functions were moved to a regulated approach (Bolton and Foxon, 2013). The complexity and interconnectedness of these liberalised energy systems has led to a broad acceptance that they exhibit traits of "large technical systems" in that they are complex, heterogeneous systems consisting of physical assets such as machinery, ICT, and the built environment, alongside non-physical artefacts such as companies, regulations, investors, societal practices and politics; each of which are interdependent (Hughes, 1983; Joerges, 1998; Geels, 2006). Socio-technical transitions approaches describe these large technical systems as multi-layered interactions between socio-technical landscapes, regimes and niches (Verbong and Geels (2010); Geels, 2004). A further literature on technical innovation systems is typically focussed on individual innovations and the processes by which they evolve within particular social and economic contexts (Hekkert et al., 2007; Bergek et al., 2007). Innovation approaches describe how technologies and practices can exhibit parallels to biological evolution such as variation, selection and retention. Both approaches are complementary (Markard and Truffer, 2008; Foxon, 2011) and allow researchers to characterise complexity in large systems and theorise ways to manage system transitions that are more compatible with sustainable futures (Kemp and Rotmans, 2005). Foxon (2011) incorporates these approaches with evolutionary approaches to economic change, to propose a "co-evolutionary" framework for analysing a transition to a low carbon economy; this approach "seeks to identify causal interactions between evolving systems" (Foxon, 2011, p. 70). These "systems", (technologies, institutions, user practices, ecosystems and business strategies) co-evolve to produce particular system trajectories that are more or less aligned with low carbon futures. Co-evolution operates on the basic ecological premise that two or more populations of entities can influence each other's evolution (Murmann, 2003, 2013; Norgaard, 1994). As such Foxon (2011) follows Nelson and Winter (1982) and Freeman and Louca (2001), describing these systems as subject to their own internal evolutionary dynamics, but as also being affected by evolutionary dynamics in the related systems. These elements of the system *co-evolve* because they have significant causal impact on each other's ability to persist (Murmann, 2003; Foxon, 2011). As such, studying these interactions and co-evolutionary processes in infrastructure systems such as electricity distribution, can facilitate a deeper understanding of the actual processes that lead to change, offering a greater chance of successfully orienting these systems towards low carbon futures.

Recently co-evolutionary approaches have described elements of the energy system. Bolton and Foxon (2013) analyse the co-evolution of energy distribution regulation in the UK, with the business strategies of distributed energy schemes. They find that a regulatory imperative, consumers' legal right to switch supplier, constrains the deployment of both individual schemes and aggregated low carbon generation options (Bolton and Foxon 2013). Hannon et al. (2013) analyse the co-evolution of UK electricity supply business models, investigating both traditional utilities and energy service companies (ESCos). Rather than relying on a business model based on distant consumer relations and kWh unit volume, ESCos build close consumer relations and offer final energy services for predefined prices, drawing revenue streams from energy savings. Focussing on supplier business models demonstrates the susceptibility of the energy system to narrow conceptions of energy value. Giordano and Fulli (2012) propose that amended business models for distribution operators and system aggregators could be enabled by smart meters and electric vehicles, and may alter the value capture opportunities in the whole system. They conclude by calling for further research to "capture the disruptive value of new business models and platforms" (Giordano and Fulli, 2012, p. 258). We follow this call by analysing the co-evolution of business model elements of the UK distribution system with institutions at the urban scale, to examine how this may yield new ways of thinking about "values in the smart grid" and how to capture them.

The importance of identifying different business models for infrastructure delivery has been highlighted in the UK Governments National Infrastructure Plan (HM Treasury, 2013). This research directly supports this search, forming part of the iBUILD[1] (Infrastructure Business models, valuation and Innovation for Local Delivery) project (HM Treasury, 2013, p. 98); iBUILD focuses on the city and city-regional scale of infrastructure delivery. Infrastructure business models in particular differ from those associated with the delivery of products and services due to high capital barriers to entry, the difficulties of excludability, their tendency toward natural monopoly, and the complexities of value capture in infrastructure delivery (Bryson et al., 2014). Whilst we recognise the utility of detailing the specific attributes of business models in particular parts of the system after Hannon et al. (2013); we see the need for a definition of *infrastructure* business models. We follow Bryson et al. (2014) in defining these as "The system of

[1] See https://research.ncl.ac.uk/ibuild/.