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The role of the state in sustainable energy transitions: A case study of large smart grid demonstration projects in Japan

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HIGHLIGHTS

- Smart grids introduce evolutionary changes in energy management systems.
- The Japanese model is government-led, community-oriented, and business-driven.
- The Japanese government has demonstrated its high governing capacity.
- But the limitations of the government have constrained the smart grid developments.
- More attention needs to be given to regulatory changes and non-state actors.

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ABSTRACT

Smart grids represent one of the most significant evolutionary changes in energy management systems as they enable decentralised energy systems, the use of large-scale renewable energy as well as major improvements in demand-side-management. Japan is one of the pioneers in smart grid deployment. The Japanese model is characterised by a government-led, community-oriented, and business-driven approach with the launch of four large-scale smart-community demonstration projects. Our case study of large smart grid demonstration projects in Japan found that the Japanese government has demonstrated its high governing capacity in terms of leadership, recombinative capacity, institutional capacity, enabling capacity, and inducement capacity. However, the major limitations of the government in introducing some critical regulatory changes have constrained the smart grid deployment from advancing to a higher-order form of smart grid developments. This paper calls for more attention to be given to the importance of regulatory changes that are essential to overcome the technological lock-in, and the complementary roles of non-state actors such as the business sector and consumers to strengthen the governing capacity of the state.

1. Introduction

Climate change impacts, rising energy costs, and renewed concerns over nuclear risks after Fukushima have heightened the urgency for a transition to a low-carbon future. Smart grids represent one of the most significant evolutionary changes in energy management systems. Through applying information technology to existing electric distribution networks, smart grids provide opportunities to integrate more decentralised supply systems (e.g. renewable energy) and allow consumers to take more proactive roles in demand-side-management (Verbong et al., 2013). Such grids are increasingly being adopted and implemented in developed and developing economies (e.g. EU, the US, South Korea, Japan, and China) (World Energy Council, 2012).

Smart grids have adopted different development pathways across the world (Verbong et al., 2013). For example, despite of some pockets of successes in, for example, Texas in the US and Ontario in Canada where millions of households have installed smart metres (Faruqui et al., 2011), smart grids in many other places have been mostly limited to demonstration projects and have not achieved market diffusion. Despite these differences, a common strategy is the emphasis on the use of pilots and demonstration projects. The four large-scale smart community demonstration projects in Japan, the smart grid testbed on Jeju Island in South Korea, and a large number of dynamic pricing pilots in the US are some examples of this global trend (Faruqui and Palmer, 2011; Ling et al., 2012; Mah et al., 2012b).

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This paper presents a case study of the four major smart community demonstration projects in Japan. Our analysis focuses on the role of government in the process of smart grid diffusion in Japan. We examine, evaluate and explain the mechanisms, achievements and limitations relating to the role of government in smart grid diffusion.

Japan is a major hi-tech, industrialised country. It merits study because its government-led, community-based and business-driven approach to developing smart grids appears to differ from development pathways in other Western and Asian countries such as the US, South Korea and China. The establishment of the four large-scale smart grid community demonstration projects in four cities – Kyoto, Yokohama, Kitakyushu and Toyota – which involves more than 5000 households is a notable characteristics of the Japanese approach to smart grid developments. The post-Fukushima energy policies as well as unique developments of smart grids in Japan can provide useful data for analysis.

This project adopts a qualitative methdology to derive rich data for ascertaining the interrelationships between the government and other stakeholders, and the impacts of these relationships on smart grid deployment in Japan (Yin, 2003; Miles and Huberman, 1994). The qualitative methodology involves desk-top research, field observations and in-depth interviews with key stakeholder groups. We conducted fieldwork in May 2012 in Tokyo and three of the four localities where the demonstration projects are located, namely Kyoto, Yokohama and Kitakyushu. Eight face-to-face interviews were conducted with respondents from major stakeholder groups in Japan including the government, business, academics and NGOs. All of the face-to-face interviews were audio-recorded and transcribed. A list of the interviewees is provided in Appendix 1.

This paper is organised as follows: Section 2 discusses theoretical perspectives and provides a framework for our analysis. Section 3 provides an overview of the development of smart grids in Japan. It highlights some key contextual factors, and the features of the four large smart community demonstration projects. Section 4 examines and characterises the role of government. Section 5 critically assesses the achievements as well as the limits of state involvement, and the role of non-state actors particularly the business sector and electricity consumers. The final section offers some concluding thoughts.

2. Smart grids from a theoretical perspective: large demonstration projects, the role of the state and governing sustainability transitions

To develop our analysis of smart grid developments in Japan, we examine social science theories in the areas of technological innovation and energy governance. One of the major challenges in the development of emerging technologies such as smart grids, renewable energy, and electric vehicles is mainstreaming: moving from demonstration projects to larger scale diffusion (Egmonda et al., 2006; Hellsmark and Jacobsson, 2012) – a stage in technological innovation processes which has been identified by some scholars as the "valley of death" (Norberg-Bohm, 2000). In the literature on technological innovation, the importance of large-scale demonstration projects as a strategy to facilitate the diffusion of emerging energy and environmentally-related technologies has been extensively documented (see for example Berkhout et al., 2010; Hendry et al., 2010). Large-scale demonstration projects, which may take various forms including field trials, government-funded pilot projects and sustainability experiments (Berkhout et al., 2010), represent an important new source of innovation and capability-formation which are required to overcome the "valley of death". These demonstration projects may provide a process through which socio-technical learning can take place and new networks can be formed. They can also offer a protected space for emerging technologies to better manage cost reduction, technology innovation and market competition before they can become commercially viable and compete with established technologies (Berkhout et al., 2010; Norberg-Bohm, 2000).

Work on technological innovation has conceptualised this transition process – from development (technologies at the prototype and demonstration stage) to niche markets and to mass market – in different ways (The Danish Government, 2011). The work by Hendry et al. (2010), for example, has identified three structural steps for firms to get to market via demonstration projects: validate an application for a particular market, cultivate partners, and use discounts and incentives to encourage ordinary customers to participate – to create satisfied customers and "product champions".

In the context of smart grid technologies, the Department of Energy (DoE) in the US has based on a number of funded research projects (Litos Strategic Communication, 2008; SEI, 2009, 2011) and published a smart grid maturity model. This model provides a framework for smart grid transformation by conceptualising the transformation process into five stages. These are: initiating, investing, integrating, optimising and innovating. This model contributes to the literature on smart grid in two major ways. Firstly, it provides a framework for examining and evaluating the current state of smart grid deployment as well as developing future strategies (SEI, 2011). Secondly, it sheds light on the non-technical elements, in particularly the business and societal ones, in smart grid development. It highlights the importance of the business cases, environmental and societal benefits in the higher levels of the smart grid maturity model. This model suggests that in order to move away from the lower levels which feature the existence of visioning and strategies, new business models must be in place so that not only operational benefits but also environmental and societal benefits can be realised.

Another theme of the literature which is useful to our analysis is the literature on energy governance. Governance is a purposive guiding process in which a social system coordinates, steers and manages itself (Paquet, 1999). The design and operation of smart grids are fundamentally different from conventional systems which are centralised, fossil-fuel based (Mah et al., 2012a). Important features of smart grids – including the emergence of new two-way utility-consumer relationships, new actors (e.g. independent power producers) and new business models in more decentralised energy systems (Devine-Wright, 2007; Parag and Darby, 2009) – present major governing challenges in the transition process of the energy socio-technical system. These governing challenges are associated with path dependence, monopoly power, resistance to pricing reforms, and behavioural inertia (Mah et al., 2012a).

A major part of understanding the governing processes is the focus on the role of the state in the literature of governance. The state is broadly understood as the executive, legislative, and judicial apparatus of the nation (Hall, 1993). The literature has argued that states assume a central role for technological and industrial innovation (Evans, 1995; Jänicke, 2005). Due to externalities of emissions and the existence of monopoly power and inertia (Goldthau et al., 2010; Norberg-Bohm, 2000; Zhao et al., 2012), the government has two major functions: firstly, to introduce policies that facilitate structural changes by overcoming information, coordination and externality issues; and secondly, to introduce policies that aim at protecting some selected firms and industries (Lin and Monga, 2010). Bulkeley and Kern (2006), on the other hand, introduce an important distinction between four types of governing modes through which governments may govern: self-governing, governing by authority, governing by provision and governing through enabling.