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The salience and complexity of building, regulating, and governing the smart grid: Lessons from a statewide public–private partnership ☆

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HIGHLIGHTS

- Smart grid introduces new socio-political variables into the electricity distribution industry.
- Smart grid technology engenders high degrees of issue salience and technical complexity.
- Smart grid deployment requires extensive industry-regulator collaboration.
- Smart grid will likely not have a significant impact on the restructuring of electricity regulation.

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ABSTRACT

Smart grid deployment unfolds within a diverse array of multi-institutional arrangements that may be too fragmented and decentralized to allow for the kind of large-scale and coordinated investments needed to properly deploy the smart grid. This case study provides an account of how one state arranged for and eventually deployed smart grid technology to over 85 percent of its resident. The study asks: does the deployment of the smart grid introduce new socio-political variables into the electricity distribution industry? To make sense of the socio-political variables shaping the industry and regulators, the Salience–Complexity Model is used to assess whether the smart grid raises or lowers the level of public scrutiny caste upon the industry (issue salience) and the level of technical capacity needed to execute and utilize the smart grid (technical complexity). The conclusions to be drawn from this study include: smart grid technology heightens the issue salience and the technical complexity of electricity distribution, but that the smart grid will likely not have a significant impact on the restructuring of electricity regulation.

1. Introduction

The evolution of the traditional analog power grid into a digital smart grid is slowly taking root within the United States (U.S.) and across the globe. The Global Smart Grid Federation (2012) defines the smart grid as "an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies." Although wide-spread deployment of the smart grid is not without significant challenges, the opportunities and expected benefits promised by industry and policy leaders have been compelling enough for utility companies and their regulators to begin a large-scale strategic capital investment into the retooling of the nation's electricity infrastructure.

The smart grid is touted for its potential to transform relationships between consumers, producers, and distributors of electricity. Proponents of the smart grid suggest it will lead to fewer and shorter power outages and grid disturbances; improved asset utilization, resulting from lower system peak demands; informed consumers who can better manage electricity consumption and costs; reduced costs, resulting from operational efficiencies; positive environmental impacts suc4h as reduced greenhouse gas emissions; and economic opportunities for businesses and new jobs for workers (U.S. Department of Energy, 2012a, p. ii).

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In a recent articles focusing on the technical and governance consideration of the smart grid, McHenry (2013), p. 834 breaks smart grid technology down into three elements: "systems that measure; systems that collect/communicate the measured data; and systems that analyze the data". To collect and communicate data, the smart grid integrates electric transmission and distribution providers with energy consumers through the development of an integrated communications "backhaul" infrastructure that allows for the transmission of electricity consumption data in real time. The technologies associated with the smart grid include upgrades to electric transmission systems, including the integration of synchrophaser technologies, wide area monitoring and visualizations, and the use of line monitors. Smart grid upgrades also involve electric distribution systems, with the deployment of automated switches and capacitors, and the utilization of distribution management systems. A third dimension of the smart grid is the deployment of advanced metering infrastructure (AMI) or "smart meters" at commercial and residential properties that are, in turn, linked to back-office demand management systems. AMI's essentially provide the real time measures of energy consumption. At the present, smart meters are the most visible feature of smart grid technologies and provide the vial link between utilities and their consumer bases. The final element of smart grid technology is the eventual utilization of customer-driven devices, including the use of in-home displays, programmable communicating thermostats, home area networks, web portals, direct load controls, and smart appliances, to assist consumers in managing their electricity energy consumption. These devices are to provide analysis for energy consumers to assist them in making informed energy consumption decisions. It should also be noted that smart grid infrastructure provides a foundation on which new energy technologies will emerge, including wide spread use of plug-in electric vehicles and microgrid, localized energy generation systems.

Those who have followed smart grid investments have noted that in order for expected benefits of the smart grid to be realized, substantial collaboration is required among utility companies, and among the utility industry and federal, state, and local regulators (Giordano and Fulli, 2011). The nature of this collaboration needs to be better understood, as new pricing schemes, the large scale collection of detailed forms of information regarding people's energy consumption patterns, and existing mixed patterns of regulatory and market mechanisms all add levels of technical complexity to the evolving nature of smart grid governance and operations. These factors also bring a higher order of salience to an industry that has attracted significant attention.

The generation and distribution of energy to a given region has been historically framed as the juxtaposition between regulatory and market forces (Andrews, 2000). Energy regulation has also historically been marked by higher orders of scrutiny and conflict, and higher orders of technical complexity as compared to most other regulated sectors (Gormley, 1986). In recent decades, these situations have only been accentuated as deregulation trends have transformed the energy regulatory landscape across many states in different ways (Ka and Teske, 2002). The heterogeneity of energy distribution arrangements across different states (and nations) suggests that smart grid implementation will most likely unfold within a diverse array of multi-institutional arrangements. Those who have studied the role of innovation in the energy sector have noted that there is a "need for empirical research and comparative case studies examining deployment of specific emerging technologies in and across different states to enable characterization of complex interactions among the many socio-political variables that have potential to influence energy technology deployment at the state level" (Stephens et al., 2008, p. 1226). This paper attempts to address this gap in our understanding, with a particular focus on the evolution of the multi-institutional arrangements required to implement and govern the new, smart grid. As such it builds on a recent article by Agrell et al. (2013), p. 657 who place an emphasis on "the interaction between agents such as the regulator, network company and energy producer involved in [smart grid] investments" applied to the European context. By providing rich and rigorous cases of smart grid deployment within an individual state in the U.S., new insights for industry and regulators may be drawn. In particular, such case studies can help to answer the question: does the deployment of the smart grid introduce new socio-political variables into the electricity distribution industry? In our conclusion we also suggest how this case offers lessons learned for raising issue saliency and addressing technical complexity for other new energy technologies.

1.1. Policy context

The drive to smart grid deployment in the U.S. has been fueled by a $3.4 billion investment in smart grid infrastructure. The Department of Energy (DOE) Smart Grid Investment Grant (SGIG) program was authorized by the Energy Independence and Security Act (EISA) of 2007, Section 1306, and was eventually amended by the American Recovery and Reinvestment Act (ARRA) of 2009. The stated purpose of the grant program is: "to accelerate the modernization of the nation's electric transmission and distribution systems and promote investments in smart grid technologies, tools, and techniques that increase flexibility, functionality, interoperability, cybersecurity, situational awareness, and operational efficiency" (U.S. Department of Energy, 2012b). The placement of smart grid technology follows the arc of energy transmission, distribution, and consumption flows.

To aid in the scoping, deployment, and use of new smart grid technologies, such as electric distributions systems (EDSs) and advanced metering infrastructure (AMI), the World Economic Forum (WEF) has published a document outlining a series of best practices for industry and regulators. It emphasizes collaborative partnerships between industries and regulators and other policy, stating:

> The execution phase [of smart grid implementation] is a dynamic environment, with various elements of the technology and business processes being challenged and revised on a regular basis. Such complexity requires a clear governance structure from the scoping stage onwards, with a commitment throughout the delivery phase and strong project management capable of ensuring alignment and communication between all consortium partners and workstreams. (World Economic Forum (WEF), 2010, p. 35)

National Science and Technology Council (NSTC) (2011) published a "policy framework for the twenty-first century grid" that also places strong emphasis on partnership development and collaborative governance. These best practices stress capitalizing on public–private partnerships to achieve the kinds of successes that are promised by the smart grid. The maturity model also places significant emphasis on the need to align and couple strategic, tactical, and operational management within individual organizations as well as across organizations.

These and other sources, including publications put out by industry experts, emphasize the need for reforms relative to the governance of energy distribution networks (McDonald, 2009; Hendricks, 2009; Stanton, 2011). This literature suggests that the governance of the smart grid may serve as a useful umbrella under which agreements can be devised, technical complexity revealed and reduced enough to mitigate risk and uncertainty, and new policy tools designed and used to ensure successful outcomes. An article titled "Wired for Progress 2.0" published by the National