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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

Center for American Progress sums up the sentiments of recent literature pertaining to smart grid governance and policy:

> Current electricity grid-planning processes are too fragmented and decentralized to enable the sort of coordinated and large-scale transmission investments that will be required if America is to promote high levels of renewable energy delivery to the national grid. The policy direction and institutional mechanisms for upgrading technology and dramatically improving reliability, security, and efficiency do not now exist. (Hendricks, 2009, p. 17)

Given that policy direction and institutional mechanisms for upgrading the grid are needed, pulling lessons from some of the early adopters of smart grid technology may yield extremely useful insights for the future.

1.2. The salience–complexity model

Introduced in the middle 1980s as a way to describe and categorize different regulatory subsystems, Gormley's Salience–Complexity Model has become one of the major conceptual frameworks used to classify and analyze regulatory subsystems. The Salience–Complexity Model consists of a basic four square matrix juxtaposing the high to low degree of "issue salience" against the high to low degree of "technical complexity" of any given regulatory regime. In this model salience applies to the degree of public attention and potential conflict arising out of the regulatory subsystem while complexity refers to technical complexity and the level of professional expertise required to understand the issue and provide adequate oversight.

Gormley places different regulatory regimes into one of the four boxes comprising the Salience–Complexity matrix. Fig. 1 provides a basic overview of his initial classification of regulatory arenas. This framework has been extensively applied to the study of these areas and has been used to analyze the roles that conflicts and technical complexity play in the operation of regulatory subsystems (Gerber and Teske, 2000).

In addition to classifying functions into one of four domains, the Salience–Complexity Model is also used to describe the different ways that regulatory relationships are mediated. Gormley refers to these distinctions as the "regulatory politics typology" built around four distinct arenas. Space precludes a detailed discussion of each quadrant and the type of action arena most common to them. However, it is important to note that those areas where issue salience and technical complexity are high (as, for instance, in electric utility regulation), the "operating room" serves as the location for regulatory subsystem activity. In these environments, there is "simultaneous pressure for accountability *and* expertise" (italic added) (Gormley, 1986, p. 611). In these situations, elected officials tend to focus on procedural reforms, focusing attention on the creation of regulatory agencies or boards that take on the responsibly and the political heat for making regulatory decisions. The critical decisions made in these situations tend to be by upper level bureaucrats who rely on the technical expertise of their staff and expert testimony. Professional norms and industry standards tend to dominate governance of these regulatory subsystems. In the operating room of electricity regulation, elected officials will have a high degree of interest in many of the details informing certain decisions, but that the technical nature of many of these decisions will require them to defer to technical experts from public service commissions and boards, state agencies, and industry. The question posed at this juncture is: how, and to what extent, has the introduction of smart grid technologies led to higher salience and higher orders of complexity?

According to Gormley (1986), issue salience may change (i.e., increase or decrease) due to a number of different factors: an underlying problem worsens or improves; demographic conditions change; or an issue is redefined by policy entrepreneurs. Gormley also suggests that technical complexity may be increased or reduced as the result of one of the following factors: a new technology generates new policy options; changes in levels of competition alter the need for detailed regulations; or an "optimizing" task is redefined as a "satisficing" task (e.g., broadcast spectrum allocation) or vice versa (e.g., occupational safety) (p. 599). In this study, the extent to which salience and complexity changed as a result of the alignment of resources that lead to the eventual deployment of smart grid technologies is examined.

2. Methods

A comprehensive case study approach (Yin, 2009) is employed to study the eEnergy Vermont (eEVT) case. A series of fifteen face-to-face interviews with industry and government leaders were conducted over a three-month period during the summer of 2011. These interviews were coded for primary and secondary themes. Additional follow-up phone calls were undertaken to bring the case up to the present. Content analysis of news media accounts, industry and government reports, legislative and board hearings, and transcripts was also used. A timeline of events leading up to the writing and awarding of the 2009 American Recovery and Reinvestment Act (ARRA) grant was constructed, as well as many of the key activities unfolding during the grant's implementation phases. From this assessment, a series of critical success factors surfaced. To complete the analysis, the Salience–Complexity Model was used to ascertain how the smart grid scoping and deployment phases were carried out within a highly complex and visible policy environment. To track the factors that led up to this initiative, we must begin with the early efforts of Vermont utility providers and regulators to advance energy

		Technical Complexity	
		Low	**High**
Public Salience	**High**	**HEARING ROOM** Electoral incentives and legal precedence • Landuse zoning regulation • Affirmative action regulation • Immigration regulation • Gun control • Abortion	**OPERATING ROOM** Professional norms and industry standards • Electric utility regulation • Water and air quality regulation • Health care regulation • Hazardous waste regulation • Power plant siting
	Low	**STREET LEVEL BUREAUCRATS** Standard operating procedures • Building inspections • Billboard regulations • Food service inspections • Motor vehicle inspections • Election regulations	**BOARD ROOM** Economic motives • Cable television regulation • Antitrust regulation • Securities regulation • Banking regulation • Transportation regulation

Fig. 1. Salience–Complexity Model of Regulatory Systems (adopted from Gormley, 1986).

efficiency and renewable energy goals. The details of the case that follows have been extracted from a report published by XXXXXX. The longer case study provides details regarding the key actors, critical events, policy development work, and industry focus. We summarize some of the key highlights of this history in Appendix A.

2.1. eEenrgy Vermont collaborative case study

The State of Vermont, known as the first state in the U.S. to deploy a near statewide smart meter infrastructure, serves as an important early example of investment in smart grid infrastructure. Vermont's story thus far has been noteworthy for several reasons. The level of collaboration between the state's utility companies and cooperatives is noteworthy and long standing. A strong policy environment has led to the enactment of a series of energy conservation and renewable energy initiatives. The state's energy distribution and transmission organizations have maintained relatively stable and collaborative relations with state regulators. These factors contributed to the creation of the eEnergy Vermont (eEVT) Collaborative, enabled by investments made in smart grid infrastructure by Congress and the U. S. Department of Energy (DOE).

The Vermont case demonstrates a clear and compelling example of a public–private partnership in the area of large-scale, public good capital improvements. To develop this case, three questions were asked: How did Vermont, with its twenty-two different utilities and cooperatives, manage to pursue and successfully obtain the resources needed to implement a statewide smart grid infrastructure? What factors led up to the development of the eEVT Collaborative, the public–private partnership designed to implement smart grid infrastructure? How did the issue salience and technical complexity of smart grid technology play a role during the scoping and implementation phases of this project?

Vermont is the first state to scope and execute a statewide plan to install and utilize smart meters for 85 percent, the vast majority of all electricity consumers in the state. In October 2009, a collaborative of twenty Vermont electric distribution utilities, the State's efficiency utility (Vermont Energy Investment Corporation), and a transmission utility (VELCO), collectively known as "eEnergy Vermont," were awarded a SGIG grant worth $69 million. The amount was matched with equal investments by local and regional utilities, generating a total of $138 million to provide smart meters for 85 percent of all electricity consumers in Vermont by 2013.

3. Results

This case study and Salience–Complexity analysis of the deployment of smart grid infrastructure in Vermont yields two types of results: (1) the policy and industry drivers of smart grid deployment in Vermont; and (2) the issues impacting the salience and technical complexity of the smart grid as viewed through the lens of regulators, industry, and consumers.

3.1. Policy and industry drivers of smart grid deployment in Vermont

A variety of factors led to the development of the eEVT Collaborative and the statewide effort to install smart meters to 85 percent of the state's households and businesses. In this section we highlight the major features of the Vermont case that appear to have driven innovation in this sector in this state.

3.1.1. Building on federal priorities

Federal legislation and grant programs have been key drivers in advancing Vermont's capacity to implement smart meters. The federal government has adopted policies that address national priorities of strengthening energy independence and reducing carbon emissions. There is growing recognition that adoption and deployment of smart grid technology could provide a path forward in addressing key national priorities. Three pieces of recent legislation highlight the federal government's regulatory commitment to the development and implementation of smart grid technology: the Federal Energy Policy Act (EPACT) of 2005; The Energy Independence and Security Act (EISA) of 2007; and The American Recovery and Reinvestment Act (ARRA) of 2009 (which provided funds for grid modernization, $4.5 billion of which was designated for SGIGs).

The EPACT (2005) and EISA (2007) helped to focus the attention of state regulators and utility industry leaders on smart grid technologies. These acts stimulated a series of efforts in Vermont, beginning with the development of statewide policies relating to net metering and eventually smart metering, which created the foundation for the industry-regulator partnership to follow. The availability of the ARRA funding made it possible for Vermont to pursue its statewide strategy. It is evident that without the legislative initiative of the federal government and the availability of federal funding to leverage private and non-federal public resources, the eEVT initiative would not have been possible.

3.1.2. Coupling of state policy streams

Although the Vermont Assembly Legislature and Executive branch did not formally address policies surrounding smart grid technology until the late 2000s, Vermont has a long legacy of forward-looking energy policy, particularly in regarding energy efficiency and renewable energy. These highly salient policies have contributed to the expansion of smart grid technology and energy efficiency in Vermont, and are representative of a broader commitment by state level policymakers to the strategic evolution of the state's energy policy. Vermont's history of progressive energy efficiency initiatives created a pool of political and social capital that was drawn on in recent years to develop the smart grid scoping, planning, and implementation effort.

The history of innovative energy policy may best be understood within the context of the coupling of "policy streams" that open policy windows (Kingdon, 1984). In the Vermont case these couplings occurs within and across two domains:

- Coupling of energy efficiency and renewables, which is recognized in the long legacy of progressive energy policy, particularly energy efficiency and renewables (e.g., Land Use Planning Law focus on efficiency, the Sustainably Priced Energy Enterprise Development Program renewable portfolio mandate, and the Vermont Department of Public Service's (VDPS) investigation of smart meters and time-based rates)
- Coupling of smart grid backhaul needs and telecommunications infrastructure, which is recognized in the statewide focus on communications infrastructure (e.g., the e-State Initiative of 2007 and development of VT Telecommunications Authority later that year focused on un-served and under-served areas, with a long-term goal of broadband and mobile phone infrastructure throughout the state)

The capacity of the Vermont Public Service Board (VPSB), the VDPS, industry leaders, and elected politicians to cast the smart grid as an extension of the State's energy efficiency and renewables goals heightened issue salience in a positive way, priming consumer perceptions of the smart grid as necessary element of the State's long term energy strategy. The heightened technical complexity of the smart grid, particularly the need to couple telecommunications infrastructure with electricity distribution infrastructure, was a serious challenge for this rural state.

3.1.3. Innovative regulatory environment

Vermont's legislative commitment to energy efficiency and implementation of smart grid technology has been supported by statewide regulatory bodies who have attempted to work with stakeholders in a cooperative manner and pave the way for innovation within the state's energy sector. The Vermont PSB encourages collaboration by organizing working groups to address issues like rates, consumer interface and communications, cybersecurity, and interoperability. These working groups, which can be requested by stakeholders (e.g., consumers, utilities, and public officials) at any time, provide an informal opportunity to dialogue outside the official hearing process.

During the fall of 2008, local utilities communicated with the PSB regarding rate recovery assurance as it related to the implementation of smart metering. Utility companies looked to the DPS to mitigate some of the risks associated with the installation and implementation of smart meters. The PSB viewed the issue as a matter of cost effectiveness, and approved a measure to provide cost recovery assurance for utilities whose plans were approved by the PSB. The decision benefited the then state's two largest utilities, Green Mountain Power (GMP) and Central Vermont Power Service Corp (CVPS), by ensuring that they were not bearing the smart grid investment burden alone, and the PSB, by ensuring that utilities would pursue smart metering and maintain open communication with the PSB about their plans, allowing the PSB to ensure the "interoperability of the system." Vermont's case follows the recommendations stemming from studies of other states, which suggest that, "without prior guidance from regulators, utilities will not necessarily anticipate all the attributes necessary to meeting public-interest requirements" (Stanton, 2011, p. 61).

The existence of an innovative regulatory environment also follows the recommendations laid out by the Smart Grid Maturity Model developed by Carnegie Mellon University. One of the critical features of successful implementation is the building of a multidisciplinary team with clear roles and design authority, "The scoping phase is an important window to establish the capabilities and governance for implementation. Pilots should ensure that they gain early alignment on the goals and objectives across the consortium members and senior management commitment" (World Economic Forum (WEF), 2010, p. 27). This appears to have happened in the Vermont case.

3.1.4. Champions, a collaborative utility industry, and project management framework

The role of one key policy entrepreneur, VELCO Vice President Kerrick Johnson, was vital in moving the planning for the ARRA grant forward. The roles of "policy entrepreneurs" have been understood as essential features of successful public policy execution (Crenson and Ginsberg, 2002). Johnson's efforts, coupled with the leadership from Vermont's congressional delegation and two Vermont governors, appears to have played a vital role in this case.

The Memorandum of Understanding (MOU) drafted by the ARRA working group laid out the project's scope, schedule, and budget early in the process. The six-page MOU provided a governance framework for the working group and helped it to work as a unified entity. With the ARRA working group as the hub of this implementation network, industry representatives, and government officials met regularly to identify problems, derive solutions, and make strategic decisions regarding the implementation of smart meter infrastructure. The willingness of these stakeholders to share information, discuss differences, and work together to find solutions has been a critical feature of the eEVT Collaborative's success to date. This collaborative capacity is evidenced by a joint effort of CVPS, GMP, VELCO, the VTA, and the DPS to devise a common AMI systems procurement procedure. Together, they issued a RFP soliciting bids from commercial communications carriers for supporting utility smart grid communicators and state broadband communication goals. In addition to the ARRA working group meetings, the DPS hosted several meetings with local and regional CEOs of the state's utilities to clarify the private industry's positions on topics related to smart grid, like dynamic pricing.

The experiences above reflect a model of collaborative governance marked by durable relationships between utilities, regulators, and other stakeholders who are able to openly discuss ways to pursue mutually beneficial objectives and mediate conflicts. This collaborative governance approach was guided by strategic leadership originating from members of the Vermont Congressional delegation, state utility leaders, and government agency heads. The willingness of utilities to work together to develop an expected vision of smart grid implementation has been noted as a key success factor in other studies as well (McDonald, 2009).

3.2. Issue salience in the Vermont energy distribution system

In order to analyze the extent to which smart grid meter deployment altered the regulatory landscape of Vermont's energy distribution system we turn to the Salience–Complexity Model. In this case, the salience of the smart grid as an issue was fueled by two factors: the evolving nature of energy policy in the state, which built upon the ongoing salience of energy conservation as an issue, and the vital role of policy entrepreneurs in framing the smart grid as a solution to the ongoing challenges with conservation and renewable energy. With VEIC, the first known energy conservation utility in the world, the State of Vermont already possessed a strong track record of innovation in the energy distribution field. The collaborative capacity developed over several decades of energy conversation initiatives paved the way for higher salience of smart grid deployment.

The coupling of smart grid deployment with energy conservation and renewable energy initiatives was critical during the early phases of a deployment strategy beginning in 2007. Meier (1991) has observed that, "Issue salience affects the rewards of the policy process; the greater the potential political benefits that can accrue to a policy actor who influences public policy" (p. 709). It was very apparent to the early policy entrepreneurs that the benefits of advancing a smart grid agenda outweighed the risks of failure. In this case, the salience of the smart grid, "increases the rewards for participation" (Meier, 1991, p. 709). Industry and government leaders sought the rewards that come with being an early champion of new technology that promises to deliver cheaper and more efficient energy. It becomes apparent from this case that issue salience was a critical feature of the planning and scoping phases of smart grid deployment strategy.

Issue salience around the smart grid continued to play a key role during the deployment phases. Concerns about the health effects of wireless meters and the privacy of consumers surfaced during the later phases of the Vermont case as the deployment of smart meters commenced. Those who have studied smart grid deployment have noted that the relevancy of consumer privacy and the specter of health concerns have been raised in relation to the smart grid. However, they have also noted that, to date, little sustained consumer resistance based on privacy or health concerns has surfaced in those regions deploying smart gird technologies (Krishnamurti et al., 2012).

In Vermont, to respond to some consumer concerns about privacy and health, smart meter opt-out provisions were adopted by the state legislature without the consent of the utility industry and out of the purview of the PSB. This demonstrates how the "operating room" of energy regulation can be taken over by lawmakers when the issue salience is extremely high and driven by interest group pressures.

Regarding the treatment of consumer data, each utility company possessed its own policy on consumer data that assumes that the ownership of the data resides with the consumer. However, several matters pertaining to the use of this data remain unsettled. It also remains to be seen what role the highly successful energy efficiency utility, VEIC, will play in helping to realize the potentials posited by smart grid proponents. Additionally, the use of smart grid data by third parties remains an open matter that has yet to be resolved.

Meanwhile, the concerns over health effects of smart meters have been taken up by the PSB and the Vermont Department of Health. These health concerns have been raised in the media and among some advocacy groups, particularly in California to thwart smart grid deployment. The concern being raised is associated with the radio-frequency radiation associated with the wireless technology (Barringer, 2011). A recent report issued by the Vermont Department of Health summarized the scientific data about radio frequency radiation (RFR) doses, concluding the their rates are lower than cell phones and pose little to no risk. Additionally, the institution of the no-cost opt-out option has dampened concerns from public advocacy groups in this area.

3.3. Technical complexity

Gormley (1986) has noted that "politicians are attracted by salience, repelled by complexity" (p. 603). Here, early agreements to pursue a smart grid deployment strategy were forged by the political and industrial leadership at the strategic level. Negotiating the technical requirements needed for successful deployment were then handed over to the tactical players of the industry and regulatory community. These industry experts from both the public and private sectors were charged with making sense of the high degree of complexity that accompanies smart grid deployment and interpreting this complexity back to the policy makers.

The technical challenges associated with smart grid deployment are substantial. In returning to Gormley's (1986) factors leading to changes in technical complexity, we find that the smart grid is a new technology that clearly, "generates new policy options" (p. 599). In terms of the technical complexity arising from the smart grid, several "operating rooms" are at work. At the national and even international level, the utility industry is organized around several industry-led associations that have been working on international standards for the smart grid. This work, championed by the National Institute of Standards and Technology (NIST), and supported by groups such as the GridWise Alliance, has developed a set of industry-wide standards to support interoperability and cybersecurity issues. The FERC is enforcing these standards, requiring all smart grid projects to comply with these standards. Thus, the operating room in which the industry regulates itself is being lead by professional industry experts, in collaboration with national level regulators like the FERC.

There still remain a very large number of technical considerations to be addressed at the scale of state level or individual utility level of implementation of smart grid technology. For example, selection of AMI technology from among a variety of different vendors is required. The fear of the eEVT Collaborative steering committee was that the decision to choose the "Betamax" version of the AMI (over the "VHS" version) was a real possibility, a concern that is common across the industry (McHenry, 2013, p. 837). The choice of AMI technology is relegated to each individual utility. However, in Vermont's case, the two largest utilities decided to work collaboratively to select a common AMI vender. It is worth noting here that these two utilities, GMP and CVPS, eventually merged.

Another area of significant technical complexity concerns how the smart meters are to communicate back to the utility companies, described as the "backhaul" capacity. As a rural state, Vermont lacks an extensive statewide broadband infrastructure. As the details of the case bear out, an important opportunity for coordination opened when VTel was awarded its own ARRA grant, helping to solidify a long-term plan to organize backhaul for the state. This result is, again, an example of how the operating room functions, with extensive negotiations between the strategic leadership, supported by their technical staff, and facilitated by the Vermont DPS. The integration of energy and telecommunications infrastructures serves as one of the major cross jurisdictional features of the smart grid.

3.4. The "Operating Room"

Viewed through the Salience–Complexity Model lens, it is apparent that this case provides an excellent example of how the operating room of electrical energy distribution regulation unfolds over time within one state context. This case presents a historical outline for how the relationships between the regulating arm, the PSB, and the utility industry, remained robust over this time and as a result, were able to realize some advanced energy policy goals in the areas of energy efficiency, renewable energy, and smart grid technology. According to many of those interviewed, the bulk of the regulatory information gathering and synthesis undertaken in this case occurred in the workshops and public hearings of the PSB. The series of negotiated MOUs that arose from the issuance of dockets provided an opportunity for stakeholders and technical experts to contribute to the development of solutions to particularly challenging regulatory issues, such as cost recovery, interoperability, rate setting, and telecommunications solutions. The combination of professional norms and industry-led standards helped to pave the way for smart grid deployment in this case.

The main actors in this case were industry leaders and technical experts who directly worked with the DPS and indirectly worked with the PSB to trouble-shoot, align interests, and coordinate decision making in certain key areas. At times, the PSB hearing room and their closed-door deliberations served as the operating room space. In other instances, that operating room space was situated within the ARRA working group and later eEVT Collaborative steering committee. The steering committee also reached out to the strategic leaders when important policy issues were to be discussed.

The opt-out provision passed by the state legislature in response to public pressure provides an interesting caveat to this picture of an operating room guided by a professional network. The proactive intervention of the state legislature, demonstrates how policy makers can, essentially, veto a professionally-driven initiative is particularly worth noting. This mandate from the state legislature circumvented the politically appointed regulatory body, the PSB, and essentially imposed its regulatory will upon the sector. Given what can be learned from this case study regarding the Vermont policy environment, this is likely of no surprise. With a "citizen legislature" with no professional staffers and somewhat limited lobbying, state representatives are extremely accessible to their constituencies. To be accountable to those few constituencies voicing concerns about smart grid safety and privacy these legislators acted outside of the established operating room, a prerogative afforded to the legislative branch.

However, it is also important to note that the legislative mandate to require opt-out procedures was not fought by the industry. According to direct conversations with two industry leaders, most of the larger electricity providers were planning for their own opt-out policies anyway. The move was actually seen by some as a positive because it ameliorated any remaining resistance they were feeling from the public at the time.

In the end, this case illustrates that the strong relationships between the public and private partners and their use of professional networks (developed through the ARRA working groups and others) essentially took the place of more direct civic involvement. The PSB, with the DPS serving as both the public advocate and industry partner, created the space for public input during frequent public hearings through the formal rule making process common to state regulation processes across the U.S. To a certain extent, these public hearings were formal extensions of the operating room. The very legitimacy of the partnership hinges on the capacity of the public have input into regulatory decision-making. In other words, the professional network that guided this process still maintained a democratic anchorage to the public at large.

4. Discussion

The Vermont case is but one among ninety-eight other smart grid deployment grants to be issued in 2009 through ARRA funding. As we noted in the early sections of this paper, the regulatory terrain of energy distribution in the U.S. is complex. A body of case study evidence is being built, including a set of case studies with individual utility companies as the unit of analysis (Jones et al., 2012). These and other cases of early smart grid deployment provide an excellent opportunity to study the changing nature of energy regulation in the U.S. Our case shows, however, that the smart grid is less likely to alter the regulatory playing field. As this example demonstrates, the smart grid deployment initiative was mounted within the context of the existing regulatory regime. As we have noted, the success of this regime to successfully pursue the ARRA grant was conducted in a regulated environment that was left unchanged. Comparing the Vermont case to other parts of the U.S. with more de-regulated states is called for to determine how, if at all, the smart grid signifies a transformation in the regulatory subsystems of particular states. Drawing on the results of this case, we would hypothesize the smart grid will not have a significant impact on the restructuring of energy regulation.

This case also illustrates how industry actors within the utility sector in Vermont collaborated with each other to achieve common objectives. It became apparent to the utility companies in Vermont early on that by working together they would be able to achieve more than each pursuing its own ends, a long standing assumption found in the resource exchange and pooling literature (Rhodes, 1997). In the development of the ARRA working group, which ultimately morphed into the eEVT Collaborative steering committee, the network had a key action arena in which strategic, tactical, and operational goals could be achieved. The leading members of the working group were credited with possessing a willingness to share information and make consensus-driven decisions. This case provides an example for how the governance of this network was led by an industry-dominated project management group. Although representatives from the PSB served on the steering committee and often played an active role on it, this network provides an example of a public–private partnership that was essentially steered by the industry members of the partnership. The extent to which other smart grid deployment projects involved these kind of multi-institution collaboratives remains to be seen. As we noted at the beginning of this paper, the majority of the ninety-nine ARRA projects funded in 2009 were awarded to individual utilities. The rollout of smart grid technology in these projects is likely to be very different. Just how different is a question worth posing.

What is somewhat more generalizable is the fact that smart grid technology will, by its very nature, engender high degrees of salience and technical complexity. As more uses for smart grid data become evident, energy consumption data will be added to the list of details that private firms have about consumers, lining up along with cell phone and internet usage data. However, smart grid data differ from these other forms of information in one important way: there is an expectation that the use of these data, either by individual consumers, third party mediators, or the utility companies themselves, can be used to inform consumer choices and behavior. This assumption, although potentially very powerful, suggests that as the development of website interfaces and dashboards, smart phone and iPad apps, smart appliances, small scale distributed energy centers, and electric powered vehicles evolves, the salience of the privacy issues confronting the use of smart grid data will continue to be very high. The stakeholders involved in the Vermont case fully recognize that installing a smart grid is merely one step in a longer-term process of evolving the relationship that consumers have to their energy consumption habits. The next chapter of this story is hard to anticipate. It is likely that a host of new actors will enter the picture, looking to build a market for smart grid enabled products.

5. Conclusion and policy implications

The lesson regarding the successful development of a smart grid infrastructure to be drawn from this case will likely be predicated on the capacity of existing socio-political systems to adapt to a new way of making, valuing, and regulating energy decisions and use. Smart grid development allows for smarter use of energy in appliances, plug-in hybrid and electric automobiles, small-scale renewable energy set-ups, and decentralized micro-grid networks. Smart grid technology will allow for the flow of energy production and consumption informatics relating to the real time management of the grid itself. An expanded capacity to collect and use an entirely new set of informatics leads to a range of questions concerning the coordination, governance, and regulation of the smart grid infrastructure. Cooperative agreements, public–private partnerships, pilot incentive programs, and conflict mediation needs are likely to surface in response to the new opportunities and challenges that face smart grid managers and users. The challenges and opportunities that a smart grid infrastructure deployment brings to existing governance arrangements and policy and behavioral systems is a topic in need of attention.

We hypothesize that smart grid infrastructure deployment will likely have a limited impact on the restructuring of energy regulation. Rather, relevant industry actors are more likely to self-regulate on the basis of customer demand. In short, the mainstream deployment of smart grid infrastructure will not engender significant change in public energy policy.

Several policy implications stem from the study. The first suggests that the high degrees of salience and complexity found in smart grid deployment projects made the governing of the smart grid all the more challenging. As we have seen in this case, this high salience, high complexity environment calls for a more “operating room” approach to collaboration. In Vermont’s case, this collaboration built on existing ties and levels of trust built up over several decades. In turn, this social capital aided in opening policy windows and keeping them open enough to secure and commence the flow of resources. This finding follows a long line of research linking social capital and innovation. The key policy implication to be drawn here, then, points to the imperative of industry and governmental leaders to identify and work with the social capital of their region. The public–private partnership found in the eEVT Collaborative is an excellent model for achieving this objective.

The second major policy implication feeds off of the first. This case points to the importance of civic engagement and the facilitated alignment of different industry and governmental actors. Within this context, a lead organization was needed to catalyze action, and in this case, this lead organization was VELCO. However, leadership also came from elected officials and visionary industry leaders. This case underscores the need for a lead entity to organize facilitate the operating room. The collaborative management structure found in the eEVT Collaborative serves as an excellent example for how this type of collaborative management structure can pay off.

In discussing the business case for smart grid technologies, Giordano and Fulli (2011), p. 252 suggest that the smart grid will enable new "consumer-centric business platforms" that may allow for new actors to enter the market and result in the shifting of "business value to electricity services in line with the notion of efficiency and sustainability". They go on to discuss the relationship between the enabling technologies associated with the smart grid and the new forms of business-consumer relationships that they enable. These new relationships are key to the eventual wide spread adoption of electric vehicles, e-mobility services, and "smart home" devices and systems. In other words, the relationship between these new technologies and the smart grid are indelibly linked. The successes and challenges faced by the utility industry to deploy smart grid technology will likely pave the way for the wider spread adoption of new energy technologies. The level of collaboration needed between industry, government regulators, third party providers, and consumers to bring about the smart grid can serve as the foundation from which new energy technologies may spring. The types of professional networks established between public and private sector leaders do not dissolve once the smart grid is deployed. In Vermont's case, this network predated the smart grid deployment and will likely remain in place as the next generate energy technology investments roll out.

As the Vermont case shows, the salience of the technology is fueled in part by the promise of new applications, greater efficiencies, and anticipated improvements to quality of life. These positive outcomes are counter balanced by some of the negative concerns about these new technologies, namely privacy and health concerns. As the platform on which future energy technologies will be set upon, the new path dependencies, collaborative ties, and judicial rulings that enable the smart grid to be deployed sets the stage for further developments of electric vehicles, smart appliances and home devices, small scale microgrid facilities, and other advancements in renewable energy and the like.

Although this case is limited to smart grid, we do anticipate that the successes in smart grid will lay the foundation for other new technologies by relying on the professional networks of the region, employing the operating room practices to harness issue salience and overcome technical complexities that new energy technologies will engender.

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Appendix A. Major historical events shaping this case

A1. 1990s: Regulatory focus on energy efficiency

In 1970, Vermont enacted a land-use planning law that mandated "energy efficiency" be included as one of the review criteria for major new construction project permits. This effort was in many ways ahead of the national trend, having preceded the 1973 oil embargo, which peaked national interest in energy issues. As the rest of the country just began to be cognizant of energy issues, Vermont policy makers and regulators were demonstrating their sustained commitments to energy efficiency, leading to early studies of "Demand Side Management" (DSM) and "Least Cost Planning" by utility companies throughout the 1980s. In response, several regulated electric utilities conducted pilot programs to further investigate energy efficiency.

During the 1990s, the Vermont's Public Service Board (PSB) issued a series of dockets supporting the development of energy efficiency measures. In 1999, the PSB reacted to the newfound information about energy efficiency by creating the nation's first statewide "Energy Efficiency Utility" (EEU). The new utility was tasked with managing energy programs previously within the purview of individual utilities. It would operate under a performance-based contract with the PSB and be funded by a volumetric "Energy Efficiency Charge" added to the bills of all retail electric customers.

A2. 2000s: Regulatory focus on renewable energy

In June 2005, Vermont enacted the Sustainably Priced Energy Enterprise Development (SPEED) Program. The SPEED program, guided by a State Renewable Portfolio Standards (RPS) mandate, was designed to promote the development of in-state renewable energy sources and to ensure that the economic benefits of these new renewable energy sources flowed back into the Vermont economy, and specifically to rate-paying citizens.

A3. Late 2000s: Regulatory framework for smart grid infrastructure

In March 2007, then Governor James Douglas established the "Vermont e-state Initiative," which sought to provide broadband and wireless internet access to all Vermont residents by 2010. The Vermont e-state Initiative promised benefits to both residents and the local software industry. In April 2007, the Vermont Department of Public Service (DPS) submitted a petition to the PSB requesting a formal investigation to evaluate the use of smart metering and time-based rates. The DPS' request for formal investigation of the costs and benefits of smart metering and time-based rates was granted on April 18, 2007, and the PSB opened Docket 7307, Vermont Electric Utilities' Use of Smart Metering and Time-Based Rates.[1]

On June 9, 2007, the Vermont Legislature enacted legislation, creating the Vermont Telecommunications Authority (VTA), which was tasked with facilitating the establishment and delivery of mobile phone and internet access infrastructure and services. The VTA became a critical actor in helping to devise a plan to manage the communication infrastructure of the new smart grid.

In December 2007, the U.S. Congress enacted the Energy Independence and Security Act (EISA), which provided federal grants for up to 20 percent of the cost of smart grid technologies and directed states to consider authorizing utilities to recover costs of AMI deployment through the rate base. Under EISA, the Federal Energy Regulatory Commission (FERC) – the independent agency that regulates the interstate transmission of electricity, natural gas, and oil – required that utilities pursue optimal functionality and interoperability. This expectation is a critical example of how the technical complexities of smart grid technology are being addressed.

In March 2008, after establishing goals to address energy efficiency and greenhouse gas reduction, Vermont enacted the

[1] Notes VELCO—Vermont's Smart Grid Efforts.

Energy Efficiency and Affordability Act. It directed Vermont's PSB to "investigate opportunities for Vermont electric utilities cost effectively to install advanced 'smart' metering equipment capable of sending two way signals and sufficient to support advanced time of use pricing during periods of critical peaks or hourly differentiated time of use pricing" (H.B. 520). Additionally, it directed the PSB to require each utility to develop plans for "investment and deployment of appropriate technologies and plans and strategies for implementing advanced pricing with a goal of ensuring that all ratepayer classes have an opportunity to receive and participate effectively in advanced time-of-use pricing plans." In November 2008, the PSB issued a Smart Metering and Alternative Rate Design Memorandum of Understanding (MOU), which established a framework for the regulatory treatment of smart metering, which enabled utilities to move forward individually with smart metering.

A4. 2009: eEnergy Vermont (eEVT) collaborative formed

In March 2009, the Board of Directors of the Vermont Electric Power Company (VELCO), the state's transmission corporation, agreed to pursue a common ARRA SGIG application under the name of "eEnergy Vermont." Soon thereafter, a collaboration of twenty distribution utilities (investor-owned, municipal, and rural cooperatives), VELCO, an efficiency-only utility (VEIC), a variety of state agencies and higher education institutions, and staff from the Vermont congressional delegation began developing an ARRA SGIG application. There was recognition early in the process that Vermont would need to differentiate itself from other applicants and, to do so, the effort would need to be truly collaborative, as most SGIG grants were going to single applicants.

During this time here was also recognition of the potential challenges associated with multi-stakeholder collaboration. Accordingly, the ARRA working group drafted a memorandum of understanding (MOU) to document the scope of the project, schedule, and budget early in the process. The ARRA working group, coordinated by VELCO, created additional working groups focused on related smart grid infrastructure and deployment issues, such as a coordinated communications plan. With the ARRA working group as the hub of this implementation network, industry representatives and government officials met regularly to identify problems, derive solutions, and make strategic decisions regarding the implementation of smart meter infrastructure.

On August 6, 2009, VELCO, as lead applicant, submitted "eEnergy Vermont," a collaborative SGIG application for ARRA funds, on behalf of all Vermont electric distribution utilities, Efficiency Vermont, and VELCO. Later that year, the eEVT Collaborative was awarded $68.9 million from ARRA SGIG funds. The amount was matched with equal investments by local utilities, providing $138 million to install smart meters for 85 percent of all electricity consumers in Vermont by 2013.

A5. 2010–2011: Early deployment through collaborative governance

In the summer of 2010, then Vermont's two largest utilities, Central Vermont Public Service (CVPS) and Green Mountain Power (GMP), along with VELCO, the VTA, and DPS, came together to work on the procurement of AMI "smart meter" systems. Together, they issued a joint RFP, soliciting proposals from commercial communications carriers for supporting utility smart grid communicators and state broadband communication goals.

During the summer of 2010, Vermont Telephone Company (VTel) began pursuing solutions for backhaul from smart meters to substations. In August 2010, the United States Department of Agriculture (USDA) awarded VTel an $81 million broadband stimulus grant and a $35 million government backed loan. The federal funds enabled the company to build a "Wireless Open World" (WOW), a 4G wireless system designed to provide internet access to Vermont residents and businesses, particularly those who were not being served by existing networks.

In June 2011, voters in Burlington, Vermont approved a $7.5 million Burlington Electric Department (BED) bond to fund the implementation of smart grid technology. The bond allowed BED to raise the necessary capital to match federal funding for the project. Just a few weeks later, the leaders of CVPS and Gaz Métro Limited announced the merger of CVPS and GMP, a subsidiary of Gaz Métro, into one utility. The merger promised significant benefits for customers, community, employees, and shareholders, namely $144 million in customer savings over 10 years, and the establishment of the Headquarters for Operations and Energy Innovation in Colchester, Vermont.

One week after the proposed merger of CVPS and GMP was announced (July 2011), the two utilities and VTel finalized a smart grid broadband agreement that would allow electric utilities to use the newly expanded broadband system to transmit smart meter data. Because utilities would share costs with their telecommunications counterpart, VTel would be able to expand broadband internet service territory by as much as 25 percent. As a result of the agreement, Vermont was the first state to utilize a "wireless canopy" to implement a smart grid system.

A6. 2012: Health concerns and opt-out legislation

Concerns about the health impacts of smart meters have been raised by some environmental and consumer protection groups, contributing to the public salience of smart grid deployment. In February 2012, in order to address these concerns the Vermont Department of Health issued a report titled, "Radio Frequency Radiation and Health: Smart Meters." The Department of Health surveyed the existing scientific literature on the impacts of radio frequency radiation (RFR) and conducted their own measurements of RFR from the type of smart meters being installed in Vermont. In September 2011, at the urging of the Vermont PSB, the PSB held public hearings regarding the privacy and health concerns arising from smart meter installation. In January 2012, the Department of Health made actual measurements at active smart meters installed by GMP in Colchester and found that they emit no more than a small fraction of the RFR emitted from a wireless phone, even at very close proximity to the meter, and are well below regulatory limits set by the Federal Communications Commission (Vermont Department of Health, 2012).

In May of 2012, the Vermont State Legislature passed legislation that allowed for utility customers to opt-out of having AMIs placed within their homes without being charged a fee, making the State of Vermont one of the first states in the country to allow for an opt-out option that does not result in increased fees to the customer. The opt-out provisions that were adopted by the state legislature were passed without the consent of the utility industry and out of the purview of the PSB.

To ensure the protection of consumer privacy, the main utility companies involved in the implementation have written privacy policies, which subsequently raises questions about how third parties will be able to gain access to consumer data as new applications for using finer grain smart data become available. The PSB remains committed to monitoring this issue and has offered a set of principles of practice to guide policy development in this area.

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