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Smart Grid Adoption by U.S. Utilities: Organizational Drivers and Impacts

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SUMMARY

The deployment and integration of smart grid technologies presents significant organizational challenges to electric utilities, which are used to operating in a relatively predictable and slowly changing technology environment. By contrast, smart grid technologies are characterized by rapid technological change and a great deal of uncertainty. As a result, some utilities have been slow to adopt, while others have faced serious challenges as they move forward with deployment.

We ask the following: (1) What organizational characteristics impact utility company adoption of smart grid technologies? (2) What kinds of organizational challenges are faced by utility companies as they deploy smart grid technologies? (3) How do utility companies respond to these challenges?

We identify organizational factors that influence smart grid adoption, including top management leadership, experience with precursor technologies, technology champions, a culture of innovation, and ownership form. We next identify a set of organizational challenges and explore how utilities respond to those challenges as they deploy smart grids. One challenge is the need for new knowledge and skills such as technology evaluation, business process change, project management skills, and data management and analysis. Utilities have acquired these skills and knowledge both through internal training and hiring and through external sources such as consultants.

Another challenge is the need to break down organizational barriers to integrate smart grid technologies with information systems and processes that cross boundaries in the organization. Utilities have addressed this challenge through new governance mechanisms, cross-functional collaboration, and better integration of data and information systems.

A third challenge is the need to interact with customers in new ways, treating the customer as active participants in managing energy use, rather than as passive ratepayers. Utilities have responded through extensive customer outreach programs when introducing smart meters, but need to do more to get customers engaged in using smart grid tools to manage their energy use.

A fourth challenge is the changing business and regulatory environment, in which utilities face new retail competition, the need to integrate distributed generation, and demands to reduce energy use, which can cut into revenues. New business models are needed, but this requires organizational change as well as regulatory approval. So far, utilities have not responded in a consistent way to this challenge.

To summarize, smart grid adoption presents major organizational challenges to utilities. Combined with rapid changes in the business and regulatory environment, these challenges could threaten the

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future viability of some utilities. Utilities have responded, but may need to make more fundamental changes in organizational culture, governance and external orientation to survive.

KEYWORDS

Smart grid, organizational siloes, knowledge, skills, customer relationship, regulatory, business model, top management, technology champion, culture of innovation, governance

Introduction

The adoption, deployment and integration of smart grid technologies presents significant organizational challenges to electric utilities. These companies are accustomed to operating in a relatively predictable and slowly changing technology environment (MIT, 2011). Utilities make long-term investments in electrical equipment that must meet the criteria of being prudent, and “used and useful”, to be approved by regulators and added to the capital base on which they can earn a return. In the case of municipal and cooperative utilities, investments must be approved by boards or other oversight bodies who must approve spending of public money or coop funds. The organizational structures, processes and cultures of utilities have developed over decades, and are suited to these conditions.

The smart grid presents a new and different set of issues. Smart grid technologies are fundamentally information technologies, and are characterized by rapid technological change and a great deal of uncertainty. There is a need for common standards to enable different technologies to work together, yet the industry is still emerging and standards are not established (NIST, 2012). New suppliers are entering the market, from large IT companies to startups. The regulatory process is often slow and unpredictable, and regulators often lack knowledge to evaluate smart grid investments (Dedrick, Stanton & Venkatesh, 2013). As a result, some utilities have been slow to adopt smart grid, while others have faced serious challenges as they move forward with deployment and integration.

Given this situation, we ask the following questions: (1) What organizational characteristics facilitate or delay utility company adoption of smart grid technologies? (2) What kinds of organizational challenges are faced by utility companies as they deploy smart grid technologies? (3) How do utility companies respond to these challenges?

Research Methodology

In order to address these and other questions, we have been conducting a study supported by the U.S. National Science Foundation (SES-1231192) on the adoption of smart grid by U.S. utilities. We have interviewed over 40 individuals in 24 U.S. utilities, including investor-owned, cooperative and municipal forms, covering 16 states with a variety of policy and regulatory contexts.

In our utility interviews, we ask about their history with grid modernization, motivations to adopt smart grid technologies, organizational challenges and impacts, extent of smart grid implementation, and the impacts of policies and regulations. We also have collected a large number of documents produced by utilities, federal and state government agencies, analysts and academics. We have analyzed the interviews and other documents using qualitative methods (See Dedrick et al., forthcoming for details). In the following sections we discuss our findings.

Organizational factors influencing adoption

We found several organizational characteristics that appear to influence the adoption of smart grid technologies.

1. Top management leadership: Leadership by top management was mentioned consistently by utilities that have advanced farthest in smart grid adoption. One manager argued that the kinds of organizational changes required could only be made through top-down mandate.
2. Experience with precursor technologies: Some of the companies interviewed have a history of introducing smart grid-related technologies such as automated meter reading and wireless networks. Such experience put those utility companies in a better position to respond to the ARRA funding opportunities, and to deploy smart grid technologies. One utility noted: “*We piloted different meter reading and other technologies through the ‘90s and early 2000s, and we sort of saw the opportunity for putting the costs of the projects in the ARRA funding. That’s why we applied and I think that’s part of the reason why we are successful*”.
3. Technology champions/change agents: Several participants pointed to the role of an internal champion for smart grid technologies in driving awareness of the potential benefits. One pointed to a particular individual: “*He [director of engineering and operations] is a more forward-thinking and enlightened individual with respect to smart grid. He has been championing distribution automation for a very long time*”.

4. Culture of innovation: Although the utility industry often is characterized as lacking in innovation, a few utility companies mentioned that their innovative culture motivated them to pursue smart grid technologies. *“We have a culture that has come from executives that have their roots in the company. We don’t like to be number one, but we do implement change readily.”*
5. Ownership form: We heard from some municipals that they were able to invest in innovations that might not have immediate or tangible benefits, because they did not face pressure from shareholders to show an adequate return on investment. In the words of one municipal utility interviewee, *“We are not driven like IOUs by return on investment. We can spend what we have in our cash flow estimates without having to get approval from a regulator. Some of the benefits of smart grid are intangible. IOUs have to show tangible benefits to make such investments.”*

Organizational challenges and utility responses

As utilities deploy and integrate smart grid technologies, they are facing a number of organizational changes.

1. New skills and knowledge requirements

Challenges: A major challenge is the acquisition and development of new skills and expertise with the adoption and implementation of smart grid technologies. Most utilities are challenged by IT-related knowledge requirements. Smart grid is characterized by the application of information and communication technologies; however, utilities are historically dominated by power engineering skills and IT has played more of a support role in the past. As one interviewee mentioned:

“Utilities had a lot of technologies but IT was not part of that. So when you go inside a substation, and transmission and distribution, up until early 80’s, you wouldn’t find any equipment with communications installed, and there is no computing and there is no integration and no IT.”

We found that utilities investing in smart grid have faced four knowledge/skills challenges that are commonly associated with IT adoption in other industries, but less familiar in the utility industry:

- **Technology evaluation:** Utilities face a formidable task of testing, installing and managing new technologies. Smart grid technologies are still evolving and many features need to be further polished. Thus, to reduce the risk of deployment failure, utilities need to possess strong technology evaluation skills to test and simulate new applications before large-scale deployment.
- **New business processes:** As smart grid technologies are integrated with legacy systems, IT is built into daily operations, entailing new business processes and work routines. This requires utilities to develop new business processes as well as new management structures.
- **Data management and analysis:** Most utilities lack data analytic skills to tackle big data problem—utilities are receiving 15-minute or even 1-minute interval data from the Advanced Metering Infrastructure (AMI) system, not to mention the large volumes of data available from other sources (e.g., sensors, SCADA, repair records, customer calls). Utilities need to advance their data analytic and management skills to capture, analyze and use all this data.
- **Project management:** Finally, to many utilities, smart grid investment represents an unprecedented scale that involves managing a number of projects in a parallel. This requires utilities to develop strong multi-project management skills to meet project goals on time and budget.

Responses: In order to address skill and knowledge gaps, most have either trained their own people, hired new technologists, and/or turned to outside sources of knowledge.

- **Internal training and hiring:** Many utilities rely on internal resources to address most of the challenges as they believe it’s good in the longer run to develop the necessary skill set internally, for instance, in areas like technology evaluation and maintenance, project management and cyber security management. All utilities in our sample have provided formal internal training to meet these demands. One interviewee stated:

“There’s a huge learning curve but at the end we’ve now got, you know, a good handful of people who have excellent knowledge of how to run the system, how to operate the system, so through the deployment, we build a strong base.”

When specific skills are needed that are not available internally, but are seen as a long-term need, many have hired new technical professionals, although this usually is in the range of one to five

people.

- External knowledge acquisition: However, all interviewed utilities agreed that they do not have all the available skill sets and do not want to hire staff to meet every need. In this case, many work with vendors to understand specific technologies, and contract with external consultants to fill the knowledge gaps, e.g. technology installation or data management.

Although utilities generally follow a mixed strategy in addressing these knowledge issues, they vary in terms of what activities are contracted out. Some of the factors that influence adoption also influence these sourcing choices. For instance, we find that:

- Utilities with rich prior experience with precursor technologies generally have accumulated strong technical, managerial and problem-solving skills and are more inclined to rely on their existing staffs to address many of the skills and knowledge challenges. Those with less experience are more likely to outsource.
- The type of knowledge required influences the decision whether to develop internally or contract externally. For instance, data management and analytics skills are difficult to find, as utilities must compete with many other industries for a limited pool of expertise, and even utilities that have deployed precursor technologies are unlikely to have experience managing very high volume and velocity data. So many choose to buy software from vendors and work with external consultants to deploy the needed tools.
- Size and financial resources also matter. Small municipals and coops face financial pressure due to the cost of IT solutions and respond by limiting their initial uses of metering and other data—mainly for meter reading, improving billing accuracy and theft detection. Some larger IOUs and municipals are integrating more functions, including outage detection, load forecasting and management, asset management, and demand response. These companies can more readily afford to hire new staff and pay outside consultants to enable these activities.

2. Need to break down organizational barriers

Challenge: Another challenge frequently mentioned by utilities is reducing departmental segregation to support cross-functional collaboration demanded by smart grid. Historically, the collaboration activities are confined to a single functional area and employees from different functional silos do not traditionally work together. However, many smart grid applications require coordination of multiple parts of the organization. One interviewee explained:

“We have the distribution, the substation, transmission and generation, and they all from different silos and in result, for example, we have substation that have completely different silos from generation and now when we start to use the smart grid, an important point to the substation is that it needs to be integrated which means that you link people all together and make them work together.”

Also crucial to this challenge is the data integration—an integrated approach involves not only blending of groups, processes, and cultures but also system interoperability and common data standards. An open, standards-based platform fosters cross-boundary collaboration by allowing users to easily search, locate and utilize working information that is necessary. This requires utilities to determine what communication platform to build, what data to collect and integrate, and who has ownership of, and access to, different data.

Responses: Our study suggests that most utilities have realized the necessity of cross-functional collaboration, referred to as “breaking down organizational siloes”. This involves new governance mechanisms and new ways of sharing information across boundaries. Many create a utility transformation program focusing on process redesign, internal education and skill development. One interviewee is excited about what they did in the early education stage:

“At the manager level we have all managers sitting in one room and talking about their operation issues together. At the operational level, we hold workshops where they have 60-100 employees representing different parts of the company (IT, HR, distribution and transmission, customer, regulatory) and they all get together and talk about different aspects of smart grid. This is very effective, as we really know what other guys are doing.”

In terms of system and data integration, many are in early stage as they usually deploy different systems first and then start considering the integration problem. Those with long-term experience of experimenting with new technologies, in comparison are more likely to plan and build in data integration process to better support cross-group coordination.

“Getting that communication problems solved, I think is the most challenging piece for most utilities. You know, if you cover 7 states, you are going to have a series of communication environment and getting all those work together. So for us, it is easy and we deployed fully out there.”

3. Customer relationship management

Challenge: Unlike traditional utility investments, smart grid technologies involve a more transparent, collaborative utility-customer relationship in which customers are no longer just electricity users and ratepayers but active participants who can control their usage, participate in demand response efforts, and even generate their own electricity and sell it back to the grid (Accenture, 2011). Especially, in those states with high penetration of distributed generation and active customer behavior, utilities are expected to collaborate with customers to integrate growing amounts of distributed resources. Furthermore, utilities are expected to be more responsive to customer needs as they are moving towards a customer-oriented culture as opposed to government-regulated monopoly. In the past, the only times that utilities interacted with end-users was when customers reported outages or needed to connect or disconnect service. Now, with new information and data from smart grid to enable better customer service, utilities are expected to identify potential customer experience problems in advance and prevent them from occurring. When emergencies do take place, they are expected to respond to events quickly and effectively.

Response: In response to this change, almost all of our interviewed utilities have realized the necessity of customer education and most of them have initiated outreach and marketing programs prior to deployment. As one interviewee pointed out:

“So you really gotta to get out of this utility centered view to more of a customer centered view. Utilities have a tendency to be parental, ‘we know what is best for them’. The key lesson now is to have proactive, mutual beneficial and collaborative customer relationship. There has to be a trust.”

In general, utilities reach their customers by all means—advertisement, community events, brochures, mail, email, and social media. We found that a community approach is widely adopted by municipals and coops as they usually represent citizens and members interests. Customer education is proven to be valuable—utilities in our sample are generally satisfied with their customer attitudes and there is usually just a small handful of anti-technology people refuse to participate. Those that did less customer communication faced greater backlash:

“No matter how much you do, it doesn’t seem like it’s enough, because we still have a lot of people that don’t seem to understand.”

Many utilities have realized that customer education is not a one-time event. What they found is that only a small portion of customers actually use smart meter data to manage their energy use, while the majority of customers are “install it and forget about it”. Thus, how to increase the use of customer systems has been the focus of many customer programs in the post-deployment stage. Customer segmentation is another technique that has been mentioned several times. It enables utilities to provide customized service to certain group of customers to support sustained interest.

Most of our interviewed utilities feel they have done a good job of developing a better relationship with customers as they deployed smart meters. However, the communication tends to be one-way, with customers viewed as passive service receivers rather than partners who can collaborate with utilities to provide energy, manage the grid and ensure a reliable supply of electricity. We found that utilities that are aggressive in their customer relationship management are usually the ones with high customer interest in demand response, distributed generation and electric vehicles, which drives them to interact with customers in a more transparent and collaborative way.

4. Changing business and regulatory environment

Challenge: The increasing penetration of distributed generation and electric vehicles, combined with customer-side applications are competing with traditional utility-provided service and challenging the utilities' centralized business model. On one hand, utilities' traditional role as being the sole source of electricity is diminishing and they are adapting to the new role of being the grid facilitator and integrator; on the other hand, distributed generation, demand response applications as well as customer behavior change are greatly affecting utilities' revenue streams, as less energy consumption is often coupled with less energy sales and potential revenue loss. Utilities who divest their generation assets are even more challenged. Unlike fully integrated utilities in which the disadvantage of selling less electricity is outweighed by the advantage of avoiding the construction of new power plants to meet peak demand, T&D utilities face more complicated market dynamics and potential revenue loss. Utilities need a new business model to accommodate growing customer-side activities while protecting themselves from any potential revenue loss. One interviewee expressed his concerns:

"We have to remember that this is our enterprise and we can't bankrupt it. We can't just reduce our revenue streams and one of the things we forget is that we try to get customer some value but it's got to be good for utility as well."

Response: Utilities vary in their reactions to the potential revenue loss, depending on state regulations. Some states have decoupled revenues from volume of electricity sold, and utilities' revenues are based on various performance metrics (Morgan, 2013). Under such market structures, utilities don't have to worry about their revenues if their smart grid efforts help reduce demand. One interviewee stated:

"In our state, revenues are decoupled from sales. Profit is a function of a different formula other than the amount of volume sold. We are encouraged to support energy efficiency, as it doesn't work against our business model. We don't make any money on the sales of electricity. We make money in the investment in the infrastructure. Other utilities wouldn't want to do that as they are not deregulated and they make money on sales of electricity."

By contrast, utilities operating in a traditional regulated market without any revenue protection mechanisms are threatened. As customers conserve energy, or begin generating their own power, utilities are more vulnerable to potential revenue loss, while still bearing the cost of maintaining the grid infrastructure. They are forced to request rate increases to maintain profits, but these can drive more customers to conserve or install solar panels, further reducing demand. Some utilities have recognized the urgency to depart from an electricity-selling model to a service model in which their revenues are based on competitive products and service rather than kilowatts. For instance, utilities could compete in the businesses of leasing solar systems or aggregating demand response capacity to sell in wholesale markets. However, new business models require regulatory approval and would put utilities in competition with unregulated competitors in the private sector, and few utilities that we interviewed showed much interest.

Discussion and implications

The adoption of smart grid technologies presents a number of major organizational challenges to utilities. There is a need for new skills and knowledge, new governance approaches that break down organizational silos, and innovative approaches to customer relationship management. Depending on ownership type and market structure, there is a potential for lost revenues as customers reduce consumption or become energy producers. Against these challenges, utilities need to embark on a journey of transformation to assimilate new technologies and create business value. Smart grid investment is an expensive and lengthy process; ignoring or underestimating these challenges could result in disastrous consequences.

Most of the utilities we have interviewed are responding to these challenges actively, despite their varying strategies. However, some challenges such as data analytics, cross-functional synergy and customer relationship management require further actions and most utilities are still in the early stage of the change. Our analysis suggests that a single factor cannot explain the variance in utilities' response. In general, utilities with extensive prior experience, innovative cultures, adequate resources and a supportive regulatory environment are adapting to challenges more quickly and usually ending

up with a more advanced level organizational change.

Our findings have implications for both utilities and regulators. Regulators and policy makers should make new policies such as adopting new revenue models and allowing utilities to experiment with new business models (Kiesling, 2010; Dedrick et al., 2013). But this does not guarantee that utilities will respond effectively. The experience of other industries (such as airlines and telecommunications) shows that incumbent firms often fail to respond to rapid changes in technology and regulation. Utilities need to change themselves or some may not survive. Current responses, including knowledge/skill acquisition, organization restructuring and customer outreach are necessary to deploy and integrate new technologies, and many utilities have not even begun the process. Meanwhile, we are seeing changes accelerating in technology, markets and policies. New entrants such as Google and Solar City create challenges that utilities have not seen before, while states such as New York and Massachusetts have announced new regulatory visions with very different roles for utilities. Many utilities may have to undergo more fundamental changes in organizational culture, governance and external orientation to survive.

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