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Adoption of Smart Grid Technologies: Results of a Survey of U.S. Electric Utilities

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SUMMARY

Smart grid technologies offer a wide range of benefits to utilities and their customers, yet adoption has been uneven among U.S. utilities. We surveyed 217 U.S. utilities regarding their level of deployment and integration of smart grid technologies, motivations for and obstacles to deployment, and the organizational impacts and challenges of smart grid adoption. We compare the responses for investor-owned utilities (IOUs), municipals and cooperatives.

Over half of the utilities have reached AMI deployment of 75% or more. Among grid-side technologies, the most widely adopted are two-way SCADA, outage management systems (OMS) and meter data management systems (MDMS). On the customer side, only web portals are widely adopted. System integration is most commonly done between AMI with MDMS and OMS. The main motivations are operational benefits such as reliability, efficiency and cost reduction. The main obstacles are the perceived immaturity of smart grid technologies, lack of funds, and lack of internal expertise.

Smart grid adoption has significant organizational impacts, such as requiring integration of systems, breaking down organizational siloes, making changes to existing processes and acquiring of new knowledge and skills. In particular, there is a shortage of skills in data management, analytics and reporting as utilities start to deal with large amounts of data from smart meters and other systems. Organizational challenges increase as firms move from simple automation of meter reading and billing to try to capture more value by integrating systems and data across organizational boundaries.

Comparing IOUs, municipals and coops, there is no significant difference in deployment rates of AMI, but there are differences in deployment of grid-side technologies such as MDMS, OMS, DER, DMS, VVO, PMU and microgrids, with IOUs having significantly higher levels of adoption. On the customer side, IOUs higher levels of HAN, EV, dynamic pricing and in-home displays, while coops have higher deployment of pre-pay pricing. There is no significant difference in current or planned integration of technologies. Likewise, there was no difference among the groups' motivations or obstacles, organizational expertise, or organizational impacts.

KEYWORDS

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Smart grid adoption, system integration, adoption motivation, adoption obstacles, organizational impact,

Introduction

Utilities today face many challenges, such as the need to upgrade an aging infrastructure, to increase the security and reliability of the electricity supply, to respond faster to major outages, to integrate distributed generation sources and electric vehicles, to reduce peak demand loads, to reduce emissions, and to give customers more control over their energy use.

In order to respond to these challenges, many U.S. utilities have been investing in smart grid technologies for communications, monitoring, computation and control purposes. Among its capabilities, the smart grid enables better outage management, grid self-healing, demand response, dynamic pricing, preventive maintenance of grid assets, integration of distributed generation resources, and two-way communications between utilities and customers (Farhangi, 2010).

In spite of its potential benefits, smart grid adoption by utilities has been uneven. In 2013, 51 million electricity customers in the U.S. had smart meters installed (EIA, 2015). While many utilities had installed smart meters for all customers, others had not installed any. The deployment rate of other smart grid technologies varied widely as well.

Given the urgent need to modernize the U.S. electrical infrastructure and reduce its environmental impacts, it is important to sort out these issues and understand the factors that are driving or preventing adoption of the smart grid by utilities. In this paper, we address the following questions:

(1) What is the level of deployment of different smart grid technologies among U.S. electric utilities? (2) What are the main motivations for smart grid deployment? (3) What are the main obstacles to deployment? (4) What are the main organizational impacts of smart grid adoption? (5) How do IOUs, municipals and cooperatives differ in terms of adoption rate, motivations and organizational factors?

In this paper we report on results from a survey of 217 respondents from U.S. utility companies, including investor-owned, municipal and cooperative utilities. The results are enriched by the findings of interviews with utility representatives, other industry experts, and regulators (Dedrick et al., 2014).

Methods

We surveyed 217 individuals representing 198 utilities[1] (for a few utilities, there was more than one respondent). This includes 38 IOUs, 64 municipals and 96 cooperatives. Forty-three states were represented, with different policy and regulatory environments, market structures, and customer demographics.

The response rate was about 15% for municipals and coops, and 25% for IOUs. We believe that the deployment levels of smart meters and other technologies by utilities in the sample are greater than that of the full population of utilities, based on government data and other sources of deployment data.

Smart Grid Deployment

Deployment varies significantly among various smart grid technologies. We collected data on AMI deployment, as well as grid-side and customer-side technologies. Of the 187 respondents that answered this question, the majority (106) had deployed smart meters to 76-100% of their meters (Figure 1).

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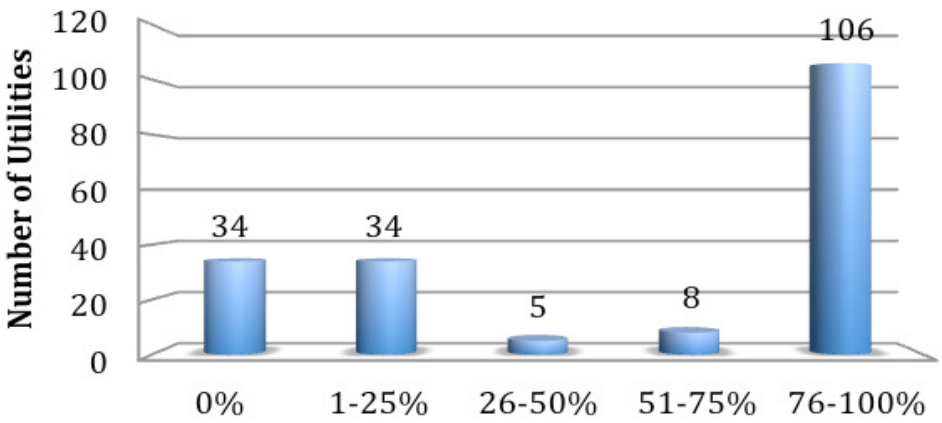
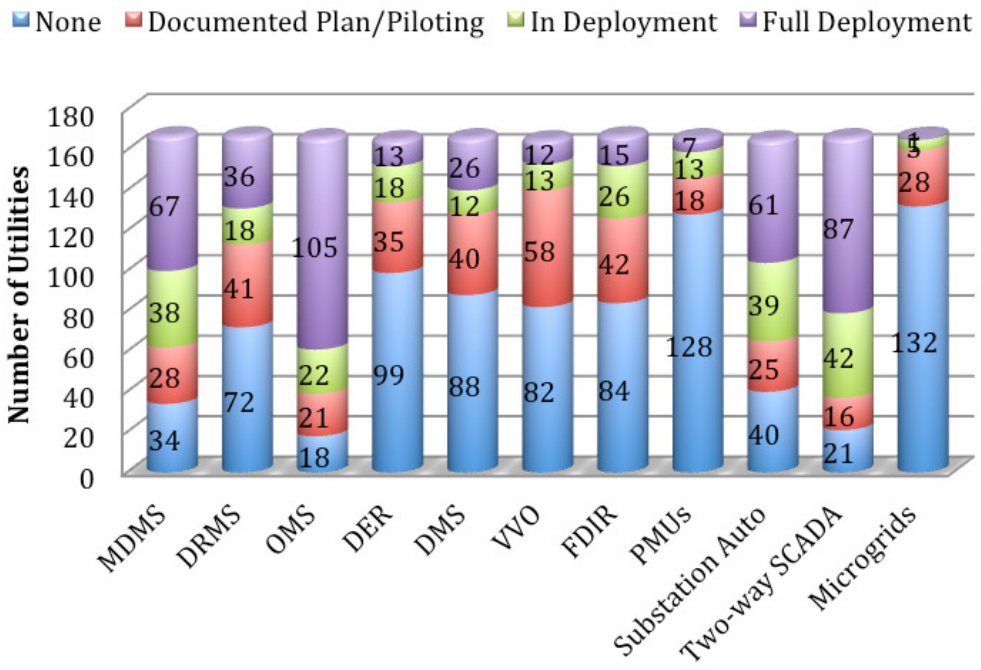
Figure 1. AMI deployment as a percentage of all meters



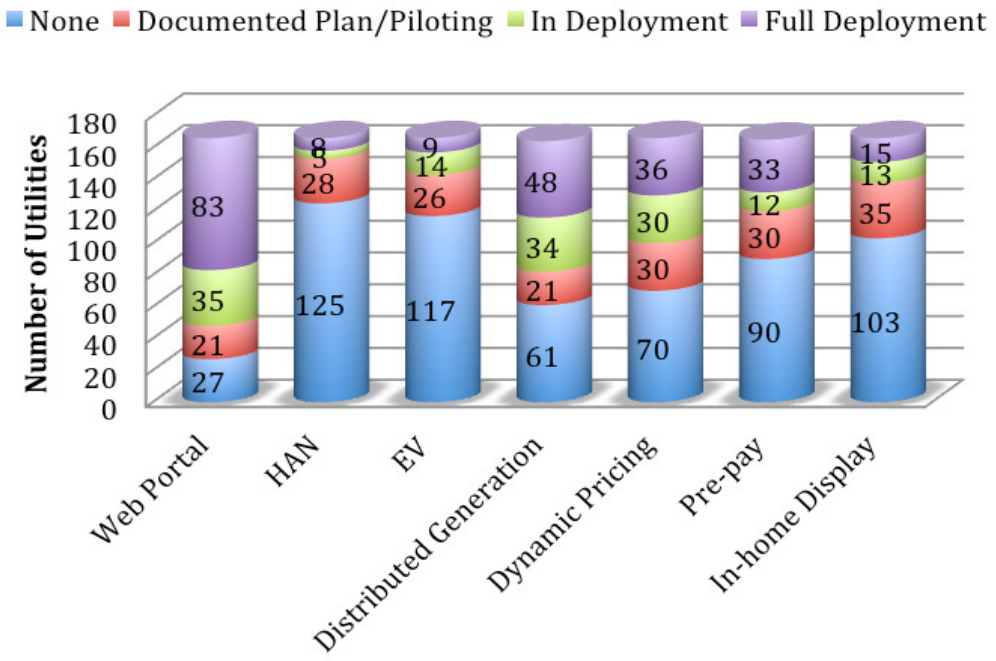
Looking at grid-side technologies, the most widely deployed are outage management systems (OMS), two-way SCADA, and meter data management systems (MDMS). By contrast the majority had no deployment or plans for microgrids, distributed energy resources (DER), distribution management systems (DMS) or phasor measurement units (PMUs).

Figure 2. Deployment Status of Grid-Side Technologies



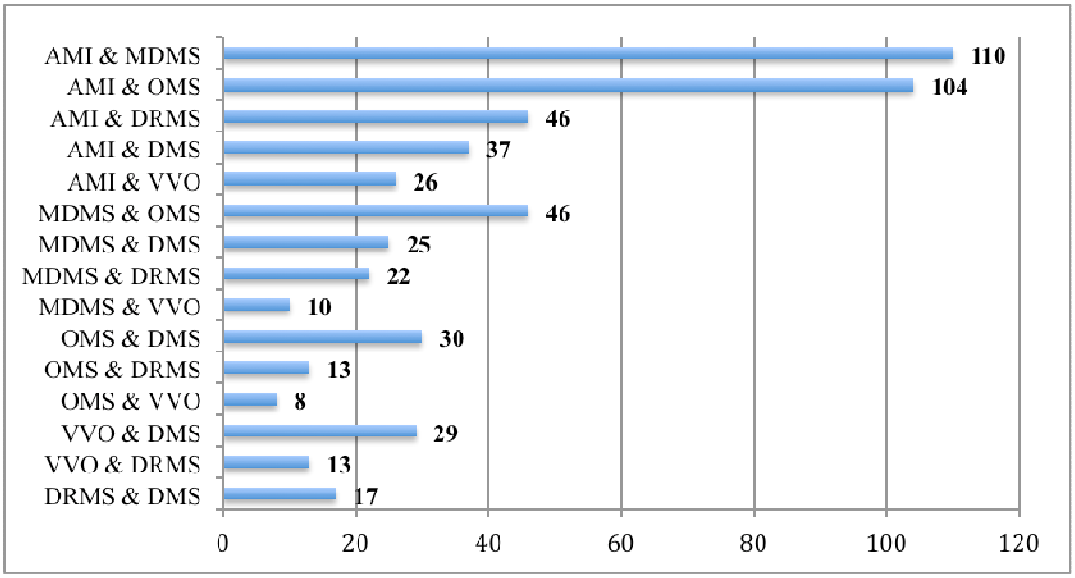
Among customer-side technologies, the most widely adopted are web portals and distributed generation, with half or more utilities at full deployment or in deployment (Figure 3). Technologies that are "behind the meter" such as home area networks (HAN) and in-home displays are not widely deployed, as the utility's reach usually stops at the meter. Other companies have begun to sell in-home products such as smart thermostats and smart appliances that can be connected to wireless networks (e.g., WiFi), and controlled by customer devices such as smart phones.

Figure 3. Deployment Status of Customer-Side Technologies



Beyond adopting smart grid technologies, an important next step is integrating them with each other and with existing systems. This enables utilities to share data among different parts of the organization and to coordinate processes that reach across internal boundaries. As Figure 4 shows, the most commonly integrated systems are AMI with MDMS (which manages all meter data), and AMI with OMS. As we will see, this is consistent with the utilities' leading motivations for adoption, which are improving reliability and efficiency.

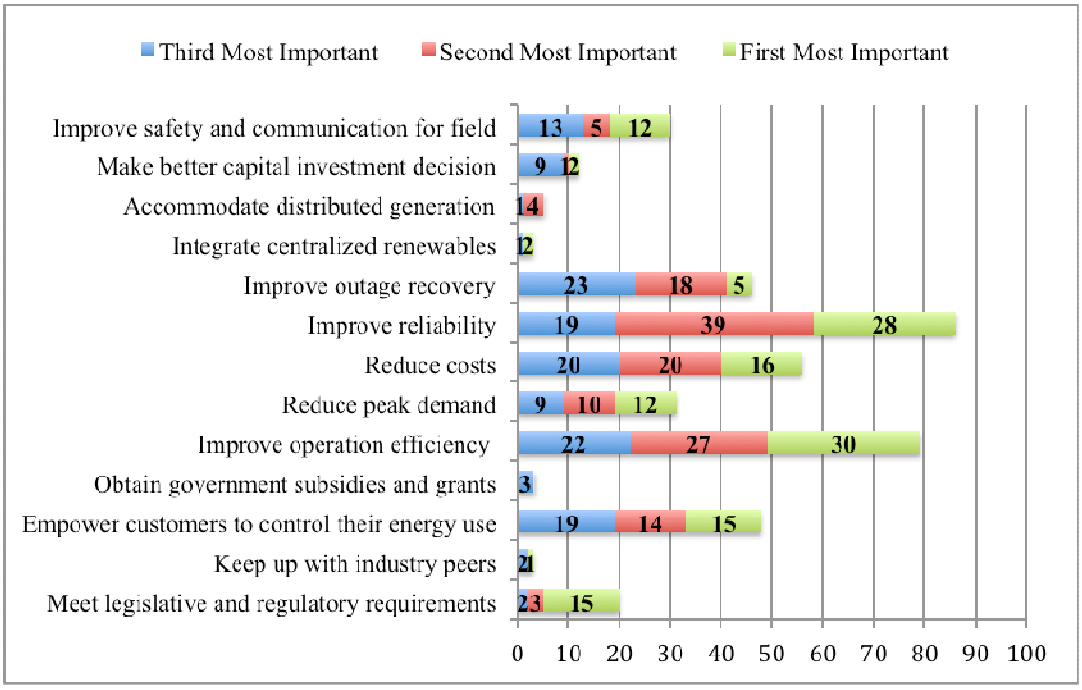
Figure 4. Integration of Smart Grid Technologies (number of companies)



Motivations and Obstacles to Adoption

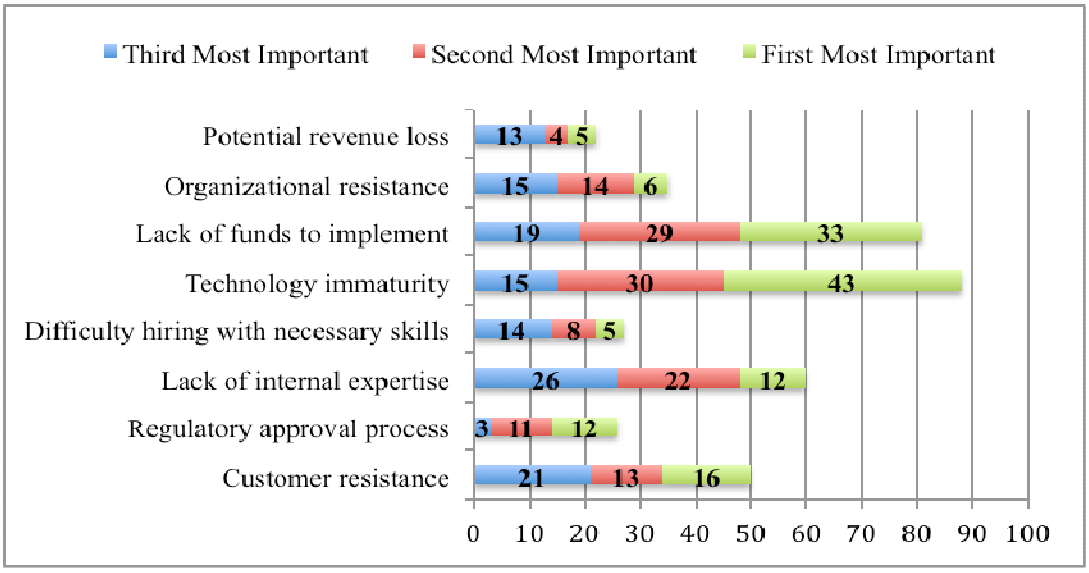
Smart grid technologies have many potential benefits to utilities, such as improved operational efficiency, resilience, safety, cost savings, avoided investments, and integration of intermittent renewables. In the survey, respondents were asked to rank their companies' top three motivations for adopting smart grid (Figure 5). The most widely mentioned were improved reliability and operational efficiency, followed by cost reduction and outage recovery. These are tangible and predictable benefits, whose adoption can be justified to regulators, investors, city governments or coop owners, all of whom tend to favor "proved and prudent" investments. More long-term motivations such as accommodating distributed generation and centralized renewables are rarely mentioned. Among policy motivations, meeting legislative and regulatory requirements was identified by 20 respondents, but obtaining subsidies and grants was not a factor, perhaps because the survey was conducted two years after the Department of Energy smart grid grants had been completed.

Figure 5. Motivations for Smart Grid Adoption--Rankings



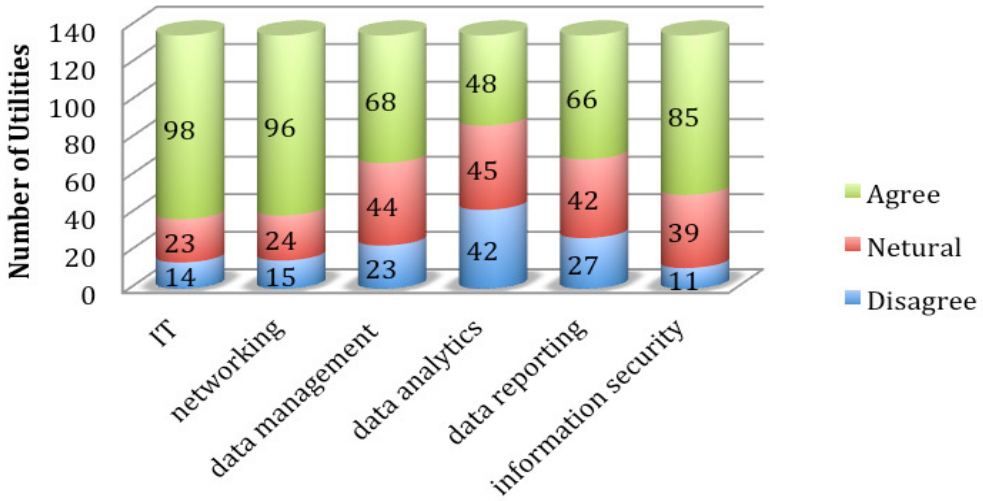
Looking at obstacles to adoption, the two biggest factors were the perceived immaturity of smart grid technologies, and the lack of funds to implement smart grid (Figure 6). After these were lack of internal expertise and customer resistance. The concern about technology maturity is consistent with the preference for proven technology investments and generally conservative approach to investment in the utility industry. Lack of funds reflects the funding process for utilities. IOUs must ask regulators to add investments to their rate base after the money has been spent, and must satisfy shareholders who often seek a reliable return from utility stocks. Municipals and coops must use operating cash or sell bonds to invest, and must be concerned with financial responsibility as well as adopting technologies that provide value to citizens or coop members.

Figure 6. Obstacles to Smart Grid Adoption—Rankings



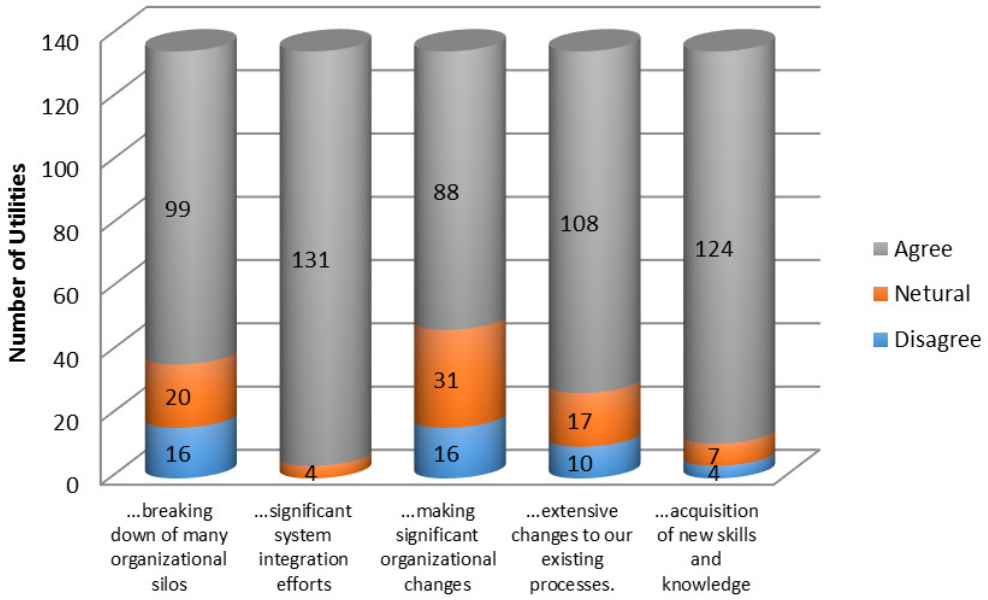
The next obstacle is lack of internal expertise. This is not too surprising, given that smart grid technologies require knowledge of IT, systems integration, network design and management and data science. As Figure 7 shows, the weakest areas of expertise are in in data management, analysis and reporting. These processes are critical if utilities are to achieve the potential benefits associated with smart grid. Utilities that we have interviewed often were scrambling to find or train people with those skills. Also, there is a need to integrate operations technology with IT, and it can be difficult to find people with knowledge in both areas to bridge that gap.

Figure 7. Organizational Expertise: "My organization has a high level of expertise in…"



Smart grid adoption entails significant organizational impacts on utilities, who have traditionally been relatively conservative organizations (Figure 8). Notable are the need for system integration, acquiring new skills and knowledge, breaking down organizational siloes and changing processes. In our interviews, we found that these challenges appear to be greater when utilities try to go beyond automation of processes (such as meter reading or billing) and start looking to capture deeper operational gains from integrating systems and data.

Figure 8. Organizational Impacts of Smart Grid Adoption: "Adopting smart grid requires…"



Comparing IOUs, Municipals and Cooperatives

We expected to find significant differences among the three groups of utilities, given that IOUs are for-profit firms whose primary goal is maximizing shareholder value, while municipals answer to city governments and coops to member/customers. Also, IOUs typically run widespread transmission and distribution networks, while municipals and coops usually just manage local distribution grids. IOUs might be expected to be more aggressive in adopting new technologies, and have greater resources to implement them (Rose & Joskow, 1990)

Among survey respondents, there is no significant difference in deployment rates of AMI, but there are differences in deployment of grid-side technologies such as MDMS, OMS, DER, DMS, VVO, PMU and microgrids, with IOUs having significantly higher levels of adoption. On the customer side, IOUs higher levels of HAN, EV, dynamic pricing and in-home displays, while coops have higher deployment of pre-pay pricing.

There is no significant difference in current or planned integration of technologies. Likewise, there was no difference among the groups' motivations or obstacles, organizational expertise, or organizational impacts.

Further Analysis

This paper reports on findings from the survey of utilities. We are conducting further analysis of the paper to test propositions developed in our in-depth interviews of utilities as reported in Dedrick et al. (2014). We will have results of these analyses by the time of the Grid of the Future Symposium and will report on them in both scholarly journals and professional publications.

BIBLIOGRAPHY

[1] Dedrick, J., Venkatesh, M., Stanton, J., Ramnarine-Rieks, A., & Zheng, Y "Adoption of smart grid technologies by electric utilities: Factors influencing organization innovation in a regulated environment." (Electronic Markets, 25 (1), 2014, page 17-29)

[2] EIA, 2015, 'How many smart meters are installed in the United States, and who has them ?' U.S. Energy Information Administration. http://www.eia.gov/tools/faqs/faq.cfm?id=108&t=3

[3] Farhangi, H "The path of the smart grid" (Power and Energy Magazine, IEEE, *8*(1), 2010, page 18–28)

[4] Rose, N. L., & Joskow, P. L " The diffusion of new technologies: evidence from the electric utility industry" (RAND Journal of Economics, *21*(3), 1990, page 354–373)