Information Systems and Smart Grid: New Directions for the IS Community

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Abstract

While there is growing awareness that smart grid is an enabler of the new “green economy”, the IS academic community has been slow to recognize the challenges and opportunities it presents. So far there is little research in the IS field on smart grid technologies, yet this issue is closely linked to a number of common themes in the IS field. We identify some of the most salient issues in smart grid to the IS field and propose ways for the IS community to engage in this emerging example of the “internet of things”.

Keywords: smart grid, IS community

Introduction

The concept of smart grid is proposed as a potential solution to many current challenges in the electric utility industry: surging power demand, overburdened grid capacity and aging infrastructure. All these challenges make the grid vulnerable to frequent overloads and outages. The electric utility sector has also been criticized for its damage to the environment —the U.S. accounts for only 4% of the world population but accounts for nearly 25% of greenhouse gas emissions (U.S. Department of Energy, 2008) and the electric power sector is one of the three major emitters of greenhouse gases due to heavy use of coal.

In response to these concerns, smart grid has been identified as a potential solution to enable a more efficient and cleaner power supply by integrating various information systems and technologies into the current electrical platform (Illinois Smart Grid Initiative, 2008). Smart grid is not a single technology; rather it is a big and complex social-technical system that consists of many sub-systems and technologies. In general, there are four types of technologies in smart grid.

The first type is AMI (Advanced Metering Infrastructure) technologies that involve deployment of smart meters, customer systems, communication networks and back-office systems to enable two-way information flow between utilities and users (U.S. Department of Energy, 2012). A key benefit of AMI technologies is the ability to reduce peak demand through demand response programs and variable pricing. With AMI, utilities are able to monitor grid traffic in real time and take appropriate actions to reduce stress on the grid in peak hours, and users can also receive information such as electricity pricing through variable pricing on a real time basis and are better incentivized to manage and adjust their energy consumption (Morgan et al., 2009).

The second and third types of technologies involve new technologies in transmission and distribution systems that aim to improve system reliability and security. These technologies can extend the lifespan of existing infrastructure and avoid investments in new generation and transmission capacity. The last type of technologies includes those that extend the original scope of electricity grid, such as distributed generation, energy storage and plug-in electrical vehicles.

Current IS-Related Issues in Smart Grid

Smart grid technology has received some attention from academics, but mostly from an engineering perspective. So far there is little research in the IS field on smart grid technologies, yet there is potentially a very large area of smart grid that is closely linked to a number of common themes in the IS field. One of the many concerns is the interoperability problem (European Commission, 2009). The

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electricity grid has historically relied on proprietary technologies, but with smart grid upgrades, utilities are seeking to use new technologies from different vendors which raise the concern of interoperability. However, there are no widely accepted standards as of yet. Also, it is not clear whether the most advanced forms of smart grid technologies are compatible with the existing utility grid infrastructure. Without uniform technical standards, it will be difficult to achieve interoperability among different networks operating in many different regulatory jurisdictions (Zysman & Huberty, 2010).

Another concern is how to deal with big data (John, 2012). Smart grid systems will generate a huge amount of data that utilities have never faced before. For instance, a smart meter could receive and send energy usage information between utilities and customers every 15 minutes. Imagine a utility that has installed more than one million smart meters, each reporting in 96 times a day, and it is easy to see how much data could be involved. This will produce challenges for utilities that lack the systems and data analysis skills to deal with these data. This is another place where IS scholars can contribute.

Data security and privacy is another issue in smart grid (WestMonroe, 2012). Smart meters record detailed energy usage information in near-real time and such information would be attractive to third party companies (Munkittrick, 2012). Such likelihood would increase the tension between data access and data privacy. In general, without effective control, the abuse of customer information would reduce trust in both utilities and customers. Utilities are aware of this issue, but would benefit more from the expertise of the IS community.

Among the data generated by smart meters, how to capture right information and present it to customers is another interesting topic to IS researchers. Customers could receive their energy consumption information on a monthly, weekly and daily basis, and the content could also contain charts or graphs to present and compare the energy usage more vividly. Such a challenge not only requires good information visualization and presentation skills, but also involves a more important set of skills—data mining.

In addition to the aforementioned issues, the lack of IT skills poses a knowledge barrier to smart grid development. For utilities, smart grid requires new IT skills such as system engineering and system architecture that is beyond the reach of traditional power engineering. Thus, scholars with an interest in system development could fill this gap by focusing on topics like system development, HCI and system evaluation in smart grid. Also, IS economists have a role in understanding smart grid management. For instance, a transaction cost perspective could also be applied in smart grid to study whether some key technologies should be developed internally or purchased externally in the market.

Future Directions

As mentioned before, smart grid presents big research and educational opportunities for iSchools and the IS community. In this section, we would like to propose some general directions that would help the IS community to engage in this emerging, big topic. It is important to note that the following is not an exhaustive list of topics but represents some issues worthy of studying in IS field. Under each direction, we also propose some research questions that would help IS scholars better approach the smart grid.

1) Information policy in smart grid: focusing on policies for developing uniform technology standards, defining data ownership, and protecting consumer privacy. Some interesting questions include: What are the impacts of current information policies on smart grid adoption and management? What alternative policies or policy elements can governments adopt to encourage innovation?

2) IS development in smart grid: focusing on design and development of new applications such as new toolkits for customers at home to understand and manage energy or data management systems governing meter data. Particular interest could be emphasized on development methods, software and hardware development and user interface design. Sample research questions are: How could traditional system development theories in IS help to develop information systems in smart grid? How could user-interface design in technologies such as smart meters or home-energy-management products help to engage more customers in energy efficiency?

3) Individual and organizational adoption and diffusion of smart grid technologies: focusing on the determinants of adoption as well as impacts of smart grid adoption on different stakeholders. Research questions worthy of studying are: What are the determinations of smart grid adoption and what forces are required to overcome institutional obstacles to smart grid adoption in such a highly regulated industry? Are traditional innovation diffusion models adequate to study the adoption and diffusion of such large-scale complex system? If not, what new angles should IS scholars take to address the adoption and diffusion

question? How can actors with different visions, interests and motivations coalesce to achieve the collective action needed to reach widespread smart grid adoption?

4) IS use and management in smart grid: focusing on how certain information systems are managed in smart grid, learning models and processes during IT use in smart grid, and evaluation of system performance in smart grid. Research questions that might be of interest to IS researchers include: How do utilities deal with organizational challenges in smart grid implementation? How could knowledge and organizational learning perspectives help to address smart grid technology assimilation and implementation problems? To what extent does smart grid represent a discontinuous innovation that requires major organizational change? What are the impacts of smart grid technologies on utility performance?

5) Others: including other interesting topics such as customer education, smart grid curriculum development, and using social networks to build green customer community. Researchers interested in this track could focus on the following questions: How would IT and social networks help utilities to outreach customers in engaging in smart grid? How would smart grid curriculum be developed and fitted in the IS field?

Conclusion

Unlike many simple technologies that have been studied in IS field, smart grid is a big complicated system involving many different but interrelated subsystems. The complexity of the system and dynamics between its components provide many opportunities for IS scholars to study. However, current efforts in IS community are still rare. We hope the guidance in this study would attract more attention and interest from the IS field.

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