SMART GRID – CONSUMER PERSPECTIVES
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ABSTRACT
The smart grid effort is the single largest grid modernization investment in American history. What began as a theoretical idea has increasingly become a reality: 54 workforce training initiatives have been selected to receive just shy of $100 million to train new hires and to develop new strategies and training curriculum for the future. Close to $10 billion in investments from both government and industry will introduce major activities in the next 3-5 years as the main momentum of the energy industry transformation. As grid development proceeds, it is necessary to realize that the final recipient of smart grid benefits should be the energy consumer. In the near term, we should empower the consumers so that they can actively participate in power grid operation and planning through demand response or other distributed energy resources; in the long term, we need to address how to build a smart grid that is both consumer-centric and capable of balancing multiple attributes (societal constraints versus individual consumer needs versus system operation constraints).

In this paper, we will address aspects of grid modernization that affect consumer-end activities — from infrastructure improvements to technological advancements to automation and integration. The roles of home automation, demand-side management, demand response, and the electrification of transportation will be discussed as they relate to the consumer. Practical considerations such as technology adoption and end-benefits will be presented.

Keywords: smart grid, home automation, demand-side management, demand response, electrification of transportation

1. INTRODUCTION

On October 27, 2009, President Obama announced the largest grid modernization investment in US history, amounting to $3.4 billion, with the purpose of promoting energy-saving choices for consumers, increasing energy efficiency, and fostering the growth of renewable energy sources like wind and solar power.[1] On November 24, 2009, Secretary of Energy Steve Chu announced that the Department of Energy would be awarding $620 million for projects that demonstrated advanced smart grid technologies and integrated systems that would help build a smarter, more efficient, more resilient electrical grid.[2] Earlier this year, 54 workforce training initiatives were selected to receive just shy of $100 million to train new hires and to develop new strategies and training curriculum for the future.[3]

The term “smart grid” has gained wide usage throughout politics and industry, yet perspectives on what a smarter grid actually entails range from an emphasis on infrastructure to an emphasis on new paradigm-shifting applications in the electric power industry. A view that has been
expressed by industry stakeholders and regulators alike is the idea that the technology of the smart grid must aid in achieving the energy policy targets set by the state to benefit consumers. From the utilities and policy-makers’ perspectives, there are three main business drivers behind smart-grid development: (a) to address the increased emission awareness and environmental concerns, (b) to improve aging infrastructure as well as grid planning and operation efficiency, and (c) to enable customer participation in energy delivery and management.

Utilities and policy-makers must realize, however, that regardless of whether their main impetus for grid modernization is emission awareness or utility planning and operation, in order to build a smart, efficient, and resilient electrical grid, such as indicated by Secretary Chu and President Obama, it is crucial to integrate the consumer into the real-time decision-making process. The pathway toward developing a smart grid that utilizes the consumer as an integral part of the system must therefore be considered. Such a pathway can be categorized into three main areas: information and infrastructure, instrument and technology, and intelligence and automation. Each of these areas will be examined in the following sections.

2. EVOLUTION PATHWAY FOR A CONSUMER-CENTRIC SMART GRID

It is critical to understand that the three areas regarding the development of a consumer-centric smart grid are mutually dependent on each other and that each area must evolve in conjunction with the others. There must be an infrastructure in place for information to pass between utility and consumer. However, such an infrastructure cannot be built without proper corresponding instrumentation and technology. And in the end, this technology will be rendered useless if it is not simple (i.e. automated) enough for the average consumer to operate easily.

2.1 INFORMATION AND INFRASTRUCTURE

In order to ensure that the customer is actively engaged in this new smart grid, it is crucial that there is active two-way communication between the utility provider and the consumer. The first step toward achieving this is the establishment of advanced metering systems, which would facilitate intercommunication between the supply side and the demand side. These systems, collectively referred to as an advanced metering infrastructure (AMI), would comprise of smart meters at the customer site, the means of communication between the customer meters and the utility provider, and any data reception and management systems located at the utility side.[4]

Similarly, consumer energy portals, essentially the “combination of hardware and software that enables two-way communication between energy service organizations and equipment within the consumers’ premises,”[5] provide consumers with access to information generated by the utility companies. As the metering infrastructure is established and improved, the information available to consumers through consumer portals could be increased, allowing for such statistics as real-time consumption and pricing data to be easily accessed. An effectively designed consumer portal would take advantage of an established AMI to provide not only information regarding usage but permit a consumer to participate in different demand-response programs and consider different personalized load-shifting alternatives.

The ultimate goal to achieve with more consumer access to information is to inspire better energy management, which can lead to peak reduction. Today, peak load duration, at 5% of the
year (or roughly 440 hours), accounts for more than 25% of distribution and more than 10% of generation assets, coming out to hundreds of billions of dollars in investments (see Figure 1).[6]

For example, if consumers were able to monitor real-time personal versus neighborhood community average energy usage data, peaks in the load curve could be reduced. With an AMI in place, citizens would be able to monitor the current load on distribution, and could then set their thermostats accordingly to help prevent a potential overloading of the system. More generally, consumers could determine off-peak times to use devices that consume large amounts of energy, such as clothes dryers and, in the future, plug-in electric vehicles (PEVs), which will be discussed later. This kind of behavior could lead to better energy management.

2.2 INSTRUMENT AND TECHNOLOGY

Realistically, it is unreasonable to expect voluntary consumption reduction to consistently prevent grid overload. To further enable and incentivize customers to aid in energy management, it is necessary to provide more than simply consumption information. Demand-side Management (DSM) and Demand Response (DR) programs are one such instrument, and include financial products (which can be categorized as non-event-based market approaches) that encourage consumers to be responsible for demands on power system delivery (through rebates, peak-pricing, etc.), energy efficiency through various technologies, and event-based load response approaches. Figure 2 shows the different levels of DSM, where at a fixed rate load management is strictly the duty of the utility company, and at real-time pricing load management is much more the duty of the consumer.

In order for any DR tradeoff to work, however, it is necessary for both the utility side and the customer side to have access to real-time information, indicating the need for a more advanced
metering infrastructure. Currently, technology is being developed by the industry that allows for much more control on the customer end, both in terms of access to information and direct control over consumption. Many products being developed are ZigBee-enabled, allowing for centralized, easy control, and intercommunication between products. As an example, the ZigBee SuperStat Thermostat provides the capability to reduce kWh usage by user-defined time and temperature setbacks and/or price signal responses. The ZigBee Thermostat, Tendril Outlet (which plugs into a standard home outlet and monitors energy consumption of any device), and others allow for more active customer participation. With this technology in place and an effective information infrastructure, DSM/DR programs can be actively used to manipulate consumption habits.

To test the effectiveness of real-time pricing, the Pacific Northwest National Laboratory set up the GridWise Demonstration Project, a year-long project in which they were able to demonstrate that “everyday household appliances can automatically reduce energy consumption at critical moments when they are fitted with controllers that sense stress on the grid.”[7] Additionally, not only did homeowners in the project generally not notice this automatic reduction of energy, most said that they would willingly purchase appliances with such controllers in them. The GridWise project illustrates three important points: (a) DR controllers can effectively act as a “shock absorber” for the grid by reducing power to selected appliances in times of peak load. (b) Up to 20% of energy usage can be temporarily paused if controllers are installed in all compatible appliances.[8] And (c), perhaps most importantly, consumer behavior can change if the technology is well designed and accessible. This last point further shows that incentive does not necessarily need to be monetary (or even particularly substantial) in order for it to be effective.

2.3 INTELLIGENCE AND AUTOMATION

As the GridWise Project indicates, consumer-side consumption manipulation has the potential to make a substantial difference. Implications of this simulation are that controlling consumption must be simple enough for the average consumer to manage (e.g. instant adjustment as in the PNNL study), and that all compatible appliances must have a standard communication and control system. On the consumer side, ZigBee- or HomePlug-enabled devices would provide simple, interactive controls. Having the same standardized communication protocol between all appliances would allow for interoperability, simplicity, and easy access to all consumption information. On the utility side, a communication protocol such as MultiSpeak or IEC 61968/CIM would standardize intercommunication and information access/presentation.

Both SCE and PG&E in California currently have Automated Demand Response (Auto-DR) programs available to consumers (a) with demand greater than or equal to 200kW and (b) who are equipped with an energy management system (EMS). The consumer’s EMS allows for automated load control, and as such, these two programs are good examples of the straight-through-process, where utility sends an event signal to the EMS, which automatically decreases non-critical consumption. Essentially a realistic application of the GridWise Project given current technological constraints, these Auto-DR programs exemplify the implications behind GridWise, providing simple, compatible technology to consumers who wish to aid in peak-load reduction.
3. EXAMPLES

Below are two examples which illustrate the application of the three areas discussed above.

3.1 PLUG-IN ELECTRIC VEHICLES (PEVs)

PEVs present critical challenges to the development of a modernized electrical grid. When charging, their energy consumption is equivalent to the energy consumption of roughly one half to one whole household. Additionally, most PEV charging scenarios are uncontrolled. This makes grid operation extremely difficult due to the large unpredictable load fluctuation. Yet despite all the issues surrounding charging, PEV batteries can be considered moving energy storage units, and could, in the future, be used to relieve stress on the grid at peak times. The near-term issues regarding charging, however, must first be addressed.

Uncontrolled charges add a significant load to the existing distribution system. As PEVs become more prevalent, these charges will account for a larger and larger percentage of total load. Because PEVs consume such a great quantity of energy per charge, they are an ideal target for DSM/DR programs. Currently, there is no coherent infrastructure in place to govern the charging of PEVs. Such an infrastructure, which may include monitoring systems, smart chargers, etc., would need to be established, and in such a way that private (home) charge-stations and public charge-stations exist within the same parameters. The technology and instruments used to control, monitor, manipulate, and access charging need to be established. For example, rate schedules could be designed accordingly, together with DSM/DR programs, to manipulate charging patterns to reduce peak load and improve the system load factor. And finally, such regulatory programs need to be automated enough to where controlled charging is as simple from a consumer standpoint as uncontrolled charging.

3.2 DEMAND RESPONSE PROGRAMS IN CALIFORNIA ISO

The California Independent System Operator (ISO) is responsible for the overall system operation of the majority of California’s electricity transmission grid. It conducts energy and transmission wholesale market activities. It also performs system dispatches to ensure reliability and stability.

California ISO has been offering DR programs to enable energy market participants to contribute to energy load reduction. Its Proxy Demand Response program is the next attainable step in reducing load peaks via financial incentives. In this product, Proxy Demand Resources (PDR) is defined as a load or an aggregate of loads capable of verifiably reducing their energy demand. PDR can submit bids into the wholesale day-ahead and real-time markets, which would help reduce load during DR events.[9] While the program has been defined and implemented, in order for it to be effective (i.e. receive widespread usage and reduce peak load) the infrastructure, technology, and automation must be in place. An infrastructure which allows for ease of communication between utility, proxy, and consumer must exist. The technology which allows for verifiable consumption reduction must be in use. And such an operation must be automated enough to where, in the case of a DR event, consumption could easily be reduced (the use of an EMS in the Auto-DR programs is a good example).
4. CONCLUSION

As discussion and development of a modernized electrical grid progresses, it is necessary to keep in mind the areas highlighted above. A new grid will only be truly effective if the consumer is fluently integrated into the architecture. The need for an infrastructure which allows for the communication of real-time information, the technology to adjust consumption based on this information, and a level of automation which ensures that the technology will actually be used, must not be underestimated. Better-informed consumers who possess the technology to easily vary their consumption habits will be critical in producing smarter, more resilient, and more energy-efficient grid.

REFERENCES


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