SMART GRID

A Customer Challenge

Consumers hold the key to technology's benefits.

By Robert Spencer and Mani Vadari

As excitement and interest in a smart grid builds, utilities across North America are launching Web sites and experiments that will help customers take better advantage of the information that will be available. But as great are the issues with privacy, data management, security and technical performance associated with two-way devices, we shouldn't delude ourselves that the customer changes ahead will be easy. Whatever the potential benefits, much will need to change both inside, as well as outside, in order for utilities to engage customers, and these changes in turn will create the most difficult challenges.

As important as funding, installation and performance issues will be, ultimately, widespread deployment and success will depend on the ability to engage large numbers of customers in different ways, as partners in energy-delivery networks. This will require customers to think differently about their energy use, and utilities to perform as change managers, in different and more sophisticated ways.

If this goes wrong, benefits will be greatly delayed and societal costs increased, so prior deliberate and thoughtful action is imperative.

Managing Change

The smart grid will move the utility industry's relationship with residential customers beyond conservation to load shaping. This will require both unlearning and new learning to be successful. As Fred Butler, New Jersey BPU commissioner and current NARUC chairman, has noted, "Consumers don't understand that it costs more to produce energy during a peak period."[1]

When electric utilities were operating in a declining marginal-cost environment, it was in their best interests to encourage consumption, often with declining marginal rates. Indeed, it's probably a misnomer to think of customers as kilowatt-hour (kWh) consumers; most are very aware of their consumption in terms of the heat, light and motion used and of the resulting bill (for kWh usage). Conservation has been approached in a similar way, with the focus on strategies that could reduce kWh consumption—such as insulation, compact florescent bulbs, *etc.*—and on the resulting bill.

However, detaching what is consumed (*i.e.*, capacity or the amount of generation capability needed to support the needs of the customers) from what is enjoyed (*e.g.*, heat, light and motion) has contributed greatly to residential customers' misunderstandings and reservations concerning rates. Why industrial customers should get better rates

Pricing strategies are hailed as a way to shape consumer behavior, but complexity likely will limit participation.

is a question many have asked, and few really understand the answer. Economists who suggest the answer can be found in better price signals for capacity used, especially during coincident peak periods, overlook the lack of a fundamental understanding of the consumption units themselves, let alone how to control them. Kilowatt (kW) pricing or even perhaps kilovolt ampere reactive (KVAR) pricing are mystical concepts for many residential households and possibly utility customer-service representatives as well.

Ray Gogel, formerly Xcel Energy's chief information officer and architect of the company's smart-grid city project, said, "Today's electric customers behave just like consumers would if they purchased food at the grocery store without knowing any of the prices. Consider how after making multiple trips to the store they get a bill finally at the end of the month. Do you suppose the bill would look different if the prices were known at the time the purchases were made? It's the same thing for electricity—smart grid will help customers know the price of electricity when they consume it, which should make consumption patterns quite different."

This is why *Forbes* reporter Andy Greenberg wrote, "The smart-metering movement slowly rolling out across the country's utility systems doesn't merely represent an invisible upgrade to America's power supply, it also aims at a more ambitious transformation: changing passive power customers into active participants in energy savings."[2] Smart-grid related load (and energy) reduction can be achieved through either curtailment (*e.g.*, thermostat set-back on space- or water-heating devices) or efficiency strategies (replacing an electric furnace and air conditioning with a heat pump).[3] But to fulfill one of its key promises, the smart grid will need to achieve both load reductions and shifting.

So the fundamental challenge is to build a common, though very different, understanding of what is consumed

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Smart Rate Designs

■ **Passive/Motivational Designs**—Programmable controllable thermostats are being developed that can provide near real-time energy-use data that are likely to be very interesting and helpful for innovators who, in turn, can help evolve related control devices and/or strategies.

■ **Active/Motivational Designs**—Positive Energy has illustrated how placing a door hanger on homes with a message of, "Did you know that when surveyed, 75 percent of your neighbors turn off their air conditioners and turn on their fan(s) during the peak evening hours" stimulated an average aggregate reduction in consumption of 6 percent (measured over six weeks).[1] This kind of approach would seem to be impactful with early adopters.

■ **Passive/Enabling Designs**—"PPL and other utilities that have begun installing the smart meters are finding that you need more than just the meters to help customers save power—there needs to be some kind of informational device, like a Web site, that will tell customers how much power they're using."[2] In a similar way, Microsoft recently unveiled its Hohm service, through which customers directly access their energy consumption information on a near real-time basis via a Web site *(www.microsoft-hohm.com)*. The best Web sites will contain some comparison with neighborhood consumption and have suggestions for how customers can reduce their energy use that would be especially of interest to the early majority.

■ **Active/Enabling Designs**—The next generation of programs will provide customers with the means of making explicit tradeoffs between comfort and efficiency or economics. In a novel field study conducted by the Pacific Northwest National Laboratory, consumers were offered incentives to allow the system operator to control their clothes drying and water heating loads through "very fast acting (~1 sec), autonomous, short-term load shedding."[3] The more consumers are able to set and forget, given the obvious lack of complexity, the broader the potential to early and late majorities and hence total participation rates.–***RS and MV***

Endnotes

1. From testimony by Jeremy Kirsch to the Pennsylvania PUC on Nov. 14, 2008.
2. Elizabeth Shogren, "Smart Meter Saves Big Bucks for PA Family," *All Things Considered*, NPR, May 1, 2009).
3. "Pacific Northwest Grid/Wise Testbed Demonstration Projects, Part 1. Olympic Peninsula Project and Part 2. Grid Friendly Appliance Project (October 2007).

and the importance of when an electrical device is operated. Many utilities have started the process through Web sites that upload consumption information to allow households (and energy advisers) to more easily identify peak periods of use. The best programs, like the one run by the Sacramento Municipal Utility District (SMUD), also include information on how an individual's consumption compares to the neighbors' usages.[4]

But programs like this still fail to build an adequate level of understanding required to make the smart grid a success. They are inadequate because they don't really illuminate the two primary components that drive use: installed consumption capacity, *i.e.*, appliance wattage ratings, and key household characteristics, such as the age of occupants, their income and (for those with electric space heat) their thermostat settings.[5] The next step required is to provide kW and kWh modeling tools to build a better understanding of how installed devices and behavioral factors influences energy and peak use. These tools also will help customer-service representatives to better advise consumers on strategies for reducing their system impacts and bills.

Influencing Residential Adoption

Typically overlooked during discussions of potential smart-grid benefits, is how presumed adoption rates will be achieved and sustained. Since the characteristics of the earliest adopters likely will be very different from others, achievements in early experiments and analyses probably aren't predictive.

All indications are that adoption rates of conservation behavior are slow. For example, a 2005 survey by the Department of Energy's Energy Information Administration found that only one third of Americans own programmable thermostats and "less than a fifth use them to change their homes' temperature during the day, even though half of Americans leave their houses empty from morning until evening."[6] If we are going to do better at influencing consumer behavior, the studies and theories concerning the diffusion of innovations[7] contain two helpful concepts: adopter categories and characteristics of the adoption process.

Each adoption category is shaped by different kinds of motivations and capabilities (or limitations) that shape the segment's propensity to adopt. In our smart-grid context there are:

■ **Innovators (~2.5 percent - the theoretical distribution)**: People who find technological innovations fascinating and desirable. They're most likely to be aware of how electricity grids function and the latest innovations, like LED lighting. Comfortable taking risks, many already have conserved substantially. Importantly, they're probably in direct contact with others who have conserved extensively, and are likely to be very green in their lifestyles. Because of their fascination with technology, they already might understand kW and kVAR concepts and will persuade early adopters especially to increase their conservation.

■ **Early Adopters (~13.5 percent)**: Can be characterized as fast followers, and usually these are people who have broader social networks in which they function as opinion leaders. Early adopters already access information on utility Web sites and use this in modifying their energy use. Because they often are better educated, they will be able to grasp the significance of kW and, importantly, be persuasive with many other households.

■ **Early Majority (~34 percent)**: Typically are brought along by early adopters who advocate change and can answer their questions. As such, they will apply the experiences of innovators and early adopters who will help them understand why kW is important. They might be using utility Web sites but might be more influenced by comparing their energy use with that of their neighbors. This is, however, a critical group to engage because of the role they play in influencing later adopters.

■ **Late Majority (~34 percent)**: Typically are much more skeptical and rarely provide opinion leadership. As a result, adoption must be simple and require little inherent understanding. This group probably has done very little conservation beyond turning lights off, and might be most prone to resentment of any change required in their time of use.

■ **Laggards (~16 percent)**: The last group to adopt, if they ever do. People in this category likely practice little or no conservation and are most likely to resist any attempts at influencing their energy-use behavior.

Some analysts associate education level, social class and age to these categories. For any utility smart-grid application, however, the distribution and composition of these segments has yet to be established. The good news is there has been enough conservation work done that factors likely to influence the adoption of smart-grid programs (*e.g.*, age, appliance mix, green behaviors, or others) should be readily identifiable. But to the degree new technologies and public subsidies are involved, resistance could be significant. In the words of AARP spokesperson Marti Doneghy, "We vigorously oppose the mandatory imposition of these smart meters in peoples' homes. Everybody has to pay for this change, and a lot of the 50-plus population simply isn't that interested."[8] Regulators should take note: Utilities that understand adoption characteristics and barriers to participation will generate more reliable forecasts of probable smart-grid benefits than those that fail to understand these characteristics.

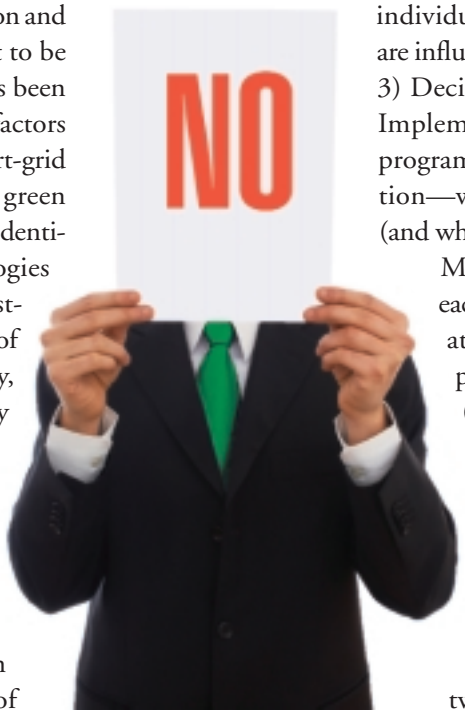

FIG. 1 SEGMENT APPEAL OF PROGRAM CHARACTERISTICS

Source: Authors' analysis

	MOTIVATION	ABILITY
PASSIVE	Appeals to Participate *(Innovators)*	Incentives to Participate *(Early Majority)*
ACTIVE	Coaching of Participants *(Early Adopters)*	Direct Help to Participants *(Late Majority)*

FIG. 2 EXAMPLE OF RATE OPTION APPEAL BY SEGMENT

Source: Authors' analysis

	MOTIVATION	ABILITY
PASSIVE	Sophisticated, High Risk/Reward *e.g.,* - Critical Peak Pricing *(Innovators)*	Control Settings, Low Risk/Reward *e.g.,* - Rebate Price Approch *(Early Majority)*
ACTIVE	Plan Oriented, Mod. Risk/Reward *e.g.,* - Real-Time Pricing *(Early Adopters)*	Delegated Control, No Risk/Reward *e.g.,* - Direct Load Control *(Late Majority)*

The adoption process is made up of five stages that describe how individuals in different segments are influenced to adopt a course of action or innovation: 1) Knowledge—exposure to basic information about actions available to residential customers to take advantage of the smart grid; 2) Persuasion—involves how individuals in different adoption categories are influenced to take interest in information; 3) Decision—whether to adopt or not; 4) Implementation—what energy device or program individuals use; and 5) Confirmation—what individuals commit to sustain (and what is abandoned).

Managing these stages, customized for each segment, will help utilities accelerate participation in their smart-grid programs. Because some segments (*e.g.*, late majority) will require higher touch approaches than others (*e.g.*, innovators), customizing approaches also will help reduce program costs.

Shaping Behavior

The smart-grid benefits utilities actually can achieve will depend on two factors: the rate of adoption and

Fig. 3 Need to Balance Employee Interventions

	Motivation	Ability
Passive	*Create Pride & New Identity* New Utility Brand Change Job Titles	*Institutional Learning* Screen Designs Process Scripts
Active	*Employee Engagement* Use in 1st Pilots Design Processes	*Individual Learning* Training Scenarios Call Recordings

Source: Authors' analysis

the magnitude of coincident and non-coincident peak-load reductions they can achieve. Key will be developing program strategies for each adoption segment that stimulate rapid and stable participation.

Consumers in the various adoption categories, however, don't respond equally well to motivation and capability development or passive and active efforts. There's a range of potential program decisions to be made and different adoption categories might appeal to varied consumers (*see Figure 1*).

Many smart-grid-related program ideas and designs provide examples of these points that allow speculation as to how segments might be engaged (*see "Smart Rate Designs"*). But while pricing strategies sometimes are hailed as another way to shape consumer behavior, complexity likely will limit participation and often might generate significant regulatory concerns. Key however, is to recognize that utilities should approach pricing by providing options that naturally will appeal to different segments (*see Figure 2 and also see "TOU Pricing Strategies"*).

Special rate programs are difficult to design and can lead to unexpected results for consumers. For example, when Puget Sound Energy introduced a simple two-tier rate structure that it touted could help households save money, the program in fact increased bills, despite changes in behavior.[9] Again, understanding how information and persuasion will drive decisions to participate is important in shaping realistic expectations and program designs.

The better utilities understand the characteristics of adoption segments and tailor smart-grid demand-side management (DSM) programs to meet their needs, the more durable and widespread the results are likely to be. Regulatory support will be important if a variety of pricing and program options are going to be used, though this will be important to maximize participation and retention over time. This is not a situation where a one-size fits all approach is likely to be effective, especially in the long run. Also, utilities might need to be incented in different ways so they truly see a benefit in long-term load reduction.

Finally, the evolution of consumer programs in support of a smart grid will require a number of changes within utilities themselves, not just a set of new incentives. Customer-service representatives, for example, will have to be re-tooled as energy advisers with the ability to provide information and persuade customers in the way to use energy and shape their loads. System operators similarly will require a greater sensitivity toward how their control activities minimize consumer and system disruptions.

The challenge in shaping development programs for internal audiences is that needs likely will be fluid as utilities come to understand the characteristics of their adoption segments better and as they work through various technical issues (*e.g.*, data management, security, *etc.*). This will require an approach that facilitates learning and that can evolve over time. It will require strong partnerships between managers and front-line employees, as well as across departments, to ensure a flow of information and development to evolve effective program strategies.

As employees achieve energy conservation advisory and technical roles, there are a few key activities (*see Figures 1 and 2*) where the focus will be on program offerings rather than segment characteristics (*see Figure 3*). For example, job titles and the utility brand will help employees take interest and pride in a new way of serving customers and performing their roles. Employee engagement in using new (experimental) energy/load control devices and then the development of new work processes will increase their abilities to be persuasive and enthusiastic with customers. Screen designs and scripts or job aids will need to evolve with customer and operational insights to make the most of opportunities as they arise. And training scenarios and call recordings can help employees better visualize impactful behavior they can use.

It's likely that independent third

TOU Pricing Strategies

Different pricing strategies naturally will align with different adoption segments.

- **Critical Peak Pricing**—since rates during critical periods could be up to 50-times higher than normal, participation will require the kind of sophistication most likely to be found among innovators. This would be a rate option best offered with little advertising and an emphasis on full disclosure of potential risks and rewards, but these are things innovators would find naturally appealing.
- **Real-Time Pricing**—a published rate reflecting the actual cost to serve can be used by customers to plan their consumption. Given the more moderate risks and rewards, this option would be more likely to appeal to early adopters. However, those with poor load shapes or who lack sufficient vigilance could find savings illusive, so some education would be required for participants.
- **Rebate Price Approach**—would integrate a control system to allow consumers to automate their desired levels of demand response with a rebate or refund. Studies suggest that this no-regrets kind of approach, where there is something perceived to be gained but nothing to lose, greatly increases the probability of involvement, signaling the obvious appeal to the early majority adoption segment. Since usage can be used to make the underlying rates transparent, there will be less education required and risks will be low.
- **Direct Load Control**—represents the easiest way to elicit participation of the late majority adoption segment. Here the customer surrenders control to the utility that can manage it in such a way as to deliver whatever kind of economic and comfort result the customer specifies. Even so, due to the intrusiveness, this might be a difficult option without a public mandate.–***RS and MV***

parties or perhaps utility spin-offs could help utilities access best-practice materials for motivating and enabling their employees. This will be important to accelerate results in the national grid and avoid costly errors or reinvention.

Achieving the Potential

For the smart grid to realize its potential, utilities and regulators will have to start treating this as the customer recruitment and retention challenge that it is. While the industry might have learned a lot about ways to shape customer participation in energy-conservation programs, accelerating smart-grid results will require a more systematic and deliberate approach—including a greater appreciation for the decision-making processes that smart-grid marketing will attempt to influence among consumers.

Accelerating the realization of benefits for the smart grid requires work in four specific areas. First, utilities need a consumption model that will help educate residential consumers on how installed capacity and life-style characteristics influence supply demands and timing. For most utilities this can be done through simple consumer surveys and multivariate statistical analyses drawing on existing models. Second, segmentation based on knowledge of specific customer characteristics will drive program designs and the rate of adoption. Prior experiences with adoption of conservation (*e.g.*, timing and extent of conservation) might be enough to define segments and factors (*e.g.*, age, price sensitivity or certain installed load characteristics) that will influence adoption rates. Third, program offers and rate designs need to be tailored for adoption segments to optimize participation and retention needed to sustain results. The next wave of studies needs to reveal how information and persuasion are best shaped to meet adoption segment characteristics, and to clarify the factors that generate a positive and sustained implementation within each group. Finally, serving customers in the more complex environment created by the smart grid will require very different services and employee skills. Utilities should, however, work to avoid reinventing programs to motivate and develop employee capabilities (*e.g.*, NARUC's Smart-Grid Collaborative). There will be a special role here for industry associations or regional system operators to help share best practices and materials to accelerate implementation and results.

This is a different and less technical approach. But the industry has reached a point where speculation needs to be replaced by a more systematic focus on what it will take to engage customers and retain them in smart-grid programs. F

ENDNOTES

1. Jesse Berst, "NARUC Chairman Charts Smart Grid Path," *SmartGridNews.com*, Jan. 9, 2009.
2. Andy Greenberg, "The Smart Grid vs. Grandma," *Forbes.Com*, May 15, 2009.
3. For an expanded discussion of curtailment and efficiency see Thomas Sanquist, "Human Factors and Energy Use," *Human Factors and Ergonomics Society Bulletin*, Vol. 51, No. 11, November 2008.
4. Leslie Kaufman, "Utilities Turn Their Customers Green, With Envy," *The New York Times*, Jan. 31, 2009.
5. See Claxton, *et. al.*, "Policy Implications for Utility Residential Consumer Surveys" *Consumers and Energy Conservation*, Praeger, New York, 1981, for a detailed set of coefficients and model of residential electricity consumption (R2 = .968).
6. *ibid*, Greenberg.
7. See Everett Rogers, *Diffusion of Innovations*, Free Press, New York, 2003, now in its fifth edition. Adopter categories and process characteristics are borrowed here from this source.
8. *ibid*, Greenberg.
9. Candace Heckman, "Off Peak Energy Plan Can Cost Users More, Utility Admits," *Seattle Post Intelligencer*, Oct. 24, 2002).