AMI and Home Networks – Will Advances in Energy Communication create a significant resource strategy?

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ABSTRACT

The electric utility industry increasingly recognizes the vital role of technologies that increase the efficiency of how its customers use energy. A consensus of utility industry, regulators, and policy makers is forming that expects energy efficiency to *create* up to half of the new energy supply needed over the next 20 years with the lowest resource cost, in a manner that has inherently less risk, less lead time, and yet more environmentally benign than any other resource.

As a key part of that strategy, the consensus is now stronger than ever for industry wide deployment of Advanced Meter Infrastructure (AMI), which, when combined with information displays and time-based pricing, is posited to increase the cost-responsiveness of consumer behavior. AMI and home networks are the cutting edge of an ongoing energy efficiency strategy*: to increase efficiency by providing meaningful information to energy consumers.*

This paper examines some of the big questions that resource planners have with this strategy: Do customers pay attention to information-based programs, and how effective can these programs become? Do we want a *Smart Grid*, or *Smarter Customers?* How will AMI and home network technology make it easier to be a smart energy consumer? How large an impact can we expect, and what can utility energy programs do to maximize that?

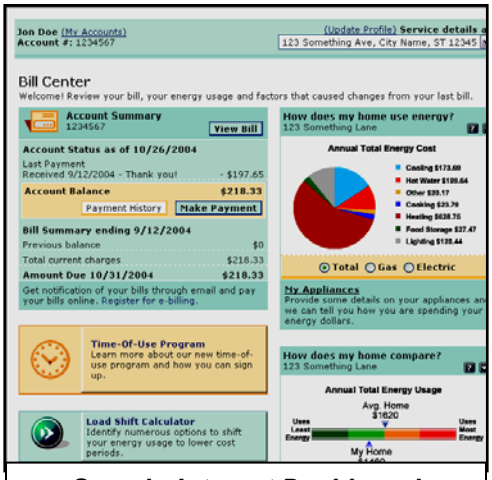
Are consumers interested in *meaningful communication*?

Despite rumors to the contrary, consumer interest in meaningful information is well established. Consider that over 20% of a utility's customers call their utility each year with a bill-related inquiry, on average 2.5 times each, according to 2005 utility survey by EPRI Solutions.

Since the 1980's, energy audits and information programs have been conducted and when evaluated, typically, savings of 2-4%% have been reported; but considering the cost of onsite services, these programs were only marginally cost-effective.[1] Recently, technologies are creating new methods of communication that may prove more effective and less expensive. For 10 years, audits have been offered via Internet, with improving quality and use rates. Several companies have rebuilt their Web customer service and call center systems to meet key customer needs to understand and manage their energy bills. Supported by advanced modeling, these *Internet Dashboards* provide the customer with actionable information including benchmarks and personalized bill-reducing strategies.

[1] ***Making it obvious: designing feedback into Energy Consumption****,* Sarah Darby, Environmental Change Institute, University of Oxford, 2001

- Over 30% of the customer base is using these dashboards each year at Puget Sound Energy, with an average of 4 visits per customer, and these use rates are growing rapidly.
- At Puget, PG&E, and PEPCO, online energy audits increased threefold when the websites connected energy efficiency tools to the customer service/bill question portion of the Website.
- In 2004, Wisconsin Public Service piloted diagnostics on the paper bill (*WPS Value Bill Pilot*), with remarkable results: 90% fewer calls from pilot participants, 7 times higher usage of utility web site, 90% found it more understandable; and 60% found it helpful for energy management



Sample *Internet Dashboard*

Smart Grid vs. *Smarter Customer*

One approach to creating resource benefits, particularly lowering system peak demand, is to install controls operated by the utility on customers' air conditioning, water heaters, pool pumps, and other equipment. These efforts, historically called load management, are now often called *Smart Grid* - a network that connects system requirements directly to customer endpoints. Companies such as Florida Power and Light, Kansas City Power and Light, and Southern California Edison have installed water heater controls as well as thermostats that can be controlled by the utility to increase temperatures during the "critical peak" period. Speculating forward on the Smart Grid option, this approach anticipates in the years ahead that generation, transmission, distribution, and end use equipment will in effect, collaborate directly as part of a single system, without any direct customer involvement.

Supporters of the Smart Grid strategy argue that it is more dispatchable than customer-side options and therefore can replace spinning reserve. While these programs have generally been cost-effective for the utility, there are concerns about customer choice and privacy, with detractors envisioning a scary *Borg-like* network as a natural extension of this approach.

Smarter Customer: AMI/Price option:

With smart meters and time-based pricing, the objective is *for the customer to decide* how to run their appliances. For 5 years, pilots have tested communicating thermostats, energy Orbs, and Web technologies as part of AMI (smart meter) initiatives. Operational benefits from smart meters include reduced meter reading costs, better load forecasting and control, and improved customer services, but increasingly the focus has been on the ability of these technologies to support time-differentiated rates, such as critical peak rates, which charge their highest rate for a few hours on a handful of days per year when loads are highest.

Theoretically, the same demand impacts can occur as with Smart Grid, with price as the arbiter and also serving as a boundary providing some privacy. Supporters argue that, independent of benefits, time-based rates are inherently more fair and inevitable: without them, some customers, such as those without peak-contributing central air conditioning, are paying too much and are subsidizing AC customers. Further, they argue that over time, both the consumer and his devices will adapt to accurate

pricing signals, reducing the system cost and providing benefits for all consumers, including non-participants.

As an analogy to clarify the benefits of pricing signals, consider the economics of food in an alternative world – where supermarkets don't have cash registers, but instead charge by weighing shopping carts as they leave the store. The price per pound of food is used, instead of the price of individual purchases, to charge supermarket customers. In this world, the price of a can of caviar is the same as a can of tuna of the same weight, even though it costs the store fifty times more. Customers without accurate price signals fill up their shopping carts inefficiently. Stores lose money on caviar which is passed on to all customers. Customers buy more caviar than they would if they understood the true cost. As a result, *everyone pays more.* In our world, conventional electric meters are like weighing the shopping cart. Inevitably, installing meters capable of time-based reads, like supermarket cash registers, increases system efficiency.

How large an impact can we expect?

As the results of each new pricing pilot become available, a common story is developing: *consumers respond to dynamic price signals.* In 2004 through 2006, a California statewide working group of utilities and government policy organizations conducted a pilot of critical peak rates for all customer groups, with a positive result leading to the decision for rollout of advanced meters and time-based rates for all customers. Notably, critical peak rates created an average 12.5% peak demand reduction.[2] Similar results were seen in smaller pilots in Texas, Missouri, New Jersey and Ontario. [3]

Below, we cite evidence that the impacts will grow with Web information and home network support. However, even at the 12.5% level, the technology "creates" the equivalent of ½ KW coincident peak load reduction for the average residential household. Notably, when installed, the impact of smart meters exceeds the capability of all other individual "clean" options for meeting future resource needs.

Further, since the system achieves operating savings in meter reads as well as customer service, only 10-40% of the advanced metering system cost is left to be attributed to achieving energy resource needs, and in most examinations is the most cost-effective means of achieving those needs.

Meaningful information will increase the impact

In the California pilot, as much as 34% average impact was seen with the assistance of supplemental information and controls. In a 2005 survey of 400 pilot participants, while 90% of pilot customers reported that they understood the rates, 70% of residential customers and 81% of commercial customers reported that they would benefit from additional information. Over 50% of residential customers were interested in a customized energy analysis by the utility to help them manage their costs. Respondents indicated that information should be customized and very specific to individual appliances. A pie chart showing the breakdown of electricity use in the customer's home or business is also reported by the survey respondents to be very valuable.

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[2] Charles River Associates, *Impact Evaluation of the California Statewide Pricing Pilot*. 2005

[3] *Latest Developments in Dynamic Pricing and Advanced Metering Adoption*, presentation by Dr. Stephan George to MA Restructuring Roundtable #99, February 9, 2007.

In 2004 and 2005, as part of the statewide pricing pilot, information approaches were tested, including an *Internet Dashboard* with diagnostics. Although sample sizes were small (approximately 200 total) information appeared to increase peak demand reduction of residential customers by .15 to .5 KW per customer, as compared with time-based rates alone, based on a statistical bill analyses. 46% reported changing their behavior in response to the information provided.[4]

How can households respond?

Since the typical utility peak period is during hot summer midweek afternoons, homes are often more flexible in their ability to shift than businesses during this time. Demand response opportunities in an individual home may seem small, as compared with the opportunity for control systems in industry and offices, but these small loads add up:

- Home central air conditioning systems in the many homes where everyone is at work or school can cut their contribution to utility peak by adjusting the clock thermostat intelligently. Thermostats that are adjustable over the Internet have become available at low cost, creating many new web-based options.
- Electric water heat can easily be shifted to off-peak. This could become more ubiquitous in the future using Internet communications and intelligence built into the water heater.
- Refrigerator defrost cycles occur randomly; in the future they may have built-in intelligence to respond to price.
- Laundry appliance, dishwasher, and pool pump usage can often be shifted by consumers who understand that prices vary by time-of-day, season, and weather conditions.
- Even on hot summer afternoons, it is not uncommon for the ubiquitous recessed ceiling lighting, with 75-100 watts each, to be running in kitchens and family rooms in homes where families are home. In response to price signals, these can be turned off, or replaced with improving compact fluorescent replacement recessed fixtures.

The HAN Showstopper: What support do customers need to achieve big impacts?

Home area network components are now viewed an important element of achieving the highest peak demand savings. In the California Pilot, average peak savings was 34.5% on households with control devices such as communicating thermostats, cycling devices, and displays. This is substantially higher than the 12.5% targeted by pricing alone, and in recent months utilities and regulators have been less willing to leave these potential benefits *on the table.*

In early 2007, PG&E pulled back on its ongoing AMI implementation to examine ways to maximize the system's demand-response capabilities using home network components. By May 2007, the three California investor-owned utilities were examining the requirements for home area networks together, under order and scrutiny from the PUC. Utilities in Texas, Midwest, and East Coast have joined the Open HAN task force begun by this process, and several have declared that their AMI vision is to enable responsive, smart energy environments within the home *that are gracefully integrated with people.*

[4] Nexus Energy Software, Opinion Dynamics Corporation, and Primen, *Information Display Pilot, Final Report*, , 2005

Some of the key issues now being evaluated make a big difference in how AMI will be implemented, and as a result, are holding back the process until they are further resolved:

Home network gateway and/or Meter network gateway*?*

A key question is whether home control devices will communicate with utility price and control options via Public Internet or through the utility's proprietary meter network.

With the meter network gateway approach, the utility provides the meter-to-display and meter-to-control devices, and in most models subsidizes them substantially. Displays are typically installed or plugged in to an outlet in the kitchen, providing basic information on metered electric use and price in real time. If the meter network is going to manage the devices, it needs to have greater bandwidth, two-way capability, and upgradeability than systems installed to date to service these needs over the next 20 years, a typical meter network system life. As a result, a meter network gateway system may have $50-$200 per home additional costs for these system capabilities and devices.

The home network approach requires that utilities provide Web-based services that are accessible to the customer, and if the customer chooses, directly to home devices. With this approach, the customer chooses and purchases devices over time from the electronics/appliance market. Home network components communicate through a home network router with the public Internet, as do other devices like printers and computers on a home network today. The customer's display of choice can be a home computer, or a log-in from a computer at work, or web-enabled cell phone (i.e. iPhone). Programmable communicating thermostats, as well end-point controls for water heaters, pool pumps, and lights, can have a web control panel as an alternative to on-device controls.

Device manufacturers such as Honeywell and Schneider Electric, as well as Internet equipment providers such as CISCO, view this approach as the obvious direction for the Smart Home. As participants in the MIT Energy Initiative's Infrastructure project, under way at the MIT Media Laboratory, various techniques for in-home communication are being evaluated and tested, to minimize costs and power requirements for these control systems. Open standards such as Zigbee (IEEE 802.15.4) and Internet 0 hold promise for near-term adoption.

With the home network gateway approach, one-way hourly meters are sufficient, and bandwidth needs are less, potentially reducing the AMI cost and increasing the number of options available. Also, since the customer buys the display and control equipment, these costs are less for the utility. The primary drawback is that the system's benefits are limited for the non-Internet-enabled households, and as a result options under consideration today often include both home and meter network elements.

The Utility's Web Workspace as the *Home Network Enabler*

What becomes clear with either of these approaches is that Web-enabled content quality will be the key to the customer's interest, and most likely, the level of impact. As we have seen with other types of Web workspaces, such as travel sites and financial sites, over time we learn how to be more effective at meeting customer needs for information, transactions become easier, and customers gain a greater sense of control.

As noted above, the success being seen today by utilities with Internet dashboards bodes well for the potential of Web workspaces to become regularly used by a majority of customers. From today's

use rates of 30% and higher, we expect further growth when the current information and transaction Websites are improved generally and enhanced with control capabilities, resulting in more traffic, more strategic value, and more impact. Therefore, one can view an investment in a quality energy management Web workspace today as a long-term opportunity for resource efficiency, as well as cost-reducing and effective customer service platform for utilities.

Further, when compared with the static content and quality of meter network-tied in-home displays, utilities can offer a richer, more interesting interface for working with customers on the public Internet. Web workspaces are more easily updated, and will work on the customer display of choice now and the display devices that we may encounter during the life of the meter network. By starting now on a workspace strategy, the utility resource strategist creates a foothold for the utility in the landscape for market-generated HAN, Web-enabled appliances, and PC thermostats in the years ahead.

Conclusion - *Time for New Paradigms*

The challenge for effective resource planning has been, for the last 20 years, to look beyond the typical paradigms of the past. Through the ability and willingness of energy resource planners to do this, we developed theories, then practices, and then proven methods of achieving resource balance through energy efficiency and demand response programs previously considered achievable only through additional generation facilities and fuel usage.

Today, within efficiency and demand response planning, we need to consider our paths forward. The industry's interest in considering AMI and meaningful information to customers, as a resource alternative, is on the right track, and should be applauded and supported. However, this paper highlighted but a few of the many paradigms, widely held, that we need to be reexamine and challenge.

Do utilities need to provide completely private networks for customer communication and device control? *No: The Public Internet is part of AMI – and will make it more effective and less expensive, but early action is important.*

Is it true that customers aren't interested in responding to energy bill information? *No: Graceful integration is a work in progress, but we know*:

- *Mass market customers understand, and respond to time-based rates.*
- *Utility customers are ready to use the Web to manage their energy costs if put in meaningful terms.*
- *Efficiency, Rate, and Customer Service communication are most effective when they merge.*
- *The Energy Bill of the Future is probably what we now think of as an Energy Audit.*

Is it true that, even if rates and information create an effective resource, we can't measure their impact? *No: Information-based savings are measurable, likely to be very important, and a good outcome worth pursuing.*