Bringing the Vision to Life: Will Advances in Energy Communication Create a Significant Resource Strategy?

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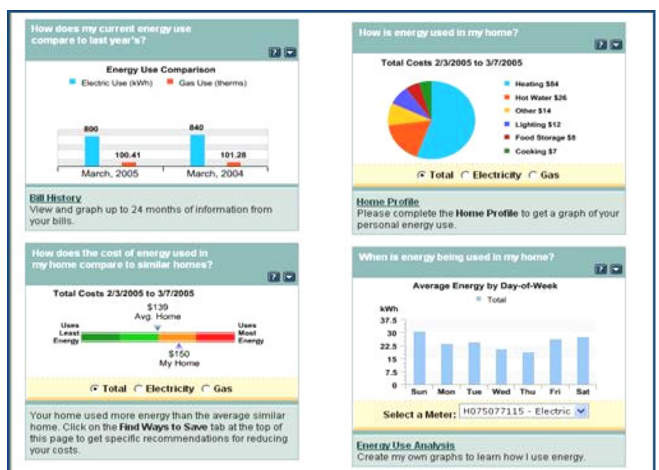
ABSTRACT

A consensus of utility industry, regulators, and policy makers is forming that seeks to increase the energy efficiency of homes and businesses to create most 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, controllable devices 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 communication systems for residential 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?



Sample *Internet Dashboard*

There is ample evidence that residential consumer interest in meaningful information is substantial and increasing.

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, utilities have conducted energy audits and information programs 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. Since 1995, utilities have offered audits 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*

[1] Sarah Darby 2001 paper reference provides a meta-analysis of energy information impacts.

provide the customer with actionable information including benchmarks and personalized bill-reducing strategies.

- 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

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. Florida Power and Light, Kansas City Power and Light, and Southern California Edison among others have installed water heater controls as well as thermostats that can be controlled by the utility to increase temperatures during the "critical peak" period. Headed by the California utilities, use cases for smart meter-to-appliance controls have been developed for thermostats and appliances. 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?

Recently several time-based pricing pilots have been conducted, and unanimously show a significant and similar result: *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]

As noted below, some evidence indicates that impacts will grow with Web information and home network support. However, even at the 12.5% level, the technology and critical peak rate combination "creates" the equivalent of ½ KW coincident peak load reduction for the average residential household on the rate (including non-responding customers). In aggregate, this suggests a national impact of over 50,000 MW of peak reduction.

Further, since the system achieves operating savings in meter reads as well as customer service, only 10-30% 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.

Increasing the impact with Information Supports

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 also indicated that:

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[2] Charles River Associates reference documents impacts of the CA statewide pricing pilot.
[3] Dr. Stephan George presentation reference shows the range of pricing pilot results.

- 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.

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 typically add to 2-4 KW on peak, as well as 5-10% energy savings:

- 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.

What Support Do Customers Need to Achieve the Highest Savings?

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 proceed with AMI without strategies to capture these potential benefits.

In early 2007, PG&E modified its ongoing AMI implementation and began additional pilots to examine ways to maximize the system's demand-response capabilities using home

[4] Nexus/ODC/Primen reference documents Internet/Information display findings.

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.* [5]

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 Intelligent Infrastructure for Energy Efficiency project, under way at the MIT Media Laboratory, various techniques for in-home communication are being evaluated and tested to determine effectiveness and minimize costs for these control systems. The communication protocol being tested (known as Internet 0) will use the IEEE 802.15.4 low power home network communication standard, as does the Zigbee Alliance, making possible near-term adoption of the enabling technology in home wireless routers.

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.

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[5] 6/26/2007 - meeting on Industry standard HAN development - PG&E, SCE, and SDG&E – presented to CPUC and CEC - Adapted from Texas PUC Smart meter Ruling - May 2007

Will Utility Web Workspaces Be 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-based websites are improved generally and enhanced with control capabilities. 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.

Bringing the Vision to Life

The ultimate load and energy impact of the smart consumer vision is certainly not known; however because early trials of home control equipment, conducted as part of the California Pricing pilot, have indicated nearly 35% peak impact potential, it is certainly a large and significant resource opportunity worthy of consideration for further research. Speculating forward to approximately the year 2015, the trends suggest that a combination of meter systems, web-enabled thermostats and other home devices, and improved Web applications will be a coordinated system that are the backbone of a more energy efficient society. Below are examples of how the vision can become operational in that period.

Meters

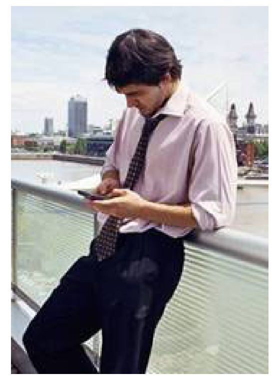
Utilities will need to provide advanced metering to price electricity on a time-differentiated basis. While many of the concerns about private meter control aren't needed for this vision, it is important that the meter systems also provide the availability of short-interval reads directly to the home for use by consumers and their web workspaces. These short-interval reads *on demand* are a key ingredient in measuring differential energy use, supporting the measurement of load, and cost, of any switchable device in the home.

Thermostats

Once local private area network capabilities are routinely included on home network wireless routers, along with 802.11 WiFi, it will be easy for device manufacturers to add home network capabilities and websites to help the consumer manage or make choices online, or on their cell phone or other Web-enabled communications.

Home network-connected thermostats are the most key to much more effective energy management in the home – by becoming readable and controllable by Web applications, it will be easy for the consumer to choose how to best manage their heating and air conditioning costs. What has become clear is that the earlier paradigm of *smart* thermostats, with displays, firmware, and utility-network connectivity, has become unnecessary. The thermostat only needs to communicate; the intelligence can be on the Web and display is any device that can connect to the Web. Water heaters, pool pumps, and refrigerators, at a minimum, are also incented and likely to be home-network accessible.

Web Applications



With device data and control available on the Web, low cost and easily upgradable Web applications can perform diagnostics and provide modulation of devices based on with consumer preferences, weather, and rate information. Utilities may be an early and common source for web workspace applications, but others are likely to find value in creating Web systems to serve their customers, including the thermostat or device manufacturers, traffic-hungry portals such as Google and Yahoo, and mobile computing for cell phones such as Palm or Blackberry.

It is hard to imagine all of the effective methods of serving the consumer, but some are obvious or already in trial:

1. *Make my AC, water heater, pool pump, refrigerator use pattern smarter.* A few questions in a software dialog will help consumers choose comfort in relation to cost, and modulate equipment to better respond to time-based pricing.
2. *Send me alerts.* On particularly expensive days, the consumer can receive a signal and choose to pay the higher price, or for example, go out to dinner and let the home remain uncomfortable. Or, the consumer can receive notice of high bill-to-date costs, and make choices.
3. *Find out what anything costs to run.* With short-interval meter data available to the home router, and then routed to a Web-based application, a Web audit on a cell phone could support the consumer walking around the home, switching loads on and off, and seeing what the impact of that switched load is – costs per hour during peak or off peak periods, carbon footprint, etc. Then, in a manner typical of Web audits, options for cost reduction including equipment replacements can be offered.

Bell Canada demo Web workspace

4. *Choose the best rate for me.* Rate complexity is no longer an issue with the availability of data and analysis on demand. Even if there are thousands of rates, the Web routines can easily determine the likely costs and benefits, rank the options, and help the consumer choose, *or choose for the consumer*.
5. *Make Me Sustainable*. Most consumers are unlikely to conduct detailed analysis. Similar to the power management on notebook computers, consumers will be able to choose a theme and get a summary of the consequences: lowest cost, smallest carbon footprint, comfortable but not wasteful, etc.
6. *OK – you can shut off my water heater sometimes.* The smart grid-load management-demand response options can be offered as options to the network enabled consumer, and can be implemented by the utility with practically no marketing or equipment cost. In effect, the utility is offering to buy a load reduction option. The price paid to the consumer can be quoted automatically, and if the consumer is interested, they choose it.

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 reexamine and challenge, as follows:

Utilities Should Install Meters to Measure Time-Based Use

We urgently need meter systems to be hourly cash registers, it costs little beyond operating benefits ($2-$3meter/year) and only time-based pricing makes economic sense ($25-$100 resource benefit per year).

Utilities Shouldn't Rely on Private Networks for Customer Communication and Device Control

The public Internet is part of AMI – and will make it more effective and less expensive, but early action is important.

- We can anticipate that the customer's display of choice will connect *with the Internet.* Web systems are low cost, flexible, and easily upgraded, promoting open, non-obsolescent customer connectivity.
- We can count *on the market* to develop and promote Internet-addressable displays, controls, and home networks. However utility time-based rates, Web-based customer workspaces, and communicating meters will encourage the market *to move faster*.

Consumers *Are Interested* in Responding to Energy Bill Information

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.
- Energy bills in the future may have similarities with energy audits of the past.

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