

Can Smart Meters Make Smarter Customers? Evaluating the Impact of Smart Meters on Consumer Energy Efficiency Behaviors

Sharyn Barata, Itron, Liberty Lake, WA
Linda Warner, Itron, Liberty Lake, WA
Michael Messenger, Itron, Davis, CA
Corrine Da Silva, LEVEL | LA, Irvine, CA

Abstract

Combining a smart meter with an educated consumer can lead to smarter energy use, but the key to understanding, or quantifying, how much energy was saved depends on blending the appropriate amount of new network functionality with tested evaluation techniques. This paper will explore various ways that smart meter technologies and feedback mechanisms are being deployed in North America, and how this is likely to impact the types of “new” energy efficiency programs and efforts to produce credible estimates of energy savings. In addition, the paper will also describe how the pursuit of these new savings opportunities help support the business case for smart grid and is likely to transform the way that utilities design, implement and evaluate energy efficiency programs.

This paper will explore customer perceptions and experience with smart feedback technologies. Various examples of how utilities can use the smart grid platform to change the way customers use electricity will be presented. Recent examples of how these programs are being evaluated across North America, including incorporation of newly established experimental design techniques, will also be discussed.

It's 2012 - How is Your Customer Getting Their Energy Use Information?

In our increasingly connected world, information flows freely and constantly from devices in our homes, workplaces and cars, to devices in our pockets, purses and briefcases. The content provides emotional context, the platforms offer relevance and the devices deliver personalized experiences based on preference and convenience. Consumers can now experience content in whatever way feels natural for them at any given moment: Their car can read them email during their morning commute. They can use their phone to remotely activate the home alarm system they forgot to set. And they can use a gaming console to access an ever-expanding library of online movies from the comfort of their couch.

We're living the dream of personalization. And we are finding ways to leverage this hyper-connectivity to speak to individuals like we've known them forever: enlisting websites to track our clicks across the internet and using algorithms to deduce what products to serve up and when. No longer content to sit idle while information is served up statically, the second screen experience has become ingrained in our daily lives. We are used to experiences that take us from one device to another and we embrace non-linear interaction.

In order for users to engage with this type of information, it needs to be manageable. And that means employing an application that can summarize the information from all the different smart devices in the home and display this information based on human interaction (i.e. someone standing in front of the device or engaging with it). A good example of this type of experience is the NEST thermostat that "wakes up" to display information whenever someone walks by.

Thanks to the updated grid and Smart Meters, energy information has not only joined the connected device age, but set the foundation for a cross-device conversation that encourages us to buy in and engage in meaningful ways.

Unfortunately, Smart Meters Are Not Enough

Recent headlines in an ACEEE Study Find: "*Smart Meters*" *Not Smart Enough to Slash Residential Power Use and Significantly Reduce Consumer Electric Bills.*"¹ But wait, did we ever think that by simply putting a "smart" meter on a home, we were going to see energy reductions? What is needed to make these smart meters realize their potential is a smarter customer.

ACEEE's 2010 report reviewed 57 different residential sector feedback programs conducted between 1974 and 2010. The conclusion of the research is that "*Advanced metering initiatives alone are neither necessary nor sufficient for providing households with the feedback that they need to achieve energy saving; however, they do offer important opportunities. To realize potential feedback-induced savings, advanced meters must be used in conjunction with in-home (or on-line) displays and well-designed programs that successfully inform, engage, empower, and motivate people.*"²

In another recent ACEEE report, John A. "Skip" Laitner, the Director of Economic and Social Analysis at ACEEE says that "*The bottom line here is very simple: Smart meters in and of themselves are just not 'smart' enough to get the job done for consumers and our economy. While advanced metering provides a useful tool, to save energy, cut consumer electric bills and reduce greenhouse gas emissions from power plants, utilities need to use these advanced meters to provide consumers with information on their consumption in ways that grab consumers attention and encourage them to take action.*"³

¹ John A. "Skip" Laitner, PR Newswire, June 29, 2012

² Karen Ehrhardt-Martinez, Kat A Donnelly, John A. "Skip" Laitner, *Advance Metering Initiatives and Residential Feedback Programs: A Meta-Review for Household Electricity Saving Opportunities*, June 2010, P.iv

³ John A. "Skip" Laitner, PR Newswire, June 29, 2012

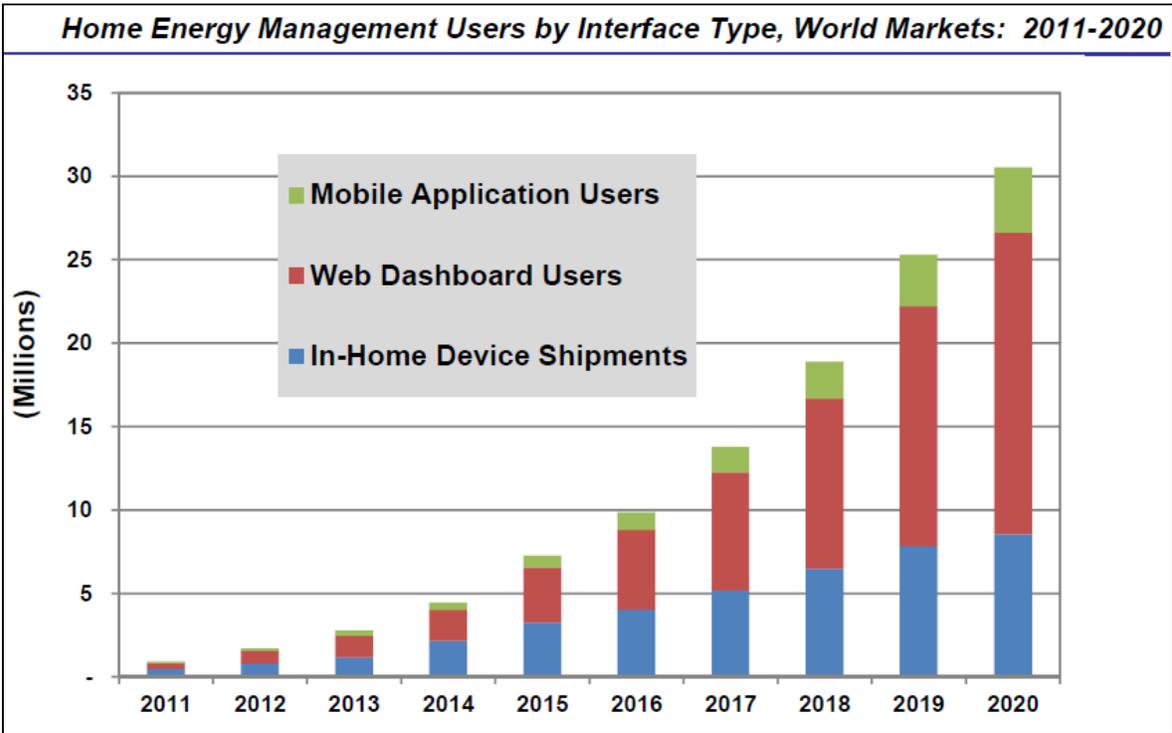
This paper looks at how customers are using “smart” meters and feedback mechanisms to consume energy more wisely. It also looks at ways that utilities are measuring savings obtained through this smarter energy use.

A Smarter Customer is Inevitable

There is much evidence available in 2012 to validate that consumers get smarter about energy use when the utility gives them easy and timely access to their consumption information. There are many who pontificate and speculate on what the next “killer app” will be in this space and often the conversation ends up focusing on the delivery device. Some will say nobody wants data on anything but a phone, others a PC, and yet others on a TV. They often disparage an In-Home Display (IHD) when the truth is many people are, and have been delighted with their IHD. The real truth is all devices have the potential to make consumers smarter. However, since people are not all alike and have different information delivery needs depending on their household composition and preferences, various types of devices are necessary to obtain optimal savings.

The following chart is from a Pike Research world study done in Q2 of 2011 that we believe accurately shows that all devices will have their place in the consumer engagement market space:

Table 1. Pike Research Study⁴



Information Delivery Device Options – A Myriad of Ways to Make Consumers Smarter

EnergyHub is a US based company that provides usage information to consumers via an IHD

⁴ Jevan Fox and Bob Gohn, Pike Research, Home Energy Management: In-Home Displays, Web Dashboards and Mobile Applications: Market Analysis and Research, 2Q 2011, p66

called the Home Base, a smart phone application, and web portal. The following customer testimonials about being made smarter were all submitted directly to EnergyHub.

A utility-program participant wrote:

- “I was so horrified by the amount of power being used by my refrigerator that I just bought a new one. If the [Home Base] readings and the projected energy use of my new refrigerator are even close, it appears I will use about 70% less energy to run my new refrigerator. I was really shocked. The monthly estimate...is about \$23/mo, about 400 watts at a duty cycle between 50% and 80% for our current, approximately 25-year old, refrigerator. The Energy Usage tag on my new appliance says it costs \$45/year to operate, at about (I think) \$0.11/kwh.

Using these numbers at face value says I can run the appliance for 10 out of 12 months for zero cost, saving over \$400/year in operating costs. The delivered cost of the refrigerator is under \$1100, so it seems like it's a 3 year payoff...Plus I get to stay married for at least until the new refrigerator is delivered and paid for. Laurie really hates our refrigerator and lets me know pretty much every day. I'm not sure if that little detail is useful to you, but it's pretty meaningful to me.”

Another customer said:

- “I look at [my Home Base] 3-4 times a day. That is the power of the unit for me – when I look at it I get real-time feedback. Same thing with pool equipment – with everything off, I look at base line and then turn the pool pump off. That wakes you up real quick! It's really easy to consciously think about [my energy use] with EnergyHub. When it's out of sight it's out of mind. Most people can't make big changes without something to tell them what they are spending. Every 30 days you open your utility bill and see what you've used. That doesn't help you identify what you could improve. But the Home Base does it very effectively. I believe in the whole process of what EnergyHub is about - making products a whole lot easier to monitor and manage your energy use...”

In Home Devices (IHD's) - Making Consumers Smarter

An IHD gives a “dinner with the family” kind of benefit; if you have children in the household, Mom or Dad's smart phone isn't going to get them involved. An IHD will allow them to participate in a way that is not possible on a personal device usually located in mom or dad's pocket.

A few testimonials follow from consumers at CenterPoint Energy in the United States tell the story. The utility provided a small, black and white screen IHD to 300 people who opted in for a pilot that ran from December 2010 to May of 2011. CenterPoint surveyed these customers three times during this period and a sampling of the final comments shows how consumers were made smarter by the experience.

- “Just two weeks ago, I noticed a substantial up charge compared to a normal expected amount during cool weather. I checked the upstairs electric water heater and notice it was leaking and not cycling. I turned it off immediately and replaced it. Without the monitor, I might not notice it until the substantially high bill would have arrived.”
- “It is very useful. I live in a house where there is constant activity. Everyone loves it; especially how it lets you know how much energy is being used at a certain time of day

and with the different types of appliances. Even the little kids are learning to read it and keep up with the usage.”

- “I am amazed at how well the device informs me the usage breakdown, it allowed us to manage when we were at our highest usage in a day and what we could do to be more cautious in what was being used and if it necessary. It’s a great way to manage my daily and monthly usage.”

The CenterPoint Energy study also points out these findings:⁵

- 93% of surveyed pilot participants were satisfied with the IHD
- 91% thought the display was easy to set up
- 80% would recommend an In-Home Display to a friend
- 71% made changes in electricity consumption behavior during the 90-day pilot as a result of information from the IHD
- You can hear directly from several pilot participants at:
<http://www.youtube.com/playlist?list=PL9203D6B5B600A398&feature=plcp>

Smart Phones - Making Consumers Smarter

A smart phone application gives a consumer remote access, and in many cases control over HAN devices. For a person who travels or works outside the home the smart phone application changes the way they can live. They are not only made smarter by learning about their usage, they can take action to consume wisely when they are anywhere.

A customer who uses a smart phone application wrote to EnergyHub:

- “The most important part is the automation side. I’m one of those people who walk out of the house and I think, ‘did I turn that thing off?’ Rather than driving back I can see that yes, I turned it off. Last summer I was spending \$120-\$130 on my utility bill [per month], this year I haven’t broke \$100. [This system] gives you a hands-on approach to see what you are going to save. I have saved a lot of money and recommended it to a ton of people...”

A utility employee evaluating a gateway with a smart phone application relayed the following story to Itron:

- *My twelve year old daughter called me at work one morning during a school holiday and asked me if she could go see the latest Harry Potter movie. I had been looking at my electric and gas consumption on the phone application for several weeks and realized I could tell by the pattern when my hot water heater turned on and when my dishwasher was running.*

I told my daughter that she could go but only if she cleaned up the kitchen first – it had been a mess when I left the house in the morning. At 12:30 she called and asked me if she could go. As I was asking her is she had cleaned up the kitchen I checked the phone app and based on patterns it looked like the water heater and dishwasher had kicked in

⁵ CenterPoint Energy Presentation – Steve Waters, Digital Communications Strategist, CenterPoint Energy, 7/26/11 and http://www.centerpointenergy.com/staticfiles/CNP/Common/SiteAssets/doc/In_Home_Display_Survey_Results.pdf

about noon. She said she had in fact cleaned everything up and had started the dishwasher at noon – the dishes were half done already.

Web Portals - Making Consumers Smarter

Energy Web Portals bring together energy related information from diverse sources in a unified way. Southern California Edison (SCE) offers their customers energy usage data through their SmartConnect web portal. Customers log into their site and can obtain detailed energy usage information obtained through their Smart meters. The following is from SCE's website:

Edison SmartConnect™ is bringing newer, smarter technology to Southern California with advanced communication between each smart meter and the system. This means shorter and more contained outages, new options for managing your energy use and spending, and energy savings and emissions reductions for the environment — in other words, a brighter future.⁶

An Itron employee had been using a web portal in conjunction with a gateway to look at his consumption and noticed that something seemed to be amiss with his HVAC system. Interestingly, the anomaly only happened around midnight once his home had cooled down to lowest level for the day. He called the repairman who discovered that he had a part that was going bad. His access to near-real-time data saved him the ordeal of losing his HVAC in the dead of a cold winter when temperatures were in the single digits.

“Competitions – Making Consumers Smarter

Last June, Itron announced their role as a founding partner of the Biggest Energy Saver Campaign, an initiative created by Texas-based utilities Oncor and CenterPoint Energy to jumpstart the market for smart meter applications and empower customers to benefit from smart meter technology. The contest, which ran August 1 – September 30, 2011, challenged consumers to make the most of their smart meter data to reduce their energy usage and potentially lower their electric bills.

After the two month contest period – in spite of being the hottest summer on record in Texas – the Biggest Energy Saver contestants reduced their energy footprint and saved money by using smart meter data. During the contest, the average savings for the top 10 percent of contest participants was 26 percent. The contest winner saved 36 percent on his electricity use. This YouTube video shows CenterPoint Energy's Biggest Energy Saver contest winners receiving their new Chevy Volt and discussing how they saved 36% on their energy use.

<http://www.youtube.com/watch?v=EPwRgjXpo8w&feature=youtube>

Grid21 - a non-profit formed to engage utility customers - understanding that the contest was intended to jump-start the market for consumer-friendly energy-management tools, and to show consumers the benefits of smart meters; created a dedicated website that provided power-use data to Texas consumers. This website generated interest from every US state and more than 80 foreign countries. Registrations on the Smart Meter Texas website jumped 172% after the contest was announced.

SmartmeterTexas.com

⁶ Southern California Edison Website 3-17-2012

So, Are these Smarter Consumers Saving Energy?

An ACEEE report released in February 2012 ACEEE found on average savings of 3.8% from feedback initiatives. These large scale pilots and experiments took place in the US, UK and Ireland between 2009 – 2011. This research built off of ACEEE's 2010 report of a review of 57 different residential sector feedback programs conducted between 1974 and 2010 which showed electricity consumption reductions between four and twelve percent.

Another interesting finding from this study was that since 1995, feedback induced savings levels have been higher in Europe than in the US. The study suggests that these differences may be due in part to cultural and policy differences between the two countries.

Evaluation Activities Tied to Smart Grid Capabilities

Increasingly utilities are being asked to quantify the energy savings associated with their behavioral efforts. The various feedback initiatives highlighted in this paper require distinct research methods to parse out the savings associated with customer energy behavior changes. Smart grid networks enable new technologies and communication pathways that will require new types of evaluation that were not possible in the 20th century. Some of these examples are shown below.

Smart meters can provide evaluators with both more tools and more data to understand how energy use requirements at the building, substation or zip code level change over time. These tools and data make it easier to develop control groups. Smart grid analytic software can be used to monitor trends in usage at the substation or individual building level in small time steps and combine this data with other building and owner characteristics to measure initial savings and the persistence of savings over time. Smart grids databases allow researchers to use cluster analysis to group buildings with different energy signatures. This allows evaluators to determine if differences in usage patterns can be parsed out into estimates of savings for different geographic areas and for different time intervals.

Given the significant increase in the level of granularity energy usage data that now is easily accessed and linked to customer accounts, there are significant new efforts focused on developing protocols to standardize new analysis techniques to take advantage of this new wealth of data and to estimate first year savings and their persistence over time. For example, in the fall of 2011, the California Public Utilities Commission hosted a workshop focusing on the importance of Experimental Design to estimate the impacts of new types of programs that use social networks and various forms of feedback to change behavior. Experimental design becomes more important when potential changes in usage are likely to be small initially and gradually build over time. The only practical way to control for different factors influencing customer energy usage is to use randomized selection of participants and non participants to estimate changes in usage over a number of households. This will allow for the control for other factors that make traditional measurement of program impacts very difficult - such as self selection bias. The following best practices were recommended as a workshop outcome:

- Randomized Controlled Experiments (for feedback program where treatment and control groups can be easily separated before the program begins)
- Quasi-Experimental Designs (for programs where customers must be recruited)

At the national level, the SEE Action group is in the process of finalizing a set of Evaluation, Measurement and Verification (EM&V) protocols for Residential Behavior-Based Energy Efficiency

programs.⁷ These protocols are designed to give local and state policy makers with simple evaluation menus or tools to decide how to quickly develop sample designs to estimate the impacts of different forms of feedback and or more general behavioral programs.

The large databases currently being set up by the smart grid pioneers to house the more granular forms of energy use data can become more useful by linking the household usage data to demographic and building characteristic data. In theory, this building and customer characteristics data can be keyed in, or linked, when the smart meters are initially installed. This small investment will provide utilities with a better idea for years to come of their customer's structural demand for energy and the energy intensity of the buildings they occupy. In addition, it can form the basis for doing more extensive ethnographic research on clusters of building usage data.

The usefulness of ethnographic research is promoted as highly valuable in the ACEEE 2012 report. Studies using ethnographic research in California in 2010 produced a treasure trove of information showing how customers gather, synthesize and act upon energy usage information and data.

Finally the new functionalities offered by smart grids and the increased availability of energy usage data can be used to tackle the most difficult of evaluation problems, estimating the persistence or degradation of savings over time. Documenting the persistence of savings, while not unique to behavioral programs, is an issue which researchers have begun to evaluate using randomized control experimental techniques. Is the new IHD merely a novelty which after a few months is merely another appliance which needs dusting each month? Or is it an important tool that is used, at least intermittently, to maintain the initial level of behavioral energy savings?

Opower has been monitoring the persistence of energy savings from its various behavior programs using monthly billing data for over four years for a number of utility clients. From the inception of its feedback programs, participant treatment and control groups were selected on a random basis with participants receiving the treatment given the option to opt out at any time. Results from their analysis show that annual savings from the program tend to steadily increase during the first year, and then continue to increase but at a slower rate in the second and third year. The analysis of annual savings has not yet shown signs of degradation, or a loss of savings, even after the third year, but the experiment is ongoing and thus it is possible that savings could start to degrade in the fourth year. Opower plans to continue to monitor savings from the same experimental and test control group indefinitely; or until their clients perceive there is no longer a need to fund the research.⁸

Opower has also begun to use the more granular energy use data from its customers who have installed smart meter networks. The more granular data at the fifteen minute or hourly basis has been most useful in improving the effectiveness of their algorithms to target customers and provide site specific insights on cost effective options to reduce the home's monthly energy usage. More specific evaluations that seek to estimate the incremental impact of different types of dynamic rates on customer adoption of peak savings technologies and or impact on the effectiveness of the Opower feedback and insight reports will probably take greater advantage of the more granular data, but there is currently limited experience with these evaluations.

Conclusion

Consumers may be reaching a saturation point in terms of the number of smart devices they are willing and able to interact with. For energy to find its place in this crowded connected world,

⁷ Evaluation, Measurement and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations - A Product of the: Consumer Information and Behavior and Evaluation, Measurement and Verification Working Groups of the State and Local Energy Efficiency Action Network March 21, 2012

⁸ Personnel communication from Nancy Hersh, Vice President of Analytics at Opower on April 23, 2012.

energy information must not only flow freely across devices that exist in the home (TV, washer, dryer, tablet, refrigerator), but it must also be packaged with other high priority information such as the weather, social connections or the local news. Tests have shown that some user segments need a more nuanced understanding of their energy consumption: Not only the usage per hour (UPH) of each device, but also what their total energy consumption is at any given point in time or is likely to be in the next monthly bill. Others are not interested in the details at the device level but want their network to manage their equipment use to a predetermined budget and provide alerts when this budget is likely to be exceeded. Providing devices that can meet the needs of a variety of customer segments will be a key challenge for energy service providers over the next twenty years.

While the early evidence is promising and suggests that consumers are not only accessing their smart meter energy information through a variety of feedback mechanisms, but that the knowledge obtained is leading to smarter customers and smarter energy decisions. Unfortunately, there are a number of threats to the success of endeavor. One of these issues is the quest for the “perfect” feedback device. Consumers should be provided a number of options and allowed to choose the option that works best for them. Secondly, we have to find a way to reassure the small, but vocal minority, that their data information can remain private.

As evaluators we can play a key role in helping to pave the way for increased customer information access and use. Results from our energy research and evaluations will make the savings more transparent and bring increased customer support for these new technologies. Savings protocols for smart grid enabled programs are already starting to spring up which we contend is a good leading indicator that success can be sustainable.

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