Research Study:

Residential Energy Use Behavior Change Pilot

(CMFS project code B21383)

Presented to:

Joe Plummer

Minnesota Department of Commerce

Office of Energy Security

April 20, 2009

Ed Carroll – Franklin Energy

Eric Hatton – Franklin Energy

Mark Brown – Greenway Insights

Table of Contents

Research Objective

This project was funded through an applied conservation research and development grant from the Minnesota Office of Energy Security (OES).[1] The objective of this research study is to gather, analyze, and present the information necessary for OES and state utilities to move forward with a solid plan for piloting residential energy use behavior change programs as part of their Conservation Improvement Program (CIP) efforts. The end goal of this effort is to help Minnesota utilities better understand how to accelerate energy savings from changes in residential energy-use behavior. This goal includes recognizing the implementation challenges of these programs as well as their cost effectiveness on a dollar per kWh saved basis.

The programs that are the subject of this research report aim to generate energy savings by impacting the behavior habits of individuals in their households. While many traditional utility-sponsored energy efficiency and conservation programs aimed at the residential sector focus on incentives to encourage and enable weatherization, appliance upgrades, and the installation of compact fluorescent light bulbs (CFLs) to generate energy savings, the programs we examine in this report seek to give information and feedback to influence customers' motivations related to the use of energy in their daily lives. They go beyond educating consumers on ways to decrease energy consumption by providing tools for individuals to better understand the nature of how their actions relate to their energy consumption and compare their consumption activities over time and to their neighbors.

As this report will discuss, there are a wide variety of approaches for utilities to address residential energy-use behavior. Some approaches involve sending customers more useful information on their energy consumption patterns and how they compare to their neighbors or similar households in terms of size or number of occupants. Others seek to recruit customers to install monitoring devices that provide real-time feedback on energy use in terms of dollars and kilowatt hours. These monitors highlight how different behaviors consume energy and drive costs allowing consumers to learn through experimentation. As some utilities have demonstrated, investments in advanced metering infrastructure can create a 2-way communication channel that gives utilities the ability to influence behavior by offering direct incentives in the form dynamic energy prices.

This report outlines the nature of these programs and provides real-world examples of how these approaches and technologies have been evaluated and piloted by various utilities around the country and beyond. It illustrates the advantages and disadvantages of different approaches, and the magnitude of the impacts realized and anticipated with respect to energy savings. Importantly, it offers insights gained from the program managers that have been involved in these efforts. Hopefully the lessons learned and critical success factors identified through their experiences can help to ensure that utility decision makers taking on similar initiatives increase their likelihood of success in achieving cost effective, persistent energy savings.

---

[1] The grant was initially provided to Glacier Consulting Group whose lead staff on this research project later became part of Franklin Energy. Despite the change in corporate authorship, the project scope remained the same as originally drafted, identified with CFMS code B21383.

Executive Summary

By evaluating published studies on energy-use behavior change interventions and in conversations with industry participants, the research team was able to identify evidence as to the variety and effectiveness of behavior change programs and pilots:

- The team identifies three broad categories of programs and solutions implemented to generate energy savings through residential consumer behavior change: 1) In-home devices and displays providing real-time feedback, 2) Customized, regular feedback delivered to customers, and 3) Dynamic pricing and rate design programs, typically involving smart meter technology. The last category, given infrastructure investment requirements, is considered to be outside of the scope of the pilot design goals of this study.

- Research suggests that direct feedback interventions such as in-home energy use monitors can generate electricity savings of 5% to 15% on average. Indirect feedback on energy use such as information reports delivered to customers can motivate residents to lower energy use from 0% to 10%. A high variability of reported energy savings speaks to the influence that participant selection, feedback provision methods, and program execution can all have on outcomes.

- While empirical evidence from utility pilot programs investigating direct and indirect feedback interventions is somewhat limited, several recent examples provide insight into the viability and savings potential of these approaches:

    - The experiences of Hydro One and NSTAR with the PowerCost Monitor devices in addition to findings from in-home display studies in Nevada and Florida, suggest that average savings of 3% to 7% with a midpoint of around 5% are likely to be achieved for participants of these kinds of direct feedback programs. It is important to stress that this savings opportunity exists for a self-selected population that is motivated enough to install the feedback device in their home.

    - Positive Energy's electricity use reports offering neighbor comparisons have motivated SMUD's customers to make changes to energy use, lowering demand by 2% in a broad non-targeted population. A powerful finding from behavior science is at the core of this program; individuals are motivated much more by their perceptions of what other people do and find acceptable than they are by other factors such as the opportunity to save money or conserve resources, contrary to even their own perceptions of motivation.

    - BC Hydro has found the use of personal commitments, incentives, and online information tools to be an effective means to drive behavior changes. The Canadian utility has enrolled more than 60,000 customers in the first few months of this effort.

- One important distinction in program reach is whether the approach requires program participants to opt into the program (e.g., agreeing to purchase a device) or whether feed back is distributed broadly to a larger group (e.g., mailing energy use reports to a large population of customers). While direct feedback programs may achieve higher savings per participant, they are only likely to attract a single-digit percentage of self-selected utility customers. On the other hand, indirect feedback programs may have more than four times the potential savings opportunity because of their opt-out nature.

- Interview respondents offer a number of valuable lessons learned and critical success factors to utility managers considering and embarking on their own behavior change program efforts. An orientation to customer motivation as the essential ingredient to program effectiveness and engagement to collect customer input into program design were stressed by multiple respondents. Program managers are also encouraged to seek out a diverse program team, take an iterative and continuous approach to piloting solutions, and be mindful of their measurements and objectives.

- The cost effectiveness of behavior change programs depend heavily on the achieved reduction in kilowatt hours and the cost to provide feedback. The savings achieved from Positive Energy's program with SMUD are reported to have around a 3¢ per kWh cost to the utility for first year savings. On the other hand, utility cost of first-year savings from real-time feedback monitor programs is more likely on the order of 30¢ per kWh. This is a function of the high cost of devices relative to customer willingness to pay as well as the substantially high drop-out rate (around a third of participants within 3 months) among participants.

- Research studies show that the reductions in energy demand achieved by behavior change programs persist as individuals have developed new habits with respect to energy use. Utility-scale pilot programs confirm these findings, showing savings persisting over periods as long a 18 months, though robust empirical evidence is somewhat lacking due to the recent nature of many of these initiatives.

- Given Minnesota's energy-use profile, it is likely that savings potential would match the average of results from programs across the country. The region has annual household electricity (11,500 kWh) and natural gas consumption (~70k cf) that is very close to the national average. While the percentage of homes with electric space and/or water heating in a particular area may influence the savings potential from in-home electricity-use monitors, many of the behaviors cited as leading to energy savings in the various utility studies conducted to date – turning off lights, laundry/dishwashing habits, and use of electronics – highlight that the impact of these programs is likely to be somewhat location-independent. Furthermore, a program's savings potential is much more a function of success in creating customer motivation than the sum of factors driven by regional differences.

Based on results of the team's research, three behavioral change program models are outlined for consideration by Minnesota utility managers. The models present concepts for implementing the types of feedback interventions reviewed in the study. A model overview is provided along with a program plan to define the necessary process steps, associated actions and outcomes, and their link to the key lessons related by study respondents. To the extent possible, reasonable savings and persistence estimates for planning purposes are provided. These models focus on interventions that can be implemented without the need for existing smart meter infrastructure (i.e., they do not consider third category of behavior change interventions such as dynamic pricing programs).

Program Models	Model 1: In-Home Energy Use Monitor	Model 2: Indirect/Comparative Feedback on Home Energy Use	Model 3: Hybrid Approach – Comparative and Direct Feedback
Program Basics	Participants receive a monitor that provides real-time feedback on home energy use in order to track and experiment with their energy use behavior	Participants receive regular reports in the mail that will compare their energy use with neighbors in similar homes. Targeted energy saving tips will also be communicated.	Participants receive regular comparative feedback reports and energy tips. Participants will be encouraged to make use of real-time power monitors that can be purchased or borrowed for several months at a time.
Customer Engagement Method	Opt-in	Opt-out	Opt-out (reports) Opt-in (in-home device)
Targeted participant household savings (as % of total kWh)	5% (mid of 3% to 7% range) Valid among self-selected participant population	2% Average in total customer population; targeted segments would have significantly higher savings (e.g., in the 5% to 10% range)	2%+ Average in total customer population; targeted segments would have significantly higher savings (e.g., in the 5% to 10% range)
Big Advantage	Real-time feedback for participants	Cost effective approach with broader reach	Hybrid approach maximizes savings potential
Big Disadvantage	Significantly higher cost per kWh saved	Requires integration with system data	Greater complexity/ resource requirements

Research Methodology

To accomplish the research objective outlined above, the research team collected input from available published research and through interviews with experienced program managers, consultants, and researchers. The team sought to identify major pilots and program efforts undertaken in recent years by utilities aimed at influencing residential energy-use behavior.

Published literature as cataloged by researchers at institutional resources including the Precourt Institute for Energy Efficiency at Stanford University (Precourt), the American Council for and Energy-Efficient Economy (ACEEE), and the Electric Power Research Institute (EPRI) served as a starting point for the team's investigation. Through these efforts, findings from experimental studies and behavioral science research going back over several decades provided valuable benchmarks on potential savings opportunities and the theory behind behavior change. Several of the more comprehensive studies are discussed in greater detail later in this report.

Based on the references in these publications, through conversations with knowledgeable individuals at key associations and team member contacts, the team approached a number of utility program managers, consultants, and researchers that had completed pilot studies and experiments or were evaluating options for their utility to apply various behavior change intervention solutions. More than 15 respondents agreed to participate in informational interviews and the sharing of published materials. Participants had varying degrees of engagement in behavior change programs ranging from oversight responsibility for utility pilot programs providing to those involved in more preliminary research and program evaluation.

The interviews and collection of publications were conducted with the end goal in mind of developing recommendations on worthwhile pilot programs to pursue with respect to residential behavior change in Minnesota. Such programs would be able to achieve real savings that could persist and be verified through appropriate control group studies or other methods of measurement and verification. Specifically the research aimed to provide input across a number of dimensions that would be of concern to program managers:

- Program objectives
- Program pilot action plan
- Target customer market
- Customer education activities
- Savings goals and assumptions
- Marketing/incentive strategy
- Quality control plan
- Key lessons learned and applied

Literature Review

The research team encountered numerous published studies on various aspects of energy-use behavior change. Some reports documented specific field studies and experiments conducted to evaluate the impact of different interventions, some served to provide an outline of behavior change theory and insights provided by the field of behavioral science, others are review studies assessing the implications of, in cases, dozens of prior studies.

Three publications in particular were found to be most useful in summarizing the findings from research in this field:

Sarah Darby at the Environmental Change Institute at the University of Oxford in England is identified in literature and through conversations with multiple interview participants to as a thought leader in the field of behavior change programs. Her publication: *The effectiveness of feedback on energy consumption: a review for DEFRA of the literature on metering, billing, and direct displays* was published in 2006. The author's conclusions are widely cited, notably that energy savings from direct feedback (e.g., in-home displays showing meter data in terms of cost and consumption) average from 5% to 15% while indirect feedback (e.g., providing energy use information with customer billing statements) has been shown to achieve 0% to 10% reduction in energy consumption depending on the context and quality of information given. It is noted that feedback is useful as a self-teaching tool to help consumers understand and adjust their habits with respect to energy consumption. (Darby 2006)

Corinna Fischer's paper: *Feedback on household electricity consumption: a tool for saving energy?* was published in February 2008. This paper reviewed 21 original studies and 5 review studies across 10 countries to investigate the effect of feedback on electricity consumption. The paper concludes that feedback stimulates energy savings with "usual" savings of 5% to 12%, though its author notes that the studies reviewed range in savings from 0% to 20%. The nature and frequency of feedback, study design, and sample size all create challenges in drawing conclusions. The author concludes that giving feedback frequently and over a long period improves its effectiveness. Also the ability to give appliance-specific information is helpful, as is communicating information in a clear and appealing way. Computerized and interactive tools are also found to engage users in energy saving behaviors (Fischer 2008).

A 2005 study from Wokje Abrahamse and other colleagues: *A review of intervention studies aimed at household energy conservation* is another helpful study in investigating research conducted over the last thirty years. The paper reviews thirty-eight field studies aimed at encouraging households to reduce energy consumption. In general, it is found that the large majority of studies addressing feedback find it to be an effective means to generate energy savings, with more frequent feedback leading to greater effectiveness. The authors express some skepticism of the conclusions drawn from many studies, noting that many have lacked the appropriate experimental conditions such as significant sample sizes or appropriate control groups to validate findings (Abrahamse et al. 2005).

These papers emphasize major themes that are useful for utility program managers considering behavior change programs. First, it is apparent that "feedback" is the primary mechanism by which behavior change is accomplished (the theory of which will be discussed later in this paper) and can generate meaningful savings. Secondly, the manner in which feedback is provided – its medium, frequency, content, and appeal – can have significant impact on the results that are achieved (Fischer 2008; Darby 2006). Additionally, as highlighted by all of the authors cited above, the methodology with which pilots or experiments are conducted – with respect to sample selection, data collection, and the use of control groups – can impact both the ability to interpret results and draw conclusions about the groups tested as well as the ability to extend these findings to broader populations. These takeaways emphasize the need for utility program managers to be careful in designing intervention programs and the methods by which they will be tested and implemented in their customer populations.

While the studies cited above provide some of the most relevant foundational research into the design and effect of behavioral change programs for residential energy use, there is an enormous volume of academic and professional research that further helps to illuminate the relationship between behavior and energy and the specific programs and approaches taken to influence it. Appendix 5 lists many of the materials collected and reviewed for the research study; where possible, links are provided. It is also worth noting that several institutional resources can serve as valuable resources. In particular, the Precourt Institute for Energy Efficiency at Stanford University has established a Behavior & Energy Cluster that provides a bibliographic database in addition to other valuable online tools. The site can be accessed at http://piee.stanford.edu/cgi-bin/htm/Behavior/behavior.php?ref=nav4. Other organizations that provided useful guidance and content to our team include the Electric Power Research Institute (EPRI), the American Consortium for an Energy-Efficient Economy (ACEEE), and the Consortium for Energy Efficiency (CEE).

It is important to note that the studies and experiments covered in the literature on energy-use behavior change are more often than not conducted for research purposes outside of utility demand-side management program activities. In fact, the amount of empirical reporting on behavior change programs conducted by/for utilities in the context of pilot programs and with an intent to discover program cost effectiveness and scalability - particularly outside of dynamic pricing programs which are not intended to be the focus of this study - was found by the research team to be somewhat limited. Much of the remainder of the report will focus of the recent programs that target behavior change in utility customer populations. Our team has also included a detailed listing of methodologies and findings for the utility behavior change pilots and programs encountered in the team's research in Appendix 2 of this report.

Summary of Interview Activity

A major goal of this research study was to conduct primary research into the experience of researchers and industry professionals that have meaningful perspectives to share on their involvement in evaluating energy-use behavior change interventions. Conversations with these individuals helped to inform our understanding of the practical challenges of introducing these programs to a utility customer base and their potential for energy savings at reasonable costs. Perspectives were gathered from researchers, utility program managers, and expert consultants.

Our team is grateful for the participation and insights provided by these individuals:

Utilities/Administrators

Austin Utilities	Kelly Lady, Energy Services Consultant
Baltimore Gas & Electric	Ruth Kiselewich, Director of DSM Programs
BC Hydro	Arien Korteland, Program Manager, PowerSmart
Connexus Energy	Bruce Sayler, Project Lead
City Utilities (Springfield, MO)	Cara Shaefer, Director, Residential Energy Management
Energy Trust of Oregon	Kendall Youngblood, Residential Sector Manager
Pacific Gas & Electric	Joanne Medvitz, Program Manager
SMUD (Sacramento, CA)	Ali Crawford, Project Manager

Consultants/Vendors

Comverge/ComEd	Kelly Papadimitriu, ComEd RRTP Program Manager
The Brattle Group	Ahmad Faruqui, Principal
Paragon Consulting	Bruce Jackson, Senior Consultant
Positive Energy	Alex Laskey, President
Van Denburgh Consulting	Elizabeth Van Denburgh, Founder

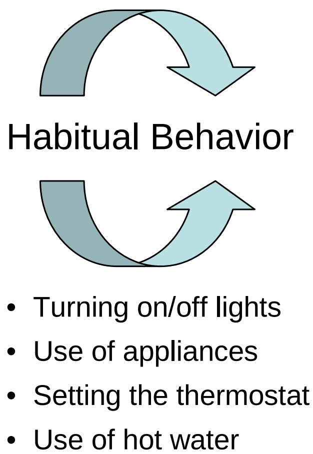
Researchers

Energy Center of Wisconsin	Ingo Bensch, Senior Project Manager
Florida Solar Energy Center	Danny Parker, Senior Research Scientist
SenterNovem (The Netherlands)	Henk van Elburg, Program Manager

Research Findings

Behavior Change Theory

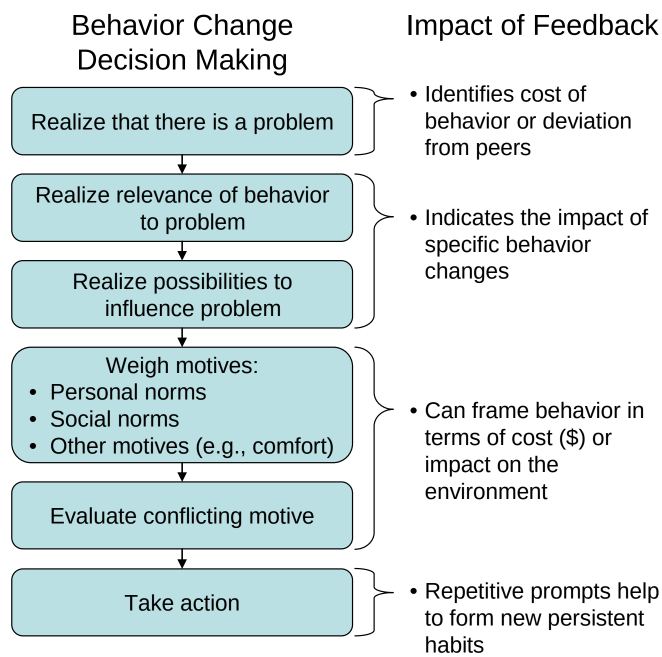
Before reviewing specific solutions and findings with respect to behavior change programs, it is worthwhile to spend some time considering the mechanics by which these programs achieve their end goals. First, it is important to consider that the intent of these programs is to influence human behavior, much of which when it comes to energy use is habitual behavior.



Many of the ways in which consumers use energy at home are the result of behaviors like how and when we turn on and off lights and televisions in the rooms we use, how we set and adjust our thermostats, our practices in doing laundry and running our dishwasher, the frequency with which we replace furnace filters, even the length of the showers we take and whether we unplug our cell phone chargers when they are not in use. Impacting these habits is difficult for a number of reasons. First it is important to recognize that electricity is an enabling product – consumers don't turn on the television or the lamp to use energy, they want to be entertained and they want to see. Electricity is an intangible necessity that, as BC Hydro identifies, like toilet paper is a dissatisfier we take for granted until it is missing (BC Hydro 2008). This is the first challenge if any behavior change program; they must get people to notice and care about their energy use.

Secondly, behavior programs are largely focused on changing old habits. The benefit of habits, as Corinna Fischer relates, is that habitual behavior is functional because it allows us to avoid expending the time and effort making decisions on issues that re-occur frequently and for which we have developed a means of addressing. The challenge is to break this cycle and protocol in order to get individuals to adopt more energy efficient habits.

Figure 1: Behavior Change Process



The adjacent figure outlines the decision-making process an individual must follow in order to take action with respect to their energy consumption behavior. Also noted are the ways in which feedback interventions can influence an individual at various steps in this process. The first three steps, sometimes referred to as norm activation, include becoming aware that a problem exists, understanding how one's behavior relates to the problem, and recognizing that there are possible options to address the problem. Feedback can be useful in these steps because it can identify the cost of behavior or suggest a deviation in an individual's behavior with respect to their peers (so called social norming). The information provided through experimentation with direct feedback or through information such as energy saving tips indicate the impact of specific behavior changes.

Next, an individual will have to weigh the various motives, personal and social, including the benefits of comfort and convenience or the opportunity to realize cost savings. Some of these motives may be in conflict, and how the individual resolves these conflicts will determine the action they will take. Feedback can be helpful in framing behavior in terms of dollar costs, impact on the environment, or what other people are doing in order to play on different norms. Repetitive prompting from the feedback helps as this process will need to repeat itself over and over again in order for new habits to form and old habits to be abandoned (Fischer 2008).

Categorization of Interventions

The research team identifies three broad categories of programs and solutions implemented to generate energy savings through residential consumer behavior change:

1. First, there are direct feedback programs that aim to provide real-time feedback to customers on their energy use, typically by devices that interface with the customer's home electric meter (no evidence of gas use feedback devices/programs was identified by the team's research activities). Examples of these interventions include the PowerCost Monitor pilots at Hydro One in Ontario, Canada and NSTAR in Massachusetts (in progress).

2. Second, there are the approaches that engage in indirect feedback, where information on consumers energy use is provided to customers in a processed manner, often through the mail or online interfaces. Examples of programs in this category include Positive Energy's home electricity reports first implemented by SMUD and the Team Power Smart program at BC Hydro.

3. Finally, there are programs based on advanced metering infrastructure, or 'smart metering' that often involve dynamic pricing protocols and are enabled by two-way communication between the utility and the residential customer.

All of these approaches have both merits and shortcomings. All are being pursued, in some cases by the same utility (Crawford 2008), as a means to achieve energy savings. In investigating these approaches and talking with individuals about their own experiences, the advantages and disadvantages of these approaches became clearer and are useful to articulate.

Category 1 - In-home devices and displays providing real-time feedback

Pros:

- Users are able to receive real-time feedback (i.e., instantly, or in a very short period of time) from their meter via a mobile monitor.
- Real-time feedback allows users to experiment and see the impact of their behavior (e.g., turning on/off lights and appliances, changing routines from day-to-day, etc.).
- Multiple utilities have demonstrated the savings achieved by customers using these devices. For example, a 3% annual energy savings is reported in an ongoing NSTAR pilot (MacLellan 2008), and a 6.5% annual savings was observed in a 500-home pilot by conducted with Hydro One's residential customers in Ontario (Mountain 2006).

Cons:

- The opt-in nature of these programs (e.g., soliciting customers to purchase and install devices) leads to low adoption rates and limited potential for scaling programs (Bensch 2008; MacLellan 2008; Energy Trust of Oregon 2008).
- Several programs have documented significant drop-out rates among participants as the novelty of the device wears off, monitors are put away, or batteries die; this raises questions about persistence and cost effectiveness of the $130+ devices (MacLellan 2008).
- Some observers have noted that the remote communications between the meter element of the device and the handheld display (particularly in the case of the Power Cost Monitor) is not 100% reliable, leading to gaps in the captured consumption. Program managers express concerns about potential conflicts with billing data (Kiselewich 2008, Parker 2008).

Category 2 – Customized, regular feedback delivered to consumers

Pros:

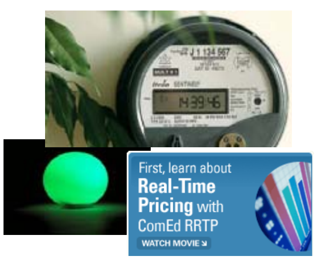
- The opt-out (vs. opt-in) nature of reports sent at the discretion of the utility to customers, allows utilities to design and conduct rigorous large-scale pilots and target entire populations in desired segments (Laskey 2008).
- Utilities have the opportunity to provide comparative feedback, showing a customer's performance relative to their neighbors, taking advantage of the power of social norms.
- Reports can be customized based on housing, demographic, and psychographic factors to provide relevant feedback and customized energy-savings tips that are found to have the greatest appeal.

- Does not require advanced metering infrastructure (AMI) to be effective, though enhanced reporting such as appliance-specific feedback through signal analysis and peak/baseload distinction is made possible in an AMI environment.
- Evidence from Positive Energy's work with SMUD is found to show savings achieved at attractive cost effectiveness – on the order of 3¢ per kilowatt hour saved on a first-year (non-levelized) cost/savings basis (Laskey 2008).

Cons:

- Indirect feedback will not match the real-time and (unless coupled with AMI-enabled technology) use-specific feedback that direct feedback devices provide, making it more difficult to see the impact of discrete behavior and individual appliances.
- Comparative feedback can have the unintended consequence of consumers who learn they are low energy consumers relative to their peers deciding to increase their energy consumption. This is more of a hypothetical as results from Positive Energy show the opposite – efficient users further decreasing their usage. Utilities must be careful in targeting and crafting their messaging in order to minimize potential negative effects.

<u>Category 3 – Dynamic pricing / rate designs (e.g., smart metering)</u>



Pros:

- Dynamic pricing provides direct monetary incentives for consumers to modify consumption behavior.
- Utilities are better able to match prices to energy production/purchase costs.
- Advanced metering infrastructure provides significant flexibility in rate design (e.g., time-of-use, real-time, critical-peak).
- Solutions typically require in-home displays that typically have much of the feedback functionality advantages (real-time and cumulative cost and energy consumption) of direct feedback displays like the PowerCost Monitor, but have the advantage of permanent installation/use.

Cons:

- AMI programs are costly infrastructure investment programs requiring substantial resources to install meters and develop integrated IT platforms.
- Programs costs are typically justified by returns from operational efficiency and capacity (i.e., peak load) management and savings; energy efficiency/conservation savings are typically secondary benefits and not primary drivers.

Direct Feedback – PowerCost Monitor Pilot Programs

Direct feedback displays allow for real-time feedback captured by sensors attached to analog meters or connected to power lines in circuit panels. Information is relayed by wireless radio transmission or through the home's power lines to display units that can be portable or wall-mounted. After collecting data from the meter, the devices display both instantaneous and cumulative power usage and cost (based on programmed $/kWh rates). Some devices also show other home diagnostic data such as temperature, humidity, and estimated greenhouse gas emissions.

Though direct feedback displays, known also as in-home displays (IHDs) or home energy displays (HEDs), of various forms have been available for some time, it is only in the last five years that they have received significant interest from utilities for use on a wide scale. A 2008 report from Pacific Gas and Electric Company notes that the stand alone IHD market is in its infancy with no more than 50,000 to 100,000 of the devices installed in North America (Green 2008). The two most noted stand alone models – not designed for use with smart meter technology – are the PowerCost Monitor (PCM) from BlueLine Innovations and The Energy Detective (TED) from Energy, Inc. Both units are currently available in the price range of $130-$140 (Source: www.powermeterstore.com). The PowerCost Monitor is more oriented for user installation while the TED device requires some technical competency to safely interface with the electrical panel. The TED device is noted to have a greater level of resolution, detecting changes of as little as 10 watts, while the PCM is unlikely to detect changes below 300 watts (Parker 2008). The PCM does have the advantage of wireless portability, while the TED requires connection to a wall outlet to receive a signal from the transmitter through the powerline.

Profiles of the PCM, TED, and other direct feedback devices are listed in Appendix 3.

Outside of a number of dynamic pricing pilots that use IHDs for facilitating price signaling and control, there have been only a handful of utility pilots for direct feedback displays. The two most notable are a two-year study in 500 homes conducted by Ontario utility Hydro One completed in 2006 (Mountain 20006) and an ongoing pilot undertaken by Massachusetts-based NSTAR (in cooperation with National Grid and WMECO) that began in May of 2008 (MacLellan 2008). Both studies utilized the PowerCost Monitor.

hydro one

BLUE line INNOVATIONS

Findings from the Hydro One Pilot (Mountain 2006):

- Impact measured based on historical comparison
- 6.5% aggregate reduction in electricity (kWh) consumption
- 8% reduction in non-electrically heated homes
- 5% reduction in non-electric heat/hot water homes
- 16% reduction in non-electric heat homes with electric hot water
- 1% reduction in electrically heated homes
- "income and demographic factors had no impact on the responsiveness to the monitor"
- 60% of participants felt the monitor made a difference; 35% planned to stop using after pilot

(Preliminary) Findings from the NSTAR Pilot (MacLellan 2008):

- Pilot began May 2008
- 3,100+ units sold at (subsidized) prices up to $50
- Media coverage (TV, print) coincided with significant rise in sales
- 2.9% savings for monitor users (~$64/year)
- 66%-75% installation rate
- 33% of initial users stopped using the monitor during the study period
- 63% of participants indicate behavior change
- 60% noticed savings in their bill

The differences in savings achieved in the Hydro One pilot based on whether heat was from an electric source (1% savings) as compared to non-electrically heated homes (8% savings) was significant. In explaining this deviation, the study's authors indicate that it appears that because the electric heating load "completely overwhelms (maybe as much as 80% of the load in the winter) the rest of the dwelling's electricity load, the participant is probably unable to detect any of their non-heating conservation actions" (Mountain, 2006). This suggests that behaviors related to home heating were not significant altered through the use of the monitors. Only 11% of Hydro One's customers have electric heat (Green 2008). The significantly higher savings achieved in homes with electrically-heated hot water (~17% savings) would suggest that behaviors related to hot water generation (e.g., water heater thermostat stetting, insulation) and use (laundry, bathing, dish-washing) became a major focus of study participants.

While the NSTAR study did not provide segmentation of savings achieved, the overall savings of 2.9% is significantly lower than that seen in the Hydro One study. It is worth noting that the data for this study (taken from a November 2008 presentation report) represents *no more than six months of data and may not be reflective of final study outcomes* (MacLellan 2008).

One notable result in both studies is the challenge of adoption and persistence seen in both studies. In the Hydro One study, one in three participants plan to discontinue using the monitor at the study's conclusion. This percentage is similar to the proportion that discontinued using the monitors in the NSTAR study. The NSTAR study also notes that more than a quarter of participants that received or purchased the device carried out installation.

Additional feedback from interview participants echoes the findings of these pilots with respect to the energy savings potential. Danny Parker at the Florida Solar Energy Center has published several papers documenting his results in small-scale pilots of the TED device. In a 17-home study conducted with a full year of pre and post data, an average savings of 7% was found in the self-selected test group (Parker 2008). A broader study supported by Bill Jackson of Paragon Consulting looking at various IHDs for Nevada homes found an average savings of 5.5% for the participant population (Jackson 2008).

The Power of Social Norms – Positive Energy's Success with Indirect Feedback at SMUD

Positive Energy, a Virginia-based company with a mission to engage Americans who are "in the dark about their energy use," seeks to leverage the power of social norms by providing comparative feedback to energy consumers (www.positiveenergyusa.com). The company, founded in 2007, has gained attention for the success of its work with the Sacramento Metropolitan Utility District (SMUD) among others and has begun work with a number of Minnesota utilities including Connexus Energy, Austin Utilities, and Owatonna Public Utilities (Laskey 2008).

Positive Energy's approach to generating residential energy savings through feedback is guided by a foundation of behavioral science research, notably the work of Dr. Robert Cialdini, the company's Chief Scientist and one of the foremost researchers in the field of influence and persuasion. Dr. Cialdini's work has provided strong evidence that individuals are motivated much more by their perceptions of what other people do and find acceptable than they are by other factors such as the opportunity to save money or conserve resources, contrary to even their own perceptions of motivation.

Illustrating the power of these concepts is a study published in 2007 Dr. Cialdini and his colleagues conducted an experiment involving hundreds of San Diego area residents as part of their investigation of conservation behavior. The study team placed door hangers on the doors of subjects once a week for a month. The door hangers had one of four messages informing residents, as described by Dr. Cialdini "that (1) they could save money by conserving energy, or (2) they could save the earth's resources by conserving energy, or (3) they could be socially responsible citizens by conserving energy, or (4) the majority of their neighbors tried regularly to conserve energy—information we had learned from a prior survey." As he explains, "Even though our prior survey indicated that residents felt that they would be least influenced by information regarding their neighbors' energy usage, this was the only type of door hanger information that led to significantly decreased energy consumption, almost 2 kWh/day" (Cialdini 2007).

The findings of behavioral science research from this study and many others form the foundation for Positive Energy's approach to providing indirect feedback to utility customers. The company partners with its clients to inform residential customers of their energy consumption as it relates to their neighbors, providing comparative feedback, along with comparisons to the customers' historical energy use and customized recommendations for reducing energy consumption. These home energy reports combine simple messaging and graphical illustrations of how an individual consumer's consumption compares to the average of neighbors in similar homes, their most efficient neighbors, and their own demand from previous periods. The company uses different housing and demographic factors in proprietary algorithms to segment the customers for the appropriate comparisons and suggest relevant improvement opportunities (Laskey 2008).

The experience of the Sacramento Metropolitan Utility District (SMUD) as described by project manager Ali Crawford has more than met expectations. The pilot program, Positive Energy's first major utility customer, was launched in April of 2008 with 35,000 customers receiving reports either monthly or quarterly. A control group of 55,000 homes (actually more than 10% of the utility's total customer base) allows the team to have robust data with which to compare population and understand the impact of targeted tips along a number of factors such as housing size, age, fuel type, and energy consumption amount and patterns as well as customer demographics such as income, age, length of residence, and whether the customer is know to be a do-it-yourself or even green-oriented consumer.

The results have been significant. In the randomly selected treatment group (receiving the reports), the program is on pace to save about 250 kilowatt hours per household per year relative to a representative control group (not receiving the reports). This represents savings around or in excess of 2% of annual consumption (the average SMUD residential customer uses approximately 9,000 kWh). The 2% estimate is based on comparing the average energy use for the control group over the study period to that of the treatment group receiving the energy reports (Crawford 2008; Laskey 2008). Prior to the reports introduction there was no difference in average energy consumption between the control and test groups.

Positive Energy's findings show that energy savings among monthly report recipients are greater than those among customers receiving the reports quarterly (Kavazovic 2009). This finding supports the assertion from the literature review that more frequent feedback leads to higher savings. Additionally, through the first 12 months of the pilot program, the impact has been found to be consistent on a month-over-month basis. In other words, it is not the case that a significant amount of savings was observed in the initial months with a slow deterioration over the course of the program. The sustained reduction in energy consumption points to the persistence of the savings achieved.

The cost of these savings is on the order of 3 cents per kilowatt hour saved in the first year. This calculation does not reflect the potential for these savings to persist beyond the first year and therefore lower the levelized cost of conserved energy. Both the SMUD's manager and Positive Energy's anticipate that this performance can be sustained on a year-over –year basis. Furthermore they point out that these results are from a non-targeted population. The cost effectiveness of the program would be even more attractive in pursuing targeted groups such as higher energy consumers.

Given the large size of the pilot population, the program team has the opportunity to conduct any number of experiments in fine-tuning and evaluating the performance of this group over time. They have the opportunity to find out what happens when they stop sending the report to see if they drop back to historical patterns or maintain the savings achieved. They can run experiments to understand what aspects of the feedback (neighbor comparisons, historical comparisons, types of graphical displays, specific tips and recommendations for energy savings) have the most influence on energy savings in different population segments.

Figure 2: Sample Positive Energy Report (Source: ACEEE)

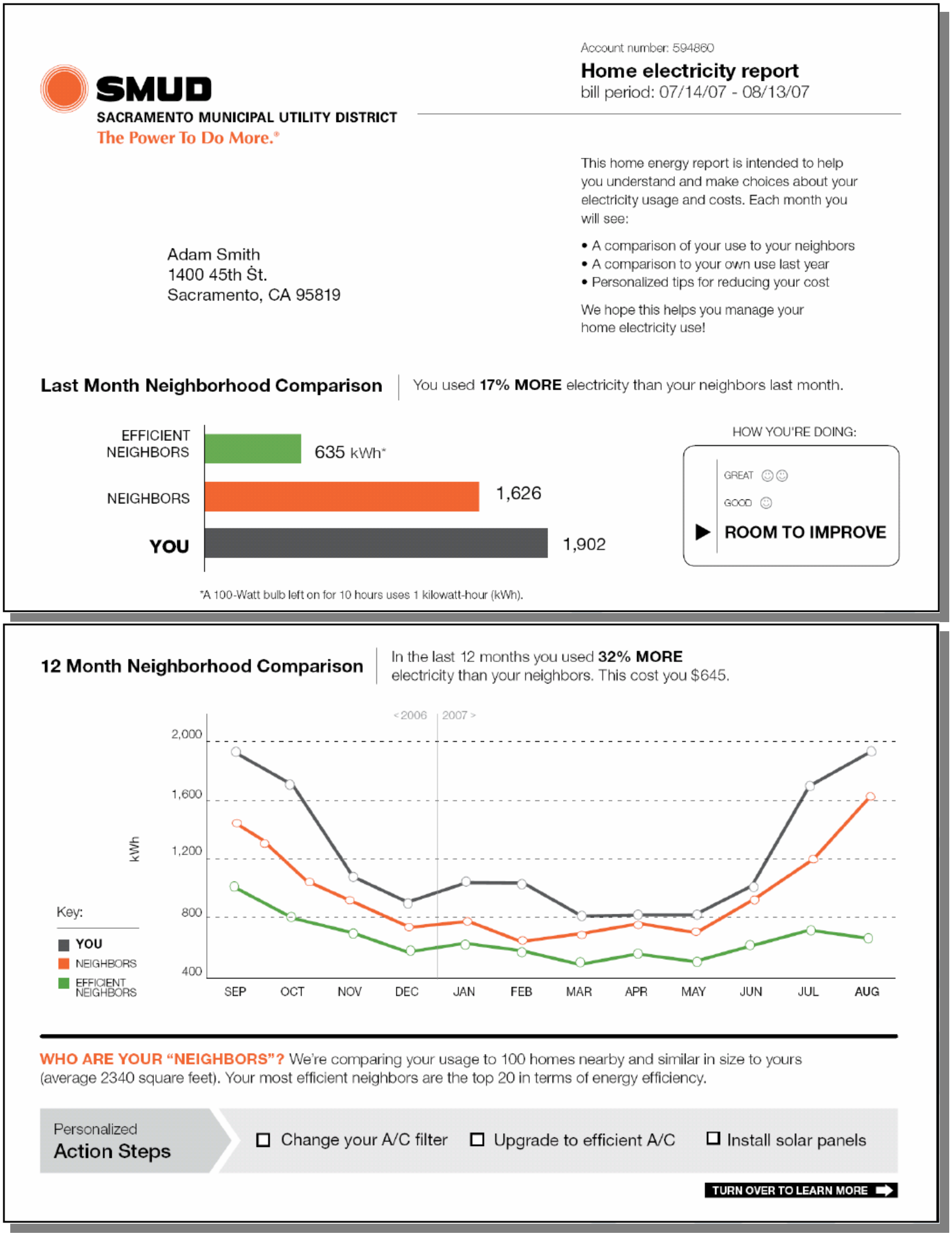


Figure 3: Sample Positive Energy Report, Continued (Source: ACEEE)

Analysis: reduce Summer use

While your energy use is 15% higher than your neighborhood average in the Spring, Winter and Fall, it is **55% higher in the Summer.**

Quick Fixes
Things you can do right now

☐ **Change your A/C filter**

A dirty filter in your A/C clogs the vent, forcing it to work harder to keep your house cold.

$64 SAVED OVER 1 YEAR

Good Investments
Save $$ and increase home equity

☐ **Upgrade to efficient A/C or install a zone system**

Efficient air conditioners can use as little as 1/2 the energy of older, oversized A/C units.

If you already have an efficient A/C think about a zone system to reduce wasted cooling in parts of the house that are empty.

$500 SAVED OVER 2 YEARS

Big Gains
Big ideas for big savings

☐ **Install Solar Panels**

Based upon your last years' electric bills, solar panels for your home would be a better investment than real estate or the stock market.

And they help the environment at the same time.

11% ANNUAL RETURN ON INVESTMENT

Goal Setting – BC Hydro's Team Power Smart Residential Behavior Program

In early 2007 Canada's third largest electric utility, BC Hydro, launched a market test program with the employees of their largest customer. Employees were recruited to participate by committing to a given electricity reduction target. The company provided an online tool to track and compare their consumption over time (another form of indirect feedback), measure their performance against their goal, and receive tips and education to reduce consumption. As an incentive, participants received a cash rebate for achieving their goal at the end of the year.

The test involved targeting participants with four different levels of reward:

Figure 4: BC Hydro Power Smart Pilot Study Incentive Levels (Source: BC Hydro)

OFFER	DESCRIPTION
20/20	Participants who reduced their electricity consumption by 20% received a monetary incentive, equivalent in value to the 20% electricity reduction (paid out as a rebate)
10/5	Participants who reduced their electricity consumption by 10% received a monetary incentive, equivalent to half of the 10% reduction (paid out a rebate)
5/5	Participants who reduced their electricity consumption by 5% received a monetary incentive, equivalent in value to the 5% electricity reduction (paid out a rebate)
10/prize	Participants who reduced their consumption by 10% were entered into a drawing for an ENERGY STAR® labeled appliance package
'control'	Participants chose their electricity savings target (5, 10, 15, or 20%), and were encouraged to reduce consumption strictly through education and information sharing

BC Hydro summarized the findings from the market test with the following table:

Figure 5: Results of BC Hydro Pilot (Source: BC Hydro)

%	All	5/5	10/prize	20/20	Control	10/5
% meeting target ("winners")	20%	41%	15%	7%	14%	19%
% lower kWh, not target ("savers")	32%	20%	36%	44%	32%	33%
% with higher kWh ("gainers")	47%	39%	49%	49%	55%	48%
Avg. % reduced by winners	15.0%	11.2%	17.0%	27.0%	16.9%	18.3%
Avg. kWh reduced by winners	2378	1777	3404	4666	2545	1847
Avg. % reduced by savers	4.8%	2.0%	4.2%	8.8%	4.4%	4.6%
Avg. kWh reduced by savers	781	282	758	1483	845	395
Avg. % reduced by gainers	-8.3%	-7.1%	-8.2%	-7.4%	-9.6%	-9.0%
Avg. kWh reduced by gainers	-1297	-869	-1463	-1325	-1641	-1025

BC Hydro concluded that the reduction target had significant impact on recruitment success, with participants finding the 20% target to be somewhat intimidating. The 5% target level succeeding in attracting participants, but was found to have a high free-rider rate of people achieving the goal without making efforts at changes. The 10% target was found to be an optimal level that struck a balance between being an achievable target yet requiring participants to work in order to reach the goal. The cash reward was found to be more appealing to customers than a prize drawing (BC Hydro 2008).

The use of an electronic newsletter was found to be an important tool for reminding participants of their commitment and drawing visitors to the feedback site. Furthermore a correlation was found between the magnitude of energy savings and the frequency of participant visits to a login access portion of the site where users could track their own consumption and compare to the previous year. Similar to the direct and indirect approaches reviewed above, this program served as a means for motivating participants to engage in evaluating their energy-use behaviors and making changes to reduce consumption. The rebate provided a reward beyond the reduction in energy costs and also appealed to participants' competitive nature. It is worth noting that literature suggests that these types of direct incentive programs are found to have effects that are short-lived once the rewards are removed (Darby 2006).

Among the behaviors participants noted were: 1) turning off unnecessary lights, 2) changing laundry habits, 3) unplugging chargers, 4) taking shorter showers, 5) turning down the thermostat, and 6) making investment changes with respect to energy efficient light bulbs and appliances.

The findings from this market test have helped to shaped BC Hydro's Team Power Smart behavior change program. Team Power Smart started as an advertising campaign in October of 2007, but has transformed into a relational strategy to engage customers in monitoring and reducing their energy consumption. The program has a strong focus on online tools, but also includes offline tools to reach customers and make the intangible product of electricity more tangible. Anyone in British Columbia can enroll in the program by committing to use 10% less electricity over one year. BC Hydro account holders that join Team Power Smart have the ability to track their consumption, compare consumption year-over-year, and compare their consumption to similar households. Through billing analysis and behavioral surveys, electricity savings can be quantified and claimed toward the savings goal. Non-customers, such as tenants whose electricity bill is included in their rent, are also encouraged to enroll in the program to show their support for energy conservation, though billing analysis and savings calculation are not possible for this population (Korteland 2009).

In addition to the use of online tools, Team Power Smart membership benefits include special offers and opportunities to win prizes in drawings and contests. Members receive a monthly eNewsletter and other communications through both online and print media. Participants who achieve their savings goal will receive a non-monetary incentive reward (to be determined). The program is supported by a roster of Team Power Smart Leaders including celebrity athletes and community leaders that serve as examples in their commitment to save energy.

The program leverages the power of social norms by providing tools to allow participants to compare their consumption to households with similar size, occupancy, and heating types. Members are also given visibility to their community's participation and performance as compared to others, fostering a degree of healthy competition among communities. A broader theme of environmental conservation and provincial identity that BC Hydro calls "Pride of Province" has been found to resonate well with many population segments in encouraging participation.

BC Hydro expects that 17% of first-year participants will achieve their goal with an average savings of 21%. Another group, referred to as savers, making up 24% of the participant population is anticipated to fall short of the goal but reduce consumption by 4.3% average. Finally, non-achievers, making up an anticipated 59% of the population are expected to not save electricity (BC Hydro 2008). As attrition occurs, the proportion of retained participants achieving their energy savings goals in subsequent years is anticipated to be significantly higher (Korteland 2009).

The company is targeting the program largely at the psychographic segment of the market it dubs "stumbling proponents," those with positive attitudes toward conservation and protecting the environment, but who are not currently acting on their beliefs. BC Hydro estimates that this segment accounts for around 20% of its residential customers. In order to involve these customers, the program leverages the key elements of the social marketing construct to promote customer acquisition, engagement, and retention. In particular, customer engagement is viewed as critical to affect behavior change, form new habits, and prevent savings 'slide-back.' BC Hydro seeks to engage customers through setting targets, providing feedback, gaining commitment, and rewarding progress. Engagement success is measured by the utility through 'interactivity' metrics such as the number of site logins and the response rate to promotional offers. The program includes both instructional aspects such as its Power Smarts Tips and Personal Energy Planner tools, as well as motivational dimensions including its home energy use comparisons, incentive rewards, membership exclusivity, and forums for members to exchange their stories.

With respect to messaging, BC Hydro has developed a matrix that cross references behavioral actions along the lines of both utility-focused categories (e.g., home heating, appliances, and lighting) as well as more 'emotive' or motivational categories in order to better fit with the interest of participants. BC Hydro has identified six emotive categories: Health+Wellness, Food+Drink, Life+Leisure, Family+Friends, Home+Garden, and Gadgets+Technology. By approaching its content creation in the context of these associations, BC Hydro is able to more effectively connect with its customers to address the barriers and motivators of behavior change (Korteland 2009).

Joining Team Power Smart provides permissive marketing opportunities to cross promote the utility's other rebate and incentive programs (e.g., lighting, appliance rebate, and fridge buy back programs). According to BC Hydro's program managers, research has shown that individuals starting with behavioral changes to address energy consumption are more likely to later follow up with investment changes than the other way around (i.e., people starting with investment changes are less likely to continue on with behavioral changes).

As of April 2009, BC Hydro's Team Power Smart Program claimed to have already enrolled more than 74,000 members (representing over 4% of its 1.7 million customers) toward their goal of 210,000 members by 2010. (See: https://wwwa1.bchydro.com/profiler/ProfileStartExternal.do for more information).

The Team Power Smart program is part of a BC Hydro's multi-pronged approach to behavior change which also includes the use of a 2-step inclining block rate structure for residential customers and the implementation of smart meters and in-home displays. These elements are central to the utility's goals to make British Columbia electricity self-sufficient by 2016, acquire 50% of incremental resource needs through conservation, and promote a broad culture of conservation.

Figure 6: Screen Shots of BC Hydro's Team Power Smart Online Tools (Source: BC Hydro)

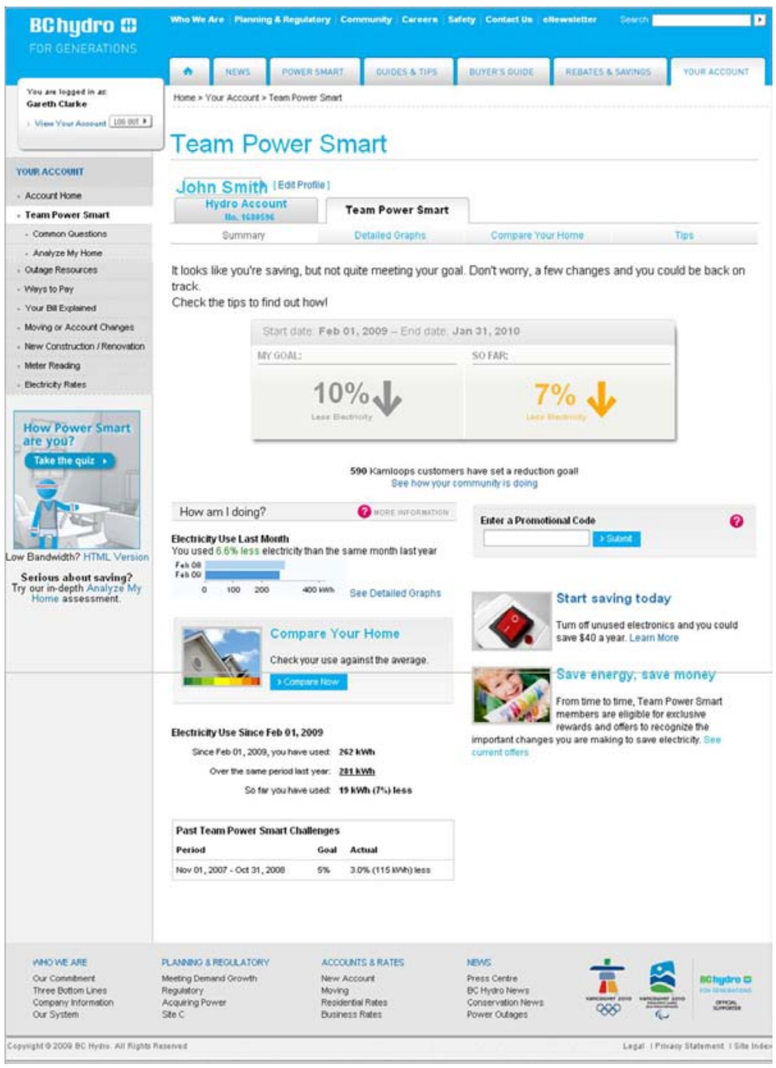
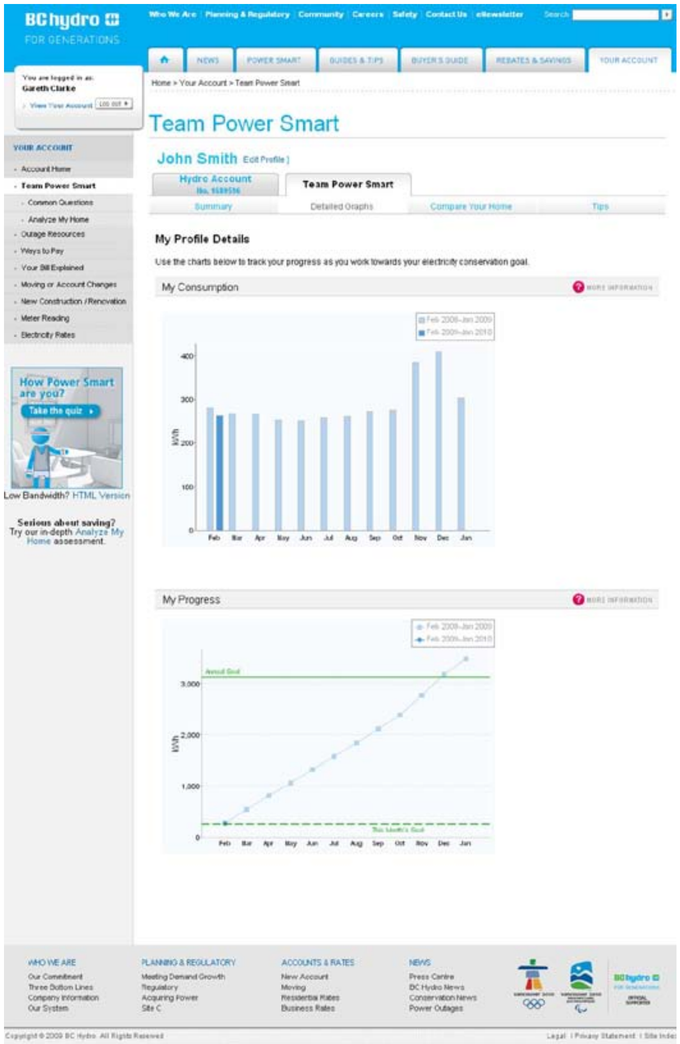
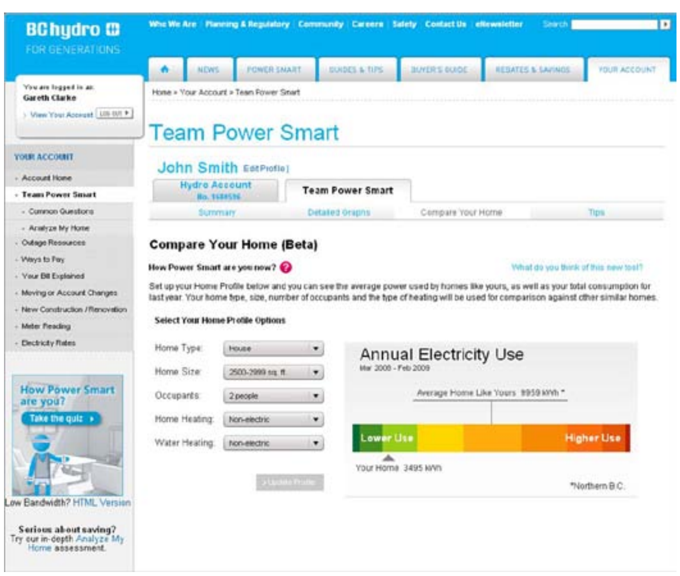


Figure 7: Screen Shots of BC Hydro's Team Power Smart Online Tools, Continued (Source: BC Hydro)





Key Lessons Learned

Opt-In vs. Opt-Out

One important aspect of the behavior programs reviewed in this study is the implication of how participants come to be engaged in programs. In programs such as the in-home display pilots and BC Hydro's reward incentive program, participants have to be recruited to agree to participate – they have to opt-in. Conversely, in the case of the home energy reports from Positive Energy sent to customers, a much greater proportion of those targeted were exposed to the feedback – they had to opt-out to stop receiving the reports. In fact, of the 35,000 customers targeted in SMUD's pilot, only 800 (around 2%) had asked to be removed from the distribution (Crawford 2008). Such high participation stands in contrast to the single digit percentages of residential customers that opt to participate in marketed programs (MacLellan 2008).

Take for example the following table based on the NSTAR PowerCost Monitor pilot:

Figure 7: Marketing Approaches Evaluated in the NSTAR PowerCost Monitor Pilot

Offering	Unit Price	Adoption Rate
Direct install during energy audit	Free	95%
Offering previous audit customers free PCM	Free	14%
Direct Mail Solicitation/ Media Promotion	$9.99	6%
	$29.99	5%
	$49.99	0.3%

Source: NSTAR, (MacLellan 2008)

The table shows the various approaches to soliciting participation in the PowerCost Monitor program. In the first case, customers were offered a free direct install in the course of a home energy audit (essentially an opt-out offer) – 95% accepted. This contrasts with the remaining populations that were asked to opt-in at various costs of participation (as NSTAR investigated customers' willingness to pay for the monitor, which retails for around $140). Around 5 in every 100 households responded positively to pay for the device and only 3 in every 1000 at a $50 cost (MacLellan 2008).

There are a couple of important implications to the nature of program recruitment under these models. First, there is the limit to program adoption posed by the low response rates achieved by opt-in programs. Even if Sarah Darby's numbers are correct, and direct feedback yields 10% savings on average, if only 5% of the population can be successfully recruited, marketing the program to all of the utility's customers may only result in a half of a percentage point reduction in system-wide consumption. On the flip side, a program like Positive Energy, which is found to achieve high single digit percentage savings in targeted populations, is already found by SMUD's example to achieve a system-wide consumption reduction in excess of 2% (Crawford 2008; Laskey 2008). Such a program has in effect more than four times the potential savings, not to mention the cost effectiveness.

Secondly, a point stressed by Positive Energy's President, Alex Laskey, is that utility program managers must have reliable means to conduct measurement and verification of savings. It is incumbent upon them to demonstrate that savings were achieved and came as a result of the programs actions. In the case of opt-in programs there is an inherent self-selection bias on the part of participants. They are by their actions showing how they are a different population from other customers that would not serve as an appropriate control group. Program managers are left to prove savings based on weather-normalized historical comparisons, calling into question the drivers of observed changes of energy consumption including difference in climate, economic factors, social marketing influences, or the actual changes in behavior from the direct feedback.

This problem does not exist in the case of opt-out programs like indirect feedback reports. The program managers can have a high degree of confidence that the population receiving information is representative of the same population as the similarly selected control group. Furthermore they can be sure that the groups were exposed to the same weather, media advertising, and economy.

Critical Lessons in Pilot Program Design

Through the course of the research team's review of published materials and in interviews with program managers and industry experts, a number of valuable lessons learned and critical success factors were identified that can serve as useful guidelines to utility managers considering and embarking on their own behavior change program efforts.

Here are 15 lessons that made an impression on our team and our interview participants:

1. Motivation is the essential ingredient

   Multiple respondents note that the real determinant of the savings achieved by participants is their own personal level of motivation and engagement. In multiple studies, a significant range of savings achieved by individual participants was explained not only by the characteristics of their home or energy use level, but also by their level of enthusiasm and commitment to taking action (Jackson 2008; Parker 2008). By understanding the mechanisms and associations causing participants to engage and sustain their motivation, utilities can discover levers to increase their program's effectiveness.

2. Upfront customer input provides invaluable guidance for successful program design

   Bruce Sayler of Connexus Energy was among those that stressed the need to get customer input early in the process of evaluating solutions and designing pilots. Your customers are the best judge of what will and will not work. In-person interaction in forums such as focus groups may provide insight that input from survey responses may not bring to light.

3. Taking an iterative approach to piloting solutions ensures consistency with goals

   With each step of the pilot process, utilities should have clear goals as to what they hope to measure and learn with their actions. Pilot activities should begin on a small scale to investigate feasibility and then roll out to a wider scale as the need for more data requires. As Ahmad Faruqui of The Brattle Group points out, you need to be clear as to whether your objective is to a) demonstrate the technology, b) test the feasibility of customer use and acceptance, c) evaluate customer interest, or d) measure the magnitude of savings. Different objective will dictate different approaches.

4. A diverse pilot team helps to ensure success

   Having perspectives from a variety of team members with a diverse set of functional backgrounds will lead to better understand of the project risks and opportunities. Having input from marketing, finance, technical and operational viewpoints will identify challenges and help to strengthen the business case to convince management and or regulators of the program's value (Kiselewich 2008; Van Denburgh 2008).

5. Be sensitive to the program's impact on customer satisfaction

   Comparative feedback programs in particular have a tendency to rub a small minority of customers the wrong way; they feel it is unacceptable to be judged against their neighbors. Having internal processes (e.g., call center resources, communications protocols) ready to addresses issues immediately as they arise will allow unhappy customers to have their needs addressed, including removing them from participation as appropriate. Energy use monitors also have the potential for customer satisfaction issues if billing data is not consistent with the monitor data. Program managers stress that it is important to be able to show that despite these instances, for 99%+ of the population, their satisfaction either increased or stayed the same (Crawford 2008).

6. Leveraging the experience of peer utilities improves chances of success

   To the extent utilities can avoid repeating the mistakes of previous endeavors and benefit from new insights, their chances of success will improve dramatically. Networking through industry associations such as Precourt, EPRI, CEE and ACEEE can put program managers in touch with others with relevant experience. The Consortium for Energy Efficiency (CEE) recently formed a Behavior Interest Group.

7. Pre-pilot surveys can establish baselines for analysis

   Ali Crawford at SMUD stresses the importance of collecting data and feedback from test and control group subjects prior to pilot execution. Having a baseline understanding of attitudes will indicate how participant's perceptions and awareness have changed as a result of the feedback intervention.

8. Incorporate a control group that is representative of the underlying population and sufficiently large to allow for the necessary precision and confidence in drawing conclusions about specific sub-segments of the population.

   A well designed experiment incorporating representative control and test groups will lay the foundation for definitive comparisons in later analysis. Studies that rely on comparisons to historical performance introduce a significant number of variables for which it may very difficult to control. A robust design with test and control groups will allow for comparison of two equivalent populations that were subject to identical environmental factors. Furthermore, a sufficiently large sample population with adequate segment representation will lead to more robust and flexible analytics.

9. The novelty of the feedback will wear off

   Particularly in the case of real-time in-home displays that tend to have participants excited and engaged to experiment with their new gadget early on, there is a tendency for participant's interest in feedback to wane over time. Utilities need to look for ways to remind and motivate their program participants to stay involved. Engaging customers through ongoing messaging and education helps to ensure persistence of savings.

   In the case of BC Hydro, an electronic newsletter sent by email was shown to drive traffic to the online feedback tool. For the PowerPlayer being piloted in the Netherlands the concept is to extend the functionality of the in-home display device. They have prototype models that in addition to providing real time energy-use feedback also double as a digital photo frame or media player. Software on the device can disable or enable the entertainment functionality based on a user's energy consumption performance. Given that the user also gets the benefit of viewing photos, videos, or listening to audio files, they are more likely to interact with the energy feedback as well (van Elburg 2008).

10. Interfacing with meters for in-home devices can present barriers

    At least three interview respondents noted problems that presented themselves in considering or attempting to use IHDs with sensors that connected to the utility meter. 2 of the 5 investor owned utilities had to be dropped from an Energy Center of Wisconsin pilot of the PowerCost Monitor because of incompatibility with a particular automatic meter reading device and one utility's policy against devices interfacing with the meter (Bensch 2008). Florida utilities were also reported to be uncooperative in allowing devices to be placed on top of analog meters (Parker 2008). Finally, in Nevada, slimline circuit breaker panel boxes on a segment of new construction homes prevented the installation of current transducers used with certain devices (Jackson 2008).

11. In-home display devices are known to be hampered by low installation rates

    NSTAR found that between one quarter and one third of participants that purchased or received a PowerCost Monitor did not install the device (MacLellan 2008). An ongoing study at the Energy Center of Wisconsin found from its first follow-up that fewer than half of the subsidized devices were installed weeks after delivery (Bensch 2008). In some cases people had not found time, in other cases people had run into trouble with the installation. Utilities should look for ways to follow-up with program participants and provide assistance to aid customers in the installation process. Otherwise, the cost of uninstalled devices will have to be carried by the savings generated from those successfully installed.

12. Ensure that the solution is well suited to the customer population

    Several utilities have run into trouble with customer acceptance of different interventions. For example, Bruce Sayler of Connexus Energy relates the disappointing results from a PowerCost Monitor pilot geared toward the low income population. In hindsight, it is viewed as a difficult match as the elderly population is prioritized in addressing the low income population. Many of the program participants recruited struggled to understand the operation and functionality of the wireless handle monitors. As a result of these user acceptance issues, there has been little impact on behavior change and energy savings.

13. Look beyond traditional customer segmentation models to find messages that resonate with particular groups

    A customer's psychographic attributes including attitudes toward conservation and energy-use behaviors can present powerful levers for utilities to appeal to their core values. BC Hydro is one utility that has made great progress in psychographic segmentation models and applications.

14. Validating the functionality of new technology can avoid headaches down the road

    One program manager stressed the need to run new technologies through user acceptance tests to identify potential technical issues. Her team was able to catch an issue with a new smart thermostat, but only after several dozen units had been installed in the field (Kiselewich 2008). Making sure technologies worked as anticipated will avoid any potential for customer satisfaction issues.

15. Utilities might want to consider making in-home displays available on a short-term basis and to specific customers

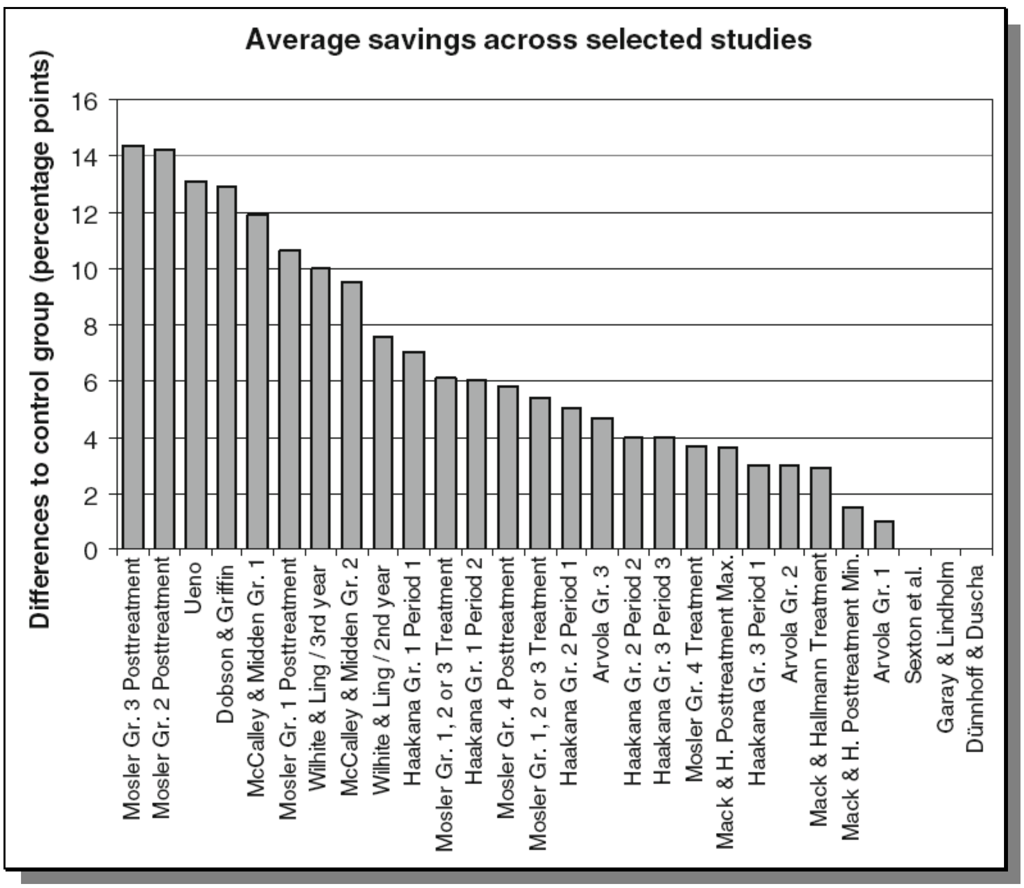
    Elizabeth Van Denburgh of Van Denburgh Consulting highlighted discussion in southern California among utilities that debated providing PowerCost Monitors or similar IHDs as an item to be borrowed by consumers as they have a demand for the service. It was suggested that devices could be kept at local libraries and checked out for a defined period. Another respondent suggested that deployment of in-home devices could be used as a means to address customer complaints and concerns about their bills, loaning the devices for customers to investigate their home energy consumption patterns. Such ideas would allow for device costs and benefits to be spread over multiple users, avoiding the problem of devices being unused and reducing utility costs per kilowatt hour saved.

Savings and Cost Effectiveness

As documented in literature and in the above discussion, savings from feedback programs range from study to study, across different feedback intervention types, geographies, and population samples.

The following chart come from Corinna Fisher's 2008 review study of 21 individual studies and 5 review studies:

Figure 8: Range of Savings from Feedback Programs



(Fischer 2008)

The impact from feedback interventions is found to range from 0% to more than 14%, leading the author to conclude that "usual savings" are in the range of 5% to 12% (Fischer 2008). This concurs with the research of Sarah Darby who states that direct feedback leads to savings from 5% to 15% while indirect feedback can generate average savings of 0% to 10%. It is worth noting that a significant portion of the data supporting these conclusions is taken from studies in the UK, Europe, Australia, and Japan which raises the question as to the impact of cultural norms and values in applying these assumptions to U.S.-based programs. For example, if the residents of Norway have different attitudes about the need for energy conservation than residents of Massachusetts, findings from the use of feedback interventions may not necessarily apply to the other.

Savings in large scale North American pilot programs at Hydro One and NSTAR have found average savings of 6.5% (Mountain 2006) and 2.9% (MacLellan 2008) respectively (though it is worth noting the Hydro One savings range from 1% to 16% depending on the housing characteristics, for example whether electric water heating is present). Findings from study interviews show other in-home display pilots in Nevada and Florida achieved average savings of 5.5% (Jackson 2008) and 7.4% (Parker 2008). From these data points, it seems reasonable to conclude that in-home display programs at utilities will likely result in average savings of 3% to 7% with a midpoint of around 5%. Again it is important to stress that this savings opportunity exists for a self-selected population that is motivated enough to install the feedback device in their home. These estimates can not be extended to the broader customer population.

To evaluate cost effectiveness, data is supplied from reports in both the NSTAR and Hydro One pilots. Taking NSTAR as an example, company materials indicate a 2.9% energy savings, which are equated to a $64 annual savings (MacLellan 2008). Based on a $.197/kWh average retail price for Massachusetts residential customers (Source: EIA Oct. 2008), this would translate to around 320 kilowatt hours saved. The stated $145 retail price of the monitor was largely subsidized, with the majority of customers paying around $30. Assuming NSTAR received somewhat of a price break, the utility-borne cost portion can be estimated at around $100 per meter delivered. In terms of raw first year savings this would work out to around 30 cents per kilowatt hour.

However the energy savings realized are likely to persist, assuming behavior habit changes are maintained. The following table provides a levelized cost per kilowatt hour across a number of assumed time periods over which these savings might theoretically persist. The estimates use a standard cost of conserved energy calculation that assumes a 5% discount rate:

$$\text{Cost of Conserved Energy} = \frac{1}{\Delta E} \times \frac{d}{1-(1+d)^{-n}}$$

where *ΔE* is the energy savings (kWh) per year, *d* is the real discount rate, and *n* is the lifetime of the measure in years (see: http://www.bookrags.com/research/conservation-supply-curves-mee-01/ for more information on the calculation).

Levelized Cost for 320 kWh of Savings Sustained over Various Time Periods - $100 Program Cost

	Assumed Persistence of Savings Realized from Use of the PowerCost Monitor							
	1 Year	2 Years	3 Years	4 Years	5 Years	10 Years	15 Years	20 Years
Cost of Conserved Energy ($/kWh)	$0.33	$0.17	$0.11	$0.09	$0.07	$0.04	$0.03	$0.03

Source: authors' calculation

A similar approximation can be developed for the Hydro One pilot and extended to other utilities based on different assumptions. For example, Pacific Gas & Electric recently published a report looking back at the data from the Hydro One study. A table of some high level comparisons is provided below.

Figure 9: Comparison of PG&E and Hydro One Customers

Table 2 – Comparing Hydro One pilot with PG&E Customers

	PG&E Service Territory*	HydroOne Sample
Avg Annual kWh	6,265	16,184
Avg Heating Degree Days	2,421	7,912
Avg Cooling Degree Days	735	201
Appliance Saturation - Electric Heating	10%	11%
Appliance Saturation - Electric Hot Water	9%	24%
Appliance Saturation - Central A/C	39%	36%
Avg Residents per Household	2.89	3.01
Avg Dwelling Size (sf)	1,525	2,155

* California Statewide Residential Appliance Saturation Study, Volume 2, Study Results Final Report, June, 2004

Source: PG&E, (Green 2008)

The PG&E analysis concluded that the savings potential for their customers was likely not as high as Hydro One's 6.5% given the lower penetration of electric hot water heat in PG&E's service territory, though it was stated that achievable saving would likely be above 5%. The cost effectiveness observed in applying these savings percentages is highly influenced by the average annual kWh for the population. The average consumption for the Hydro One pilot participants is more than 2X the average annual KWh for PG&E's service territory.

Levelized Cost of Savings for 6.5% of 16,184 kWh Sustained over Various Time Periods - $100 Initial Program Cost

	Assumed Persistence of Savings Realized from Use of the PowerCost Monitor							
	1 Year	2 Years	3 Years	4 Years	5 Years	10 Years	15 Years	20 Years
Cost of Conserved Energy ($/kWh)	$0.100	$0.051	$0.035	$0.027	$0.022	$0.012	$0.009	$0.008

Levelized Cost of Savings for 5% of 6,265 kWh Sustained over Various Time Periods - $100 Initial Program Cost

	Assumed Persistence of Savings Realized from Use of the PowerCost Monitor							
	1 Year	2 Years	3 Years	4 Years	5 Years	10 Years	15 Years	20 Years
Cost of Conserved Energy ($/kWh)	$0.335	$0.172	$0.117	$0.090	$0.074	$0.041	$0.031	$0.026

Source: authors' calculation

The Hydro One scenario shows that the program would translate to a 5 cent per kilowatt hour cost assuming savings persist for at least two years. In the case of the PG&E assumptions, savings would have to be sustained for well over five years for this level of cost effectiveness to be reached.

With respect to the indirect feedback programs such as Positive Energy, we know from program managers that energy savings for a non-targeted population are on the order of 2%, or 250 kWh per household per year in Sacramento. The cost per kilowatt hour is given to be around 3 cents per kilowatt hour of first year savings (Laskey 2008), which indicates an annual cost for the program to send out the home energy reports roughly $7.50. The program managers feel confident that incremental savings will recur each year to continue justifying the annual cost, though they are also quick to point out that as soon as cost effectiveness begins to deteriorate, there is always the option to cease sending the reports and eliminate the variable cost of the program (Crawford 2008). If the savings from the first year were to persist, the implied levelized cost over various horizons is much more attractive to any of the direct feedback program scenarios previously evaluated.

Levelized Cost for 250 kWh of Savings Sustained over Various Time Periods - $7.50 Program Cost

	Assumed Persistence of Savings Realized from Use of the Home Energy Reports							
	1 Year	2 Years	3 Years	4 Years	5 Years	10 Years	15 Years	20 Years
Cost of Conserved Energy ($/kWh)	$0.032	$0.016	$0.011	$0.008	$0.007	$0.004	$0.003	$0.002

Source: authors' calculation

Persistence

Various research studies have addressed the persistence of savings resulting from feedback interventions. In commenting on the persistence of the effect, researcher Sarah Darby notes that savings will be made permanent when individuals develop new habits. To encourage this transformation, successful behavior change programs will incorporate sustained feedback and advice for individuals to make adjustment to their routines. It is noted that where reward incentives are used as means to achieve energy savings, behavior may change but the changes are likely to fade away when the incentive is taken away. Darby offers a rule of thumb that "a new type of behavior formed over a three-month period or longer seems likely to persist – but continued feedback is needed to help maintain the change and, in time, encourage other changes" (Darby 2006).

A three year trial of informative billing in Norway found that the reduced energy effect lasted throughout the trial. Researchers note that interviews of the customers involved did not present any uniform pattern of behavior changes or investment decisions to account for the savings. In fact, it is noted that interviewees rarely remembered any specific changes without prompting. The authors of the study concluded that, "Our impression from the interviews is that after three years the changes people made had become so routine that they had trouble identifying them" (Wilhite and Lang 1995).

Unfortunately, many of the most relevant utility programs have not had the time to bear any definitive conclusions with respect to the persistence of savings. The Hydro One PowerCost Monitor pilot, lasting for 18 months, found no evidence of a drop-off of savings. Other studies with the device in British Columbia and Newfoundland and Labrador also showed a persistence of savings beyond one year (Mountain 2006). However, Positive Energy's first program is still within its first twelve months of existence. Though program managers feel confident that savings will persist, and in-fact continued year-over-year improvements are expected, there is no empirical evidence to prove it.

One concern that has become apparent with many a number of the U.S. studies of the PowerCost monitor is an issue with participant retention. In an ongoing NSTAR pilot of the device, among the more than 3,000 participants, more than 1,000 had stopped using the device within the first six months (MacLellan 2008). Likewise, a pilot at the Energy Trust of Oregon also found that 34% of participants had stopped using the device within a few months (Energy Trust of Oregon 2008). While this does not suggest that the overall savings achieved by the participant population will not persist, it does suggest that there is a tendency for participants to become disengaged and fail to utilize the device to pursue energy savings. To the extent that utility program managers can maintain participation and engagement, they increase the savings likely to be produced by the program.

Applicability to Minnesota Housing Stock

In considering the applicability of behavior change programs to Minnesota's unique residential market, it is important to stress that these programs have universal application. Many of the behaviors cited as leading to energy savings in the various utility studies conducted to date – turning off lights, laundry/dishwashing habits, use of electronics – highlight that the impact of these programs is likely to be somewhat location-independent. Studies using feedback on customer populations in Ontario, California, Florida, Nevada, Massachusetts, British Columbia, and Norway all have found significant opportunity for energy savings.

While well executed behavior change programs are likely to have an impact in any customer population, a number of location and population-specific factors can influence the potential for energy savings. Factors some as home sizes, heating fuel sources, the average age of homes, the penetration of different appliances, and the number of heating and cooling degree days in a particular region can all influence the total amount of energy used and the corresponding opportunity for savings by modifying the behaviors driving that energy use.

One useful starting point in evaluating the opportunity for savings is to consider the average electricity consumption per household across different geographies. The following table from the Energy Information Administration (EIA) provides household consumption data for a number of energy types segmented by region.

Figure 10: Energy Use by Region

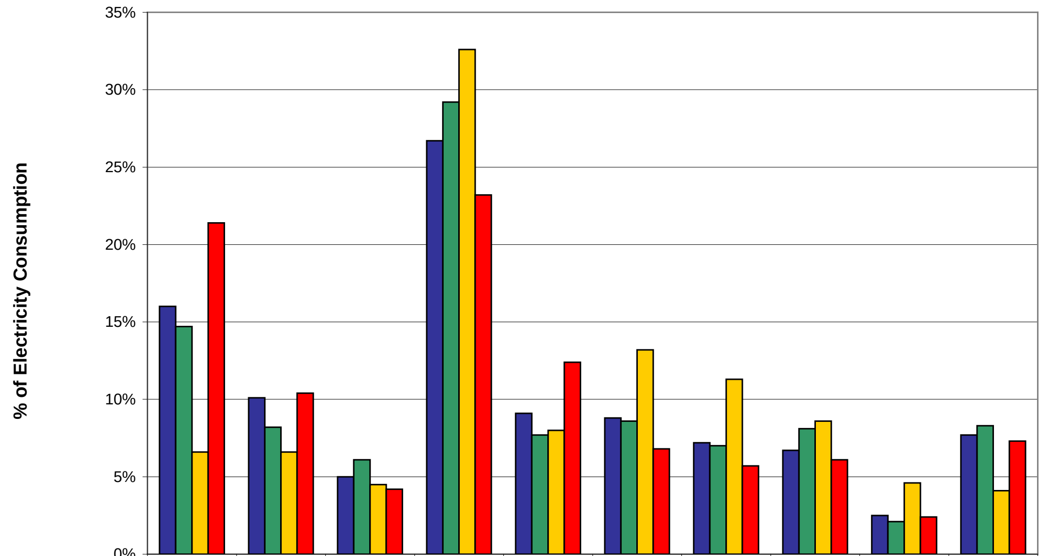
Table US8. Average Consumption by Fuels Used, 2005
Physical Units per Household

	U.S. Households (millions)	Fuels Used (physical units of consumption per household using the fuel)					
		Electricity (kWh)	Natural Gas (thousand cf)	Fuel Oil (gallons)	Kerosene[4] (gallons)	LPG (gallons)	Wood (cords)
Total	111.1	11,480	67	742	76	457	1.5
Census Region and Division							
Northeast	20.6	8,227	82	798	54	387	2.5
New England	5.5	7,432	88	855	62	450	1.6
Middle Atlantic	15.1	8,514	80	762	Q	364	2.9
Midwest	25.6	10,790	83	528	Q	652	1.8
East North Central	17.7	10,479	89	535	Q	650	2.1
West North Central	7.9	11,493	70	Q	Q	654	1.4
South	40.7	14,895	52	569	80	381	1.2
South Atlantic	21.7	14,721	57	576	85	343	1.1
East South Central	6.9	15,928	56	Q	61	451	1.7
West South Central	12.1	14,619	46	N	N	382	1.0
West	24.2	9,230	53	566	Q	435	1.2
Mountain	7.6	10,855	60	Q	N	501	1.6
Pacific	16.6	8,492	50	673	Q	365	0.9
Four Most Populated States							
New York	7.1	6,882	71	803	Q	374	3.9
Florida	7.0	15,862	28	N	Q	Q	Q
Texas	8.0	15,149	44	N	N	291	0.9
California	12.1	6,992	45	Q	N	376	0.8
All Other States	76.9	11,829	75	723	81	493	1.5
Urban/Rural Location (as Self-Reported)							
City	47.1	9,896	62	711	41	317	0.6
Town	19.0	10,982	73	806	45	333	1.1
Suburbs	22.7	12,598	74	808	Q	308	0.7
Rural	22.3	14,108	61	700	103	525	2.3

The data shows that West North Central states (including Minnesota) have electricity (~11,500 kWh) and natural gas consumption (~70k cf) that is very close to the national average. California, at less than 7,000 kWh per household is on the lower end of the spectrum. Certainly this difference is the result of a number of factors including the state's milder climate, the relative age distribution of its housing stock (and related appliance efficiency), the population's attitude toward conservation, and the amount of resources going toward energy efficiency and conservation programs. On the other end of the spectrum are states like Florida with nearly 16,000 kWh per household, a number comparable to the magnitude of energy used by Ontario households in Hydro One's service territory (Green 2008). Much of this difference can be attributed to differences in climate, with Ontario requiring much greater resources for space heating and Florida having the same to keep homes cool.

Another way to look at the energy savings potential is to look at the activities driving energy consumption. Data on electricity consumption end use across regions was compiled by the EIA in a 2001 survey. The following chart shows the percentage of electricity demand accounted for by different end uses across selected regions covered by the survey (note: survey data is not available for the West region, including California).

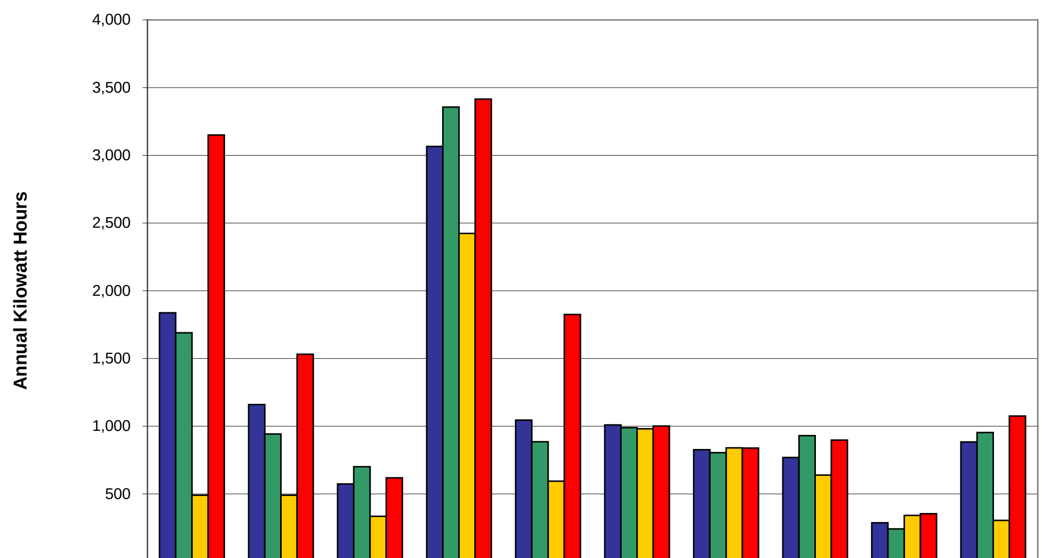
Figure 11: Residential End Use Share of Electricity Consumption by Region (Source: EIA)



	Air Conditioning	Space Heating	HVAC Appliances	Kitchen Appliances	Water Heating	Lighting	Home Electronics	Laundry Appliances	Other Equipment	Other End Uses
U.S. Avg.	16.0%	10.1%	5.0%	26.7%	9.1%	8.8%	7.2%	6.7%	2.5%	7.7%
West North Central	14.7%	8.2%	6.1%	29.2%	7.7%	8.6%	7.0%	8.1%	2.1%	8.3%
New England	6.6%	6.6%	4.5%	32.6%	8.0%	13.2%	11.3%	8.6%	4.6%	4.1%
South Atlantic	21.4%	10.4%	4.2%	23.2%	12.4%	6.8%	5.7%	6.1%	2.4%	7.3%

Using the data on average household electricity consumption yields:

Figure 12: Average Household End Use Electricity Consumption by Region (Source: EIA)



	Air Conditioning	Space Heating	HVAC Appliances	Kitchen Appliances	Water Heating	Lighting	Home Electronics	Laundry Appliances	Other Equipment	Other End Uses
U.S. Avg.	1,837	1,159	574	3,065	1,045	1,010	827	769	287	884
West North Central	1,689	942	701	3,356	885	988	805	931	241	954
New England	491	491	334	2,423	595	981	840	639	342	305
South Atlantic	3,150	1,531	618	3,415	1,825	1,001	839	898	353	1,075

This analysis illustrates several important points that influence the level of opportunity for behavior change programs in a particular area, including Minnesota. Though there are a number of areas in which there is variability across regions, the chart of kWh shows that there is uniformity in the number of kilowatt hours the average household consumes for lighting and home electronics whether you are looking at the Minnesota's West North Central region, New England or the South Atlantic. These uses are independent of climate and location. To the extent that behavior change programs benefit from changes in these uses, the expectation would be that they are directly transferable to another state or region.

Secondly, there are differences in home heating and cooling energy consumption that reflect differences in climate and fuel types. For example, South Atlantic states use much more electricity on air conditioning because of the warmer climate, but they also use more electricity on space heating than even the cooler states in the North, likely the result of greater use of electric heating. The greater reliance on natural gas and oil in New England states for home heating and cooking is also shown by the lower electricity consumption.

In considering the implications for savings potential in Minnesota, the following are important points to consider:

- In general, the West North Central's electricity use profile closely matches the national profile. Therefore, it is likely that the savings potential would match the average of results from programs across the country.
- With respect to lighting, home electronics, and appliance use (kitchen, laundry, etc.), the state's electricity consumption profile meets or exceeds other regions on an average kWh basis. Given that these uses involve frequent behavioral interaction, they are likely to be major sources of the savings achieved by behavior change programs.
- The region is slightly below the national average for electricity consumption used for space heating and cooling. This is primarily a function of climate and the use of natural gas as a fuel source. To the extent that air conditioning and/or home heating are major sources of behavior change savings, Minnesota households may see a slightly smaller opportunity for electricity savings.
- Generally homes in the West North Central region also use slightly less electricity for water heating on average (~900 kWh per household annually) than is typical for the U.S. (~1,050 kWh per household annually), likely a result of the penetration of natural gas water heaters. As a result, there is slightly less opportunity for savings in this category than in other regions. However, there are regions within Minnesota that have very high saturations of electric water heating (80%+ of homes) and utilities serving in these regions have a much greater opportunity for targeting savings tied to a behavior change effort.

Additional factors, such as the population's attitudes toward conservation and willingness to pay for devices such as in-home displays would have to be taken into consideration in order to estimate the savings potential. Income and demographic differences could be reasoned to have an impact on the success of behavior change efforts, though the Hydro One study as an example concluded that there was none (Mountain 2006).

Perhaps even more important, as covered in the literature review section, is the level of savings achieved can vary significantly depending on the medium, frequency, and format of feedback. The means in which programs are marketed, and the specific segments that are pursued can influence the results achieved. As many of the interview respondents in the study stressed, the key to success is motivation. If customers feel motivated to act and are given the knowledge to know what actions can be taken, they will find ways to curb their energy use. A program's savings potential is much more a function of success in this dimension than the sum of the factors driven by regional differences.

Program Models to Consider

Based on results of the team's research, three behavioral change program models are outlined for consideration by Minnesota utility managers. The models present concepts for implementing the types of feedback interventions reviewed in the study. A model overview is provided along with a program plan to define the necessary process steps, associated actions and outcomes, and their link to the key lessons related by study respondents. To the extent possible, reasonable savings and persistence estimates for planning purposes are provided. These models focus on interventions that can be implemented without the need for existing smart meter infrastructure (i.e., they do not consider third category of behavior change interventions such as dynamic pricing programs).

Program Models	Model 1: In-Home Energy Use Monitor	Model 2: Indirect/Comparative Feedback on Home Energy Use	Model 3: Hybrid Approach – Comparative and Direct Feedback
Program Basics	Participants receive a monitor that provides real-time feedback on home energy use in order to track and experiment with their energy use behavior	Participants receive regular reports in the mail that will compare their energy use with neighbors in similar homes. Targeted energy saving tips will also be communicated.	Participants receive regular comparative feedback reports and energy tips. Participants will be encouraged to make use of real-time power monitors that can be purchased or borrowed for several months at a time.
Customer Engagement Method	Opt-in	Opt-out	Opt-out (reports) Opt-in (in-home device)
Targeted participant household savings (as % of total kWh)	5% (mid of 3% to 7% range) Valid among self-selected participant population	2% Average in total customer population; targeted segments would have significantly higher savings (e.g., in the 5% to 10% range)	2%+ Average in total customer population; targeted segments would have significantly higher savings (e.g., in the 5% to 10% range)
Big Advantage	Real-time feedback for participants	Cost effective approach with broader reach	Hybrid approach maximizes savings potential
Big Disadvantage	Significantly higher cost per kWh saved	Requires integration with system data	Greater complexity/ resource requirements

Model 1 Program Overview: In-Home Energy Use Monitor

Program Objective The objective of this pilot behavior change program is to assist utility customers in lowering their energy use through feedback from in-home energy use monitors. Through execution of the pilot study, the utility will be able to verify the achieved savings and determine the cost effectiveness of the program on a $ per kWh basis. Furthermore, utilities would be able to measure if these customers participated to a greater extent in other utility offerings (e.g., ENERGY STAR, lighting, home insulation/weatherization, and high efficiency HVAC equipment).

Target Customer Market Given the opt-in nature of this program, a large customer population would need to be solicited in order to have a significant number of participants recruited. Previous utility experiences suggest that around 5% of customers would respond to offers provided costs to the customer are well under $50 (i.e., a utility subsidy of at least $100 on the cost of a device like the Power Cost Monitor). Feedback from program managers suggests that some population segments - elderly low income customers was one example given - may have more difficulty making use of the feedback devices, limiting their ability to generate meaningful savings. Customers with a 'techie' bent are among the most likely to have success. Homes with electric water heat are also among those that should be prioritized for marketing efforts (to the extent they can be readily available) given the substantially higher electricity savings achieved in the homes in other utility studies.

Program Logistics The program will promote a discounted sale of one or more in-home feedback displays. Examples of available devices (Power Cost Monitor, Kill-A-Watt, etc.) are provided in Appendix 3. Depending on the device design, customers may need assistance with installation (e.g., The Energy Detective). Distribution could be carried out via a utility mail order system or through retail partners (e.g., local hardware stores, online retailers). Device prices, as listed in Appendix 4 may be as low as $35 (Kill-A-Watt) to more than $200 for other energy monitors.

Customer Education Participants would be provided with education materials that identify behavior change recommendations to accompany purchase of the device. Experience suggests a small number of measures likely to be relevant to the home are more effective than an overwhelming list. Utility program managers should also consider providing case studies and results from select customers that have had success with the device. To the extent that (online) community forums can be facilitated, the program has the potential to also benefit from the power of social norms as participants seek to model the behavior of other participants and share in their success.

Enhancements The utility should raise awareness and promote associated devices that can aid the customers' behavior changes. Some examples could include promoting devices such as the centralized Green Switch/Energy Hub – which shuts off multiple outlets from one centralized location, or the Smart Strip power strip that automatically shuts off power to devices in home office / theater systems. See Appendix 6 for more information.

Trade Ally Plan It is recommended the utility make provisions for some type of technical assistance be made available from the utility or local electricians for the installation of more involved devices (e.g. TED) given safety concerns.

Savings Goals and Assumptions Savings estimates for planning purposes fall in the range of 3% to 7%, with a midpoint of 5% based on prior utility program experiences. These percentages can be applied to average energy consumption to approximate unit (e.g., kWh) quantities. These numbers are based on electricity-focused programs as the feedback devices measure power use in kilowatts. Though there are likely to be natural gas savings as a direct result of changes to thermostat settings and customer hot water use, the current stand-alone devices being marketed provide only feedback on metered electricity.

Savings can be conservatively estimated to last at least one year, with 18 months of persistence having been shown in the Hydro One pilot. Though behavior change programs are found in research studies to typically persist for perhaps several years (Darby 2006), the issues of customer defection documented previously suggest that a cautious approach may be warranted until more robust data from utility programs is available.

Marketing/Incentive Strategy Two primary incentives can be offered including 1) a utility subsidy/rebate on the cost of the device (as discussed earlier) and 2) discounted technical assistance for the installation of certain devices (e.g., TED). Thought can be give to promotion of associated devices (e.g., Green Switch) over time based on results of the program and evidence of savings from the use of those technologies to contribute toward energy savings.

The program will require a multi-media campaign approach to promotion. Though direct mail brochures and company Web site promotion will be central recruitment channels, other utilities (MacLellan 2008) have experienced significant spikes in demand when stories are picked up in local newspapers, Web sites, radio and television programs.

Quality Control Plan Ensuring program success will depend on robust pilot design, ongoing data tracking, and customer satisfaction and engagement. Having adequate pilot scale and measurement systems will ensure that cost effectiveness can be accurately quantified. Following participants over a multi-year period will uncover the true persistence of savings. Anticipating and addressing customer needs will help to limit participant defection.

A critical aspect of accountability will be the ability to avoid double counting savings when customers participate in utility energy efficiency programs beyond the behavior change program (e.g., they get a rebate on a new furnace). To address such cases, mechanisms must exist to adjust kWh consumption to account for the new appliance/load profile.

Program Budget Considerations The large majority of monitor device costs will need to be paid for (e.g., $100 of the $130 Power Cost Monitor) by the utility. Additional resources will be needed to develop and deliver educational materials, respond to customer needs, and oversee the program.

Model 1 – In-Home Energy Use Monitor – Behavior Change Pilot Program Plan

Process Step	Inputs	Actions	Outputs	Critical Success Factors (Applicable Lessons Learned)
Identify Team/Objectives	• Available internal resources • Potential implementation partners	• Identify required program pilot team with cross functional (operational, finance, technical, customer service) capabilities to address all aspects of program execution and business case assessment • Define project timeline and specific pilot learning objectives (e.g., quantify savings potential and $/kWh for program) • Quantify resource and budget requirements	• Project team • Project plan • Define pilot program outcome measures • Pilot program budget	• A diverse pilot team helps to ensure success
Prepare for Customer Engagement	• Identification of feedback devices to include	• Review work of peer utilities; engage in dialog • Engage manufacturers to obtain devices for trial and evaluate program logistics • Test internally (i.e., have team members install at homes) • Develop list of items on which to collect customer input	• Identified device manufacturers/terms for pilot • Identified pitfalls with device trials • Customer input objectives	• Taking an iterative approach to piloting solutions ensures consistency with goals • Validating the functionality of new technology can avoid headaches down the road • Leveraging the experience of peer utilities improves chances of success
Collect Customer Input	• Small customer (e.g., focus group) population • Customer input objectives	• Solicit customer engagement • Collect feedback from a focus group (or survey) • Collect feedback on key aspects of program marketing and execution: o Receptivity to application of in-home device o Willingness to pay o Attitudes toward conservation	• Identified barriers to customer response • Identified barriers to user acceptance of device • Key themes to incorporate in customer targeting and messaging • Identified population segments to target/avoid	• Upfront customer input provides invaluable guidance for successful program design • Ensure the solution is well suited to customer population • Interfacing with meters for in-home devices can present barriers

Process Step	Inputs	Actions	Outputs	Applicable Lessons Learned
Define Program Parameters	• Available data on customer energy use and segmentation parameters: o Level of energy use o Age o Income o Home size/type/age • Device purchase and installation cost estimates	• Establish desired customer segments on which to determine program impact • Calculate required program sample size (in each population) to allow for adequate precision/confidence in program outcomes measurement* • Determine if there are any viable means to establish a control group for comparison that is representative of the treatment group (e.g., has the same selection biases) • Develop marketing and customer education plans to maximize participation and ensure • Determine device cost to customer/utility subsidy	• Necessary program treatment group size • Identified customer segment representation desired in pilot group • Viability of establishing a control group • Customer marketing plan • Customer education plan • Program cost (to utility, to customer)	• Incorporating a control group that representative of the underlying population and sufficiently large allows for the necessary precision and confidence to draw conclusions about specific sub-segments of the population • [device cost to customer will likely need to be <$50 to attract meaningful response >1%]
*Note: See Appendix 1 for discussion of sample size determination. The selection bias of device user population requires historical data comparison to evaluate savings.				
Recruit and Educate Participants	• Customer contact/ information	• Solicit customers to participate through direct mail (e.g., bill inserts) and/or telephone recruitment • Utilize available customer interactions (e.g., Web site, home energy audits, customer service/billing calls) to promote the program – consider implications to pilot sample bias • Provide materials to educate customers about the functionality and benefits of the device(s)	• Pilot program participant population of adequate size • Customer understanding of program	• Motivation is the essential ingredient • Look beyond traditional customer segmentation models to find messages that resonate with particular groups
Conduct Pre-Pilot Survey	• Customer focus group feedback • Example surveys from past programs and other utilities	• Define survey to capture: o Home characteristics (e.g., appliances) o Demographics o Energy use behaviors/patterns o Attitudes toward conservation o History of participation in utility energy efficiency programs (e.g., rebates, etc.) • Collect feedback from a representative sample of the pilot program participants • Collect feedback from a representative sample of customer population	• Baseline profile of customer characteristics • Identified meaningful differences in participant population vs. total customer population (e.g., skews toward customer with affinity for conservation, higher/lower income, etc.)	• Pre-pilot surveys can establish baselines for analysis

Process Step	Inputs	Actions	Outputs	Applicable Lessons Learned
Execute Pilot Study	• Identified committed program participant population • Resources to support device distribution/installation • Resource to field customer calls, questions, issues • Customer communications	• Collect customer payment • Distribute energy display devices (and provide installation assistance if needed) • Assist/respond to customer questions/issues with device installation/operation • Provide customer communication/education materials as appropriate to identify savings opportunities and encourage engagement • Consider offerings customer the opportunity to establish an energy reduction goal	• Pilot program participation • Addressed customer concerns • Motivated and educated participants	• Ensure pilot execution allows for measurement of cost effectiveness • Be sensitive to program's impact on customer satisfaction
Collect Participant Feedback	• Pilot program participation	• Develop survey instruments to evaluate: o Customer adoption rates (install, use rate) o Level of device use/persistence o Perceptions of device utility o Perceptions of savings o Behavior changes made/tested o Investments made o Participation in other utility energy efficiency programs (e.g., rebates/incentives) – Important for savings adjustments/avoid double-counting o Conservation attitudes • Collect feedback from pilot participants	• Ability to adjust savings for concurrent efficiency program participation • Survey data/feedback on participant experience and satisfaction	• In-home display devices are known to be hampered by low installation rates
Evaluate Program Results/Savings Cost Effectiveness	• Energy consumption data • Quantification of pilot program costs • Data from participant feedback survey	• Obtain measures of actual consumption over treatment period for treatment, control (if any), and population (sample) • Compare to normalized historical consumption or control group data to determine impact of the devices on energy conservation	• Measurement of participant energy savings • Determination of program cost effectiveness ($ per kWh of savings)	• The novelty of the feedback will wear off
Continue monitoring	• Pilot program participation	• Execute customer surveys and data collection to determine persistence of energy savings	• Data on device use pattern • Data on persistence	• [Limited data on persistence of savings from existing programs]

Model 2 Program Overview: Indirect/Comparative Feedback on Energy Use

Program Objective

The objective of this pilot behavior change program is to leverage the power of social norming to motivate residential customers to take action to address their energy-use behaviors. Through execution of the pilot study, the utility will be able to verify the achieved savings and determine the cost effectiveness of the program on a $ per kWh basis. Utilities would be able to measure if these customers participated to a greater extent in other utility offerings (e.g., ENERGY STAR, lighting, home insulation/weatherization, and high efficiency HVAC equipment).

Target Customer Market

This is an opt-out program in which the utility has flexibility to decide which households will receive information and which will not, creating significant opportunity for collecting information on which customer segments should receive the most attention. Targeting specific customer segments is likely to be an important means to optimize the program, though initially it will likely be best to target a broad population cross section. Data from a broad-based pilot will allow program managers to characterize the relative performance of different segments (home size, age, income, etc.) and analyze the biggest opportunities to maximize cost effectiveness. As a cautionary note, a program manager who currently runs this type of program notes a small, but vocal minority of customers that take offense to the message of neighbor comparisons. Utilities must be quick in responding thoughtfully to these libertarian individuals to avoid customer satisfaction issues.

Program Logistics

In order to produce the home energy reports, utilities will need to have either their own internal IT system for report generation or contract for the services of a third party such as Positive Energy. Robust data on houses and homeowners will be necessary to systematically identify the comparable homes for a given report. Likewise, a means to attach relevant energy savings tips to each customer's report will need to be automated. An operation to generate and mail the reports will need to be defined and a protocol for addressing customer concerns will need to be articulated.

Customer Education

The nature of this behavior change program is one of customer education. Each report represents another opportunity to engage customers in understanding their energy use profile and helping them to know where they rank amongst neighbors. Importantly, the limited targeted tips give customers ideas to take action. The monthly report will include 2 to 4 targeted energy savings recommendations that are particularly relevant for the specific customer based on a detailed analysis of load patterns, the housing stock, and available demographic data. For example, fixed income customers, or renters may receive messages that are no or low cost. Customers in older homes may receive air sealing recommendations while customers with higher summer use than their neighbors may receive suggestions related to cooling measures. Coupons and other promotional items will be included with the report to encourage persistent participation.

Savings Goals and Assumptions

Though the nascent nature of the neighbor comparison programs leaves limited opportunity for quantification of expected savings, the robust nature of the SMUD/Positive Energy pilot that began in April 2008 (N=35,000) creates a fairly high degree of certainty that savings are real and meaningful. The 2% average savings found among customers receiving the energy reports seems modest until it is considered that these savings can be realized on the entire customer population at a vary affordable cost. This number is on the lower end of the 0% to 10% range for indirect feedback noted in research literature (Darby, 2006).

Savings have persisted in these programs over the first year and are expected to remain indefinitely as a result of changes to underlying behavior habits as noted by Darby and others. Program managers are likely to find that even using a one-year savings basis yields attractive cost effectiveness, though assuming 2 or 3 years may still be conservative. As program managers also point out, the cost of sending the reports can be eliminated at any time.

Ongoing measurement of performance for the pilot group is recommended to establish baselines for long term impact of the home energy report intervention.

Marketing/Incentive Strategy

The program will be operated as an opt-out effort, meaning that all customers selected will be considered participants unless they specifically opt out of the program. All customers will receive a monthly report with a very clear and easy-to-understand normative message which is a comparison of their electricity consumption to similarly sized homes in their neighborhood/area. Treatment and control groups should be sufficiently large in order to allow for precise estimation of the difference in population means (i.e., statistical power to detect the 2% difference). The size of the required sample will be a function of the savings target, the desired statistical confidence, and the variability home energy use levels in the underlying population.

In addition to the feedback and recommendations in the report, additional measures can help to enhance the customer experience. For example, integrated an online community discussion forum may help to emphasize the social norming message (i.e., being more like others, competing) while also providing customers with additional energy saving ideas.

Quality Control Plan

Ensuring program success will depend on robust pilot design, ongoing data tracking, and customer satisfaction and engagement. Having adequate pilot scale and measurement systems will ensure that cost effectiveness can be accurately quantified. Following participants over a multi-year period will uncover the true persistence of savings. Anticipating and addressing customer needs will help to limit participant defection.

A critical aspect of accountability will be the ability to avoid double counting savings when customers participate in utility energy efficiency programs beyond the behavior change program (e.g., they get a rebate on a new furnace). To address such cases, mechanisms must exist to adjust kWh consumption to account for the new appliance/load profile.

Program Budget Considerations

Reports from Positive Energy's work with SMUD suggest that the annual cost per customer to generate and distribute the home energy reports can be less than $10 per household, but this is largely dependent on the scale of the effort given the fixed costs involved in setting up the IT infrastructure and processing operations.

Model 2 – Indirect/Comparative Feedback – Behavior Change Pilot Program Plan

Process Step	Inputs	Actions	Outputs	Critical Success Factors (Application of Lessons Learned)
Identify Team/Objectives	• Available internal resources • Potential implementation partners	• Identify required program pilot team with cross functional (operational, finance, technical, customer service) capabilities to address all aspects of program execution and business case assessment • Define project timeline and specific pilot learning objectives (e.g., quantify savings potential and $/kWh for program) • Quantify resource and budget requirements	• Project team • Project plan • Define pilot program outcome measures • Pilot program budget	• A diverse pilot team helps to ensure success
Prepare for Customer Engagement	• Identification of potential program partners (e.g., Positive Energy)	• Review work of peer utilities; engage in dialog • Engage program partners (if necessary/desired) • Develop IT integration plan to enable generation of home energy use reports • Develop list of items on which to collect customer input	• Determination of program partner engagement • Identified challenges to report generation • Customer input objectives	• Taking an iterative approach to piloting solutions ensures consistency with goals • Leveraging the experience of peer utilities improves chances of success
Collect Customer Input	• Small customer (e.g., focus group) population • Customer input objectives	• Solicit customer engagement • Collect feedback from a focus group (or survey) • Collect feedback on key aspects of program marketing and execution: o Receptivity to comparative feedback o Desired report information elements, format/graphics o Attitudes toward conservation	• Identified customer concerns with reports • Key themes to incorporate in customer targeting and messaging	• Upfront customer input provides invaluable guidance for successful program design • Ensure the solution is well suited to customer population

Process Step	Inputs	Actions	Outputs	Applicable Lessons Learned
Define Parameters for Customer Comparison	• Available data on customer energy use and segmentation parameters: o Level of energy use o Age o Income o Home size/type/age	• Establish desired customer segments on which to determine program impact • Calculate required program sample size to allow for adequate precision/confidence in program outcomes measurement* • Establish a control group of (at least) similar size for comparison that is representative of the treatment group • Develop customer education plans to maximize awareness and satisfaction • Determine means/parameters to group customer homes for energy use comparisons (e.g., 100 homes of similar size in neighborhood) • Determine program budget	• Necessary program treatment and control group size • Identified customer segment representation desired in pilot group • Customer education plan • Program budget	• Incorporating a control group that representative of the underlying population and sufficiently large allows for the necessary precision and confidence to draw conclusions about specific sub-segments of the population
*Note: See Appendix 1 for discussion of sample size determination. Control and treatment groups should be defined to observe impact of feedback.				
Develop Energy Report Content	• Customer segmentation data	• Develop energy use reports to communicate customer energy use in comparison to neighbors and historical consumption • Develop/obtain comprehensive lists of energy savings measures to potentially recommend • Establish means to select customized energy savings tips for customers based on known segmentation parameters	• Template for home energy use report • Means to determine customized savings tips to include (may come from program partner)	• Motivation is the essential ingredient • Look beyond traditional customer segmentation models to find messages that resonate with particular groups
Conduct Pre-Pilot Survey	• Customer focus group feedback • Example surveys from past programs and other utilities	• Define survey to capture: o Home characteristics (e.g., appliances) o Demographics o Energy use behaviors/patterns o Attitudes toward conservation o History of participation in utility energy efficiency programs (e.g., rebates, etc.) • Select pilot treatment and control groups (likely random/stratified sample) • Collect feedback from customers across treatment, control, and total population	• Baseline profile of customer characteristics and attitudes • Confirmation that treatment and control samples are representative and unbiased	• Pre-pilot surveys can establish baselines for analysis

Process Step	Inputs	Actions	Outputs	Applicable Lessons Learned
Execute Pilot Study	• Selected treatment population • Resources to support report generation and distribution • Resource to field customer calls, questions, issues • Customer communications	• Distribute customer education materials describing program/reports • Regularly generate and distribute home energy use reports to treatment group customers o More frequent feedback has been shown to lead to greater energy savings • Assist/respond to customer questions/issues with device installation/operation • Consider offerings customer the opportunity to establish an energy reduction goal	• Pilot program participation • Addressed customer concerns • Motivated and educated participants	• Ensure pilot execution allows for measurement of cost effectiveness

Collect Participant Feedback	• Pilot program participation	• Develop survey instruments to evaluate:
		  o Perceptions of home energy use reports
		  o Impact on motivation
		  o Behavior changes made
		  o Investments made
		  o Participation in other utility energy efficiency programs (e.g., rebates/incentives) – Important for savings adjustments/avoid double-counting
		  o Conservation attitudes
		• Collect feedback from pilot treatment/control groups
			• Ability to adjust savings for concurrent efficiency program participation
			• Survey data/feedback on participant experience and satisfaction
				• Be sensitive to program's impact on customer satisfaction

Evaluate Program Results/Savings Cost Effectiveness	• Energy consumption data • Quantification of pilot program costs • Data from participant feedback survey	• Obtain measures of actual consumption over treatment period for treatment, control (if any), and population (sample) • Compare to normalized historical consumption and control group data to determine impact of the feedback intervention on energy conservation	• Measurement of participant energy savings • Determination of program cost effectiveness ($ per kWh of savings) • Determination of differences across segments (e.g., savings for high energy users)	• Opt-out nature of program allows for results to be more reasonably extended to potential for savings in entire population • Specific customer segments (e.g., higher energy users) are likely to see different levels of savings
Conduct ongoing monitoring	• Pilot program participation	• Execute customer surveys and data collection to determine persistence of energy savings and customer involvement	• Data on device use pattern • Data on savings persistence	• [Limited data exists on persistence of savings from utility programs]

Model 3 Program Overview: Hybrid - Comparative and Direct Feedback

Program Objective

The objective of this pilot behavior change program is to assist residential utility customers in lowering their energy use through feedback from both indirect reports sent regularly to compare performance with neighbors and also give opportunity to utilize in-home monitors. While the comparative feedback aspect of the program would target all customers, participants would have to request the use of real-time feedback devices that could be managed with a temporary use lending model.

Target Customer Market

The program would combine the broad reach of the opt-out home energy report model with the ability to enhance the experience of targeted and self-selected segments through the provision of tools for real-time feedback monitoring. The utility can use data from the broad indirect feedback program to identify the customer segments with the greatest potential to benefit from direct feedback and target marketing of the devices to these groups.

Program Logistics

In order to produce the home energy reports, utilities will need to have either their own internal IT system for report generation or contract for the services of a third party such as Positive Energy. Robust data on houses and homeowners will be necessary to systematically identify the comparable homes for a given report. Likewise, a means to attach relevant energy savings tips to each customer's report will need to be automated. An operation to generate and mail the reports will need to be defined and a protocol for addressing customer concerns will need to be articulated

For the supplementary provision of in-home devices such as the Power Cost Monitor, The Energy Detective, or the Kill-A-Watt, the utility can consider the same subsidized purchase model as proposed in Model 1 or a temporary device check-out model in which customers take home devices to use for several months to learn about their consumption patterns. Sharing the benefits of the monitor across a number of customers has the dual benefit of spreading costs over a greater number of kWh savings and also helps to curb the problem of devices going uninstalled or unused.

Customer Education

In addition to providing energy-use feedback and conservation tips, the utility could use the home energy report as a platform to promote the availability of the in-home monitors.

Enhancements

As with the other models, the utility can raise awareness and promote associated devices that can aid the customers' behavior changes such as Green Switch or the Smart Strip.

Trade Ally Plan

In the case of devices tying into panels and using current transducers, the utility should arrange for technical/installation assistance to be made available from the utility or local electricians.

Savings Goals and Assumptions

The savings estimates would mirror the 2% savings target identified for Model 2 for the entire participant population. The sub-segment of participants that elects to make use of a real-time monitor to aid in tracking progress and identifying behavior change modifications would be expected to realize even higher savings, pushing the population total above 2%.

Similar to the persistence estimate identified for Model 2, savings have persisted in these programs over the first year and are expected to remain indefinitely as a result of changes to underlying behavior habits as noted by Darby and others. Program managers are likely to find that even using a one-year savings basis yields attractive cost effectiveness, though assuming 2 or 3 years may still be conservative.

Ongoing measurement of performance for the pilot group is recommended to establish baselines for long term impact of the home energy report intervention.

Marketing/Incentive Strategy	The utility can weigh whether a device renting/borrowing program is feasible. Otherwise, providing major subsidies for customer purchases would, as with Model 1, be necessary. To the extent device installation requires technical expertise, discounts on electrician services would also be necessary. The monthly energy use report can serve as the primary medium for promoting the real-time power monitors. As with other models, challenging participants to make a commitment to achieving a personal energy savings goal serves to maintain involvement and motivation. Feedback on goal progress can be incorporated into the monthly report.
Quality Control Plan	Ensuring program success will depend on robust pilot design, ongoing data tracking, and customer satisfaction and engagement. Having adequate pilot scale and measurement systems will ensure that cost effectiveness can be accurately quantified. Following participants over a multi-year period will uncover the true persistence of savings. Anticipating and addressing customer needs will help to limit participant defection. A critical aspect of accountability will be the ability to avoid double counting savings when customers participate in utility energy efficiency programs beyond the behavior change program (e.g., they get a rebate on a new furnace). To address such cases, mechanisms must exist to adjust kWh consumption to account for the new appliance/load profile.
Program Budget Considerations	Depending on the device distribution model chosen, the utility may have to bear most, if not all, of the cost of the in-home display device. The cost effectiveness of the device program may be greater under a rental/temporary checkout model as a larger number of customers benefit from the same device. Program cost on a per household basis for the home energy reports would be, as described under Model 2, dependent on the scale of the operation.

Model 3 – Hybrid of Comparative and Direct Feedback – Behavior Change Pilot Program Plan

Process Step	Inputs	Actions	Outputs	Critical Success Factors (Application of Lessons Learned)
Identify Team/Objectives	• Available internal resources • Potential implementation partners	• Identify required program pilot team with cross functional (operational, finance, technical, customer service) capabilities to address all aspects of program execution and business case assessment • Define project timeline and specific pilot learning objectives (e.g., quantify savings potential and $/kWh for program) • Quantify resource and budget requirements	• Project team • Project plan • Define pilot program outcome measures • Pilot program budget	• A diverse pilot team helps to ensure success
Prepare for Customer Engagement	• Identification of potential program partners (e.g., Positive Energy)	• Review work of peer utilities; engage in dialog • Engage program partners (if necessary/desired) • Develop IT integration plan to enable generation of home energy use reports • Develop list of items on which to collect customer input • Obtain real-time feedback devices and test internally	• Determination of program partner engagement • Identified challenges to report generation • Identified device preferences • Customer input objectives	• Taking an iterative approach to piloting solutions ensures consistency with goals • Leveraging the experience of peer utilities improves chances of success • Validating the functionality of new technology can avoid headaches down the road
Collect Customer Input	• Small customer (e.g., focus group) population • Customer input objectives	• Solicit customer engagement • Collect feedback from a focus group (or survey) • Collect feedback on key aspects of program marketing and execution: o Receptivity to comparative feedback o Desired report information elements, format/graphics o Attitudes toward conservation o Interest in real-time feedback devices o Interest in device distribution/rental arrangements	• Identified customer concerns with reports • Key themes to incorporate in customer targeting and messaging • Identified barriers to user acceptance of device	• Upfront customer input provides invaluable guidance for successful program design • Ensure the solution is well suited to customer population • Interfacing with meters for in-home devices can present barriers

Process Step	Inputs	Actions	Outputs	Applicable Lessons Learned
Define Parameters for Customer Comparison	• Available data on customer energy use and segmentation parameters: o Level of energy use o Age o Income o Home size/type/age	• Establish desired customer segments on which to determine program impact • Calculate required program sample size (in each population) to allow for adequate precision/confidence in program outcomes measurement* • Establish a control group of (at least) similar size for comparison that is representative of the treatment group • Develop customer education plans to maximize awareness and satisfaction • Determine means/parameters to group customer homes for energy use comparisons (e.g., 100 homes of similar size in neighborhood) • Determine program budget	• Necessary program treatment and control group size • Identified customer segment representation desired in pilot group • Customer education plan • Program budget	• Incorporating a control group that representative of the underlying population and sufficiently large allows for the necessary precision and confidence to draw conclusions about specific sub-segments of the population
*Note: See Appendix 1 for discussion of sample size determination. Control and treatment groups should be defined to observe impact of indirect feedback. The selection bias of device user population requires historical data comparison to evaluate savings.				
Develop Energy Report Content	• Customer segmentation data	• Develop energy use reports to communicate customer energy use in comparison to neighbors and historical consumption • Develop/obtain comprehensive lists of energy savings measures to potentially recommend • Establish means to select customized energy savings tips for customers based on known segmentation parameters	• Template for home energy use report • Means to determine customized savings tips to include (may come from program partner)	• Motivation is the essential ingredient • Look beyond traditional customer segmentation models to find messages that resonate with particular groups
Develop Real-Time Feedback Device Distribution Model	• Device preferences • Identified barriers to user acceptance of device	• Identify plan for device lending/rental program (e.g. distribution through mail, library checkout, etc.) • Purchase adequate number of devices to support pilot • Develop necessary customer education materials to facilitate device lending program	• Device lending program resources	• Real-time feedback gives users the opportunity to experiment in finding energy saving behaviors

Process Step	Inputs	Actions	Outputs	Lessons Learned
Conduct Pre-Pilot Survey	• Customer focus group feedback • Example surveys from past programs and other utilities	• Define survey to capture: o Home characteristics (e.g., appliances) o Demographics o Energy use behaviors/patterns o Attitudes toward conservation o History of participation in utility energy efficiency programs (e.g., rebates, etc.) • Select pilot treatment and control groups (likely random/stratified sample) • Collect feedback from customers across treatment, control, and total customer populations	• Baseline profile of customer characteristics and attitudes • Confirmation that treatment and control samples represent the underlying population	• Pre-pilot surveys can establish baselines for analysis
Execute Pilot Study	• Selected treatment population • Resources to support report generation and distribution • Device distribution/ collection model • Resource to field customer calls, questions, issues • Customer communications	• Distribute customer education materials describing program/reports • Regularly generate and distribute home energy use reports to treatment group customers o More frequent feedback has been shown to lead to greater energy savings • Promote opportunities for participants to obtain real-time feedback devices to aid in their efforts to save energy • Facilitate distribution and collection of real-time feedback devices • Assist/respond to customer questions/issues with device installation/operation • Consider offerings customer the opportunity to establish an energy reduction goal	• Pilot program participation • Addressed customer concerns • Demand for real-time feedback devices • Motivated and educated participants	• Ensure pilot execution allows for measurement of cost effectiveness
Collect Participant Feedback	• Pilot program participation	• Develop survey instruments to evaluate: o Perceptions of home energy use reports/devices o Impact on motivation o Behavior changes made o Investments made o Participation in other utility energy efficiency programs (e.g., rebates/incentives) – Important for savings adjustments/avoid double-counting o Conservation attitudes • Collect feedback from pilot treatment/control groups	• Ability to adjust savings for concurrent efficiency program participation • Survey data/feedback on participant experience and satisfaction	• Be sensitive to program's impact on customer satisfaction

Process Step	Inputs	Actions	Outputs	Lessons Learned
Evaluate Program Results/Savings Cost Effectiveness	• Energy consumption data • Quantification of pilot program costs • Data from participant feedback survey	• Obtain measures of actual consumption over treatment period for treatment, control (if any), and population (sample) • Compare to normalized historical consumption and control group data to determine impact of the feedback intervention on energy conservation	• Measurement of participant energy savings • Determination of program cost effectiveness ($ per kWh of savings) • Determination of differences across segments (e.g., savings for high energy users)	• Opt-out nature of program allows for results to be more reasonably extended to potential for savings in entire population • Specific customer segments (e.g., higher energy users) are likely to see different levels of savings
Conduct ongoing monitoring	• Pilot program participation	• Execute customer surveys and data collection to determine persistence of energy savings and customer involvement	• Data on device use pattern • Data on savings persistence	• [Limited data exists on persistence of savings from utility programs]

Appendix 1 – Note on Sample Size Determination

An important objective of the pilot program is to quantify achieved energy savings in order to evaluate program cost effectiveness and determine an appropriate plan for larger roll-out.

Opt-In Device Programs:

Due to the self-selected nature of the treatment population in the case of an opt-in program such as the purchase and use of an in-home energy monitor, it is difficult to have a control group that is representative of the treatment group. Therefore the device's impact must be using a comparison to historical consumption. There are two approaches that may be used to determine the program's impact:

Approach #1: Comparing the change in energy consumption of the program participants following installation of the monitor device to their consumption in prior periods can be used to measure the impact of the feedback intervention. In order to account for climate differences, data would need to be weather-normalized to adjust for the additional cooling or heating requirements. Comparisons should be made to the same time periods to best match seasonal differences (e.g., daylight hours, etc.). The mean change in energy consumption in the weather-normalized analysis can provide a central measure to assess program impact. Statistically significant results could be demonstrated by comparing the confidence interval around the mean to conclude, for example, that a meaningful impact was observed (e.g., confidence interval does not include zero) or that the average energy savings was greater than a certain limit. The larger the selected sample size the tighter the confidence interval on the mean as defined by:

$$C.I. = \overline{X} \pm z_{\alpha/2} \frac{\sigma}{\sqrt{n}}$$

for 95% confidence, $z_{\alpha/2} = 1.96$: $C.I. = \overline{X} \pm 1.96 \frac{\sigma}{\sqrt{n}}$

Approach #2: Comparing the mean % change in energy consumption for the treatment group to the mean % change in energy consumption among a sample of the overall population would be another approach to deal with adjusting for changes in climate, technology, and the overall economic environment. In this case a weather-normalized adjustment of the data would not be necessary as both groups would be subject to these exogenous variables. In this case, the formula to determine the appropriate minimum sample size required to test the difference in two population means, μ_1 and μ_0, with common variance, σ^2, is:

$$n = \frac{2\left(z_{1-\alpha/2} + z_{1-\beta}\right)^2}{\left(\frac{\mu_0 - \mu_1}{\sigma}\right)^2}$$

Rule of thumb: $$n = \frac{16}{\left(\frac{\mu_0 - \mu_1}{\sigma}\right)^2}$$

For $\alpha = 0.05$ (95% confidence) and $\beta = 0.20$ (80% power) the values of $z_{1-\alpha/2}$ and $z_{1-\beta}$ are 1.96 and 0.84, respectively; and $2(z_{1-\alpha/2} + z_{1-\beta})^2$ = 15:68, which can be rounded up to 16, producing the rule of thumb above. For example, if the standard deviation for the % change in energy consumption over a given period (e.g., one year) is 10% and the hypothesis is that there will be a 5% difference in the means between the treatment and control groups, than a sample size of 64 would suffice in illustrating if the difference in means was statistically significant.

Opt-Out Indirect Feedback Programs:

In the case of an opt-out program in which the treatment group is not self-selected, but rather selected by the program administrator (utility), a sample that is representative of the overall population with respect to energy consumption, demographics, and housing characteristics can be targeted. As a result, the impact of the feedback intervention can be determined by observing the difference in average energy consumption between the treatment and control groups in the current period. This approach avoids the problem of comparing changes in usage from one period to another that are subject to macro factors such as weather patterns, economic conditions, and media messaging as well as individual household factors such as tenant changes, occupancy, renovations, etc.

Based on the above calculation for testing the difference in means, the following table provides examples of the required sample size to draw conclusions given the variability of average energy consumption within the population and the hypothesized level of energy savings to be detected:

		Hypothesized Annual Energy Savings (to Test)			
		1%	2%	5%	10%
		100 kWh	200 kWh	500 kWh	1000 kWh
Std. Dev. of Annual Energy Consumption	1000 kWh	1,600	400	64	16
	2000 kWh	6,400	1,600	256	64
	3000 kWh	14,400	3,600	576	144
	4000 kWh	25,600	6,400	1,024	256
	5000 kWh	40,000	10,000	1,600	400

In most cases it is unlikely that a single population sample will provide a satisfactory program design as program managers would likely want to evaluate program effectiveness for different population segments such as households of different types (e.g., single vs. multi-family), sizes, ages, or energy consumption strata. The program may also aim to test the impact different reporting formats and the frequency of feedback delivery. In this case an analysis of the required sample size from each segment, with consideration for segment overlap, may be appropriate to ensure adequate data to have statistical validation of findings.

Appendix 2 - Summary Table of Behavioral Programs Reviewed

Hydro One – PowerCost Monitor Pilot Program

Timing: Pilot study conducted from June 2004 to September 2005

Program Design/Research Methodology	Results/Findings

• Pilot conducted beginning in June 2004; ran through September 2005
• Stratified random sample of participants was designed to cover different geographic regions and electricity demand levels
• Participants received real-time monitoring device – the PowerCost Monitor from Blue Line Innovations at no cost
• Historical data was adjusted for weather and appliances in order to evaluate energy savings
• 500 participants and 52 control customers included
• Study excluded customers that lived in apartments, condominiums, town homes, and row homes or were renters
• Study period >1 year
• 400+ participants
• Sample across wide variation of climate and geography
• Impact measured based on historical comparison
	• 6.5% aggregate reduction in electricity (kWh) consumption across program participants
	  o Study concludes an average reduction of 7% to 10% is "feasible"
	• 8% reduction in non-electric heat homes
	  o 5% reduction in non-electric heat and non-electric hot water homes
	  o 16% reduction in non-electric heat homes w/ electric hot water
	• 1% reduction in electrically heated homes
	  o Study concludes that separating out feedback from the electric heating load for the rest of the load would be required to encourage saving in this segment
	  o Suggests that home heating may not be a major opportunity area for behavior change
	• "income and demographic factors had no impact on the responsiveness to the monitor"
	• 60% of participants felt the monitor made a difference in their homes
	• Rating the usefulness of the monitor on a scale from zero (not useful) to 5 (very useful) participants responded in the following proportions:
	  o Zero – 5%
	  o 1 – 14%
	  o 2 – 19%
	  o 3 – 24%
	  o 4 – 21%
	  o 5 – 17%
	• 39% of participants reported consulting the monitor either daily (24%) or multiple times per day (15%)
	• 65% of participants planned to continue using the monitor once the pilot study was complete

Source:

- *The Impact of Real-Time Feedback on Residential Electricity Consumption: The Hydro One Pilot*, Dean Mountain Ph.D., Mountain Economic Consulting and Associates Inc., March 2006

NSTAR – PowerCost Monitor Pilot

Timing: Pilot study initiated in May 2008

Program Design/Research Methodology	Results/Findings

• Pilot began May 2008
• 3,100+ units sold
• Coordinated effort between National Grid, NSTAR, and WMECO
• Targeted audit participants and general customer population (via media promotion and direct mail)
• Selected PowerCost Monitor from Blue Line Innovations, identifying following attributes:
  o Compatibility
  o Wireless display
  o Instant real-time display
  o Self-install by customer
  o Cumulative kWh and usage
	• 2.9% savings for customers who used the monitor; equated to annual savings of ~$64
	• 63% of participants indicate behavior change
	• 60% noticed savings in their bill
	• Self-identified savings amount from customer survey (e.g., “How much are you saving?”):
	  o 17% - saving <5%
	  o 48% - saving 5% to 10%
	  o 18% - saving 10% to 15%
	  o 8% - saving 15% to 20%
	  o 4% - saving >20%
	  o 5% - don’t know
	• 29% of customers receiving the PowerCost Monitor did not install the unit (62% had not gotten to it, 28% had trouble installing the transmitter, 14% had difficulty programming the monitor)
	• 33% of initial users stopped using the monitor during the study period; reasons cited:
	  o 40% - monitor did not work well
	  o 23% - battery died
	  o 22% - unit broke
	  o 9% - don’t need anymore; know what they use
	• Three distribution models to measure adoption and willingness to pay:
	  o Free device direct install offered during home energy audit - 95% adoption rate
	  o Free device for previous audit customers (solicited by mail) – 14% adoption rate
	  o Direct mail solicitation (with media marketing) at different user price levels to subsidize the ~$140 cost of the monitor
	    ▪ $9.99 customer price – 6% adoption rate (National Grid)
	    ▪ $29.99 customer price – 5% adoption rate (NSTAR)
	    ▪ $49.99 customer price – 0.3% adoption rate (National Grid)
	• Identified source raising awareness:
	  o 58% - television news
	  o 16% - direct mail
	  o 12% - newspaper/web
	  o 10% - word of mouth
	  o 4% - no answer
	• Media coverage (TV, print) coincided with significant rise in sales

Source:

- *PowerCost Monitor Pilot*, David MacLellan, NSTAR, Presentation to BECC conference November 2008

SMUD – Positive Energy Pilot

Timing: Ongoing; Pilot study initiated in April 2008

Program Design/Research Methodology	Results/Findings

• First large-scale pilot of Positive Energy's Home Electricity Reports
• Pilot program launched in April 2008
• 35,000 customer treatment group; 25,000 receive report monthly, 10,000 receive quarterly
• 55,000 customer control group
• Treatment group receives reports that provide a comparison of the customer's energy consumption pattern to similar neighbors (e.g., 100 homes in their area of similar size); also provides comparison to customers' own historical consumption
• Report includes a limited number (3) of targeted tips that are customized based on the known demographic and housing factors
• Savings basis determined by comparing treatment and control groups (i.e., not a historical comparison); ensures confidence that populations are subject to same weather, economic conditions, and media messaging
• Proprietary algorithms for customer segmentation, messaging
• Founded on principles of behavioral science research including work of Dr. Robert Cialdini, the company's chief scientist
	• 2.5% energy savings achieved across total population (non-targeted)
	  o On pace to save 250 kWh per household, per year
	  o Could target program to achieve significantly higher savings, but would be applicable to fewer people
	• 3¢ per kWh savings cost average
	• Significantly higher savings achieved by:
	  o Higher energy consumers
	  o Greenergy (renewable energy) customers
	• Indication of correlation of higher savings for lower income population
	• 800 of 35,000 decided to opt out, demonstrating the broad reach of this type of program (as compared to opt-in programs such as customer purchase/installation of in-home feedback monitors)
	• <1% of 35,000 responded to set personal goal
	• Positive customer feedback
	  o Program manager reports increased customer engagement, requests for additional tips
	  o Taps into competitiveness (e.g., "I'm closing the gap between me and my neighbors")
	  o E.g., "this is the best thing SMUD has ever done"
	• Few very negative reactions from customers that take offense to the comparative feedback
	  o E.g., "you don't have the right to tell me"
	  o Protocols to respond immediately to address customer concern and mitigate dissatisfaction (e.g., explain program, address concerns, discontinue reporting to customer, etc.)
	• Large treatment sample will allow for hypothesis testing in subsequent years (e.g., impact of changing report format, persistence of energy savings, potential for additional incremental savings)
	• Pre-survey used to establish a baseline of customer attitudes toward SMUD, energy efficiency
	  o Will be used to measure difference in attitudes between pilot group and control group after the program
	• Survey planned for end of program (after 12 months)
	  o Importance of avoiding double-counting of savings associated with other utility energy efficiency programs
	• In addition to Positive Energy, SMUD also has an AMI project underway with plans to roll out 2-way meters over the next 4-5 years
	• SMUD is also piloting the use of the PowerCost Monitor for real-time direct feedback

Sources:

- Interview with Ali Crawford, Program Manager at SMUD, December 2008
- Interview with Alex Laskey, President, Positive Energy, November 2008

BC Hydro – Power Smart Behavior Change Program

Timing: Pilot study initiated in early 2007

Program Design/Research Methodology	Results/Findings
• Pilot conducted to test cash incentive program for customers achieving energy savings goal • 1-Year pilot launched early 2007 • Recruited employees of BC Hydro's largest customer • Participants commit to a given electricity reduction target • Use online tool to track/compare consumption • Participants received cash rebate for achieving target (e.g. 5% electricity rebate for achieving • 4 Different incentive rewards tested	• 52% of pilot program participants reduced their energy consumption; 20% achieved their savings goal • 10% energy savings goal found to strike best balance between providing an achievable stretch target while not incurring too many free riders • 19% of participants for the 10% reduction target reached their goal with an average kWh reduction of 1,847 kWh • 33% of participants for the 10% reduction target saved energy despite not reaching the goal; an average of 395 kWh was saved by this group • 48% of participants for the 10% reduction target did not save energy with an average increase in consumption of 1,025 kWh (9% increase) • 20% savings goal found to be intimidating to customers • 5% savings target had hid free-rider rate (i.e., people achieving the goal without making effort) • Cash rewards more motivating than prize drawings • Quarterly eNewsletter was effective in driving traffic to the online feedback and education tool • Cash rewards more appealing than prize draw rewards • eNewsletter drove online visits • More frequent visitors to online tool achieved higher electricity savings • Reported behavior changes included: o Turning off lights, changing laundry habits, shorter showers, unplugging chargers, turning down the thermostat • Based on pilot, BC Hydro launched an engagement program for 2009 that allows customers to commit to a 10% energy reduction in hopes of receiving a reward incentive o 17% of participants are expected to become 'Achievers' reaching the goal o 24% are expected to be 'Savers' that fall short of the goal but reduce energy consumption by around 4% on average o 59% of participants are expected to be 'Non-Achievers' that do not save electricity • Program target market is the "stumbling proponents" psychographic segment – customers with attitude toward efficiency and conservation, but who are not acting on their beliefs – believed to be around 20% of the customer population • Inclining block rates and smart meters also being pursued by BC Hydro

Sources:

- *BC Hydro's Approach to Behavior Change*, company publication
- *Power Smart Residential Behavioural Program Overview*, company presentation, December 2008
- Interview with BC Hydro program manager Arien Korteland, December 2008

Nevada Power – In-Home Energy Display (HED) Study

Timing: Pilot study conducted in 2008

Program Design/Research Methodology	Results/Findings
• Involved Nevada Power and Sierra Pacific Power Company customers • Seven basic and specialized devices deployed across residential households in the Reno and Las Vegas communities • ~200 customers targeted for trial • Sampled from energy use tiers based on kWh/month • No control group (i.e., "results not statistically projectable") • Goal to identify and validate role of HEDs among Sierra Pacific Resources' programs; prepare for AMI infrastructure • Did not provide additional messaging beyond manufacturer literature • Aim to identify incremental value of particular design over alternatives • Past year month-to-month bill comparisons • Recruiter and installer surveys • Periodic participant surveys to profile households, record reports of changed behavior • Concluding conjoint survey to assess feature/function impact	• Devices included o Kill-A-Watt (P3 International) o PowerCost Monitor (Blue Line Innovations) o The Energy Detective -TED (Energy, Inc.) o Whole House Energy Monitor (Energy Monitoring Technologies) o The Energy Joule (Consumer Powerline) o In-Home Display (AzTech) o Power Cost Display Monitor (ECSI)(multifamily) • Significant number of program drop-outs – "I'm not doing this anymore" – created issue of survivor bias • Savings found to be on the "lower end" of the manufacturers' stated expectations for the entire population and in the middle for the study survivors o 5.5% savings for entire population o 9% for those that survived through the entire market test and saved energy in at least four of the six months • Savings ranged from 0% to 48% among participants • Savings persisted for 85% of participants during 6-month study • Third energy tier (1251 to 2500 kWh per month) demonstrated the highest savings • Savings in comparing against the different types of devices were fairly consistent, a surprising study finding o Kill-A-Watt device, was reviewed positively for its appliance-specific feedback and achieved savings similar to the whole-house energy monitors • Encountered issues with installation of devices that require use of current transducers because of slim-line panel boxes in many new homes (e.g., couldn't put the cover back on) • Report due to Nevada Utility Commission to detail outcomes

Sources:

- Interview with Bill Jackson, Senior Consultant, Paragon Consulting, November 2008
- *Home Energy Displays: The Nevada Product Trials*, Craig Boice, Boice Dunham Group and Bill Jackson, Paragon Consulting, Southwest Energy Efficiency Project, Albuquerque, New Mexico, November 16, 2007

Baltimore Gas & Electric – Smart Energy Savers Program

Timing: Ongoing; Program portfolio filed in 2007

<table>
<tr><th>Program Design/Research Methodology</th><th>Results/Findings</th></tr>
<tr><td>Filed comprehensive BGE Smart Energy Savers Program in January 2007 spanning energy efficiency and demand response
Current efforts aimed at behavior change consist mainly of broad-based media campaign
Evaluating the use of email to target specific segments with customized messages (e.g., purchasing data on customer psychographics to target customers with a greater propensity to save)
Conducted Smart Energy Pricing pilot in summer of 2008
Tested different technologies and pricing levels across different segments; included use of control group
Subsequent Smart Energy pricing pilot planned for summer 2009</td><td>Smart Energy Pricing program under development ties with Peak Rewards air conditioning cycling program
“Carrot” approach found to be more affective than penalty (“stick”) approach
Includes feedback to customers on their energy savings (e.g., “you saved $20 this week”) via email or mailings separate from billing statements
Found that use of an energy “orb” to signal pricing changes to customers to allow voluntary action, in combination with automatic AC cycling switches resulted in increased savings for customers and reduced energy demand
Still evaluating technologies that provide actual data as opposed to the flashing colored lights of the energy orb
One driver of second pilot for dynamic pricing program is that initial studies showed smaller energy savings than expected; peak demand reductions were excellent, but overall energy savings were low
“Carrot” approach found to be more affective than penalty (“stick”) approach</td></tr>
</table>

Source:

- Interview with Ruth Kiselewich, Director, Demand Side Management, Baltimore Gas & Electric Company, December 2008

British Columbia, Newfoundland and Labrador – PowerCost Monitor Pilots

Timing: Pilot studies initiated in 2005

Program Design/Research Methodology	Results/Findings
• Pilot conducted beginning in the spring and summer of 2005 • Pilot participants and control customers followed over a 3.5 year period • Involved ~200 customers of Newfoundland Power and BC Hydro • Stratified sample spread across diversity of geography, weather regions, demographics, and appliance configurations • No price or conservation incentives were give to sample participants	• Real-time feedback of energy consumption found to be effective in promoting conservation • 18.1% overall aggregate reduction in electricity consumption (kWh) across the study sample for Newfoundland • 2.7% aggregate reduction for the British Columbia sample o Reductions in the winter months in British Columbia were much higher than the rest of the year – "as high as 9.3%" • Response was found to be persistent and was not found to decrease over the study period • Within the Newfoundland sample, the electric water heating households had higher savings than non-electric water heating households • Education level was a significant variable affecting responsiveness in British Columbia sample • Positive attitudes toward conservation were found to have correlation with the reduction in electricity consumption • Senior citizens were found to achieve lower savings

Source:

- *Real-Time Feedback and Residential Electricity Consumption: British Columbia and Newfoundland and Labrador Pilots*, Dean C. Mountain, PhD, Mountain Economic Consulting and Associates Inc., June 2007

Energy Trust of Oregon – Home Energy Monitor Pilot

Timing: Pilot study initiated in 2008

Program Design/Research Methodology	Results/Findings

• Use of PowerCost Monitor from BlueLine Innovations
• Two types of programs: direct-install at home energy review (HER) at no cost (N=200) vs. self-install early adopters (EA) purchase for $29.99 (N=170)
• Home Energy Review sample stratified by region (Northern, Southern, Eastern), age of home (1959 & earlier, 1960-1989, 1990 & later) and primary heat source (gas or electric)
• Early Adopter segmented by region (N, S, E)
	Survey #1 - one week post-installation:
	• 64% of HER group report they look at the display unit 3 or more times per day; 32% indicate 1-2 times per day
	• Willingness to pay is low::
	  o HER group: 65% would pay $0-$40, 29% would pay $41-$80
	  o Early adopter group: 60% would pay $0-$40, 37% would pay $41-$80
	• Actions identified as leading to lower energy consumption for 71% of HER group, 58% of early adopter group. % of respondents citing:
	  o Indoor lighting – 71% (HER) / 56% (EA)
	  o Outdoor lighting – 25% / 19%
	  o Television – 23% / 20%
	  o Electric cooking range – 18% / n.p.
	  o Oven – 22% / n.p.
	  o Computer – 31% / 37%
	  o Computer monitor – 33% / 39%
	  o Electric space heating – 26% / 19%
	  o Electric water heating – 19% / n.p.
	  o Electric clothes drying – 40% / 47%
	  (*n.p. indicates "not provided"*)
	• 20% of early adopter households had trouble with installation; 18% had trouble programming the monitor
	Survey #2 – 6 months after install
	• Survey response rate: 45% (HER) / 63% (EA)
	• 64% (HER) / 66% (EA) still using the monitor
	• 27% (HER) / 20% (EA) report monitor no longer functional
	• 8% (HER) / 14% (EA) report functional monitor, but no longer using
	• 65% (HER) / 73% (EA) believe monitor has changed use of energy
	• 78% (HER) / 90% (EA) indicate satisfaction with the monitor
	• Identified useful features:
	  o Instantaneous consumption
	  o Instantaneous costs
	  o Temperature and clock display
	• Identified participant suggestions for improvement
	  o Simplification of programming
	  o Home computer interface (trending)
	  o Sensitivity – doesn't read usage below .3kW
	  o Signal strength
	  o Batter life
	  o Ability to pinpoint specific end uses
	Calculation of actual energy savings not yet completed

Source:

- Energy Trust of Oregon, presentation at BECC Conference, Nov. 2008

Connexus Energy – Residential Behavior Change Programs

Timing: Ongoing; launched initiatives in 2008

<table>
<tr><th>Program Design/Research Methodology</th><th>Results/Findings</th></tr>
<tr><td>

Three separate pilot programs launched in 2008 to evaluate behavior change:
Smart metering pilot; ~1,000 homes
Use of in-home displays (Aztech display) for low income segment; 60-customer pilot
Positive Energy home energy reports (not yet underway); 40,000 customer pilot
Cost per kWh saved will be the benchmark for determining which programs to pursue on a larger scale
Conservation programs currently achieving a cost of around 10 to 19 cents per kilowatt hour saved
Customer focus group helped to reveal customer preferences

</td><td>

Due to ongoing nature of programs, achieved savings estimates are not currently available
Key message from preliminary customer focus group: “keep it simple”
Preliminary findings:

In-home display pilot in low income population:

No specific targets for energy savings
Current results have been below expectations
Aztech display chosen over PowerCost Monitor because it was an “under-glass” solution on the meter that metering technicians preferred to the external reader used with the PowerCost Monitor
Provide Kill-A-Watt meter in addition to Aztech device
Program funded out of state mandated spending requirement
Finding problems with customer acceptance; elderly customers prioritized for the program report confusion and issues with utilizing device technology
Cost to put a display unit in a customer’s home found to be ~$250
Anticipates program may be a niche program for the “techie” demographic

Positive Energy:

Targeting 3% to 5% savings at a cost of about 4 to 5 cents per kWh
Includes 40,000 customer control group

Smart Meters:

Customer focus groups show that customers would expect greater savings in order to be attracted to a critical-peak pricing program
Emphasis shifting to more of an energy education home display unit (i.e., achieving savings through feedback)
Still working on rate structure details

</td></tr>
</table>

Source:

- Interview with Bruce Sayler, Program Manager, Connexus Energy, December 2008

Florida Solar Energy Center – Residential Energy Feedback Device Pilot

Timing: Pilot conducted from June 2006 to May 2007

Program Design/Research Methodology	Results/Findings

• 2-year pilot
• 22 homes in Florida participated
• No cost to study participants for use of ($140) device
• Average energy use data from 2 million homes in the territory used as a control to adjust for differences in historical periods when making comparisons on the treatment group's observed energy use
• The Energy Detective device selected over PowerCost Monitor
  o Resolution of 10W vs. 100W for PowerCost Monitor
• One-page survey sent to homeowners at the end of the study
	• Study author admits selection bias of sample – "not a statistical sample (the participants were self-selected"
	• 7% average reduction in energy use among participants vs. weather-normalized historical consumption
	  o 18,396 kWh/year average pre-installation consumption among participants (range from 6,000 to 41,000 kWh per year)
	  o 3.7 kWh per day average normalized savings; equates to ~1350 kWh in annual savings
	• Among the 17 homes in the final analysis group, normalized savings ranged from an increase of 9.5% to a decrease of 27.9%
	• Home with the largest consumption generally experienced larger savings
	• Identified behavior modifications among large savers:
	  o Changes to household lighting
	  o Reduction of pool-pump hours
	  o Replacement of older AC unit (one home)
	• Significant variation in amount of attention paid to the device among households
	• Households reporting greater interest and actions achieved higher savings
	• Since interest and motivation were found to be large factors in determining savings, author suggests that consumers worried about high bills or otherwise interested in lowering their energy use could be the best candidates for using the technology
	• Study author notes that the execution of a protocol to help users develop an inventory of individual loads by switching off circuits and appliances could be a powerful means to reduce energy use

Sources:

- *Pilot Evaluation of Energy Savings from Residential Energy Demand Feedback Devices*, Parker, D., Hoak, D., Cummings, J., Florida Solar Energy Center, January 2008
- Interview with Danny Parker, Principal Research Scientist, Florida Solar Energy Center, November 2008

Appendix 3 - Summary Table of Feedback Devices/Service Providers

Product/Service	Vendor	Features/Installation
PowerCost Monitor 	Blue Line Innovations Inc. 1st Floor, ICON Building 187 Kenmount Rd. St. John's, Newfoundland and Labrador Canada A1B 3P9 Phone: 709.579.3502 http://www.bluelineinnovations.com	• $110-140 retail price • Optical sensor connection to read analog meter or pulse of automatic meter • real-time display of moment-to-moment and total electricity costs in dollars and cents and kilowatt hours; also displays peak energy cost within the last 24 hours • Resolution of 100W down to 0.3 kW • Wireless display refreshes once per minute • 30,000+ deployed to Hydro One (Ontario) • 3,000+ unit pilot at NSTAR (MA) • 200+ unit pilot at Energy Trust of Oregon • Pilot at SMUD (CA)
The Energy Detective (TED) 	Energy, Inc. 3297 Pacific Street, Charleston, SC 29418 Phone: 843.766.9800 http://www.theenergydetective.com Founded: 2002	• $140 retail price • Current transducer clips on to powerline at electrical panel (may require electrician) • Display unit plugs into any outlet to communicate with sensor via powerline • Instantaneous display of $, kW; cumulative display of day/month-to-date/monthly $ and kWh; displays peak demand $and kW • Programmable alarm can be set if cost/hour or kW/hour exceed limit, if $ or kWh per day or month-to-date or monthly projection exceed limit • Resolution of 10W; true power every second • TED Footprints software package; download data from device for storage and analysis • Florida Solar Energy Center 20-home pilot • Featured in Popular Mechanics, REDBOOK, AOL's Energy Saving Tips

Product/Service	Vendor	Features/Installation
Positive Energy Home Energy Reports 	Positive Energy Positive Energy 1911 Ft Myer Drive Suite 702 Arlington, VA 22209 Phone: (703) 778-4544 www.positiveenergyusa.com	• Industry's first behavioral science driven, customer-centric, data analysis and communications software platform – the Home Energy Reporting System • Utility clients securely transfer energy consumption data to Positive Energy's software system (programs usually target 50,000 - 100,000 homes in the initial year) • Demographic data elements are combined with this consumption data • Energy profiles are created for each household, using rigorous segmentation and analysis • Reports are generated detailing how each residential customer is doing relative to similar households ("neighbor benchmarking") with respect to energy consumption, and specific recommendations on how to continue to reduce consumption are packaged with this benchmarking to residential customers both in the mail, online, and through a CSR tool • Savings are measured using rigorous M & V • Achieving 2% energy savings for random population sample of 35,000 customers at SMUD at cost of around 3 cents per kWh
Kill-A-Watt 	Aztech Associates Inc. 213-215 Main St. Annapolis, Maryland USA 21401 Tel: +1 (613) 384-9400	• $40 retail price • Monitor placed between outlet and appliance to monitor appliance-specific energy use • Calculate electrical expenses by the day, week, month, even an entire year • Cumulative kWh monitor • Also displays volts, amps, watts, Hz, VA • 0.2% Accuracy

Product/Service	Vendor	Features/Installation
Cent-A-Meter  	Manufactured by : Clipsal Australia Pty Ltd http://cacms.clipsal.com/consumer/products/cent-a-meter U.S. Distribution Contact: Intrec Services LLC 191 University Blvd, #850 Denver CO 80206-4613 United States of America Tel: 858 674 2555	• $140 retail price • Licensed electrician installs the Clip-On Sensor by attaching it to the main active or phase cable at the switchboard • Wireless hand-held Receiver Unit can be taken from room to room or placed in a central location • Displays the instantaneous $, kWh, temperature, humidity, greenhouse gas emissions • Does not record cumulative kWh or electricity cost • 11,000+ installed in Australia and New Zealand • For sale in U.S.
Aztech In-Home Display  	AzTech ASSOCIATES INC. Aztech Associates Inc. 213-215 Main St. Annapolis, Maryland USA 21401 Tel: +1 (613) 384-9400	• Completely wireless connection to smart electrical meters. No retrofits required • Readings can be in kW/kWh or dollars, or both; instantaneous and continuous • Arched light pipe color for easy viewing of Time-Of-Use/Peak rate • 24 hour and 30 day histogram graphical output • Optional computer connectivity via USB • Optional intelligent thermostat control • Expandable to display water and gas readings

Product/Service	Vendor	Features/Installation
EML 2020-H 	Brultech Research Inc 79 Crestdale Ave St Catharines, ON, Canada L2T 3B4 Phone: 905-228-0755 http://www.brultech.com/	• $230 retail price • View the amount (KWh) and cost of energy used. • Display the average daily, weekly and monthly cost of energy. • Set and track a desired target electricity budget. • Determine the power required by individual appliances or loads by using a "tare power" method. There is no connection required to those loads. • Record, chart and print the energy usage. • Export records to other applications such as spreadsheets
MEA (Mobile Energy Assistant) 	San Vision Energy Technology Inc. 12170 Via Milano San Diego, CA 92128 Phone: (858) 405-6827 http://www.svetinc.com	• In-home display picks up wireless information from compatible smart meters • Records and displays energy consumption and cost data • Incorporates 2-way communication functionality for the administration of utility dynamic pricing programs • Uses zigbee wireless protocol to connect to home area network • Connects to Internet to communicate with MEA hosted servers and provide remote access to information (e.g., web, mobile phone) • Not currently available for purchase; “under pilot studies at several utilities and national laboratories”

Product/Service	Vendor	Features/Installation
EMS – 2020 	USCL Corporation 2433 Garfield Ave. Carmichael, CA 95608 Phone: 916-482-2000 http://www.usclcorp.com/	• Integrates with smart meter technology • Budget screen allows the user to configure parameters for the user to manage their utility budget (billing period, rate-type, rate, dynamic pricing options) • Can view daily budget cost, monthly budget cost, percent of daily/monthly, alarm limits • Monthly usage displays total accumulated kWh and cost; separated by tier/TOU period • Incorporates 2-way communication functionality for the administration of utility dynamic pricing programs • Mobile in-home display • Cost dependent on scale of installation
PowerPlayer 	Home Automation Europe Joan Muyskenweg 22 1096 CJ Amsterdam The Netherlands Phone: +31 (0)20-4621680 www.homeautomationeurope.com	• Color-rich touch screen energy monitor concept • Wireless RF connectivity to utility meter w/ transmitter • Designed to incorporate entertainment media functionality (e.g., digital photo display, audio/video file viewing) to increase user interaction • Can display instantaneous and accumulated electric, gas, and water consumption in units (kWh) and dollars • Accommodates dynamic pricing • Programmable to set budget/goal parameters and link entertainment functionality to energy consumption • Deployment anticipated in 2009 with prices targeted from $75 up

Appendix 4 - Comparison of Energy Use Meters

(Source: http://www.powermeterstore.com/c550/power_use_monitors.php)

	Power Cost Monitor	Cent-a-Meter	The Energy Detective	EML 2020-H
				
	In Stock Qualifies for Qwik-Ship		In Stock Qualifies for Qwik-Ship	In Stock Qualifies for Qwik-Ship
Price	$109.00	$141.62	$144.95	$229.00
Ratings	★★★☆☆	★★★★☆	★★★★☆	★★★☆☆
Popularity				
Comments				
Install	User install	Recommend electrician	Recommend electrician	Recommend electrician
	Power Cost Monitor	Cent-a-Meter	The Energy Detective	EML 2020-H
Measure				
Max Volts AC	no	120V / 240V	120V / 240V	120V / 240V
Temperature	yes	yes	no	no
Humidity	no	yes	no	
Running Cost	yes	yes	yes	yes
Average Monthly Cost	yes	No data	yes	yes
Cummulative Cost	yes	No data	yes	yes
Greenhouse Gas Emissions	no	yes	no	no
	Power Cost Monitor	Cent-a-Meter	The Energy Detective	EML 2020-H
Power & Energy				
kWh / Kilowatt hours	yes	no	yes (total, projected)	yes
Watts / Kilowatts	yes	yes	yes (instantaneous, max)	yes
	Power Cost Monitor	Cent-a-Meter	The Energy Detective	EML 2020-H
Feature				
Memory	none	none	12months	13000 records
Recording	no	yes	yes	yes
Screen	Remote LCD	Remote LCD	Remote LCD	LCD
Windows Software	no	no	Yes	Basic version included
Communication	n/a	n/a	USB	USB
Alarm	no	yes	yes	no
Warranty	1year	1year	1year	1year
Batteries Required	yes	yes	no	no
Adustable Energy Rate	yes	yes	yes (true energy bill emulation)	yes

Appendix 5 – References

Abrahamse, W., L. Steg., C. Vlek., & T. Rothengatter. 2005. A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, 25, 273-291. < http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6WJ8-4HJ482W-2&_user=10&_coverDate=09%2F30%2F2005&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=9a76a7543d5b4bf1d555c655b6920d64>

Allen, D., and K. Janda. 2006. The Effects of Household Characteristics and Energy Use Consciousness on the Effectiveness of Real-Time Energy Use Feedback: A Pilot Study. *2006 ACEEE Summer Study on Energy Efficiency in Buildings*, 7:1. Washington, D.C.: American Council for an Energy-Efficient Economy.

American Council for an Energy-Efficient Economy. 2007. In-Home Energy Use Displays. *Emerging Technology Report*, June. < http://www.aceee.org/emertech/2006_EnergyDisplays.pdf>

BC Hydro. 2008. BC Hydro's Approach to Behavior Change. November.

Benders, R., R. Kok, H. Moll, G. Wiersma, K. Noorman. 2006. New approaches for household energy conservation – In search of personal household energy budgets and energy reduction options. *Energy Policy*, 34, 3612-3622.

Bensch, Ingo. 2008. Energy Center of Wisconsin, Madison, WI. Telephone interview by author. 24 November.

Cialdini, Robert. 2007. Testimony to the Subcommittee on Research and Science Education, House Committee on Science and Technology. At a hearing on: *The Contribution of the Social Sciences to the Energy Challenge*. <http://democrats.science.house.gov/Media/File/Commdocs/hearings/2007/research/25sept/cialdini_testimony.pdf>

Crawford, Ali. 2008. Sacramento Metropolitan Utility District, Sacramento, CA. Telephone interview by author. 23 December.

Darby, Sarah. 2006. The effectiveness of feedback on energy consumption – A review of the literature on metering, billing, and direct displays. Environmental Change Institute, University of Oxford. < http://www.eci.ox.ac.uk/research/energy/electric-metering.php>

Darby, Sarah. 2008. Why, what, when, how, where, and who? – Developing UK policy on metering, billing, and energy display devices. *2008 ACEEE Summer Study on Energy Efficiency in Buildings*, 7, 70-81.

Elburg, Henk van. 2008. SenterNovem, Utrecht, The Netherlands. Telephone interview by author. 11 December.

Energy Trust of Oregon (2008). Home Energy Monitor Pilot, Presented at the Behavior, Energy & Climate Change Conference, Precourt Energy Efficiency Center, Stanford University, Sacramento, CA, 19 November 2008. < http://piee.stanford.edu/cgi-bin/docs/behavior/becc/2008/presentations/19-5E-01-Energy_Trust_of_Oregon_Home_Energy_Monitor_Pilot.pdf>

Faruqui, Ahmad and Sanem Sergici. 2008. Household response to dynamic pricing of electricity – A survey of seventeen pricing experiments. The Brattle Group, 13 November.

Faruqui, Ahmad. 2008. The Brattle Group, San Francisco, CA. Telephone interview by author. 4 December.

Fischer, Corinna. 2008. Feedback on household electricity consumption: a tool for saving energy?. *Energy Efficiency*, 1, 79-104 < http://www.springerlink.com/content/276m42024x61wh1h/>

Green, Andrew. 2008. Potential of In-Home Displays in the PG&E Service Territory, Pacific Gas and Electric Company Emerging Technologies Program, CWA #0711 CEE-T-4335, 28 January.

Harrigan, M. and J. Gregory. 1994. Do savings from energy education persist? Alliance to Save Energy, Washington DC

Jackson, Bill. 2008. Paragon Consulting, Portland, OR. Telephone interview by author. 19 November.

Kiselewich, Ruth. 2008. Baltimore Gas & Electric, Baltimore, MD. Telephone interview by author. 11 December.

Kavazovic, Ogi. 2009. Positive Energy, Arlington, VA. Email correspondence with author. 8 April.

Korteland, Arien. 2008. BC Hydro, Vancouver, BC. Telephone interview by author. 11 December.

Korteland, Arien. 2009. BC Hydro, Vancouver, BC. Telephone interview by author. 15 April.

Lady, Kelly. 2009. Austin Utilities, Austin, MN. Telephone interview by author. 14 January.

Laskey, Alex. 2008. Positive Energy, Arlington, VA. Telephone interview by author. 26 November.

MacLellan, David. 2008. NSTAR Power Cost Monitor Pilot. Presented at the Behavior, Energy & Climate Change Conference, Precourt Energy Efficiency Center, Stanford University, Sacramento, CA, 19 November 2008. < http://piee.stanford.edu/cgi-bin/docs/behavior/becc/2008/presentations/19-5E-03-NSTAR_Power_Cost_Monitor_Pilot.pdf>

Medvitz, Joanne. 2008. Pacific Gas & Electric, San Francisco, CA. Telephone interview by author. 19 December.

Mountain, Dean. 2006. The Impact of Real Time Energy Feedback on Residential Electricity Consumption: The Hydro One Pilot, McMaster University, Ontario.

Mountain, Dean. 2007. Real-time feedback and residential electricity consumption: British Columbia and Newfoundland and Labrador pilots. Mountain Economic Consulting and Associates Inc., Ontario

Papadimitriu, Katie. 2008. Comverge, Inc., Chicago, IL. Telephone interview by author. 29 December.

Parker, D., D. Hoak, J. Cummings. 2008. Pilot evaluation of energy savings from residential energy demand feedback devices. Submitted to the U.D. Department of Energy by the Florida Solar Energy Center

Parker, Danny. 2008. Florida Solar Energy Center, Cocoa, FL. Telephone interview by author. 24 November.

Peters, J. 2007. White paper: Lessons learned after 30 years of process evaluation. Prepared for Behavior, Energy & Climate Change Conference November 7-9, 2007.

Ueno T., Inada R., Saeki, O., Tsuji, K., (2005). Effectiveness of displaying energy consumption data in residential houses. Analysis on how the residents respond. Proceedings, European Council for an Energy-efficient Economy, paper 6.100.

Roth, K. and J. Brodick. 2008. Home energy displays. *ASHRAE Journal*, July 2008, 136-138

Sayler, Bruce. 2008. Connexus Energy, Ramsey, MN. Telephone interview by author. 19 December.

Schaefer, Cara. 2008. City Utilities, Springfield, MO. Telephone interview by author. 5 December.

Stein, L. 2004. Final report: California information display pilot technology assessment. Prepared for Southern California Edison by Primen, Inc.

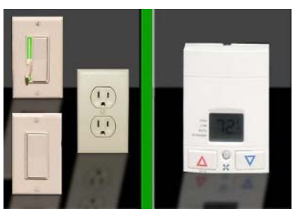
Stein, L., and N. Enbar. 2006. Direct Energy Feedback Technology Assessment for Southern California Edison Company. EPRI Solutions.

Van Denburgh, Elizabeth. 2008. Van Denburgh Consulting Group, Los Angeles, CA. Telephone interview by author. 1 December.

Wilhite H and R Ling (1995) Measured energy savings from a more informative energy bill. *Energy and buildings*, 22, 145-155.

Youngblood, Kendall. 2008. Energy Trust of Oregon, Portland, OR. Telephone interview by author. 25 November.

Appendix 6 – Additional Intervention Measures

Product/Service	Vendor	Features/Installation
Smart Strip Power Strips 	BITS Ltd. 2101 Starkey Rd. #Q-2 Roger's Business Park Largo, FL, 33771 http://bitsltd.net/ConsumerProducts/index.htm	• $30 - $45 retail price depending on model • Includes control outlet (e.g., for computer, television) that is used to determine if power is supplied to automatically switched outlets o Example: if computer goes into sleep mode, peripherals (e.g., printers, chargers, etc.) are switched off to avoid use in standby mode or phantom power loss • Constant hot outlets for devices that are meant to be left on (e.g., fax)
GreenSwitch Products 	GREENSWITCH® SWITCH TO ENERGY SAVINGS Green Earth Global 1636 Smithfield way Suite 1150 Oviedo, FL 32765 1-877-407-2244 http://minnesota.greenswitch.tv/	• GreenSwitch Master Switch sends a protected radio frequency signal to other GreenSwitch components throughout the home, shutting off power to selected lights, outlets, and signaling a programmable thermostat • Individual switches, outlets, and programmable thermostats are available for purchase/install that allow customizable design of what components are controlled by the master switch • $500 to $1000 estimated cost to outfit most homes • Payback calculator available on Web site