

Behavior: The Final Frontier

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ABSTRACT

Real time energy feedback is entering into a new era of widespread implementation that is set to explode in the near future. Increased awareness of how personal consumption and lifestyle choices impact the environment is giving behavioral energy savings programs an opportunity to thrive. Energy efficiency program administrators have the opportunity to adopt behavior change as a major energy saving resource, also increasing the effects and adoption of energy saving products and projects.

Energy Trust of Oregon is implementing a home energy feedback pilot program to study the effect that feedback devices have upon energy consumption. This program follows in the footsteps of several ongoing and completed pilot programs that have used the Power Cost Monitor made by Blue Line Innovations. This paper will describe the process of designing and implementing the Home Energy Feedback Pilot Program. Issues such as sample and survey design, implementation method, evaluation methodology, and marketing avenues are discussed. Early survey results indicate that education, installation, and delivery method important factors in the pilot program.

Introduction

Energy is uniquely tied to everyday modern human activity. In an amazingly short amount of time humans have discovered electricity, prospered upon it, and managed to create a problem of scarcity around it. Energy is unique in that it is itself invisible, but manifests itself in almost everything we consume, produce, and enjoy. If energy were more present in our minds as a factor whose use can be conserved for the same level of enjoyment and productivity in the household, we would be better off.

Social scientists started to seriously research how households use energy in the 1970's. Increased public awareness made a plethora of research funding available to study household energy consumption. A number of these studies focused on the effectiveness of energy consumption feed back, the ability to know how much energy you are consuming instantaneously or over a period of time. Several different types of feedback were studied including informative billing, self-metering, pay-as-you-go, ambient displays, and direct displays. Immediate direct feedback has been shown to have the highest savings between 5%-15%, and monitors showing instantaneous consumption are the most useful type of feedback (Darby 2006).

Residential energy feedback devices have received renewed attention in recent years. Concerns about the environment and climate change have raised awareness among people to take action to lower their environmental footprint. Others simply want to reduce their energy bills to offset increases in energy prices. One of the most recent and commonly cited studies on feedback devices is a pilot program implemented by Hydro One, an electricity provider in Ontario, Canada. Analysis shows that 500 homes which used the Blue Line Power Cost Monitor saved an average of 6.5% of their electric consumption (Mountain 2006). More studies

involving feedback devices are needed to verify or refute the findings of the Hydro One pilot program study. Regardless of future findings, behavioral energy savings are being taken seriously as reliable conservation resource.

Product Testing at Energy Trust of Oregon

Energy Trust of Oregon believes that behavioral energy savings are a potentially significant source of energy savings. Energy feedback devices may be an effective tool for households to lower their overall electricity consumption. Education can also be an effective tool to change energy using behavior. No study can isolate with certainty the effect of feedback, education, or even efficient appliances and insulation. However, a properly planned study and sample can reduce much of the uncertainty around behavioral energy savings.

Energy Trust of Oregon began to consider testing real time energy feedback devices soon after initial results of the Hydro One Power Cost Monitor Pilot Program indicated significant energy savings are possible. Many studies on energy feedback devices have been conducted, however, Energy Trust believes that the Hydro One study is the most comprehensive and reliable study to date. Energy Trust researched and considered several products to include in a testing phase including Blue Line's Power Cost Monitor, The Energy Detective, and Kill-A-Watt meter. Energy Trust decided that products which need to be connected to the main electric panel of the house and require an electrician to install are too cost prohibitive for a small scale pilot program that needs a couple hundred homes for reliable results. The cost of an electrician alone would drive up the cost of the pilot program to such a point that only a very small sample of homes would be possible. A study with reliable energy savings estimations requires a sample of several hundred homes. Energy Trust Planning and Evaluation decided that the Blue Line Power Cost Monitor was the only real time energy feedback device available in the market that could be easily self-installed, and was affordable enough to produce a large enough sample.

The Blue Line Power Cost Monitor is an instantaneous electricity feedback device. The Power Cost Monitor is a two piece unit, the first piece attaches to the home's electric meter and sends a wireless signal to a digital display unit. The second piece, the display unit shows electricity consumption in four different ways. The display unit has a digital readout of instantaneous consumption in kilowatts, and alternatively the accumulation of consumption in kilowatt-hours since the time of last reset. The Power Cost Monitor also calculates the instantaneous costs in dollars per hour, and accumulation of dollars since last reset. Costs are calculated by programming the household's electricity rates into the display unit. The Power Cost Monitor allows for tiered and time of use rates. The Power Cost Monitor displays in a graph format how current consumption compares with the highest recorded consumption in the last 24 hours. The Power Cost Monitor also displays the outdoor temperature and current time. The Power Cost Monitor is powered by four AA batteries, two in the sensor and display unit.

Initial product testing was undertaken by Future of Energy Group, a newly formed group of young energy professionals in Portland. Energy Trust ordered three Power Cost Monitor's for testing among the group. Word spread quickly among the Future of Energy Group and Energy Trust staff who wanted to participate in early product testing. Ten units were eventually ordered to distribute among staff, board members, and Future of Energy Group members.

Valuable information was obtained from short surveys of households that participated in the early testing phase of the Power Cost Monitor. A total of 23 households participated in the testing and completed the survey. Analysis of the survey indicated the following results. A

strong majority of households heat with natural gas (85%), while 15% heat with oil. A majority (70%) of households have 2 people, with 23% having 4 inhabitants, and one household having 1 inhabitant. Slightly less than half (45%) of the participants installed the Power Cost Monitor within one day, while 27% took less than 5 days, and 27% took more than 5 days. People seemed to have little difficulty setting up the sensor unit on the electric meter, but had more difficulty programming the display unit. Problems from the 30% of households who had difficulty installing the sensor unit included; the metal band used to attach to meter is too big, instructions didn't match what their meter looked like, and one household has solar PV and a net meter which is not compatible with the Power Cost Monitor.

Half of the early participants had difficulty setting up and using the display unit. Nearly all of the problems related to understanding their own utility rates and programming them into the unit. Participants were confused about their actual per kWh charge with all of the service fees, transmission & distribution fees, renewable energy extras, etc. Other problems related to deleting old information entered by the last household to use the monitor.

Early participant households described how they used the monitor, and gave suggestions on what could be improved. Most households state that it took them less than an hour to understand the display unit. Responses varied from understanding the unit in 15 minutes to more than a week, and one household never understood it. A majority (57%) of households placed the Power Cost Monitor display in the kitchen, with one to two households placing it in the dining room, coffee table, book shelf, and near the computer. A majority (61%) of households state that they found real time consumption (kW) the most valuable in understanding their electricity consumption, 39% valued real time costs (\$/hour), 33% valued kWh history, and 22% valued accumulated cost the most. Most people (62%) referred to the unit 1-2 times per day, with 31% stating they referred to the unit more than 3 times per day.

It is interesting to note that a strong majority of product testing households believe that they did not alter their energy consumption as a result of using the Power Cost Monitor. 64% believe that they did not alter their consumption, with 24% believing they used less, and 7% were not sure. Of the people who altered their consumption, a majority identified the "other" category of end uses as the source of energy savings. The most common end use indicated is the computer. One quarter of the respondents believe that they reduced their electricity use of indoor lighting, and another quarter indicated that stereo equipment was a significant source of energy savings.

The product testing phase provided valuable information that informed the Home Energy Monitor Pilot Program. Households suggested a number of improvements that could be made to the Power Cost Monitor and the installation process. Responses included better information to calculate utility costs, making programming easier, fewer buttons, more precise measurement, including carbon dioxide emissions in the display, back lighting, and a better display and analysis of consumption over time. Energy Trust used these early results to build the pilot program.

HEM Pilot Program

In late fall of 2007 Energy Trust of Oregon and Conservation Services Group decided to go forward with a small scale pilot program employing the Power Cost Monitor. To identify its program, Energy Trust chose to name it the Home Energy Monitor Pilot Program. Firstly, Energy Trust wants to produce a reliable savings estimate from the pilot program, and

secondarily, it wants to gain more knowledge about how people use the monitor and identify areas of difficulty. In general, the pilot program is meant to test the feasibility and success of a much larger program.

Reliable savings estimates require a large representative sample. The first task in building the pilot program was to develop a sample that takes into account geography, house age, and heating fuel which is presented in Table 1. Energy Trust built the sample to be representative of its electric service territory which includes Portland General Electric and Pacific Power. The sample is divided into three different geographical zones to account for the possible influence of weather and cultural differences throughout Oregon. House age is believed to be especially important in homes with electric space heat where significant savings are possible. Lastly, prior studies (Hydro One) suggest that savings may be lower in homes with electric space heat, the sample is divided into heating fuel splits to test this hypothesis.

Table 1: Home Energy Monitor Pilot Program Sampling Plan

Region	Vintage	Gas sample	Electric sample	Total
North	1990 and later	28	8	36
	1960 through 1989	28	18	46
	1959 and earlier	28	10	38
	Total	84	36	120
South	1990 and later	6	8	14
	1960 through 1989	5	11	16
	1959 and earlier	6	4	10
	Total	17	23	40
East	1990 and later	10	7	17
	1960 through 1989	6	7	13
	1959 and earlier	6	4	10
	Total	22	18	40

Savings estimates will be analyzed using a pre - post billing analysis. Participant electric and gas utility account numbers are captured when the participant signs up for the program. One year of post-installation consumption, in addition to one year of pre- installation consumption is required for an accurate billing analysis. A control group will be gathered of households who did not get a Home Energy Monitor to account for changes in baseline energy consumption. Results of the billing analysis will be presented in an evaluation report which is expected late in the Spring of 2009.

Participant feedback and demographic information is crucial to analyzing program results. The second task was to develop participant surveys to learn how households used the Power Cost Monitor, and to capture information which will be used in the savings impact evaluation. Participants will be surveyed twice, once at the beginning of their participation and again after six months. A non-participant survey will also be formulated to account for actions people take in the absence of having a Home Energy Monitor. The participants will be mailed the initial survey one week after installation, and also reminded by e-mail to fill out the survey online if an e-mail address was provided. As an incentive to complete the surveys, a \$100 visa gift card is drawn after each 100 completed surveys are returned.

Several different program delivery methods were considered for the pilot program. Energy Trust decided to test two different delivery methods, which are sufficiently different from each other. The first method discussed is the Home Energy Review Pilot Program, followed by the Early Adopter Pilot Program.

Home Energy Review - Home Energy Monitor Pilot Program

Energy Trust is concerned about the ability to obtain a representative sample, and control for difficulties in installing and programming the Power Cost Monitor. Since 2002 Conservation Services Group has managed the Energy Trust's residential sector energy efficiency programs, referred to as the Home Energy Solutions Program. The Home Energy Solutions program offers the Home Energy Review, an in home energy audit conducted by a Conservation Service Group trained contractor. The Home Energy Review Pilot Program will be managed by Conservation Services Group in which 200 monitors will be installed in eligible homes. The participant will get to keep the Power Cost Monitor. If the participant wants to return the monitor an address will be provided to return it to the Energy Trust. This Home Energy Review method ensures both the quality of the installation and the representative sample.

Single family home owners will be offered the opportunity to participate in the Home Energy Monitor pilot program free of charge when they call to schedule a Home Energy Review, and pass the screening questions. The household must be a ratepayer of Portland General Electric or Pacific Power, must pay their own electricity bill, have access to their utility meter, and must not have a solar electric panel. The pilot program was not marketed at all, but simply offered to customers as they called to schedule a home energy review. It was necessary to schedule participant homes on the initial phone call because the Home Energy Reviewer requires an extra 30 minutes to install the monitor and teach the home owner how to use it.

The Home Energy Review technician installs the Power Cost Monitor and teaches the home owner how to use and interpret it. The technician explains how to use the monitor, and gives the homeowner a limited amount of information on how to use it to save energy. The participant is given a brochure listing some tips on how to use the monitor to lower energy consumption. Tips listed include: turning off and on appliances to learn how much they consume, placing display unit in a frequently used room, compare high use to low use days, and looking at the monitor before leaving home to see if anything was left on.

A substantial number of initial surveys indicate how people are using the Powers Cost Monitor and indicate actions households plan to take to reduce energy consumption. 139 surveys have been received and analyzed. Participants are first asked what they have already done to save energy in their home. A majority (66%) of participants installed at least one compact florescent light bulb (CFL) outside of the free light bulbs installed during the Home Energy Review. 24% of participants installed more than five CFL's. Participants report taking behavioral actions since the Home Energy Review took place. Actions include turning off the heater when not needed, turning down the thermostat, fixing air leaks, turning lights off when not in use, using of cold water for laundry, taking shorter showers, and making their kids more aware of saving energy. Actions participants plan to take in six months are more capital intensive actions including installing insulation, windows, efficient appliances, and taking advantage of passive solar techniques. One participant indicated that they are going to buy more solar and crank operated devices to lower their energy use.

It appears that participants are finding it easier than the product testing group to learn how to use the display unit, as 57% indicate that they are familiar with the display in a couple of minutes, and 29% indicate it took less than an hour. This is not surprising given the fact that the Home Energy Reviewer teaches them how to use it. Early results indicate that participant households are looking at the unit more often than the product testing group, as 67% indicate they look at the unit 3 times a day or more, and 32% look at it 1-2 times per day.

Participants appear to value the instantaneous display functions over the historical accumulation functions. Households indicate that they find the instantaneous consumption (kW) function most useful of which 38% indicated so, with 22% stating that the instantaneous cost display in \$/hour is most useful to them. Many households indicated that two functions are useful to them with most indicating instantaneous KW and cost, and slightly less indicating both the instantaneous cost and cost history as useful. Participants find value in other useful functions of the monitor including the temperature display with 83% indicating they find it useful, 51% find the clock useful, and 24% find the 24 hour consumption graph useful.

Placement of the device is thought to play an important role in affecting the household's behavior. Participants are placing the display unit in the kitchen most of the time, with 50% indicating so. The second most popular room to place the device is the living room with 32% indicating they placed the device there. The remaining places are evenly spread out among the dining room, book shelf, coffee table, office, and bedroom.

Home Energy Monitor Pilot Program households believe that they are altering their consumption as a result of having the Power Cost Monitor. A majority (68%) indicate that they have changed their energy consumption. It is interesting to note that when asked which particular end use they saved energy on, the only category with a majority of respondents indicating a "slight decrease in usage" is indoor lighting. Every other end use category had a majority of respondents indicating that they "did not change usage." End use categories which had greater than 20% of respondents indicating a decrease in usage include computers (32%), clothes dryers (30%), television's (21%), and electric space heating (20%).

Finally, Energy Trust wants to know how much people are willing to pay for the Power Cost Monitor, and overall satisfaction. Most (65%) state that their willingness to pay is between \$0 - \$40, and 28% state they would pay \$41-\$80. A strong majority (81%) rate their overall satisfaction with the Power Cost Monitor a 4 or 5 on a scale of 1-5. 85% would recommend the Power Cost Monitor to a friend. Additional comments about the Power Cost Monitor included a desire for high electricity use alerts, more graphs and in depth analysis of consumption over time, a desire for a gas monitor, and automatic resets that are tied to the billing cycle. One participant stated "I quickly figured out that my old water heater sucks electricity like there's no tomorrow."

Early Adopter - Home Energy Monitor Pilot Program

Early Adopters of new technologies are usually different from the average person. Can we say that about early adopters of the Power Cost Monitor? Energy Trust wants to know what differences may exist between two groups of participants. What types of households seek out and pay a reduced cost for the Power Cost Monitor rather than accept it for free during a Home Energy Review? In addition, the units in the Early Adopter Group are self installed, which will more accurately indicate the level of difficulty to install and program the Power Cost Monitor.

The Home Energy Review installed Power Cost Monitor ensures a clean sample and a correctly installed monitor, however it does not model reality. It would not be possible in a large scale program to install the monitor in each home. An actual program would resemble more of a retail program than an audit program. Participants would come to the program implementer to purchase the product, rather than the implementer offering it to households free of charge. The program models are fundamentally different.

The Early Adopter - Home Energy Monitor Pilot Program is smaller than the Home Energy Review Pilot Program. Slightly more than 100 Power Cost Monitor's will be sent to households that purchase a unit for a reduced price of \$29.99. The sample for the pilot is formulated solely on geography divided into three territories in Oregon, Northern (50), Southern(30), and Eastern(30). The promotion is marketed in a small scale manner via Energy Trust website, utility e-newsletters, targeted e-mails, and word of mouth. Energy Trust contracted with Blue Line Innovations to deliver the program. Blue Line handles the orders, shipping, and takes customer service calls to address difficulties with installation and programming. Interested homeowners fill out their information online, and if they meet the screening criteria, they are approved to participate in the program. Orders are processed online by Blue Line and customers receive their monitor's in the mail.

The Early Adopter Pilot had encountered learning experiences early on. Demand for the Power Cost Monitor was underestimated. The pilot was advertised on the Energy Trust website and orders were placed on day one. Portland General Electric advertised the promotion in their e-newsletter which goes out to a small percentage of their customers. The day that the e-newsletter was sent out, the Blue Line call center received over 250 calls and web orders for the Power Cost Monitor. Portland General Electric reported a large volume of calls about the offer as well. In a short time the allotted sample for the northern Oregon sample had filled up. Due to difficulties in the ordering process many customers were told they qualified, but the quota was actually filled. It is encouraging to see that a lot of excitement about the Power Cost Monitor, but a lesson in over marketing a small pilot was learned.

Surveys indicate that Early Adopters are successfully installing the Power Cost Monitor in most cases. Surveys have been received from 78 participants. The Early Adopter survey is slightly different in that home characteristics are being captured because they are not being captured in the Home Energy Review. In addition, questions are added regarding self-installation and programming of the monitor.

Participants are having little difficulty installing the sensor unit, but are have more trouble programming and understanding the display unit. Less than half (43%) of the participants installed the unit the same day they received it, while 38% waited 2-5 days, and 16% took more than 5 days to install the monitor. A strong majority (82%) of participants state that they had no difficulty installing the sensor unit. The people that did have difficulty eventually were able to successfully install the sensor. Difficulties with installation were mostly problems fitting the unit around the glass cover of the meter. Some of the glass covers on the electric meters were too big or too small. A majority (49%) installed the sensor in 6-15 minutes, slightly less (39%) took less than 5 minutes, and 10% took 16-25 minutes.

Most of the program participants (80%) did not have difficulty programming the display unit. A majority of the respondents who did have trouble indicated that they did not understand their utility rates from their bill well enough to program the unit. A smaller amount stated that both the written directions and accompanying DVD did not help them solve problems

programming the display unit. A majority took less than one hour to become familiar with the display, while for 28% it took only a few minutes.

The Early Adopters and the Home Energy Review participants are very similar in the placement of the display unit, and feelings about how they may have changed their consumption by end use. About half (51%) of the Early Adopters placed the Power Cost Monitor display unit in the kitchen, while 16% placed it in the living room. Other locations were evenly spread out between the family room, dining room, and office. Early Adopters are less likely to state that they reduced their overall energy consumption with 55% stating so, compared to 68% of the Home Energy Review participants. A small amount (18%) are not sure if they saved energy overall. Very similar responses were recorded regarding if and how households changed their energy consumption by end use. Indoor lighting was the only category to receive a near majority (49%) stating that they reduced energy in that end use.

Early Adopters are very similar to Home Energy Review participants in their preference of display functions. A near majority (47%) prefer the instantaneous consumption (kW) display, and 40% prefer the instantaneous cost (\$/hour) display function. A small amount (8%) indicated that they prefer the historical consumption (kWh). Most (79%) of the participants found value in the temperature display, while 52% found value in the 24 hour consumption graph, and 47% found value in the clock. Most (75%) look at the monitor 3 times a day or more, while 22% look at it 1-2 times per day.

The greatest number (27%) of Early Adopters were made aware of the offer through the Energy Trust website. Almost as many participants (22%) heard about the offer through their utility which in this case was either an e-mailed newsletter or direct e-mail offer. A significant number (14%) heard about the offer from a friend, or colleague at work. A majority (74%) of Early Adopters had not heard about an energy monitor before the Power Cost Monitor offer, while 26% had heard of the device before. This could be attributed to some media coverage about the monitors in a local Portland newspaper.

Satisfaction with the Power Cost Monitor is high among users. 82% of Early Adopters rated their satisfaction a 4 or 5 on a 1-5 scale. Slightly more than this (86%) would recommend the monitor to a friend. Only a small minority of participants (6%) would pay full price for the monitor. A majority (56%) are willing to pay a price of \$0-\$40, and slightly less (38%) are willing to pay \$41-\$80 for the Power Cost Monitor. Ten percent more of the early adopters are willing to pay \$41-\$80 for the monitor. This is to be expected since they already paid \$29.99 for it.

The Early Adopters provided many comments. Among the improvements that they suggested are a more precise lower consumption band (the Power Cost Monitor cannot measure consumption below 300 watts due to technical reasons). Many people commented that the delay between monitor readings is too long, people could not immediately see how much energy they were consuming from the monitor. Several participants believe that a device which is built into the electric meter and built into the house would be more effective and more accurate. Finally, several participants stated that having the ability to plug the monitor into an outlet would save the trouble of having to replace batteries.

Some insights are gained from early results of the two Home Energy Monitor Pilot Programs. Education is important to people's perception of energy savings, and may affect their overall ability to save energy. It is clear that people do not know their own utility rates, if people are made more aware of how much they are spending, it may affect overall electricity consumption. Early Adopter participants are less likely to say that they saved energy overall.

Participants who received the Home Energy Review are more likely to believe that they saved energy from using the monitor. Perhaps Home Energy Review participants feel like they are more educated about ways to save energy in their home. This suggests that education about how to save energy is important to behavioral energy savings programs.

Home Energy Review and Early Adopter households are different. Program delivery method is an important aspect of the Home Energy Monitor Pilot Program. Early Adopters who sought out the monitor, purchased it, and installed it tend to be more motivated about saving energy and are in general more excited about participating in the program. Twenty percent more Early Adopters stated they are willing to pay more for the Power Cost Monitor. This is not surprising given the fact that they did pay \$29.99 for the unit. Early adopters provided much more in depth and lengthy comments in the surveys. They feel strongly about improvements that can be made to the monitor, and voiced more frustration when installation and operation of the monitor did not go smoothly. We shall see if they save more energy.

References

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