Transforming Energy Behavior of Households: Evidence from Low-Income Energy Education Programs

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ABSTRACT

One way to reduce energy consumption in the residential sector is to increase the adoption of energy-saving behaviors. While there is clear evidence that households are willing and able to make behavioral changes, particularly in response to energy price increases, there is no general population program model for behavior change that has been shown to effectively motivate households to make long-run changes in energy behaviors.

Over the last twenty years, there has been considerable investment by low-income usage reduction programs in energy education procedures, tools, and technology. Some programs have been successful in reducing energy usage and/or increasing reports of energy-saving behaviors. Other programs have fallen short of their goals.

In this paper, we review program evaluation research from some of the most innovative approaches and consider which program models offer opportunities for future initiatives with both low-income households and for broader market initiatives. Our review of the literature finds that, for low-income households, direct interaction between an experienced educator and the client is a model that results in behavior change and energy savings. We also find that multi-contact approaches are effective. To date, programs that have made use of technology to disaggregate client energy use and identify the best energy saving opportunities have not been successful in motivating clients to change their energy-using behaviors.

The success of higher-cost in-home energy education program models may be useful to consider as Home Performance with ENERGY STAR programs are implemented and expanded throughout the country. At the same time, given the experience with low-income programs, program implementers would do well to subject technology-based program designs to considerable testing to ensure that the barriers experienced in low-income programs can be effectively overcome.

One problem this paper reveals is that most energy education programs have not been designed in such a way that the direct impacts of the energy education component can be measured. Rather, they are most often implemented in conjunction with other program services and with no attention to the independent measurement of program impacts. To get better information on the potential for energy education programs, program implementers will have to pay more attention to measurement issues.

Introduction

Energy using behaviors in households have a significant impact on the total amount of energy used in the residential sector. Households decide how warm to keep their home in the winter and how cool to keep it in the summer. They decide whether to leave lights and appliances on or to turn them off. They select the temperature of the water they use to wash their clothes and they decide which cycle to use on their dishwasher. Households either actively or passively make decisions about how to use their major household energy systems. They may practice setback (either manually or with an automatic thermostat) to change heating and cooling loads for their homes, reduce hot water temperatures to both increase safety and reduce standby losses, and/or upgrade the energy efficiency of appliances when they are replaced.

Educating and motivating households to consistently practice energy efficient behaviors could result in significant changes to energy usage for individual households and for the residential sector as a whole. However, we see three challenges faced by energy education programs. First, since most individuals already practice a certain number of energy efficient behaviors, an energy education/motivation program must find a way to identify opportunities that a household has not yet adopted. For example, installing a setback thermostat in a home where the household members consistently manually adjust temperatures when appropriate can actually increase consumption. Second, since the potential savings from any action are a function of an appliance's efficiency and use rate, behavioral changes have a different impact in each home. For example, getting a household to turn off computers saves far more energy for a computer manufactured in 1999 than for one manufactured in 2007. In such an environment, delivering meaningful and reliable information on energy savings potential represents a real challenge. Finally, it is difficult to get any household to focus on the routine energy behaviors that result in sustained energy savings.

In a number of states, utilities and state energy offices are undertaking initiatives that are intended to educate households about energy saving opportunities and motivate them to take action. Many of these initiatives are information focused; they seek to give households information on energy saving opportunities and deliver feedback on energy use. Evaluations of past programs of this type (e.g., 1980's energy audit programs) routinely found that such programs delivered few, if any, energy savings. But, with new technology and the potential for automation of behavioral decisions, there may be potential for these programs to succeed where others have not.

Low-income energy programs have devoted substantial resources to energy education. Many of these programs have been designed by individuals who are well-versed in the theory of adult education and motivation, and a number have incorporated sophisticated energy analysis tools that provide clients with detailed information on energy savings opportunities. As policymakers consider the options for general population programs, the lessons learned from two decades of low-income programs are relevant and useful. In this paper, we look at some of the most innovative low-income energy education program models to consider what the findings from these programs tell us about possible designs for general population programs.

Targeting Behavior Change Opportunities

It is clear the households can and will reduce energy consumption if properly informed and motivated. In response to the electricity crisis of 2000/2001, California initiated a number of energy efficiency programs, including a major public information campaign. "In 2001, California averaged a 10% cut in peak demand during the summer months … and overall electricity usage declined by 6.7% after adjusting for economic growth and weather." (ACEEE, 2003) Similarly, an analysis of the 2001 RECS found that the nationwide 25% increase in the price of natural gas was associated with a 16% reduction in gas usage compared to 1997 after controlling for weather. (APPRISE, 2005)

However, in the absence of such significant events, it is useful to consider what behavior changes are mostly likely to find acceptance in general population programs. A low-income needs assessment study conducted in 1996 with Niagara Mohawk LIHEAP recipient households, asked respondents to discuss which energy savings actions they would be willing to adopt. (Response Analysis 1996) The survey question listed possible energy saving actions, identified the potential benefit (saving $75), and identified a perceived drawback from adopting the behavior. (For example, the survey identified the action of installing a low-flow showerhead and warned that a household might find that the water pressure would be different from what they have now.)

Table 1 presents some of the key findings. Many low-income households already practice energy saving behaviors. Low-income households are willing to take additional actions to save money, despite the fact that the action might reduce their level of comfort. There is considerable variation in the rate at which actions are currently taken and in the willingness of households to take additional actions.

Table 1. Self-Reports on Energy Saving Actions

Action	Already Take Action	Willing to Take Action	Total
Setback thermostat at night	51%	14%	65%
Turn down water heater	35%	29%	64%
Use low-flow showerhead	39%	32%	71%
Use compact fluorescent	22%	53%`	75%
Cold water wash	38%	11%	49%
Plastic on windows	57%	18%	75%

(Response Analysis, 1996)

From a program design perspective, these findings have important implications. First, for any population targeted by a program, it would be valuable to know what actions are already commonly taken by that group of households. Second, when presenting options to households, it would be important to give them realistic estimates of the energy saving potential for each measure. Third, it would be important to understand which energy saving actions are not appealing to households because of preconceptions about their impact on the household. Conducting research with customers prior to designing and implementing behavior change programs is likely to help designers to select better behavior change targets and design messages that are more effective in motivating change.

Multi-Session In-Home Education Programs

In the early 1990s, two multi-session in-home energy education programs were implemented; one by Niagara Mohawk Power Corporation (NMPC) and one by the Ohio Weatherization Assistance Program (WAP). In both cases, the energy education was delivered separately from the traditional weatherization services. In the case of the NMPC program, there was an experimental design that enhanced the quality of program impact measurement.

The 1990 NMPC Power Partnerships Pilot experimental design had a control group, a weatherization-only group, a weatherization & education group, and a group that received weatherization, education, and a gas heating feedback device.[1] The education groups received three two-hour in-home education sessions, one prior to weatherization, a second one month after weatherization, and a third six months later.

The education sessions were comprehensive. The first session (February) gave the household "an explanation of the house as a system, space heating, effective use of the setback thermostat, and hot water heating management." The second session (April) was conducted when the household had received its first post-weatherization energy bill. The last session (September) was a "problem-solving" session related to both bill payment and energy usage.

Table 2 furnishes information on the gas impacts from the program. The Weatherization Only homes had good energy impacts; program spending was about $2,000 per home and the weatherization measures were estimated to save about 304 therms (16%). The two groups that included the three education visits achieved significantly higher energy savings, with about the same investment in weatherization measures. The additional cost of the three energy education visits was about $500.

Table 2. Power Partnerships - Gas Savings Impacts

Group	Number	Baseline Usage (Therms)	Savings (Therms)	Percentage Savings
Control	39	1,682	-37	-2%
Weatherization Only	47	1,729	304	16%
WX and Education	47	1,645	445	26%
WX, Education, & Feedback	47	1,957	547	26%

(Harrigan, 1992)

In reviewing the reports on the study, it is not clear what specific actions the education groups took to achieve the higher level of savings. Did they reduce the temperature of their homes? Were they able to identify problems that occurred after the weatherization crew left and resolve them? Or, did the return visit by a knowledgeable energy professional result in resolution of additional problems? It is not clear. However, it is clear that the incremental savings associated with the investment in energy education was cost-effective. The education visits increased the cost of the weatherization services by about 25% ($2,500 compared to $2,000) and increased the savings by at least 45% (445 therms compared to 304 therms).

Unfortunately, Niagara Mohawk was not able to implement a full-scale program with this energy education model. Since on-going program funding was provided by electric DSM dollars, the high level of gas savings was not helpful in getting the program to pass TRC tests. (Note: The electric savings for the Weatherization Only Group were about 4%, while the electric saving for the Weatherization & Education Groups were about 7%.)

The 1992 Ohio WAP project achieved similar results. In this model, most homes received an initial visit and a follow-up visit. The weatherization and education group had average savings of 21% (310 CCF per year), while the weatherization only groups had average savings of 15% (215 CCF per year). (Gregory 1992) The difference is savings is reported to be statistically significant. However, since this study did not use an experimental design and there

[1] While the Wx, Education, and Feedback group has higher baseline usage, the households were randomly assigned to the three groups.

was significant attrition in the sample, the results should not be considered to be as robust as those from the NMPC study.

In both programs, the in-home contact allowed the educator to gather information from the client about current energy knowledge, energy using behaviors, and comfort and convenience preferences. Using this information, the educator could tailor energy education in a way that addressed information gaps, identified an acceptable energy behavior plan, and furnished feedback on the expected outcomes.

While this program approach is expensive on a per client basis, the high level of savings (5%-10% of baseline usage) makes it appropriate for certain circumstances. For example, it might represent an excellent supplement to a Home Performance with Energy Star (HPwES) program. Some homeowners who participate in the HPwES program will have significant savings opportunities related to energy behavior changes; the direct focus on energy education might allow the HPwES program to capture additional savings potential. In addition, for those homeowners who do not have the financial resources to purchase the HPwES services, the energy education services might represent an affordable alternative way to capture some of the savings potential that might be lost to the program.

Technology Assisted Programs

Over the last decade, a number of organizations have attempted to use technology to address the educational and motivational issues related to changing energy behaviors. In this approach, an energy auditor/educator collects detailed information about home, its energy using equipment, and the household's energy using behaviors. By combining this information with the household's energy bills, the auditor/educator is able to use the audit tool identify the potential energy savings from both the installation of energy saving measures (e.g., insulation, energy-efficient showerheads, and CFLs) and energy saving behaviors (e.g., thermostat setback, turning off appliances, and using cold water wash). The audit tool furnishes the households with tailored energy education information (e.g., a graph of the top ten energy users in the home), and supplies the auditor/educator with a list of energy saving opportunities that can be discussed with the client. Finally, once the client agrees to adopt one or more energy saving behaviors, the auditor/education can furnish the client with an agreement that is expected to reinforce that decision once the auditor/educator leaves the home.

In 2002, the Ohio Department of Development (ODOD), Office of Energy Efficiency implemented the ratepayer-funded Electric Partnership Program (EPP) using such technology. At that time oversight of the Electric Percent of Income Payment Plan (PIPP) program shifted from the electric utilities to ODOD. As part of that transition, the electric utilities began sending electric usage data to ODOD for all PIPP customers. Using that rich database, ODOD was able to identify PIPP customers with high baseload usage (greater than 8,000 kWh per year). ODOD assigned high usage customers to local service delivery agencies. The agencies were expected to recruit these households and deliver EPP services.

As part of EPP service delivery, agency personnel collect detailed electric energy usage information in the home. The protocol involves metering of the refrigerator, getting an inventory of the electric appliances and their usage rates, and getting an inventory of lighting in the home. These data were entered into the SMOC-ERS software. The software then compares aggregate usage from energy bills to the detailed energy usage profile to assess the major energy users in the home. The software identifies cost-effective baseload measures, as well as the most effective energy saving actions. Service delivery staff are expected to work with the household to develop an energy-saving action plan to reduce electric energy usage. This approach was expected to be particularly effective because it would be specifically tailored to the opportunities for the household based on a comprehensive understanding of their energy usage and opportunities for energy usage reduction.

There were important barriers to the effective implementation of the program. As part of the program implementation, the SMOC-ERS software was adapted to be installed on "heavy duty" devices that could withstand rough treatment in the field. As a result, the SMOC-ERS software did not perform as it had been originally designed, thereby making it difficult for service delivery staff to make use of the technology and energy education training that they had received. Additionally, service delivery staff were overly focused on matching total calculated energy usage to energy bills, to the detriment of the energy education. Direct observations of service delivery, as well as client interviews, found that most clients did not receive the full energy education protocol.

The impact evaluation for EPP demonstrated that the program had a significant impact on electric usage. However, because all homes were recorded in the database as receiving energy education services, there was no way to directly assess whether the energy education contributed to the level of electric savings realized by the program. To get some understanding of the impact of energy education, a follow-up client survey asked households to report the energy saving actions that they took as a result of program participation.

Surveys were conducted every six months during the first three years of the EPP program implementation. Table 3 shows the results from the five rounds of surveys. Throughout the evaluation period, the survey consistently found that about 20% of participating customers reported actions that could be expected to have high energy savings potential, about 50% reports actions that would have low energy savings potential, and about 30% reported that they were not taking any energy saving actions.[2]

Table 3. Ohio EPP- Client-Reported Energy Savings Actions

Type	Survey Round 1	Survey Round 2	Survey Round 3	Survey Round 4	Survey Round 5
High Savings Potential	19%	25%	14%	20%	22%
Low Savings Potential	55%	42%	48%	54%	45%
No Action	26%	34%	39%	27%	33%

(APPRISE, 2005)

Since the EPP model placed an emphasis on client behavior change, the results of the survey were troubling to the program sponsor. [Note: A similar survey for an NMPC Workshop Energy Education program evaluation found that 69% of the clients reported taking actions with high energy savings potential, while only 5% reported no action.] In addition, since efforts were made to improve the energy education program component after receipt of the first-year survey results, it was disappointing to see that subsequent rounds of the survey did not find significant improvements in client reported actions.

[2] In the survey, clients were asked what energy saving actions they were taking as a result of participation in the program. The "unaided" responses of clients were coded as having "high energy savings potential" or "low energy savings potential." If the client was unable to identify a specific action that they were taking to reduce energy usage, their response was coded as "no action."

The program evaluation found a number of challenges associated with effective use of the technology. To use the technology required extensive training of service delivery staff. The first version of the technology had errors; certain computations were incorrect and certain features didn't work. Perhaps most importantly, it was challenging for the auditor/educator to reconcile the energy use pattern predicted by the appliance inventory and reported energy using behaviors with the household's actual energy bills. All of these factors made it difficult for the auditor/educator to do an effective job of educating the client on how they were currently using energy and to give them good information on the best energy saving opportunities. In addition, since the auditor/educator also was responsible for assessing the household's eligibility for a new refrigerator, installing CFLs, and for installing other energy saving measures, it may have been too much to expect that the auditor/educator also would have had enough time in the home to do an effective job with energy education.

With the installation of "smart" metering systems, there is discussion of the potential for furnishing customers with a new level of information about their energy use. However, one might question whether customers would have the skills to make use of these technological systems. In the EPP program, experienced energy auditors who received extensive training on the SMOC-ERs software faced challenges in using the information to identify an energy behavior strategy for clients.

A recent pilot study installed energy feedback technology in homes. (Allen and Janda, 2006) The evaluation of that pilot found that, while some households found the feedback device interesting and informative, none had actually used the device to develop an effective strategy for reducing energy consumption. The Gridwise Demonstration Project in the Pacific Northwest was effective in reducing energy bills. (Lohr, 2008) However, it did so by giving customers the opportunity to input information on comfort/cost trade-offs and then allowing the technology to manage their energy systems in response to time-of-use price information supplied by the utility.

Comparison of Low-Cost Methods

In 2007, the Governor's Energy Office in Colorado implemented a mass distribution program using three different service delivery models – direct install, one-on-one workshop, and a direct mail approach. Each service model focused on delivery of low-cost energy efficiency measures and on encouraging participating households to adopt energy saving actions. The benefit of this approach was that it allows GEO to make comparisons among the different delivery models in terms of overall energy savings and cost-effectiveness. For the purposes of this paper, the experience furnishes information about the value of personal interaction between an individual and an energy educator.

The program measures included CFL's and low-flow showerheads. Clients also were given devices to measure hot water temperature and refrigerator temperature. For each approach, the goal was to get the CFLs and low-flow showerheads installed, and to educate the client how to manage the water heating temperature, the refrigerator temperature, and furnace temperatures and setback procedures. In the direct install model, Youth Corps staff went to the client's home and installed the measures. The Youth Corps staff were also tasked with explaining how to use the hot water and refrigerator measurement tools and discussing the furnace settings. In the workshop model, a counselor reviewed energy education materials with the client and then gave the client the measures. In the direct mail approach, LIHEAP recipient households were sent kits with education materials and the measures.

As part of the program evaluation, clients were surveyed to assess what measures they had installed and what actions they had taken as a result of the program intervention. Table 4 shows the rate at which participants in each group reported taking the targeted energy saving actions. More CFLs and showerheads were installed in the homes where those measures were directly installed by the Youth Corps staff. However, the survey showed that the Workshop participants had a much higher rate of self-reported energy saving actions than the other two groups. These results seem to suggest that, because of the emphasis on CFL and showerhead installation in the direct install model, there was less opportunity for the household to focus on the potential for energy saving behaviors. Additionally, while the direct install providers were instructed to educate only on the temperature turndowns, the workshop materials and some of the mass mailing materials included information on saving energy by turning off computers when not in use, unplugging unused refrigerators and other appliances, and using cold water for washing. In particular, the direct install customers were the least likely to report that they had used the thermometers to measure their hot water temperature or the temperature of their refrigerator.

Table 4. Measures and Actions by Delivery Method

	Delivery Method		
	Direct Install	**Workshop**	**Direct Mailing**
Number of CFLs In Use per Home	9	3	3
Percent of Homes With Showerheads In Use	55%	44%	31%
Changed Water Heating Temperature	18%	42%	26%
Changed Refrigerator Temperature	20%	43%	28%
Reduced Space Heating Temperature	9%	27%	13%
Turned Off Computers When Not In Use	7%	11%	9%
Cold Water Wash	9%	19%	10%
Any Energy Saving Action	26%	55%	25%

(APPRISE, 2007)

The program evaluation includes a usage impact analysis that is not yet complete. Based on engineering estimates, the direct install program is estimated to have the highest rate of savings, because it installed a large number of CFLs and showerheads. However, because of the lower cost of the other two methods and the higher level of adoption on energy saving actions, they are projected to be more cost-effective than the direct install method. The impact evaluation will furnish an excellent test of whether self-reported energy actions are reliable indicators of energy savings.

However, the results of the survey are clear. An in-office discussion with an energy education counselor resulted in a higher level of reported actions than an in-home visit from trained Youth Corps staff. With the available information, we cannot assess what it was about the interaction that was more effective. It could have been that the in-office counselors focused on the energy education component of the program while the Youth Corps staff were more focused on installation task. It may have been that the counselors were more credible in some way than the Youth Corps staff. In either case, the findings highlight the importance of working carefully to think carefully about the client/educator interface and assess the effectiveness of any model prior to implementation of any large-scale program.

Low-Cost Follow-Up Procedures

The NMPC and Ohio multi-session education models may be perceived as too expensive for large scale implementation. However, the concept of working with a client over a more extended period of time seems to have merit. Findings from the evaluation of the LIURP program implemented by PECO offer some evidence that lower-cost follow-up procedures also can be effective.

For many years, the PA PUC has required that all regulated Pennsylvania utilities furnish LIURP services to their low-income customers (Low Income Usage Reduction Program). PECO has operated one such program for many years. The energy education component of their current LIURP program includes several unique features. The basic model is similar to those implemented by many other utilities. An energy service professional conducts an audit of a qualifying home and conducts energy education as part of the audit. The energy education services include reviewing the customer's bill, discussing the determinants of energy usage, and asking the customer to commit to one or more energy saving actions.

However, in addition to those basic services, the PECO program includes two unique program elements. First, each program participant receives an energy newsletter every month for 12 months following service delivery. Second, the energy service delivery vendor reviews the bills of program participants and conducts follow-up with those program participants who increase usage during the 12 months following service delivery. The initial contact is by telephone. In some cases, a field visit is made to the home.

As with many other combination programs, it is difficult to measure the impact of energy education separate from the delivery energy saving measures. However, a recent evaluation found that a group of homes that were eligible only to receive CFLs achieved far greater kWh savings than would be projected from the CFL installation alone. The expected energy savings from the CFL installations was about 274 kWh. However, these homes saved an average of 953 kWh. (APPRISE, 2007)

The best test of the impact of energy education would be to implement an experimental design in which energy saving measures alone were delivered to some homes, while energy saving measures and energy education services were delivered to others. However, in the absence of such a design, the evaluator employed an alternative approach to assess the impact of energy education on electric usage reduction. A survey was conducted in which homes with low savings, moderate savings, and high savings were asked to describe their energy education experiences and to identify the energy saving actions that they implemented as a result of the program.

The univariate and multivariate analysis of the survey research findings furnishes some evidence that the energy savings impacts result, in part, from actions taken by the client to reduce energy usage. Table 5 shows that clients who reported that they took certain actions to save energy had higher savings than those who did not. The analysis also shows that clients who reported that they read more of the newsletters saved more energy, and clients who used their CFLs for longer periods of time saved more energy. Since only a few of the univariate comparisons and regression parameters are statistically significant, we are still left with uncertainty about what aspect of the program is responsible for the high level of energy savings. However, his analysis gives us a good working hypothesis to test in further research efforts.

Table 5. Electric Savings (kWh), By Reported Reduced Use of Appliances

	Reduced Use	Did not Reduce Use
Electric Space Heater**	1,150	611
Air Conditioner	947	723
Electric Dryer	995	792
Dishwasher	641	935
Dehumidifier	1,058	837
Number of Lights Left on All Night*	1,174	781
Lights	879	797

**Statistically significant at the 99 percent level. *Statistically sig at the 90% level.
(APPRISE, 2007)

Summary and Conclusions

In this paper, we examined the effectiveness of a number of different energy education models in the context of low income energy programs. They varied in terms of the delivery mode (in person vs. pamphlet), the delivery setting (in-home or in-office), the degree of personalization (specific to the household and housing unit vs. generalized list of energy saving measures), and the type of delivery personnel (professional educator, experienced weatherization staff, newly trained service delivery staff). While this comparison does not furnish conclusive evidence on the most effective energy education practices, a number of hypotheses can be developed for further testing.

This review demonstrates the untapped potential from the NMPC and Ohio in-home education programs. Those programs achieved a high level of gas energy savings by giving clients comprehensive information about their homes and their gas energy using systems. It is not clear whether it was the direct educator/client interface, the multi-session approach, or the interaction between the weatherization and the education that was most effective. However, though the program was expensive to implement, the level of incremental energy savings would be likely to be cost-effective with today's gas prices and the model might be particularly applicable in the context of HPwES programs.

The review also identifies the challenges associated with technology-based solutions. Even when the technology was implemented by trained staff, there were challenges in achieving the specific goal that the technology was designed to address. The technology was expected to furnish the client with personalized information on energy consumption and energy savings opportunities. However, the technology was not consistently able to deliver that information in a way that both educated clients and motivated them to take action.

We also find some evidence that lower cost solutions might be effective in bringing about some behavior change. In the Colorado program, the one-on-one counseling session led to a high rate of reported actions. In the PECO program, the combination of in-home education during an energy audit along with follow-up activities led to both a higher level of reported actions and a higher measured level of energy savings.

Based on the findings from these programs, it appears to us that the most promising approach to behavior change for low-income households involves direct interaction between a credible energy education professional and the client. In addition, multi-contact approaches appear to also be effective. To date, the technology-based approaches appear to be less successful. However, the concept of allowing the client to make decisions on energy use patterns and then have the technology implement the behavior as in the Gridwise program might be an effective model. It also is possible that the technology-based solutions may be more effective for population segments that have more familiarity and comfort with such systems.

Our review found that the measurement challenges for all program were significant, leading to ambiguous results. Our recommendations would be that both new and existing energy programs should be designed in such a way that the impact of individual components of the program can be adequately measured, and over the long run, the program can be implemented in the most cost-effective manner. Such an approach should generate information that is needed by program managers to design programs that are effective in bringing about significant changes in energy using behaviors.

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