The Persistence of Savings from a Comprehensive, Low-Income Energy-Efficiency Program

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ABSTRACT

This paper examines the persistence of energy saving from a comprehensive low-income program that began in 1996. The program expands upon earlier low-income program designs by evaluating all electricity usage in each dwelling, by focusing on baseload electricity usage, and by combining customer education with installations of a range of low-cost and high-cost measures. Billing analysis results suggest that net energy savings estimates from the first year after participation (1997) have persisted into 1998 without significant decline for customers who remained in the participating home. As more than 20% of participants moved within two years of participating in the program, future research will focus on exploring whether measure savings continue to exist in the participating dwelling after participants move and whether the educational aspects of the program provide continued energy savings to participants who move.

Introduction

New England Power Services Company (NEPSCo) introduced its Appliance Management Program (AMP) in 1996. The AMP program expands upon previous low-income program designs by evaluating all electricity usage in each dwelling rather than restricting the program to a limited set of energy efficient measures. It therefore has two primary differences relative to previous low-income programs: its focus on baseload electricity usage and its comprehensiveness in offering both customer education and a range of low-cost and high-cost measures. Local Community Action Program (CAP) organizations are responsible for marketing and delivering the program, which includes the following services:

- home energy audits
- installation of appropriate low-cost measures such as energy-efficient lighting, water heating measures, and air conditioning filters
- a comprehensive education component and customer action plan designed to change customers' energy-using behaviors
- replacement of major appliances such as refrigerators, freezers, and waterbed mattresses when their replacement is cost-effective

We conducted evaluations of the AMP program in 1997 and 1998 (RIA, 1997 and 1998) and found both high levels of customer satisfaction and energy savings during its first two years of operation. Statistical billing analyses suggested that, in the first year following installation of AMP measures, net savings exceeded 90% of engineering estimates.

This paper begins the process of examining the persistence of AMP program savings over time and seeks to answer the following questions: Did the energy savings previously documented for the

1996 AMP program persist beyond 1997 into 1998? How do savings vary over this period? Are there differences by year?

Description of the Appliance Management Program

AMP is one of the "new generation" of DSM programs – serving the low-income sector through a partnership with community agencies. The Program benefits thousands of low-income customers by reducing their electric bill by more than 10%, or over $100 per year. The objectives of the program are: 1) to reduce electricity usage of low-income customers, both for their direct benefit and for the indirect benefit of all ratepayers and the utility; 2) to offer a personalized service, by conducting in-home visits, which maximize and tailor the achievable energy saving opportunities for each household; and 3) to deliver these services as effectively as possible – overcoming barriers that may otherwise hinder participation and improving cost-effectiveness.

The key characteristics of AMP are that it serves customers at or below 175% of poverty who consume 13 or more kWh/day in "baseload" (non-heating) uses, and it combines education leading to recommended changed in customers' energy-consuming behavior with the installation of energy efficient technologies, including free replacement of inefficient freezers and refrigerators.

One of the hallmarks of this program is the carefully coordinated relationship between the utility, the community agencies' staff, and the customers. The close, interactive relationship allows for good communication and ongoing problem solving as the program grows and evolves. For example, activities such as marketing and outreach are joint efforts of the utility and the Community Action Program (CAP) Agencies. The program's services are delivered by energy managers employed by the CAPs. Energy managers schedule and conduct in-home visits and follow-up calls to interested customers, they also make use of educational booklets, offered in English and Spanish, that were developed by the utility. The utility also created in-home audit software intended specifically for this program.

During an in-home visit, the energy manager and customer "walk through" the home together, completing a detailed appliance assessment, entering their observations into the computer and monitoring the refrigerator's usage. The audit helps describe how use of these appliances adds up to the customer's monthly utility bill. In the process, the customer learns about opportunities for energy savings specifically suited to his/her household's needs and usage patterns. In partnership with the energy manager, most customers plan to take actions to reduce their consumption. The actions span a variety of end uses. For example, they range from turning off appliances not in use, such as the icemaker in the refrigerator, an empty second refrigerator, televisions or lights, to setting back water heater temperature, air-drying laundry, microwave cooking instead of slow cooking in an electric oven, or installing timers on air conditioners or pool heaters. On average, three or four actions are planned per customer.

In addition, most customers receive one or more energy conservation measures. The measures include a mix of small, potentially mobile items, such as compact fluorescent lamps, refrigerator brushes, showerheads, timers, water tank wraps, insulated waterbed mattress covers, and faucet aerators, to larger, less mobile measures such as replacement of waterbed mattresses with new standard mattresses or replacement of inefficient refrigerators or freezers. The list of measures is constantly evolving. For example, compact fluorescent fixtures and compact fluorescent torchieres are being added to 1999 program. There is considerable flexibility in the appliance replacement part of the program. For example, a customer may choose between several eligible models of a given appliance and may also choose to receive one larger refrigerator in place of two inefficient appliances. All of the refrigerators and freezers removed from customers' homes are delivered to a vendor who takes the appliance out of service and recycles the refrigerant and other scrap metals. More than 90% of the customers receive compact fluorescent lamps and roughly 40% receive a replacement refrigerator or freezer.

Evaluation Summary of the AMP Program

The AMP program has been in existence for more than three years. With each year, the participation has increased, and the program has expanded from a pilot in the first year to a program now offered in three New England states – Massachusetts, Rhode Island, and New Hampshire. Demographically, the diversity of the participants has increased somewhat. In the first year, a large proportion of the participants attracted to the program were seniors. Subsequently, the participants have been roughly evenly distributed in age, from 25 through over 66. The majority of the participants are homeowners who have relatively strong relationships with the CAPs. Roughly one third of the participants are in households of one or two people. People who do not participate in AMP tend to express lower satisfaction with the CAPs and their utility, are more likely to rent their home and to have already participated in utility programs. Many feel they have already taken all the conservation actions they can.

Process and impact evaluations of the 1996, 1997, and 1998 AMP program have been completed. The purpose of these evaluations has been to assess customers' satisfaction with the program and measures installed, to assess effectiveness of marketing and delivery mechanisms, and to estimate energy savings and short-term measure persistence. The evaluations were based on telephone surveys of participants and nonparticipants, and savings were estimated through a billing analysis using econometric models that incorporated telephone survey results.

In brief, the evaluations have consistently found that AMP has "high quality service delivery and high rates of measure installation and customer satisfaction." (RIA, 1998, p. 49)

Findings on Educational Attributes of the Program

In the process evaluations of the AMP program, customers who had planned to take specific actions were asked about the number of actions they implemented. In 1996, on average, 3.5 actions associated with distinct end uses were recommended per customer. Based on survey responses, about 2.5 actions per customer, almost 70%, had been implemented. In 1997, 3.3 actions were recommended and 2.3 were implemented. Furthermore, when asked how often the actions were implemented, 60% of the customers reported implementing the cooking actions everyday, and 44% of the customers reported implementing the laundry actions two to three times per week. This indicates that the actions are viewed as routine behavior.

Measures Received

In addition to recommended actions, participating customers were provided with measures. Table 1 summarizes the distribution of measures in 1996 and 1997. The samples of participants used in the evaluations exhibited very similar distributions of measures received.

In the evaluations, each participant who received a measure was asked if he/she had removed or replaced the measure since it had been installed. In most cases the answer was no. However, in some cases, most commonly with compact fluorescent lamps, measures were removed within the first year after participation. Table 2 summarizes the instances where measures have not persisted. The removal rates in the 1996 program are somewhat misleading. The report of the refrigerator removed is most likely a respondent who was confusing his response to this question with the fact that his old refrigerator had been removed. The faucet aerator that was removed was one of five installed overall, and it was removed so that the customer could hook up a dishwasher. Also, one of the respondents in 1996 reported that he/she removed the compact fluorescent bulb and took it along when he/she moved. Finally, we note that the removal rates for bulbs, faucet aerators, and showerheads are similar to those reported by Pigg, Dalhoff, and Gregory (1995) for a low-income program in Iowa.

Table 1. AMP Measures, 1996 and 1997

Measure	Percent of Measures Received by Participants in 1996 (n=241)	Percent of Measures Received by Participants in 1997 (n = 1,092)
New Refrigerator or Freezer	41.9%	40.8%
Waterbed Mattress / Insulation	2.9%	4.9%
Refrigerator Removed	2.1%	3.4%
Water Heater Wrap	1.7%	2.8%
Compact Fluorescent Lamp	84.2%	91.3%
Faucet Aerator	2.9%	26.4%
Low Flow Showerhead	0.8%	14.4%
Hot Water Pipe Insulation	5.4%	10.7%
Filter for HVAC	2.5%	10.4%
Refrigerator Coil Cleaning	88.8%	95.7%
Timer for Pool Pump or AC	1.2%	7.9%
Water Heater Temp. setback	1.7%	6.8%

Table 2. Measure Persistence as Reported by AMP Participants, 1996 and 1997

Measure	Percent of Measures Removed or Replaced in 1996 Program (n = 112)	Percent of Measures Removed or Replaced in 1997 Program (n = 401)
New Refrigerator or Freezer	2.0%	.06%
Waterbed Mattress/Insulation	0.0%	0.0%
Refrigerator Removed	0.0%	0.0%
Water Heater Wrap	0.0%	0.0%
Compact Fluorescent Lamp	12.0%	23.1%
Faucet Aerator	20.0%	13.8%
Low Flow Showerhead	0.0%	5.2%
Hot Water Pipe Insulation	0.0%	2.5%
Filter for HVAC	0.0%	0.0%
Refrigerator Coil Cleaning	0.0%	0.0%
Timer for Pool Pump or AC	0.0%	11.7%
Water Heater Temp. setback	0.0%	7.4%

Persistence Analysis Methodology

We used statistical billing analysis to explore whether participant measure removals accelerated in the second year after participation, and to gauge whether the educational components of the program were continuing to yield energy savings. The approach builds upon the approach used in previous AMP impact evaluations (RIA, 1997 and 1998), where customer bills were combined with program tracking information and data developed from participant and non-participant surveys in a multiple regression framework. In these evaluations energy usage over a two-year period (with up to 12 months of post-participation electricity bills) was specified as:

$$E = \alpha + \beta * C + \delta_1 * M_1 + \delta_2 * M_2 + \ldots + \delta_n * M_n + \varepsilon, \quad (1)$$

where

- E is average daily electricity usage
- α is the intercept term
- C is a set of household characteristics and other non-AMP factors affecting usage
- β is a vector of coefficients associated with characteristics set C
- M_1 through M_n are measures provided to participants through the AMP program, interacted with a post-installation dummy variable
- Coefficients $\delta_1, \delta_2, \ldots, \delta_n$, represent the *net* savings from each measure
- ε is the regression model error term

To ascertain savings persistence over a longer period, we added a second year of post-participation customer bills for the 1996 participant sample. The model estimates savings for AMP measures over the entire 1997-1998 post-period and also includes variables that measure any deviation in these savings for 1998:

$$E = \alpha + \beta * C + \delta_{11} * M_1 + \delta_{21} * M_2 + \ldots + \delta_{n1} * M_n + \\ + \delta_{12} * M_1 * D98 + \delta_{22} * M_2 * D98 + \ldots + \delta_{n2} * M_n * D98 + \varepsilon \quad (2)$$

Coefficient estimates from the second row of equation (2) reflect differences in measure savings between 1997 and 1998. The "null hypotheses" is that these parameters are zero, so, if the estimates are not significantly different from zero, the results would be consistent with savings persisting over the entire two-year post-period. If, for example, δ_{12} is positive and significant, then the results would suggest a decline in savings, which would be consistent with a lack of measure persistence.

Data Development

There were 241 participants in the 1996 AMP program. The database contained complete information on program participation for 232 participants. From these 232 cases, we conducted 112 telephone surveys in 1997. Two of these were incomplete, yielding 110 participants for this persistence analysis.

A representative sample of nonparticipants was derived from a 1998 survey of eligible low-income customers. Eligible customers met low-income threshold requirements and used at least 15 kWh/day. The original sample of 400 nonparticipants included customers from CAP agencies who offered the AMP program in 1996 and from CAP agencies who began offering AMP services in 1997. Since the nonparticipant sample was much larger than the nonparticipant sample, we reduced the nonparticipant sample to provide a more balanced set of participants and nonparticipants. This was accomplished by retaining nonparticipants from those CAP agencies that offered the program in 1996. A total of 101 customers remained after applying this screen. In addition to achieving a balanced number of participants and nonparticipants, this procedure ensured that both groups were from the same geographic area.

Both participants and nonparticipants were asked a series of demographic and attitudinal questions to aid in determining whether the two samples were comparable. These demographic variables included number of adults, total household size, age of head of household, dwelling type, and home ownership. With the exception of home ownership, where participants are more likely to own homes, there were no statistically significant differences across these categories. To summarize, the nonparticipant and participant groups were comparable in terms of geographic location, income, daily electricity consumption, and most demographic variables. Participants are more likely to own homes, and as mentioned previously, and have greater affinity to CAP agencies and their utility.

The next step in the data development process matched billing records from 1995 through 1998 for each dwelling to program tracking information and to the customer characteristics collected in the surveys. An important analysis issue among this population is how to deal with customer's moving to other residences. We considered two options: keeping these customers in the analysis via dummy variables, and eliminating them from the analysis. We ultimately decided to remove these customers to minimize any bias that might not be picked up through dummy variables.[1] The participant sample was reduced to 85 customers after eliminating households who moved between 1996 and 1998. Similarly, the nonparticipant sample was reduced to 74 customers after eliminating customers who moved or subsequently participated in the program.

Regression Model Specification

Stepwise regression procedures were used to identify statistically significant variables other than AMP measures influencing average daily consumption each month. In addition to customer demographic variables, the stepwise regression included monthly dummy variables to approximate weather influences on electric usage, previous CAP and utility energy-efficiency program participation, and average daily energy consumption in 1995. This last variable, which we refer to as "pre pre-period" consumption, captures differences in consumption across households that cannot be attributed to other factors, including AMP program participation.

This procedure provides a good indication of which variables explain variation in electricity consumption without over complicating the model with variables that do not influence consumption. For example, we applied monthly dummy variables to approximate the impacts of weather over the sample period, and the stepwise procedure indicated that these variables were statistically insignificant in the months of May, September and November.

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[1] We note, however, that the billing analysis results reported here do not vary substantively when these premises are kept in the analysis with dummy variables representing changes in premise demographics in periods when customers other than those surveyed occupied the dwelling. This suggests that any remaining bias is probably very small.

The stepwise regression indicated that the following variables should be included in the statistical billing analysis:

- KWHDAY95: average consumption per day in 1995
- HHSIZE: Number of people in the household
- AGE: An interval scale for the age of survey respondents
- OWN: A binary variable set equal to 1 if the household is owner-occupied, and zero otherwise
- SFHOME: A binary variable set equal to 1 if the home is a detached single-family home, and zero otherwise
- PREVCAP: The number of previous CAP programs the customer has participated in
- JAN, FEB, MAR, APR, JUN, JUL, AUG, OCT, and DEC: Binary variables reflecting monthly differences in energy consumption

Following RIA (1997 and 1998), we initially attempted to estimate savings for particular measures and groups of measures (e.g., "large" and "small" impacts), but ultimately the analyses revealed that there simply weren't enough participants remaining in the sample to estimate measure-specific savings and persistence impacts. We, therefore, applied a very standard billing analysis approach with two savings variables:

- POST: A binary variable set equal to 1 in the post-period if the household participated in the AMP program, and zero otherwise
- POST98: A binary variable set equal to 1 in 1998 for AMP participants, and zero otherwise

Regression Model Results

Table 3 shows the results from a regression model where we do not attempt to separate 1998 savings from the rest of the post period. Household electricity consumption rises with the level of pre pre-period consumption, household size, age, and customers dwelling in single-family homes. Consumption falls with home ownership, previous participation in CAP programs, and customers who participated in the AMP program. The POST coefficient of -2.28 per day translates into an annual savings equivalent of 832 kWh per year.

We then added POST98 to this specification, and, as shown in Table 4, while its coefficient is positive, it is not statistically significant. POST98 was zero in these models. The results, therefore, indicate that there is no difference in savings across the two years. Put differently, billing analysis suggests that the savings level from 1997 persisted into 1998.[2]

We recognize, however, the inherent uncertainty in these results. Although the hypothesis that there is no difference in AMP savings in 1997 and 1998 cannot be rejected, there may indeed be differences. If we take the coefficient estimates in Table 4 at face value and ignore their statistical significance, the results indicate a slight degradation in savings from 848 kWh/year (2.323 per day) in 1997 to 807 kWh (2.211 per day) in 1998, or less than a 5% decrease.

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[2] One reviewer suggested that serial correlation might be impacting these results, so we ran two alternative generalized least squares (GLS) regressions. The first GSL method showed that savings fell by more in 1998 than reported in Table 4, but the coefficient on POST98 was again insignificant. The second GLS method yielded opposing results, with higher savings in 1998 relative to 1997, and in this model POST98 was statistically significant. Along with the OLS results reported in Table 4, these GLS analyses do not unequivocally indicate differences in AMP savings in the second year after participation relative to year 1.

Table 3. AMP Billing Analysis without Persistence Variable

Variable	Coefficient Estimate	t-statistic
INTERCEP	1.565	1.642
KWHDAY95	0.705	45.463
HHSIZE	1.190	11.345
AGE	0.375	2.736
OWN	-1.345	-2.999
SFHOME	3.817	8.658
PREVCAP	-0.992	-2.433
JAN	6.914	11.154
FEB	6.262	9.728
MAR	5.354	8.641
APR	2.602	4.249
JUN	-1.572	-2.521
JUL	1.358	2.215
AUG	1.914	3.052
OCT	-1.447	-2.031
DEC	4.775	6.598
POST	-2.280	-6.694
R-square	0.404	
Number of observations	5000	

Table 4. AMP Billing Analysis with Persistence Variable

Variable	Coefficient Estimate	t-statistic
INTERCEP	1.571	1.647
KWHDAY95	0.705	45.459
HHSIZE	1.190	11.344
AGE	0.375	2.737
OWN	-1.345	-2.998
SFHOME	3.816	8.656
PREVCAP	-0.992	-2.434
JAN	6.902	11.083
FEB	6.252	9.681
MAR	5.342	8.586
APR	2.591	4.215
JUN	-1.584	-2.528
JUL	1.347	2.189
AUG	1.905	3.026
OCT	-1.440	-2.019
DEC	4.785	6.595
POST	-2.323	-5.734
POST98	0.112	0.196
R-square	0.404	
Number of observations	5000	

Conclusions

The statistical billing analysis results suggest that AMP savings have largely persisted nearly two years after installation. There is no statistical difference in participant savings over this period, and even if one ignores statistical significance, the difference in savings across the two years is less than 5%.

We reviewed other low-income and residential program persistence studies to determine if our results are similar to those reported elsewhere. Ecker, Degens, and Sullens (1991) use billing analysis to show that residential weatherization savings persist for several years and that there is little difference between year 1 and year 2. Bordner, Siegal, and Skumatz (1994) use survival analysis to measure savings persistence and report higher than anticipated survival rates for several water heating measures, and compact fluorescent lighting survival probabilities exceeding well over 90% in the first few years after installation. Given their results, we are not surprised by the persistence of savings in the AMP program after two years without a significant decline.

The educational component of the AMP program was designed to help low-income customers modify behavior in a way that makes energy conservation a habit. If this occurs, energy savings will be realized even after AMP measures begin to degrade.

Perhaps one of the most important findings from our research occurred during the data development process, where we discovered that 25 of 110 sample participants (22%) from 1996 moved within two years of participating in the AMP program. Larger samples and additional information is required to determine the persistence of savings from this mobile, low-income population. Customer characteristics for the new household are needed to discern from billing analysis whether savings are persisting in the original dwelling. And customer characteristics for previous occupants are required to estimate a traditional pre-post model to determine whether the educational aspects of the AMP program are continuing to provide savings as participants move to new homes. Alternatively, it might be feasible to estimate consumption differences between participants and nonparticipating low income customers in a "post-post" regression model.

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