Persistence Happens

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A rigorous statistical analysis of participant energy usage was conducted using carefully kept records of energy-efficient heating, ventilation, and air conditioning actions, and a follow-up participant survey to identify additional actions taken and changes to their business operations. The findings are quite definitive in showing that savings from these measures installed by commercial customers under a utility rebate program persist. The study further revealed that a substantial proportion of participants took additional measures, both in subsequent years' programs and on their own. The results indicate a number of ways that utilities can continue to use energy service programs to educate and influence customers' equipment purchase decisions, energy usage patterns, and perhaps even engender brand loyalty to the utility.

INTRODUCTION

Objectives of the Persistence Study

Many studies have now been conducted to measure the energy impacts of utility efficiency programs (Bordner, Siegal & Skumatz 1994; Cambridge Systematics 1994; Cawley & Bongiovanni 1994; Coates 1995; Harrigan & Gregory 1994; Hopkins, Weisbrod & Megdal 1994; Pacific Consulting 1993, 1995; Piette et al. 1994; Steckel & Hildebrandt 1994). Almost all of those evaluation studies have focused exclusively on first-year effects; that is, resulting energy savings in the first year after the action was taken. The vast majority confirm that savings do occur. But what happens after that? Relatively few studies have explored the persistence of these savings. Of these studies, most have investigated the physical retention of the energy-savings measures. But the persistence of energy savings is a broader question than that. Do the energy savings persist? How long do they last? Do they remain constant or drop off? What other actions might this participation spark in later years?

Focused Study, Far-Reaching Conclusions

This paper reports on a follow-up study to a first year commercial rebate program impact evaluation that aimed to answer precisely these questions. The study was successful far beyond this goal: not only was it clear that savings live on beyond the program year, but we learned of a systematic pattern of continued investment in efficient technologies among program participants in subsequent years' programs as well as outside programs. Through the study we were also able to assess what types of data are needed to gain insight into the factors and behaviors that result in sustained savings.

STUDY APPROACH

Focus

The focus of the analysis was HVAC equipment installations made by commercial customers under the Energy Management Services and Hardware Rebate Program during the 1990 program year. Since program installations were made throughout the year right up through December, the first year of impacts was either 1990 or 1991.

We had previously conducted a first-year impact evaluation after at least one year had elapsed for each 1990 program installation. In this study, we aimed to evaluate the savings one, two, and three years after the installations had been in place. In both studies, we examined the persistence of savings for the four HVAC measures most frequently installed under the program.

In this paper, we focus on the impacts of the packaged air-conditioning units measure. More than 80% of customers included in this study installed one of the program's popular measures, and 72% of the 523 participants installed packaged AC.

The largest number of these participants were customers in office buildings, as Table 2 shows.

Project Activities

The study had two main activities: a survey of participants who installed the HVAC measure, and an econometric analysis of these participants' energy savings in 1990/91, 1992, and 1993.

Table 1. *Popularity of Top HVAC Measures*

Measure Label	Measure Type	No. of Accounts (population)	No. of Respondents (study sample)
1108	Packaged A/C	380	139
1100	Misc. HVAC Measures	91	36
1110	Roof or Wall Insulation	52	9
1114	Energy Mgmt. Systems	29	7
	Unique Customer Accounts	523	170

Table 2. *Distribution of Participants Across Building Types*

Building Types	Proportion of Installers
Offices	26.8%
Restaurants	8.2
Retail Stores	15.3
Food Stores	3.4
Refrigerated Warehouses	0.4
Other Warehouses	4.2
Primary/Secondary Schools	7.5
Colleges and Universities	0.4
Hospitals	1.3
Other Medical	1.1
Hotels and Motels	15.7
Miscellaneous Services	11.9
Transportation & Communication Utilities	3.8

Telephone Survey. Participants were interviewed by telephone, using a survey that lasted less than 15 minutes. With the survey, we aimed to collect information on program and non-program related activities that affect energy consumption. We obtained completed surveys for 139 of 380 participants who installed packaged AC in 1990.

Survey Results. The survey results themselves gave us some insight into different factors that might influence savings levels achieved or sustained.

- Very few customers, only 8%, made notable changes to operating hours in three years since they installed the equipment.
- Very few customers, 6%, modified the size of their facilities over those three years.
- A significant number of respondents, 21%, could not estimate the number of occupants in this facility and how this changed over time.
- Respondents were able to clearly identify seasonal fluctuations in operating hours.
- Correlation between program records and respondents' estimates of facility size was about 80%; a notable number of the respondents, 28%, could not answer.
- All survey respondents indicated that they had kept the equipment and it was still working at the time of the survey, a minimum of four years after installation.

Savings Analysis. In the analysis of savings persistence, we performed a regression analysis using pre-installation and post-installation electricity consumption data. Having allowed several years to elapse before attempting to estimate the persistence of impacts, we were able to assemble at least three years of post-participation data along with at least one year of pre-participation data for the participating sites surveyed. In the analysis, we isolated the program measure impacts by year, accounting for other changes in the customers' facilities, weather variation across years, and differences in energy use across building types.

The model used to estimate savings that resulted from installation of the packaged AC units builds on a formulation commonly used to explain variation in electricity consumption. The estimated change in electricity use resulting from a program-related equipment change is of particular interest. By including a variable to reflect the installation of the efficient equipment under Edison's 1990 program (INSTAL) we estimated the change in electricity use as a result of the installation of the HVAC measure. The basic model can be written as follows:

$$E = \sum_{k=1}^{K} b_k X_k + C \cdot INSTAL + e \quad (1)$$

where

E = kWh use recorded on bill

X = explanatory variables other than program measure installations that vary across customers and/or over time

b = estimated level of electricity use per unit of each variable in X

INSTAL = number of packaged AC measure(s) installed (set to zero before any installations made)

C = estimated change in electricity use per measure installed

e = error associated with the model

For each period prior to installation of the measure, the counter INSTAL is zero for each customer. After an installation was made, INSTAL is at least one and it rises incrementally with additional installations in subsequent billing periods. l represents the energy change associated with the installation of each unit. This is a standard model formulation that is commonly used by program evaluators to estimate initial-year savings.

Since it is possible that initial impacts increase or decrease for program measures over time, we estimated the extent to which the energy impacts increase or decrease by using additional data on customer energy usage for several years after program measures were installed. We separated the estimates of energy savings in the first, second, and third years after program measure installation by including installation counters ($INSTAL_1$, $INSTAL_2$, $INSTAL_3$) for these years in place of the single INSTAL variable.

In reality, energy impacts from program measures are driven by both the number of installations and characteristics of their use. Within this utilization construct, we may include some combination of items such as weather to reflect the utilization of the measure. Such utilization-sensitive installation effects can be captured by including an INSTAL-interacted term in the model.

Finally, we developed an enhancement aimed to distinguish the effects of additional post-participation installations from the effects of changes from the 1990 program measure. The model we actually used to estimate savings persistence has the following form:

$$\begin{aligned} E = {} & \sum_{k=1}^{K} b_k X_k + C_1(INSTAL_1 \bullet WEATHER) \\ & + C_2(INSTAL_2 \bullet WEATHER) \qquad (2) \\ & + C_3(INSTAL_3 \bullet WEATHER) + \sum_{j=1}^{J} d_j Z_j + e \end{aligned}$$

where

Z_j = additional information, collected by survey, about customers' actions and equipment use that affect their electricity use after 1990

d_j = estimates the change in electricity use associated with the set of variables included in the set of J variables in Z

In this formulation, Z_j consists of a vector of several variables. These variables include, for example, customer-specific information about the seasonality of equipment use, operating hours of the equipment, additional efficient equipment installed under Edison's programs after 1990, and efficient equipment installed after 1990 outside Edison's programs. Some or all of the additional efficient installations may have been spurred directly or indirectly from satisfactory program participation. The impacts from these additional, non-program installations reflect one element of spillover: additional actions taken by program participants.

This model captures the energy-consumption effect of important activities by the customers outside the program. Accounting for additional activities allowed us to isolate the 1990 program-measure energy savings in subsequent years from the effects of other activities by the customer.

The advantages of this formulation are (1) more accurate savings estimates due to interactions and (2) clearly defined effects of the 1990 program measures in the subsequent years, since the effects of additional program measures are captured separately.

Econometric Analysis Findings. In the original study of first-year impacts, we did not have customer survey data available. With the survey data collected for this persistence study, we were able to test the usefulness of different pieces of information. Factors that affected the estimate of measure savings include:

- seasonality of each customer's operating hours
- identifying measures taken outside program
- knowing program participation in subsequent years
- weather deviations from normal

A number of other factors turned out to have little effect on the savings estimates when included in the model. The level of operating hours overall proved less effective than directly including information on the seasonal fluctuations. Changes in facility square footage had little effect, probably because there were so few changes reported. Most of the economic indicators we included proved uninformative, probably because we already included customer-specific factors from the survey which captured changes to their energy use better than the regional economic measures could.

Here are the results of the regression analysis used to estimate persistence one, two, and three years after measure installation. They are quite definitive in showing strong persistence of savings over the years. The one exception to this is for the measure installed by only seven customers. Having the largest representation in both the population and the sample, we continue our focus on the packaged air conditioning units measure (number 1108).

As discussed above, great effort was made to ensure that other activities, such as additional measures taken at later dates, were not responsible for the reported persistence results. As many of these factors as we could reasonably obtain data on from either the customer survey or Southern California Edison's program records were used in the analysis, making it perhaps the most complete of its kind to date for a commercial program.

The model results proved to be extremely robust across specifications and quite consistent across almost all the measure types. With only the one exception noted above, savings have clearly persisted over this post-installation period. This result is consistent with previous studies of persistence performed on this program for Southern California Edison (Cambridge Systematics, 1994).

Complete results and supporting documentation, including the customer survey instrument used to collect information for the study, are reported in the study report prepared for Southern California Edison (PCS, 1995a).

Table 3. *Persistence Regression Model Results*

Explanatory Variables	Estimated Parameters
SIZE	0.9*
$WEATHER_A$	15.9*
ENERGYSALE	0.2*
POSTHVAC	1,978.9*
POSTLITE	− 9,762.4*
POSTOTHER	− 40,315.3*
HIGHMNTH	2,764.5
LOWMNTH	− 8,500.7*
ADDITION	3,784.3
REPLACE	7,183.6*
$INSTAL_{1108,1} \bullet WEATHER_A$	− 20.2*
$INSTAL_{1108,2} \bullet WEATHER_A$	− 18.7*
$INSTAL_{1108,3} \bullet WEATHER_A$	− 24.2*
$INSTAL_{1100,1}$	− 3,758.6*
$INSTAL_{1100,2}$	− 3,767.9*
$INSTAL_{1100,3}$	− 4,591.3*
$INSTAL_{1110,1} . WEATHER_A \cdot SIZE$	− 0.001*
$INSTAL_{1110,2} . WEATHER_A \cdot SIZE$	− 0.0009*
$INSTAL_{1110,3} . WEATHER_A \cdot SIZE$	− 0.0012*
$INSTAL_{1114,1} \bullet WEATHER_A$	− 112.0*
$INSTAL_{1114,2} \bullet WEATHER_A$	− 78.0*
$INSTAL_{1114,3} \bullet WEATHER_A$	− 36.6
Adjusted R^2 =	0.77
No. observations =	9,402

The estimated model includes SIC Code intercepts. Those marked (*) are statistically different from zero at the 95% significance level.

RESULTS

Program Savings Persist

The analysis yielded monthly savings estimates of 2321 kWh, 2584 kWh, and 2976 kWh in the three years after installation, respectively. The results do two things. First, they confirm the first-year savings estimate that had been developed in the earlier evaluation of the packaged AC impacts, with spillover, nonprogram savings, and increases associated with additional equipment installation that had been embedded in the initial estimate now separated out. This

Table 4. *Description of Variables in the Model*

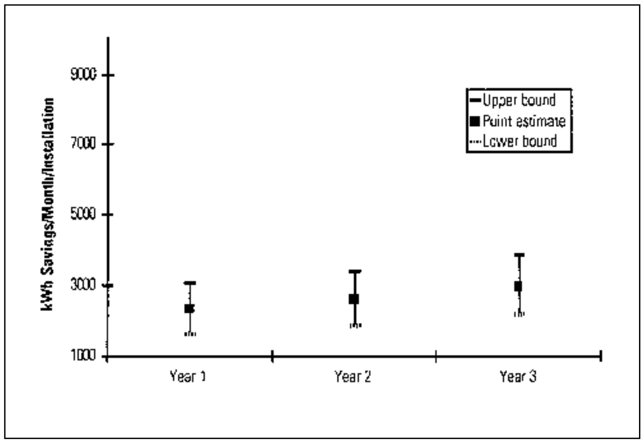
SIZE =	size of customer's facility in square feet
$WEATHER_A$ =	cooling-degree days experienced by the customer in each billing period
ENERGYSALE =	monthly electricity sales to Edison's commercial customers
POSTHVAC =	HVAC measures installed by the customer under Edison's programs after 1990
POSTLITE =	lighting measures installed by the customer under Edison's programs after 1990
POSTOTHER =	other measures (other than lighting and HVAC) installed by the customer under Edison's programs after 1990
HIGHMNTH =	customer-specific indicator of month with high facility use
LOWMNTH =	customer-specific indicator of month with low facility use
ADDITION =	counter to indicate additional equipment installed by the customer outside the programs
REPLACE =	counter to indicate equipment replaced by the customer outside the programs

$INSTAL_{1108,i}$, $INSTAL_{1100,i}$, $INSTAL_{1110,i}$ $INSTAL_{1114,i}$ = number of 1990 measures present in the ith year ($i = 1$ to 3 to represent 1991, 1992, and 1993)

was made possible by the inclusion of additional information collected from the telephone surveys. Second, the results show that the savings strongly persist beyond the first year. The second- and third-year savings estimates are within the band of uncertainty around the first year estimate, giving claim to the robustness of the persistence. At the same time, increases of 11% in year 2 and 15% in year 3 are large enough to ask for explanation.

The savings estimate increases, in combination with the survey results, suggest that customers have heightened awareness of their electricity use after program participation

Figure 1. *Range of Estimated Savings for Packaged Air Conditioners: 1108*



and act on that awareness by modifying behavior. This might entail setting thermostats more carefully, turning off equipment when not in use, and cleaning and maintaining measure-affected and other equipment better to increase its efficiency, to name a few behavioral adjustments that could result in additional savings over the years.

Customers Participate in Subsequent Programs

The customer survey results indicated that 32% of the customers who installed equipment under the 1990 program went on to participate again in a later year. This is quite consistent with findings from other years' programs as well (PCS, 1993, 1995b). Customers took a total of 328 actions within the program between 1991 and 1993. All of them took additional HVAC measures and most also took lighting measures. A high percentage of these customers indicated that their decision to participate in the program again was linked to their participation in 1990. This suggests that customers are quite satisfied with the program.

Customers Initiate Efficiency Actions on Their Own

Perhaps the strongest indication of the effect the program has had, at least on customers' awareness of measure options available to them, is that 36% of the participants went on to take additional actions outside of the program; they reported taking 896 actions. Over half of these customers made purchases of standard or efficient office equipment purchases, though 40% of the 896 installations were lighting related. According to the survey, as much as 24% of all these independently taken actions can be attributed to what these customers learned from participating in the program in 1990.

Information is Power

The modeling results showed that we can make direct use of post-participation survey data to help separate the energy impacts of a particular program installation from other actions taken in later programs or outside the program.

The results also suggest that customers make continued use of what they learn from program participation. It appears that the 1990 participants continued to make behavioral ''improvements'' that increased savings further. They also took additional measures both within and outside programs in subsequent years. For customers, information is power and they have indeed exercised it.

All measures except one with very few installers showed some increase in savings over the years. The survey responses indicate that these program participants made more and more energy efficiency improvements over time. Overall, customers said that they maintained (perhaps even increased) their use of program measures; the analysis clearly supports their report. What was unsaid, but is suggested by these results, is that these customers may have initiated some behavioral changes that contributed to the increase in savings. For example, they may have begun more diligent maintenance and cleaning of equipment or more careful monitoring of temperature settings. To determine this, Edison would have to field follow-up on-site visits. Information is power, but it's not always inexpensive.

IMPLICATIONS FOR UTILITY PLANNING

Well-designed programs and persistence studies produce a high return on investment.

Receive ''Credit'' for Energy Savings Persistence and Spillover

Almost without exception, utilities can claim shareholder incentives based on first-year savings only. Subsequent-year savings are either disregarded or assumed to vanish, at least in regulatory circles. The results of this study provide ample and robust evidence that a well-run and well-established energy efficiency program yields savings well beyond the first year. This is compelling evidence with which to petition for additional shareholder incentives. Repeated documentation of persistence and spillover such as this arms the utility with enough ammunition to successfully make the case for additional returns. Of course the demise of natural monopoly regulation is predicted but as long as the current regulatory environment prevails, utilities can quite legitimately claim these rewards.

Programs Can Keep Customers Happy without Sacrificing Revenue

Almost 40% of the participants went on to take additional actions. Even so, more than half the participants showed increases in overall electricity use, while decreasing use was associated with measure-affected equipment. This suggests that customers with the greatest growth potential or inclination toward greater electrification are reaping the benefits and maintaining their satisfaction with the utility as their electricity provider. Since these are the customers utilities in the competitive world will want to keep the happiest, this strategy of helping them save money will likely pay handsome returns.

Gain Insight into Programs and Services that Increase Customer Satisfaction

As part of a program evaluation, asking customers to rank aspects of the program they found most useful and value most highly provides the utility with useful information on attributes the utility should not only retain, but also consistently offer and publicize in order to foster customer loyalty to the company.

Get a Foot in the Door to Sell Additional Services

Utilities in the competitive world, like other businesses, will want to secure their futures with customers. It is not news to anyone, even utilities long under the wing (or yoke, depending on one's viewpoint) of regulation, that selling more goods to already satisfied customers is easier than wooing new customers. Utility credibility is built by bringing benefits to customers, in this case, as education and energy savings. Having gained the trust of today's customers by helping them reduce their energy costs and operate more efficiently, the utility can extend the set of products and services offered and strengthen its revenue stream.

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