Evaluating Educational Effects in Pacific Gas and Electric's Energy Savings Plan

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Residential customer education is a large part of many DSM programs. However, it is difficult to evaluate the impact of residential customer education as a part of the total impact of a DSM program. Customers' responses to education may consist of changes in customer behavior, changes in customer equipment stock, or spillover effects (increased likelihood of a customer participating in other DSM programs). Educational effects are particularly important for low-cost residential DSM programs, since even small educational effects in such programs can result in significant changes in total program impact.

This paper presents several means of evaluating educational effects in DSM programs, using as an example Pacific Gas & Electric's (PG&E) Energy Savings Plan (ESP) Program. In our evaluation of this program, we found that participants in the portion of the ESP Program that included on-site visits were more likely to replace their existing refrigerators and freezers than nonparticipants. The effect turned out to be one of the most significant measures in accounting for the program's total impact, representing approximately a quarter of total program electrical savings.

Introduction

One of the major benefits of DSM programs lies in the provision of information to customers about household energy efficiency. Some DSM programs are devoted entirely to the provision of this information. For example, several utilities provide regular seminars to architects to explain how offices can be designed in an energy-efficient fashion.

Even when provision of information is but a minor part of a DSM program, it can still be the key to the program's success. One class of DSM programs where the education is especially important are low-cost residential DSM programs. Typically these programs provide some combination of customer audits; installation of low-flow showerheads, high-efficiency light bulbs, water heater wraps, and blower door tests; and rebate coupons for other energy-efficient devices. These programs can be conducted by mail or can involve a home visit by a utility representative or contractor.

There is usually an explicit educational component to these programs. Educational efforts can range from the provision of a booklet detailing energy-savings measures, listing recommended energy-savings measures based on an audit of the customer's premises, or providing an estimated disaggregated end-use energy usage for a specific customer based on billing and audit information. Possible savings from these educational efforts can be significant, since the goal of low-cost residential programs is to achieve large program impacts by having many participants each contribute a small impact. Anything that can magnify the size of that per-participant impact will, in turn, have significant total program effects.

Description of the Energy Savings Plan Program

Since 1991, PG&E has offered the ESP Program to its residential customers. The ESP Program is a low-cost program aimed at single-family homes. This program is divided into two components: an on-site portion, where a PG&E representative visits homes to install energy-efficient devices and to provide information, and the direct mail portion, where the consumer receives rebate coupons and information through the mail, without an on-site visit. This paper focuses on the on-site component of the ESP Program. This program is designed to provide customers with the information necessary to understand where their energy budget is being spent and what they can do to

reduce these expenditures, while also providing some low-cost energy-savings measures.

To participate, a customer must fill out a questionnaire regarding the type of appliances they use, their energy-use patterns, and the type of home in which they live. This questionnaire is either mailed directly to a processing center or submitted by the PG&E representative who visited the customer. The information is fed into a computer model along with the customer billing history. A comprehensive set of color graphs is produced for each respondent depicting monthly energy use, broken out into various end uses. Energy-savings recommendations specific to the customer's energy usage are made by calculating both the energy-savings potential and dollar-savings potential. The customer is also informed of available utility incentives for replacing their appliances with more efficient ones or making improvements to their home. A discussion of the environmental benefits of energy efficiency is also included.

In addition, energy-savings devices are installed during on-site visits to illustrate energy-savings actions, and ensure savings during each visit. This on-site visit installation provides the customer with immediate energy savings, demonstrates how easy it is to implement the devices, and motivates the customer to take further low-cost actions.

Devices installed during on-site visits include:

- Two compact fluorescent lamps that demonstrate application and encourage ongoing compact fluorescent use and purchase.
- Energy-saver showerheads for each qualified shower to encourage energy savings and water conservation.
- A water heater blanket, where applicable, to reduce hot water heater standby storage thermal loss.

Thus far, customer response to this program has been very positive, based on post-participation surveys.

Potential Methods of Determining Impacts

Educational effects can be defined as energy-efficient actions taken by a utility customer for which the utility does not directly compensate the customer. These can be distinguished from "direct" DSM measures, where a customer receives a rebate or some energy-saving measure directly from the utility. Educational effects are similar to "free driver" effects because both apply to energy-efficient actions taken in response to DSM programs without compensation by the utility. The difference is that "free driver" effects apply to nonparticipants who take energy-efficient actions because they have been exposed to DSM program marketing materials, while educational effects apply to participants who are motivated by program materials to take energy-efficient actions.

Differing Kinds of Educational Effects

In our analysis of PG&E's ESP Program, we looked at two different kinds of educational effects. These are:

- Customer actions which change the household equipment stock (such as the purchase of a more efficient refrigerator or freezer or the installation of a more efficient furnace).
- Energy-efficient changes in customer behavior not related to equipment removal or replacement.

The key results of this study focus on changes in equipment. Findings on behavioral effects were more difficult to determine. The methods tested are discussed here.

Determining Impacts Caused by Household Equipment Changes

To determine impacts related to energy-efficient changes in household equipment stock, an initial finding needs to be made whether there is a difference in the rate of such changes between program participants and nonparticipants. If a difference is found, the number of "excess" participants who changed equipment stock has to be determined. The number of "excess" participants is defined as the difference between the percentage of participants to change household equipment stock and the equivalent percentage of nonparticipants, multiplied by the total number of participants in the program. The number of "excess" participants is multiplied by the estimated per-participant impact estimate for the given change in household equipment stock to yield the total impact from this source.

The total program impact from energy-efficient changes in household equipment stock is:

$$N(p_p - p_{np})I \quad (1)$$

where:

N = the total population of participants in the DSM program;

Pp = the percentage chance that a participant makes an energy-efficient change in household equipment stock;

P_{np} = the percentage chance that a nonparticipant makes an energy-efficient change in household equipment stock; and

I = the estimated per-customer impact of a change in the household equipment stock.

Determining Impacts Caused by Behavioral Factors Other Than Equipment Replacement

For determining behavioral effects that don't involve equipment replacement, there can be significant problems in isolating behavioral effects from other program effects. The difficulty is that participants receive both educational materials and direct measures simultaneously, so it is difficult to isolate educational and direct effects when comparing participants to nonparticipants. A variety of possible approaches could be used to isolate behavioral effects.

One possible approach, where specific education materials such as billing disaggregations are normally provided to customers as part of the program, is to not provide a sample of participants with the educational materials, but to provide them only with the direct measures. Analysis could then be done to see how the per-participant impacts differed when the educational materials were omitted. This approach is likely to lead to the most reliable estimates of behavioral effects, but requires development of a special participant sample for analysis.

A second possible approach is to compare a program with a given level of educational materials to similar programs that do not provide the same level of educational materials, to evaluate whether estimated per-measure impacts vary systematically with the level of educational materials provided. This approach would allow separate estimation of direct and educational effects. However, this approach is unlikely to be tractable because there are many differences between programs other than the level of educational materials provided, so it will be difficult to spot any systematic trends.

A third possible approach is to evaluate the realization rates from a SAE analysis, which indicate how statistical estimates of impact compare to engineering estimates of impact. If the statistical measures of impact seem consistently higher than the engineering estimates of impact, this would indicate that some factor was affecting the estimated statistical impacts. This SAE approach can probably only provide some preliminary indications of the presence of behavioral effects, because many other factors influence the relationship between engineering estimates and statistical estimates. This was the approach attempted in the analysis of the on-site portion of the ESP program. This approach did not provide conclusive results.

Analysis Techniques Used

This paper focuses on the analysis of the educational impacts of the on-site portion of the ESP program. Both customer actions affecting the household equipment stock and other behavior effects were examined in the analysis of the on-site portion of the program. Figure 1 shows the analysis plan for the on-site portion of the ESP program.

Estimating Impacts Caused by Household Equipment Changes

Educational effects on equipment replacement in the on-site portion of the ESP was estimated by conducting a telephone survey of a sample of participants and a sample of nonparticipants. Some of the questions on the survey asked customers whether they had replaced certain specified appliances after the inception of the ESP program. The information from this survey was combined with customer billing information which covered a time period before and after the administration of the program. A program database was used to provide information on direct measures installed under the program, and estimated end-use disaggregations were available for the participant sample. Multiple linear regression techniques were then used to explain variations in customer bills, and to determine per-participant impacts. The impact of replacing various kinds of appliances was determined using the regression techniques.

Educational effects on customer equipment replacement were estimated using Equation (1) above. Differential rates of replacement between participants and nonparticipants were determined through use of the telephone survey.

Estimating Impacts Caused by Behavioral Factors Other Than Equipment Replacement

As indicated in the discussion on methods, it is difficult to analyze behavioral effects that do not involve equipment replacement, because of the interaction between behavioral effects and program measures directly installed as part of the program. Behavioral effects were examined by comparing engineering and statistical impact estimates for direct measures for which engineering estimates were available.

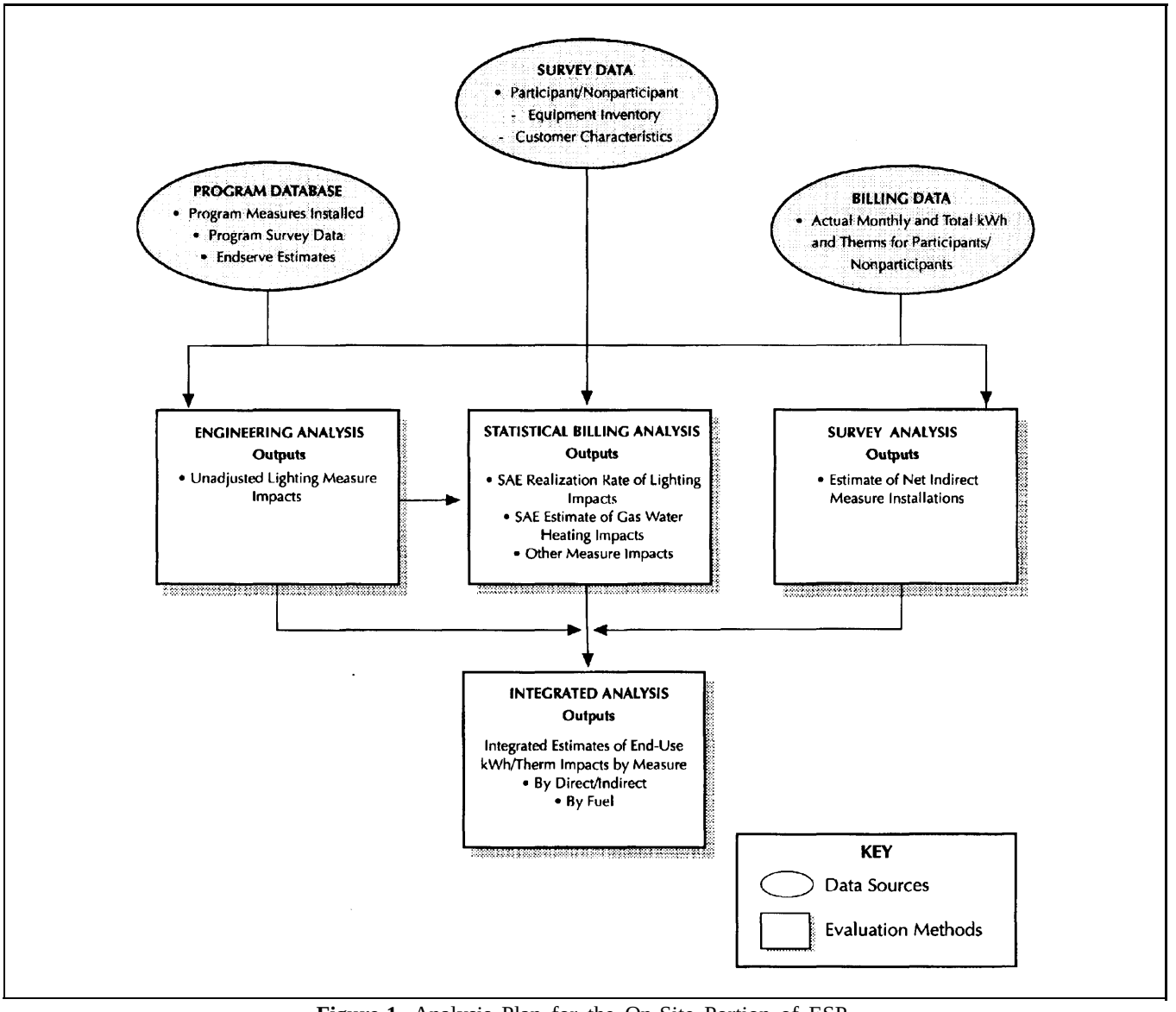

Figure 1. Analysis Plan for the On-Site Portion of ESP

Results

Per-participant impacts for various measures were estimated with a billing analysis using multiple linear regression techniques, which explained the differences in electrical usage before and after program participation using two kinds of variables: direct measures, which represent measures directly installed as part of the ESP program; and indirect measures, which are measures not directly installed by the ESP program, but may be influenced by participation in the ESP program.

Direct measures included:

- A per-participant engineering estimate of savings from light bulbs installed under the ESP Program.
- Low-flow showerhead installation.
- Water heater blanket installation.

Indirect measures included:

- Cleaning of refrigerator coils.
- Savings from light bulbs installed outside the ESP program.
- Refrigerator changeout.
- Freezer changeout.
- Dryer changeout.

Estimation was done during the period of November-March, to minimize the effect of air conditioning loads on the analysis.

Significant per-customer differences in electrical use were found for two indirect measures: the replacement of refrigerators and freezers.[1] For both of these appliances, participants replaced appliances at a higher rate than did nonparticipants. On-site ESP participants replaced refrigerators at a much higher rate than did nonparticipants (27 percent vs. 15 percent). Although the replacement rate for freezers was lower (4 percent vs. 2 percent), there were still more replacements among participants than nonparticipants. The billing analysis showed that customers who replaced a refrigerator used about 528 kWh per year less than those who did not (±168 kWh with a 90 percent confidence interval), and those customers who replaced a freezer used about 732 kWh per month less than those who did not (±396 kWh with a 90 percent confidence interval). Using Equation 1, the per-participant savings due to excess refrigerator replacement were (O. 27 -0. 15) * 528 kWh, for an expected savings of 63 kWh per participant. The equivalent per-participant savings for excess freezer replacement is (0.04 - 0.02) * 732 kWh, for an expected savings of 15 kWh. Dryer switchouts were also examined, but the per-customer impacts were not significant.

Overall, the contribution to total program savings by appliance replacement induced by the ESP Program was quite significant. Of the total estimated program energy savings, 26 percent was attributable to appliance replacement[2] (23 percent from refrigerator replacement and 3 percent from freezer replacement).

There was not a clear pattern in the results that could prove or disprove the existence of behavioral effects other than those reflected in equipment replacement. Three direct measures were examined: efficient light bulbs, low-flow showerheads, and water heater blankets.

In each of these cases, the statistically estimated per-participant impact was compared to a PG&E engineering estimate. In the case of efficient light bulbs, the statistical estimate was lower than the engineering estimate, but was not significantly different from the engineering estimate at a 90 percent confidence level. For low-flow showerheads, the statistical estimate was higher than the engineering estimate, and was significantly different from the engineering estimate. For water heater blankets, the statistical estimate was lower than the engineering estimate, but was not significantly different from the engineering estimate. Thus, no pattern was evident in the results.

Avenues for Future Research

An additional educational effect to be investigated in the future are the impacts caused if participation in one DSM program makes it more likely that a customer will participate in other DSM programs. If such a difference exists, it should be reflected in the impact analysis. One approach will be to credit the DSM program that induced participation in other DSM programs with some portion of the impact associated with other programs. The other DSM programs would have to be debited by the amount of the credit, to avoid double counting of impacts. However, this approach gives the incorrect conclusion that there is no net benefit to recruiting customers from one DSM program to other DSM programs, since the total impact remains the same.

A more useful approach to accounting for recruitment into additional DSM programs is to give a "marketing credit" for DSM programs that induce participation in other DSM programs. The marketing credit should reflect the cost of recruiting participants into DSM programs, and could be used to improve the cost-effectiveness of DSM programs that serve a recruiting function.

Such an analysis may be quite complex for utilities that have a broad portfolio of DSM programs with differing recruitment costs per customer, because the DSM participants in one program would have to be tracked into other specific DSM programs offered by the utility in order to calculate the marketing credit.

Another avenue for future research would be to use survey techniques that identify the motives of participants and nonparticipants in replacing refrigerators and freezers. This would allow more precise estimates of program impacts.

Conclusion

A major contributor to the total impact of the on-site portion of the ESP Program was the differing behavior patterns of program participants and nonparticipants in the energy-efficient replacement of refrigerators and freezers, contributing 26 percent of the total electrical savings.

Improvements in estimating the impact of changes in the customer equipment stock could be made by developing engineering estimates of the impact of the changes. Such engineering estimates would require gathering appliance model information (both pre- and post-replacement) from customers, as well as behavioral information about appliance usage.

Mixed evidence was found for impacts from educational effects not related to energy-efficient equipment replacement. This is because it is difficult to measure the impact of educational effects that do not directly result in a major impact, such as switching out an appliance. Examining this effect by looking for statistical estimates of savings higher than engineering estimates is unlikely to succeed, given all the other factors that influence statistical estimates.

The method most likely to provide reliable estimates of impacts caused by behavioral factors other than equipment replacement is to run a controlled experiment along the lines of the first suggested approach in an earlier subsection. This would involve creating a control group that would receive the direct measures but not the educational materials, so that impacts between the two groups could be compared.

Acknowledgments

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Endnotes

1. Not enough gas heaters or air conditioners were replaced in the participant or nonparticipant samples to allow analysis. Whether or not the customer had cleaned the refrigerator coils did not have significant per-participant impacts.

2. Estimated per-participant savings for the on-site portion of the ESP Program were 276 kWh per participant per year.

Reference

Caulfield, T. O., Ciraulo-Lim, J. C., O'Meara, K. P., and Uhlaner, R. T. 1994. *Pacific Gas & Electric Energy Savings Plan Evaluation.* Quantum Consulting Inc., Berkeley, California.