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Direct Assistance Program Audit Pilot

Prepared For:

Southern California Gas Company

Direct Assistance Program

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Executive Summary

In early 1996, Southern California Gas Company (SCG) committed to a study of audit based weatherization for their Direct Assistance Program (DAP). The goal of the project was to test an advanced methodology that targets customers based on billing data, screens for effective measures by phone, and installs the appropriate measures in an efficient and effective manner.

This project targeted the 5% of the low income population with the highest natural gas consumption. It determined the measures that were likely to be most effective in addressing the excessive consumption by these customers. The project was licensed a developmental version of a computerized screening tool which assigned measures to homes.

The project found that addressing duct leakage, uncovered evaporative coolers, and attic insulation could capture as much as 75% of the available savings on these homes. Customers were almost universally happy with the program and 23% of the customers reported that the program improved their satisfaction with Southern California Gas Company. Nearly all the other customers had no change in opinion toward The Gas Company because they were already quite satisfied.

These very high use low income customers are regularly under significant pressure with respect to gas bill payments. Over a third of them are sent overdue notices in January, February, and March. After the retrofit, the Participants received less overdue notices than the non-Participants. The Participants overdue rate averaged 85% of the non-Participants for January through May.

Considering the results of this pilot program and the experiences of low income weatherization programs, Proctor Engineering Group recommends that providers of these services:

1. expend the majority of their low income weatherization effort on the customers with the highest energy consumption,
2. target the programs at high use customers,
3. include effective[1] duct sealing as a significant portion of the program,
4. provide immediate feedback to field technicians to ensure their increased competence and confidence,
5. include hot water leak repair in the program,
6. investigate gas furnace upgrade (fan off temperature, heat rise, etc.) as a possible measure[2], and
7. investigate a streamlined one visit program design.

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[1] While it may seem unnecessary to point out that ineffective duct sealing is of no value, duct sealing is often integrated into programs in external appearance only.

[2] This measure was not included in this pilot partially because of the lack of experienced technicians in this area.

Introduction

In early 1996, Southern California Gas Company (SCG) committed to a study of audit based weatherization for their Direct Assistance Program (DAP). The goal of the project was to test an advanced methodology that targets customers based on billing data, screens for effective measures by phone, and installs the appropriate measures in an efficient and effective manner.

This study includes an evaluation of customer satisfaction, an energy usage analysis of measure and program effectiveness, and a review of the impact on customer payment behavior.

The challenge of providing customer service and energy savings to low income customers is complicated by the fact that not all customers live in similar buildings, or have equal opportunity for energy savings. This study was designed to assist SCG in determining what low income customers used excessive amounts of natural gas for base use and/or heating, what measures could be effective in reducing that excessive consumption, what methods could be effective in delivering those measures to SCG customers, and how those methods might be incorporated into the existing DAP.

One approach to providing cost effective service and energy savings is the Proctor Engineering Group system (PEG System) of customer targeting, screening, installation, and quality assurance. This study measures the effectiveness of this system as it was applied in the SCG pilot.

Three steps are involved in the application of the PEG System:

1. Customers are targeted based on their energy savings potential as determined through billing analysis.

2. Measures are screened and the appropriate measures are selected based on additional information about the customer and their residence. In this pilot, a phone screening process was tested in place of on-site screening. Telephone screening was believed to have potential as a more efficient allocation of resources by the installation contractor.

3. Appropriate measures are installed in an efficient and effective manner as a result of work flow design, training, and feedback to improve efficiency, competence, and confidence.

STUDY OBJECTIVES

Prior to implementing an audit guided weatherization program, SCG needed to know the causes of high usage in their low income population and if phone audits were capable of effectively qualifying customers and accurately selecting installation measures. The pilot was designed to answer these research questions:

- What percentage of the DAP customers could be effectively served by an advanced audit based program?
- What problems cause high gas consumption for low income customers?
- What measures are effective in addressing these problems?
- What are likely production costs and savings associated with these measures?

- What is the least cost method of applying these measures to the appropriate homes?
- How can measures applicable to an individual home be assessed from billing data, telephone interviews, and any other readily available information?
- How can this approach be used in a future program of Southern California Gas Co.?

OVERALL APPROACH

Concept meetings between SCG and PEG led to the study approach. SCG's needs and previous national research were discussed. It was determined that a quasi-experimental (treatment vs. comparison group) study would best address some of the research questions. The PEG System was used along with recruitment, audit, and income qualification by phone. Agreement signatures and proof of income were handled through the mail. Treatment and comparison groups were randomly selected from low income customers.

The study includes:

1. A population assessment that determined heating and base use of the SCG low income customers. The assessment established how the high use customers compared to the rest of the low income population and helped determine expenditures appropriate to achieve particular levels of energy savings.
2. A field evaluation and measure analysis of 25 randomly selected high use low income customers to determine potential measures and projected savings.
3. Implementation of a phone audit tool to screen appropriate measures.
4. Income qualification and agreement processing by phone and mail to reduce the effort necessary to accomplish this task.
5. Weatherization of targeted and screened homes using step by step diagnostics, form review, and feedback to the technicians.
6. Inspections to verify the work was satisfactory and the measure selection was appropriate.
7. A savings and customer satisfaction evaluation to determine the level of savings attributable to individual measures and customer satisfaction.
8. An assessment of pre-service and post-service payment patterns.

Step 1 - Population Assessment

The population assessment addresses the question, "What percentage of the Direct Assistance Program customers could be effectively served by an audit based program?" A random sample of 30,000 SCG customers (representing SCG's entire service territory) on the low income rate was analyzed for heating and base natural gas consumption. Results from the initial sample showed how the high use population is distributed. Figure 1 displays the annual gas energy consumption of the low income population served by Southern California Gas Company.

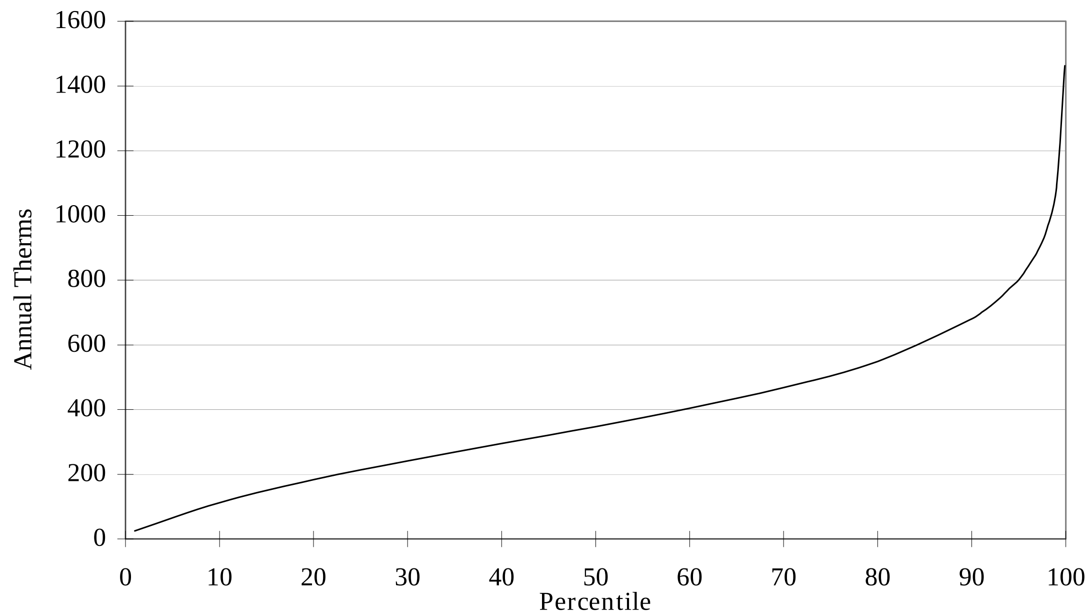

Figure 1. Gas Energy Consumption of Southern California Gas Company's Low Income Customers

Any number of programs can be built around this information. In discussion with SCG, it was determined that the pilot would focus on the top 5% (in heating and/or base consumption) of the DAP population.

The average annual gas consumption of Southern California Gas Company's Low Income Population is 382 therms (standard deviation 261 therms).

POPULATION ASSESSMENT RESULTS

Particular sections of the SCG service area have a high percentage of high use customers. This can be due to a poor state of repairs, a colder climate, or other factors such as occupant behavior. These locations are excellent targets for effective weatherization services. These locations are listed in decending order by RATE in Table 1. Appendix A details rates for the entire service area.

Table 1. Rate of high use customers by three digit zip code
(top usage quartile customers per 100 low income customers)

Zip Code	Local high use customers per 100	Zip Code	Local high use customers per 100	Zip Code	Local high use customers per 100	Zip Code	Local high use customers per 100
935	59	933	45	923	34	936	32
932	52	925	37	913	34	924	30
937	50	910	37	908	33	911	30

Other sections of the service area have a large number of low income residents and therefore also have a large number of high use customers. Zip codes beginning with 900 (LA area) are such regions. These locations are listed in declining order in Table 2. Appendix A details estimates for the entire service area.

Table 2. Number of high use customers by three digit zip code
(top usage quartile customers based on 1.3 million low income households)

Zip Code	High use customers (thousands)	Zip Code	High use customers (thousands)	Zip Code	High use customers (thousands)	Zip Code	High use customers (thousands)
900	225.2	925	101.1	**935**	72.5	922	43.7
917	125.5	913	83.2	923	61.5	906	37.6
932	116.6	902	73.8	926	50.1	907	33.3

The population assessment disaggregated gas consumption into heating and base use. Heating and base consumption are graphically displayed in Figures 2 and 3. Over 35% of the customers showed no heating use. The heating percentiles are based on the remaining 65% of the customers. Additional information about the percentiles is found in Appendix A.

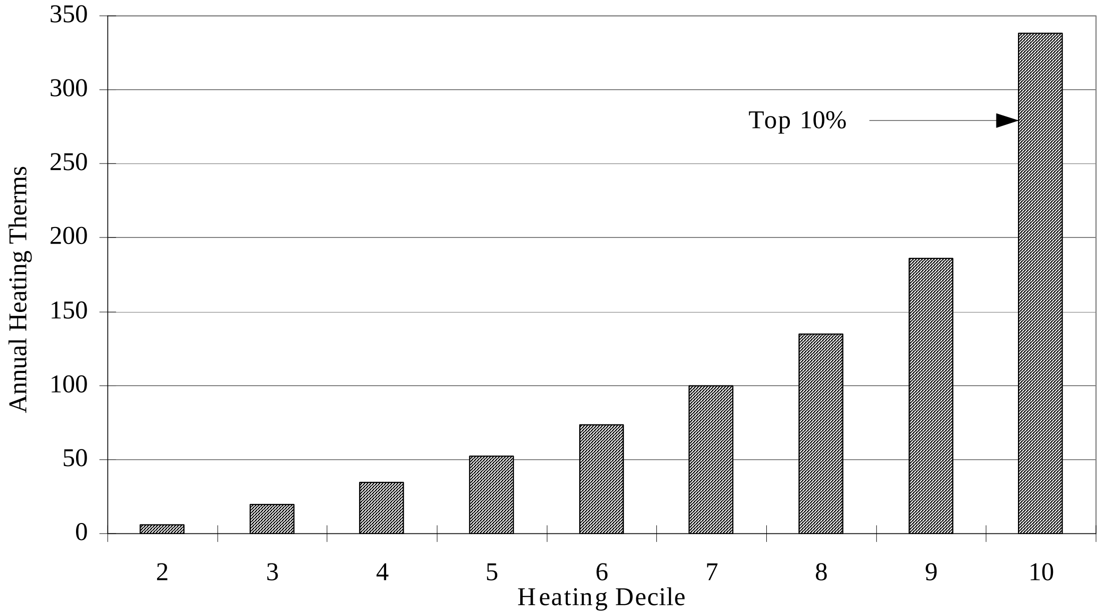

Figure 2. Average Gas Heating Consumption of Southern California Gas Company's Low Income Customers (by decile)

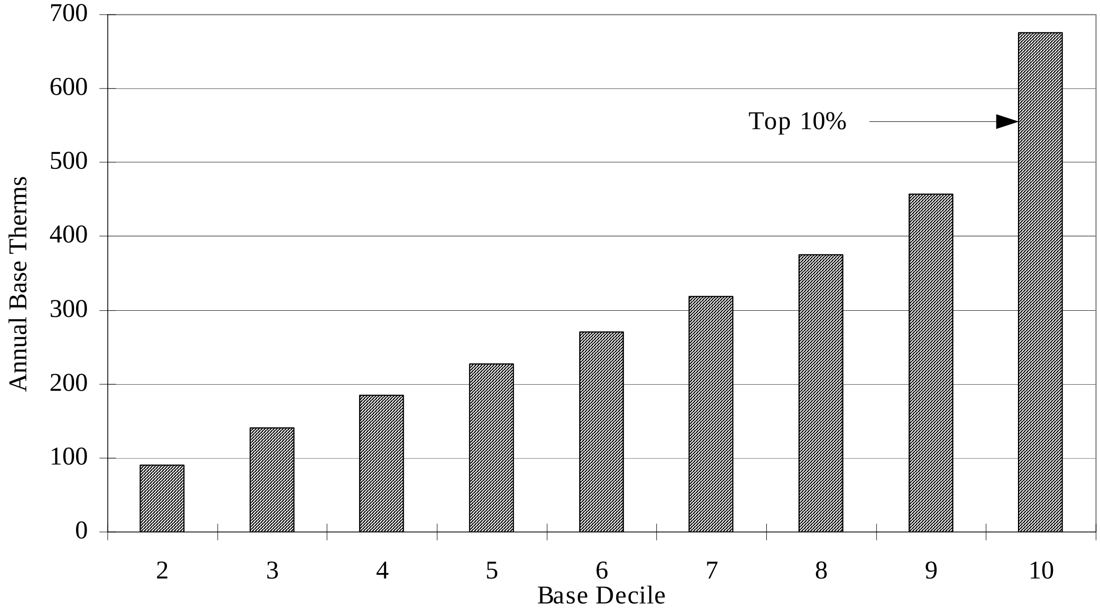

Figure 3. Average Base Gas Consumption of Southern California Gas Company's Low Income Population (by decile)

The average annual gas consumption of Southern California Gas company's Low Income Population is 382 therms

Step 2 - Field Investigation and Measure Analysis

The population assessment showed that there are a significant number of low income customers that have high energy consumption well in excess of other low income customers. The next logical question is: "Do these high use customers have energy consumption problems that can be addressed cost effectively?" In order to determine the answer to that question, a random sample of 25 high use low income homes were selected for intensive on-site analysis.

The purpose of the initial intensive investigation of 25 homes was to provide in-depth information on high use households. The field evaluations were conducted by a two-person team highly trained in all facets of weatherization, including HVAC testing, building shell leakage testing, and duct leakage testing. The visits determined the causes of high consumption in each residence. The parameters examined are summarized in Table 3.

Table 3. Summary of Field Investigation Diagnostics

Parameter	Tests	Description
Occupancy Patterns/ Behavior	Interview	Determination of whether occupancy (full or part-time) or occupant behavior such as heating system thermostat set point, water heater temperature, cooking, dishwasher, laundry, shower usage are contributing factors to the customer's high usage
Unusual Gas Usages	Visual inspection	Identification of irregular gas usages, such as mistaken plumbing (i.e. hot water plumbed to an evaporative cooler), other households sharing gas through customers meter (i.e. shared laundry facilities in a duplex) as contributing factors to the customer's high usage
Hot Water Leaks	Visual inspection and measurement	Visual inspection of all faucets including kitchen, bath (including bath tub diverter when the shower is on), laundry and water heater tank for leaks. Leakage flow measurement
Shower Flow	Measurement of shower flow	Measurement of shower flow using a micro-weir.
Building Features	Visual inspection and measurement	Measurement of building (surface areas, volume, etc.) and inspection of all exterior building surfaces for effective insulation levels. Determination of water heater insulation levels and structural problems (i.e. missing windows or doors, damaged exterior components, excessive interior moisture).
Combustion Appliance Operation	Combustion appliance efficiency and safety	Testing of all combustion appliances for safe operation(gas leaks, CO production, adequate venting, controls) and efficiency (anticipator and fan switch settings, heat rise).
Duct Leakage and Conduction	Duct Blaster™ leakage tests	Measurement of duct system leakage (both to the interior and exterior at a duct test pressure of 25 pascals), determine percentage of leakage attributable to supply and return portion of the system, record normal operating duct pressures, duct location and insulation values.
Building Insulation	Visual inspection and thickness measurements	Determination of insulation levels for all exterior surfaces.
Building Shell Leakage	Blower Door leakage tests	Measurement of building shell leakage, measurement of key building zones pressures to determine leakage to those zones.

FIELD INVESTIGATION RESULTS

The targeting procedure determined the excess gas use of the target customers over other low income customers. The billing analysis combined with the field investigation provided an estimate of the amount of the excess consumption that could reasonably be addressed by changes in the house or the equipment.

Base Consumption Reduction Items:

Thirty-one percent of the target customers in the field investigation had hot water leaks. These leaks were estimated to be the largest single contributor to excess base use. Other base use measures with less total impact on energy consumption but applicable to a large number of homes were water heater jacket installation and high flow showerhead replacement. While water heater temperature adjustment does not have a high savings potential, it was applicable to 5% of the customers and is inexpensive enough that it would be cost effective even with a low success rate.

Practices Resulting in High Base Consumption:

High occupancy levels and laundry practices are often responsible for substantial portions of the high base use. A third area of practice that increases use is direct or indirect use by others (i.e. neighbors wash their cloths in the laundry that the customer supplies the hot water). Specific discussions with the customers may have some effect on these practices.

Heating Consumption Reduction Items:

Duct leaks were the largest contributor to excess heating use. Duct leaks and thermostat problems both occurred in 12% of the target customers' homes. Thermostat problems (no thermostat, incorrect thermostat, thermostat falling off the wall, incorrect anticipator setting, etc.) account for a significant energy loss and repairs may be cost effective.

Repairable problems with excessive infiltration fell into three categories: evaporative coolers open to outside during the winter (often in a hallway right over the wall furnace), severe (glass missing) window or door damage[3], and excessive air leakage into the attic and out of the crawlspace[4]. Severe window problems are cost effective to repair, but half of the homes with broken windows already have noticeable moisture problems.[5]

Attic insulation was a cost effective and applicable measure that would apply to 8% of the targeted units.

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[3] Door and window replacement/repair is only cost effective in cases where they represent a very significant leak. The current direct assistance program provides for these repairs (as do most programs in the state), most likely well beyond the level of cost effectiveness. For this pilot door replacements were excluded while window pane replacements were included in pilot services but not evaluated in cost savings.

[4] Caulking and weatherstripping are traditional infiltration control measures that have been proven to be of little consequence in reducing infiltration. These measures were not included in the pilot.

[5] One unwanted effect of window repair is the reduction in ventilation and the increase of moisture in the home. Many of these homes had high occupancy rates and visible moisture problems (mold, etc.) already.

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Behavior Resulting in High Heating Consumption:

High setpoints or other occupant control issues (leaving the windows open with the heater on) are responsible for a significant portion of the excess heating use. Some of this can be addressed through education, but some of the high setpoints are due to health problems.

Step 3 - Pilot Measure Selection

Considering the existing capabilities of the weatherization agencies and new measures that could be introduced within the pilot timeline, the following measurements and repairs were applied by two of the existing agencies:

1. Measure and repair hot water leaks
2. Measure shower flow rates and replace high flow shower heads
3. Install water heater jackets and adjust water heater temperatures
4. Install, repair, replace, and adjust thermostats
5. Install air tight evaporative cooler covers
6. Install attic insulation where it is cost effective
7. Address practices identified specific to the customer and the house that result in excess use
8. Verify the results of the phone audit

A private non-profit contractor with experience in instrumented duct and air sealing along with combustion safety testing was used to apply these measures:

1. Measure and repair duct leakage
2. Measure and repair air infiltration paths to attic and from crawlspace
3. Test combustion safety parameters

A number of potentially cost effective measures were not applied in this pilot due to logistical issues. These measures included:

1. Major hot water leak repair requiring a plumber
2. Heating system control repair or replacement requiring a heating contractor

Step 4 - Pilot Location Selection

The pilot was conducted in two geographic areas using the local weatherization agency. These areas were postal zip areas 935xx and 917xx. Selection was made based on a number of factors including agency willingness and area characteristics as well as the necessity of avoiding conflicts with other concurrent SCG pilots.

In total, 220 houses were visited in the pilot. Of these, 137 were owner occupied and 83 were rentals. Only 9 of the households served were in multiple family dwellings.

AREA 935

This area includes Lancaster which has 2908 heating degree days (reference 65°F). This area is cold enough to require a noticeable amount of heating. This was also the area with the highest percentage (59%) of local customers in the top quartile of gas consumption.

The average house size served in this area was 1326 square feet.

The area is served by an agency from Ventura County which poses logistical problems. In spite of the logistical issues, the agency completed 143 units in the pilot.

Because of the large sample size and cool temperatures this area is ideal for evaluation of heating related measures. The average initial heating use of sample customers in this area was 806 therms. The average initial base use was 336 therms.

AREA 917

This is the San Gabriel Valley area. The heating degree days range from 1500 to 2000. Energy consumption in this area is dominated by base use. This area is near average in that 24% of the low income population is in the top quartile of energy consumption. Because of the large low income population, this area has the second highest number of top quartile low income customers.

There were 77 units visited in this area. The average house size was 1567 square feet.

Heating consumption is low in this area. The sample customers had an initial heating use of 438 therms. The initial base use was 483 therms. Because of the small heating consumption this area is appropriate for evaluation of measures related to base consumption end uses.

Step 5 - Targeting

Targeting customers for specific energy efficiency measures provides a wide range of benefits. Past research has shown that not only the absolute amount of energy savings increases with customers that initially use more energy, but also the percentage of savings increases with higher use customers. Targeting allows more efficient use of resources to achieve more overall benefit to the low income population and society.

In this pilot, customers were selected that fulfilled any of the following criteria:

1. Total annual gas consumption in excess of 783 therms
2. Seasonal heating gas consumption in excess of 282 therms
3. Annual base gas consumption in excess of 595 therms

These criteria are the 95th percentile of consumption as determined in the population assessment.

Southern California Gas Company supplied data for 30,127 low income customers in the two pilot areas. In that group there were 4705 customers with good data that met one of the inclusion criteria. These customers were randomly assigned to the treatment and comparison groups.

Step 6 - Screening

Screening energy efficiency measures based on information about the customer and their residence has the potential to reduce the cost and increase the effectiveness of any program. High quality energy audits that have to reconcile projected energy savings with existing consumption are one example of screening. In this pilot two screening methods were applied. The telephone audit projected energy savings based on phone questions and billing data. On-site screening was provided by the installation technician through direct measurements on the item to be repaired, modified, or replaced.

It was hoped that these two methods could be used to validate each other.

PHONE AUDIT

One of the concepts tested in the pilot was a computerized telephone audit protocol that could predict the measures needed by a customer. Proctor Engineering Group modified its existing audit tools to provide measure selection based on billing analysis and telephone interview.

The computerized display and interview guide allows the telephone auditor to visualize the customer's energy usage patterns. This helps them better understand peculiarities or changes associated with this customer's account. This is particularly helpful in finding customers that have had an occupancy or other change that would not be identified by annual base or heating therms alone. One customer's consumption graph is shown in Figure 4.

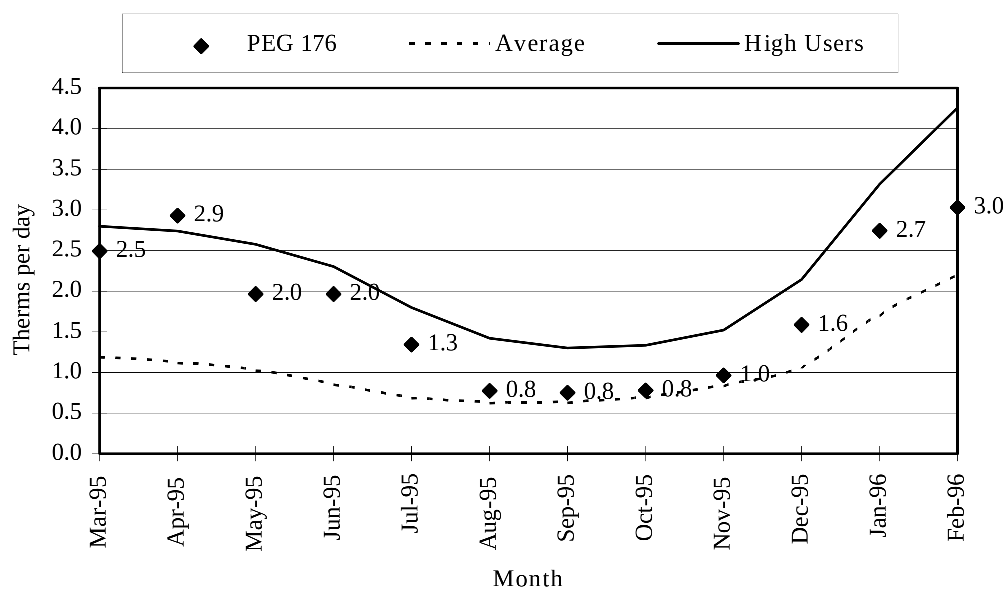

Figure 4. Audit Display of Consumption Pattern

The usage graph assists the auditor in determining whether the excess usage is base consumption, heating consumption, or both. The graph shows the gas use (therm/day) for the average low-income customer (the dotted line), the average high-use customer (the solid line) and this particular customer (the diamond shaped data points) for the same time period.

Audit questions lead the phone interviewer through items specific to each customer's usage patternEach potential problem is connected to several questions. The answers are used to predict the contribution of that problem to the excess usage. Successful audits result in a list of measures projected to be cost effective for this customer, an estimation of potential savings, and, in some cases, unexplained excess consumption that may warrant investigation by on-site personnel.

PHONE AND MAIL ELIGIBILITY

Along with the phone audit the pilot tested phone screening for eligibility and mail confirmation. This is one method of reducing overhead costs associated with income qualification. Currently personnel from the weatherization agency visit the house and income qualify the customer prior to the weatherization visit. In this pilot, SCG customer eligibility questions were asked as part of the telephone audit.

For customers who passed the telephone eligibility screening a completed application was mailed to the customer for signature. The customer also received a packet of materials on energy education and program qualifications.

ON-SITE SCREENING

On-site screening provides additional input to the process. Some measures cannot be accurately screened in a telephone interview. Attic insulation for example is difficult to screen by phone[6]. The installation technician, when properly trained and motivated, is in the best position to determine the applicability of many measures. This is generally accomplished interactively between the energy consumption data and measurements at the home. In this pilot, the technicians were not used to screening measures based on consumption. The technicians did verify the applicability of measures by specific measurements and tests.

Management and installation personnel from the two weatherization agencies were trained to diagnose and repair program approved measures during a one week intensive training session. The first two days of the training were held in the classroom/lab at the SCG Santa Fe Springs, training facility. The last three days of the training were spent visiting participants' houses to diagnose and repair the problems causing high energy usage.

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[6] However, unexplained excess heating consumption may be an indicator.

Table 4 details the inspections and measurements in the on-site screening visit.

Table 4. Measurements at on-site screening

Parameter	Tests	Description
Occupancy Patterns/ Behavior	Interview	Determine if occupancy (full or part-time) or occupant behavior (heating system set point, water heater temperature, cooking, dishwasher, laundry, shower usage) are contributing factors to high usage
Unusual Gas Use	Visual inspection	Identify irregular gas uses, such as mistaken plumbing (i.e. hot water plumbed to an evaporative cooler), other households sharing gas through customers meter (i.e. shared laundry facilities in a duplex) as contributing factors to high usage
Hot Water Leaks	Visual inspection and measurement	Inspect all faucets including kitchen, bath (including bath tub diverter when the shower is on), laundry and water heater tank for leaks. Measure hot water leakage flow
Shower Flow	Flow measurement	Measurement of shower flow at full flow using a micro-weir.
Insulation Levels	Visual inspection and measurement	Inspect attic and water heater for effective insulation levels.
Air Leakage Reduction	Visual inspection	Inspect for structural problems (i.e. missing windows or doors) and interior evaporative cooler covers
Gas Appliance Problems	Visual inspection and measurement	Test all combustion appliances for gas leaks. Examine thermostat to ensure it is secure and level. Adjust anticipator to the measured heating system circuit amperage. Replace defective or mismatched thermostats (different gas valve and thermostat operating voltages) and thermostats on 24 volt systems without anticipators

The on-site screening and installation visit was designed to take one individual between a half hour and two hours to complete. Time on-site was dependent on the extent of repairs.

INSTRUMENTED DUCT AND SHELL SEALING

A limited number of sites (59 homes) were visited by experienced duct and shell diagnostic and repair crews. As is the standard practice, these sites were initially tested for shell leakage, duct leakage, and combustion safety. Further work on these homes was dependent on the outcome of these tests. Thirty-four of these homes had ducts and/or the building shell sealed and the tests repeated. When properly monitored, this process produces cost effective and safe applications of these measures.

TARGETING RESULTS

Customer targeting based on gas consumption was successful in identifying households with problems causing high use. Seven hundred and eighty-six measures were identified on 220 homes. The targeted homes averaged 3.6 applicable measures (median 4). There were 5% of the homes where no applicable measure was found.

High Heating Consumption

A profile of the high heating use customer is available from the installation technicians' data. Based on problem occurrence, high heating use is characterized by:

- heater control problems in 62% of the homes,
- leaky ducts in 60% of the homes,
- the presence of an evaporative cooler without a cover in 36% of the homes,
- excessive building shell leakage in 40% of the homes, and
- the need for attic insulation in 17% of the homes.

High thermostat settings were identified as a contributing factor to high heating use in 35% of the cases.

High heating consumption homes with duct systems had very leaky systems. Average duct leakage to outside was 687 CFM measured at 25 pascals (CFM_{25}). This is a very significant amount of duct leakage. The initial field investigation found an average 438 CFM_{25} of duct leakage. Both groups (the Instrumented Sealing Group and the Field Investigation Group) have much higher than normal duct leakage. Normal duct leakage is in the 290 CFM_{25} range. For example, investigations of existing homes by Proctor (1991) and Tooley and Moyer (1989) found 299 CFM_{25} and 290 CFM_{25} of duct leakage, respectively.

The high duct leakage in these homes was found to be repairable. Thirty-four duct systems were repaired with an average leakage reduction of 431 CFM_{25}.

While it is not altogether unexpected that targeting based on heating use produces a high percentage of ducted systems, finding 60% ducted systems is significant given the low income housing stock in The Gas Company's service area.

High Base Consumption

A profile of the high base use customer was built from installation technicians' data. Based on problem occurrence, high base use can be characterized in this manner:

- Most high base use customers are also high heating use customers (75% of high base use customers are also high heating use customers).
- High base use is often caused by factors outside the control of a weatherization program (34% of high base use customers do a high amount of laundry, 16% have very high occupancy rates, 6% have others using gas from their meter for appliances).

- High base use is also characterized by a lack of water heater wrap (72%) and high shower flow (61%).

- A high base use house is also likely to have some combination of high hot water temperature (39%), hot water leaks (25%), or shower diverter leaks (16%).

The estimated impact from hot water leaks was found to be quite large. A single small hot water leak has a sizable impact on annual consumption. A hot water leak of 0.5 cups per minute will waste 90 terms of gas per year. The technicians measured the leakage rate of the dripping faucets. The average leakage was 0.83 cups per minute.

SCREENING RESULTS

The telephone screening was useful in improving the hit rate over cold calling on missing evaporative cooler covers, attic insulation, and water tank insulation. The screening logic identified ducted heating systems. The presence of a duct system and high usage was found to be an adequate screen for this measure.

The phone audit was twice as effective at finding existing hot water leaks as “cold call” visits to high use customers.

The questions used were not successful in identifying houses that needed instrumented air sealing, or some of the heater control problems. The questions need to be refined to be useful for those items. The screening protocol used was not very successful in improving the hit rate on high flow showers, diverter leaks, or high hot water temperature.

Table 5. Screening Effectiveness

Measure	Correctly Identified (Opportunity was identified and present) % of Opportunities	Cold Call Identification (Opportunities present) % of Targeted Population	Incorrectly Identified (Opportunity was identified, but not present) % of Identifications
Duct Sealing	76%	61%	2%
Evaporative Cooler Covers	72%	36%	34%
Heater Controls	39%	59%	50%
Shower heads > 5 gpm	24%	64%	35%
Attic Insulation	57%	20%	69%
Water Heater Insulation	64%	30%	4%
Hot Water Leak Repair	40%	18%	67%
Water Heater Insulation	64%	30%	4%

The telephone screening improved the “hit rate” on a number of the base case problems. A high “hit rate” means that less houses need to be visited to find a problem. For problems outside the control of weatherization the hit rate increased by a factor of 1.6 for “High laundry use” and a factor of 9 for “Others use base”.

In most cases the phone screening can be modified to increase its usefulness.

Analysis

GEOGRAPHIC ZONE COMPARISON

There are substantially different savings impacts between Area 935 (the Lancaster area) and Area 917 (the San Gabriel area). These differences can be due to a number of items. The delivery agencies were different. There were significant differences between the climate and housing stock. Some of these differences are shown in Table 6.

Table 6. Characteristics of Sample by Geographic Area

Characteristic	**Area 917 mean (std. dev.)**	**Area 935 mean (std. dev.)**
Annual Gas Consumption (NAC)	902 (224) therms	1105 (274) therms
Annual Gas Consumption for Heating	329 (246) therms	738 (244) therms
Participants	76 homes	139 homes
Non-Participants	1821 homes	2630 homes
Participants with Savings Data	67 homes	118 homes
Non-Participants with Savings Data	1477 homes	1922 homes

The average annual gas consumption for all Southern California Gas Company's low income customers is 382 therms (standard deviation 261 therms).

Table 7. Characteristics of Participants by Geographic Area

	Area 917	**Area 935**
Average Occupancy	4	3.6
Average Bedrooms	3.1	2.9
Hot Water Leaks	17%	21%
Evaporative Coolers	22%	80%

BILLING ANALYSIS AND RESULTS

A two-stage impact evaluation was performed to assess the energy savings achieved in the pilot and the energy savings potential for a program. This involved data collection and cleaning, first stage analysis of energy consumption, a second stage analysis of factors associated with high and low impacts, and a synthesis of the results.

The primary data sources for the impact evaluation were the program tracking system, the monthly usage data for participant and non-participant groups, and weather data. These data were screened, cleaned and merged into a master data set. During that process anomalous data was investigated and estimated meter readings were merged into actual reading periods. A discussion of sample attrition is contained in Appendix B.

This analysis is primarily based on pre-retrofit/post-retrofit use for participants (those who received a site-visit) and non-participants (all others). The pre- and post-retrofit annual gas consumption for each customer was first weather normalized based on historical local weather data. This normalization process used the PRInston Scorekeeping Method™ (PRISM™). The resulting annual consumption estimate is referred to as Normalized Annual Consumption (NAC). The gross savings for each customer were calculated as the difference between pre- and post- NAC.

For Participants, the "treatment date" was the last recorded day of work on the unit. Each member of the Non-participant group was randomly assigned a pseudo-treatment date matching one of the Participant treatment dates.

In the stage 1 analysis, the savings for each group was estimated using both mean and median values (due to the presence of outliers). The net savings was then estimated as the difference between the participant and the non-participant groups. The potential for sample bias was investigated and may be present.

In stage 2 supplementary analysis approaches were explored. The PRISM™ results from stage 1 were used as variables in multiple regression models. The purposes of stage 2 included providing a better understanding of the potential savings by measure and providing additional confidence in the results.

Based on these results, on engineering analysis, and on empirical data from other studies, the savings potential by measure and by program design was estimated. This synthesis should be helpful to Southern California Gas Company in their future program designs.

Normalized Annual Consumption

The PRISM™ model was estimated in two modes. In mode one, three coefficients: a (base use), b (heating slope), and tref (reference temperature for heating degree days) were developed. In mode two, tref was fixed at 65°F. The model coefficients were estimated from the billing data for the pre-retrofit period, and for the post-retrofit period. These estimates were derived from the typical PRISM™ model:

$$C_{it} = a_{it} * days_t + b_{it} * HDD_{it(tref\ i)}$$

Where:

C_{it} = Gas consumption for house i in billing period t

a_{it} = Base gas consumption for house i in billing period t

days = Days in billing period t

b_{it} = Heating slope (therms per heating degree day) for house i in billing period t

$HDD_{it(tref\ i)}$ = Heating degree days for weather at house i in billing period t, based on the $_{tref\ i}$ which is the best fit reference temperature for house i in the (pre-/post-) period

The model was fit to both the pre- and post- retrofit data, statistics produced, and the consumption normalized to historical weather data. The form of the normalization is:

$$NAC_{ip} = a_{ip} * 365.25 \text{ days} + b_{ip} * HDD_{(tref\ ip)}$$

Where:

NAC_{ip} = Normalized Annual Gas consumption for house i in treatment period p (pre- or post-)

a_{ip} = Base gas consumption for house i in treatment period p

365.25 = Days per year

b_{ip} = Heating slope (therms per heating degree day) for house i in treatment period p

$HDD_{(tref\ ip)}$ = Historical annual heating degree days for weather at house i, based on the $_{tref\ ip}$ which is the best fit reference temperature for house i in the (pre-/post-) period

Stage 1 Results

The fixed tref mode gave more stable results and was used in the final analysis. The mean weather normalized gas savings estimates are shown in Table 8.

Table 8. Mean Normalized Savings Estimates in Therms by Area

	Participants	**Non-Participants**	**Net Savings**
Area 917	108 therms	92 therms	16 therms
Area 935	29 therms	31 therms	-2 therms

Because of the attrition due to timing and usage data, the mean savings values are potentially biased by outliers. The median can be a better estimate of savings under such circumstances. The median weather normalized gas savings estimates are shown in Table 9.

Table 9. Median Normalized Savings Estimates in Therms by Area

	Participants	Non-Participants	Net Savings
Area 917	122 therms	71 therms	51 therms
Area 935	10 therms	-1 therms	11 therms

The low savings in Area 935 was unexpected. That area has twice the heating load as Area 917. Analysis of the installation data showed that none of the homes in Area 935 had attic installation installed in the pilot. There was also less duct sealing done in Area 935.

The next step was multivariate regression analyses of the normalized consumption.

Stage 2 Results

One of the goals of this analysis was the production of savings estimates for individual measures. In order to produce reasonably reliable estimates for individual measures, a six-step analysis was completed.

1. First, the pre- and post-retrofit annual gas consumption for each customer was weather normalized based on historical local weather data.

2. Second, a multiple regression model was built and the measures were tested for inclusion. The result of this model is a predictive model of savings related to some of the measures.

3. Third, the regression model was tested for the influence of outliers, high leverage data, and the applicability of standard statistical assumptions.

4. Fourth, The coefficients of the regression model were taken as an estimate of the effect of each measure as long as the coefficient was physically possible and in line with other empirical studies. When the data were insufficient to produce a defensible savings estimator, engineering analysis tempered by empirical data was used to produce an estimate.

5. Fifth, The mean value of the predictor[7] for homes treated with the measure was computed.

6. Sixth, The product of the mean predictor value and the regression coefficient was used to predict the average savings per home attributable to that measure.

PEG explored a number of regression methods and models. Some of the regression models explored were; ordinary least squares, robust regression, and least-absolute value regression. Each of these estimate the central tendency of data, but deal with outliers in different manners. Because the final analysis group was small and over a limited period, a least-absolute value model proved to provide the best estimate based on physical analysis, the presence of outliers, and empirical data from other studies.

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[7] 1 for "dummy" variables and arithmetic mean for variables such as change in duct leakage.

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The regression models provided stable and statistically significant regression coefficients for: duct sealing and attic insulation. The models also provided a stable and possible coefficient for evaporative cooler covers. These results are displayed in Table 10.

Table 10 Regression Estimates of Annual Measure Savings for Low Income Customers with Normalized Annual Consumption Greater Than 790 Therms

Measure	Zone 917		Zone 935	
	Coefficient	Standard Error	Coefficient	Standard Error
Duct Sealing	0.196 therms per cfm25 duct leakage[8] reduction	0.084 therms	0.258 therms per cfm25 duct leakage reduction	0.029 therms
Attic Insulation	90 therms	52 therms	see footnote[9]	
Evaporative Cooler Covers	37.8 therms		54.7 therms	

[8] Duct leakage to outside tested at 25 pascals.

[9] No attic insulation was installed in this zone in the pilot.

Combining the regression results, engineering estimates, measure penetration in the pilot, and measure availability the estimated pilot savings and potential savings were computed. The results are shown in Tables 11 and 12.

Table 11 Estimates of Annual Measure Savings for Low Income Customers with Normalized Annual Consumption Greater Than 790 Therms Situated in Zone 917

Measure	Engineering Estimate (therms)	Regression Estimate (therms)	Installed in Pilot	Potential Installations	Pilot Savings (therms)	Potential Savings (therms)
Duct Sealing	77	100	21%	60%	16	46
Evaporative Cooler Cover	26	38	11%	17%	3	5
Attic Insulation	100	90	14%	30%	14	30
Heater Control Repair	13		58%	58%	8	8
Water Heater Insulation	17		34%	87%	6	15
Hot Water Leak Repair	41	46	11%	21%	4	9
Water Temperature Adjust	3		25%	25%	1	1
Shower Head	2		30%	30%	1	1
Estimated Annual Pilot Savings						**52 therms**
Projected Targeted Screened Program Annual Savings						**113 therms**

Table 12 Estimates of Annual Measure Savings for Low Income Customers with Normalized Annual Consumption Greater Than 790 Therms Situated in Zone 935

Measure	Engineering Estimate (therms)	Regression Estimate (therms)	Installed in Pilot	Potential Installations	Pilot Savings (therms)	Potential Savings (therms)
Duct Sealing	97	90	12%	60%	11	58
Evaporative Cooler Cover	50	58	51%	72%	26	36
Attic Insulation	190		0%	14%	0	27
Heater Control Repair	24		60%	60%	15	15
Water Heater Insulation	17		28%	74%	5	12
Hot Water Leak Repair	41	46	14%	21%	6	9
Water Temperature Adjust	3		40%	40%	1	1
Shower Head	2		74%	30%	2	1
Estimated Annual Pilot Savings						**65 therms**
Projected Targeted Screened Program Annual Savings						**158 therms**

CUSTOMER SATISFACTION

The objectives of the participant survey were to determine customer impressions of the DAP program implementation and their satisfaction with the process. The information will allow the program to be adjusted to the needs and expectations of the customer. Inspectors administered a structured survey while they were on site for the inspection. The surveys addressed these questions:

- Telephone income verification and audit procedure.
    - ◊ Were the customers satisfied with the telephone income verification procedure?
    - ◊ Were the customers satisfied with the telephone audit procedure?

- Community Based Organization (CBO) performance.
  - ◊ Were the customers satisfied with the CBO personnel's' performance and conduct?
  - ◊ Were the customers satisfied with the CBO personnel's' ability to fully explain what they were able to accomplish for the customer?
- Energy Education.
  - ◊ Did the customers find the energy education component of the program helpful in educating them about ways they can further reduce their energy use?
- Customer impression of Southern California Gas and the Direct Assistance Program.
  - ◊ Were the customers satisfied with the service they received from DAP?
  - ◊ What is the customers overall impression with SCG?

One hundred sixty-three customers were surveyed. They were asked to rate their impressions of the program services on a scale of one to four with one being very dissatisfied and four being very satisfied. In the case of energy education the scale of one to four represented one being not useful and four being very useful.

Customer Satisfaction Results

Telephone income verification and audit procedure:

- The telephone income verification procedure was well liked by the majority of customers. Eighty-eight percent of the customers reported they were very satisfied and rated their impression of the effectiveness of the telephone income verification procedure as 4/4. Eleven percent of the customers responded with a rating of 3/4. Only one of the 163 customers rated the income verification procedure as a 2/4 and none rated it as a 1/4.

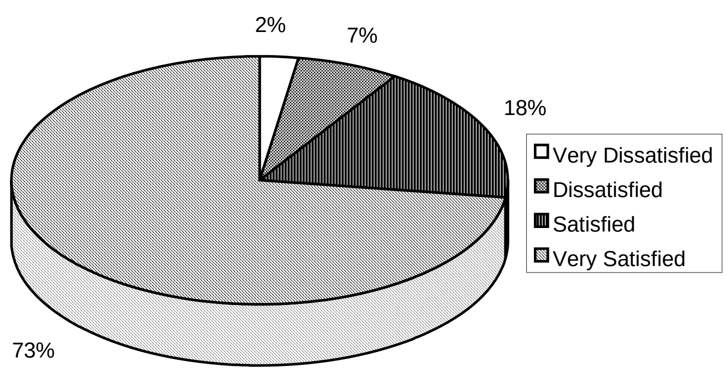
- The telephone audit procedure was highly rated by the majority of customers. Eighty-six percent of the customers reported being very satisfied and rated their impression of the effectiveness of the telephone audit procedure as 4/4. Twelve percent of the customers responded with a rating of 3/4. Only one customer reported that they were not satisfied with the telephone audit procedure.

- Customers were very satisfied with the CBO personnel and their conduct in the home. Seventy-nine percent of the customers reported a rating of 4/4. Fifteen percent of the customers responded with a rating of 3/4. The remaining six percent of the customers reported they were not very satisfied with the CBO personnel performance.

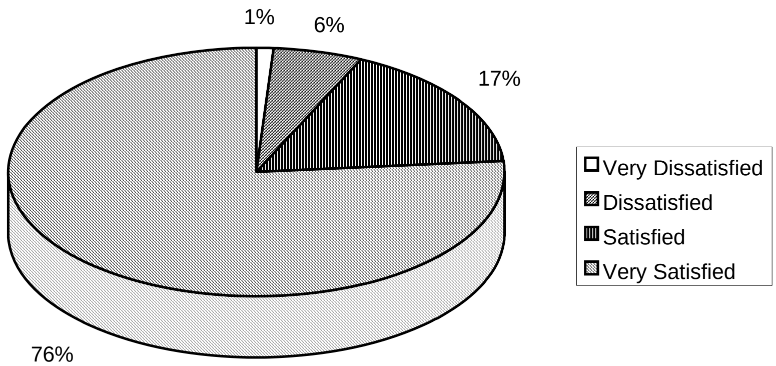
- Seventy-seven percent of the customers reported that they were very satisfied (4/4) with the CBO personnel's' ability to explain the program and the work they did. Seventeen percent of the customers responded with a rating of 3/4. The remaining six percent were not very satisfied with that ability. Much of the dissatisfaction was associated with the customer's expectations that more work would be done. Several of the customers reported that they thought they would receive weather-stripping around their doors.

- The ability of the CBO personnel to address residential energy problems was highly rated. A combined total of ninety seven percent of the customers reported that they were satisfied (3 or above) with the measures taken

- The least effective of the program components in the customers view was the energy education. Only seventy-three percent of the customers reported that they were very satisfied with this component of the program. This is the lowest rating of all items addressed in the survey. Nine percent of the customers reported that they viewed the energy education component of little or no value to them.

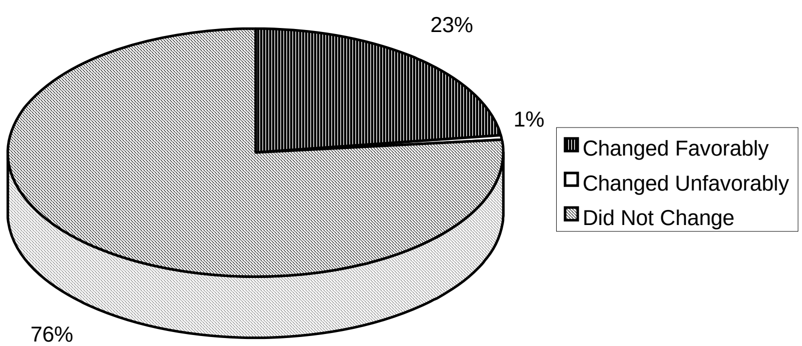


- The majority of the customers were left with a favorable impression of the DAP program. Seventy-six percent of the customers reported being very satisfied. Seventeen percent of the customers responded with a rating of 3/4. Only two of the 163 customers were not satisfied with the DAP program. Both of these customers had complaints about the performance of the CBO. One indicated too many phone calls from CBO and the other did not like the CBO personnel.



- Seventy-six percent of the customers reported that their impression of SCG did not change as a result of the DAP program. These customers already had a favorable impression of SCG (Eighty-two percent rated their impression of SCG as 4/4 and sixteen percent indicated a rating of 3/4).

- Twenty-three percent of the customers indicated that their impression of SCG was favorably influenced by the DAP program. Ninety-two percent of these customers gave SCG a rating of 4/4, the remaining eight percent rated their impression of SCG as 3/4. Only one customer (0.62 %) indicated that their impression of SCG was unfavorably changed by the DAP program. This customer gave SCG a rating of 1/4. This customer was the one who did not like the CBO personnel.



CUSTOMER PAYMENT BEHAVIOR

One objective of this pilot was to gather data on customer payment behavior and to explore the possible effect of program participation on that behavior. Twenty indicators of payment behavior were examined. Overdue notices were the most prevalent indicator of payment behavior. This sample of customers (low income high gas consumption) showed a very strong seasonal pattern. Approximately 35% of the low income high use customers received overdue notices in January, February, and March of 1997.

The seasonal changes in late payment notices are shown in Figure 5.

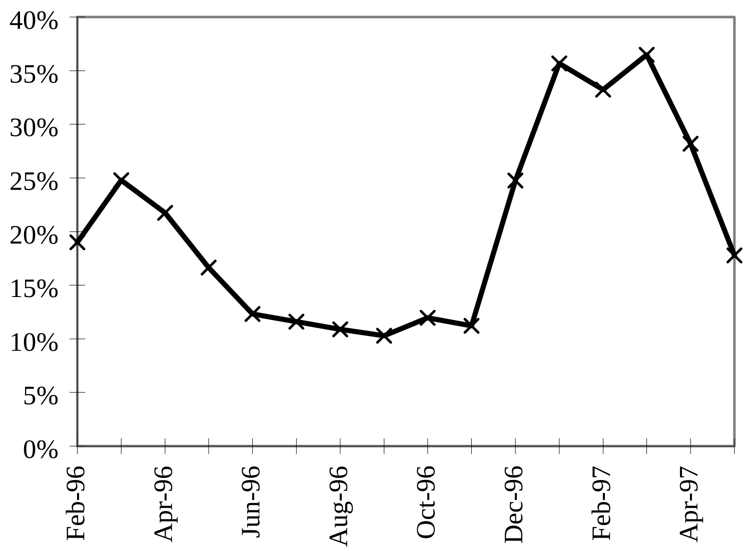


Figure 5. Seasonal Variations of Late Notices

Payment behavior differences between Participants and Non-participants were examined for the pre-retrofit period of February 1996 through May 1996 and for the post-retrofit period of January 1997 through May 1997. Overdue notices provided the highest possibility of determining statistical significance of observed payment differences between the two groups. Figure 6 shows that while the proportion of overdue notices was nearly equal in the pre-retrofit period, there were statistically significant (at the .05 level) differences between the proportions in the months following the retrofits.

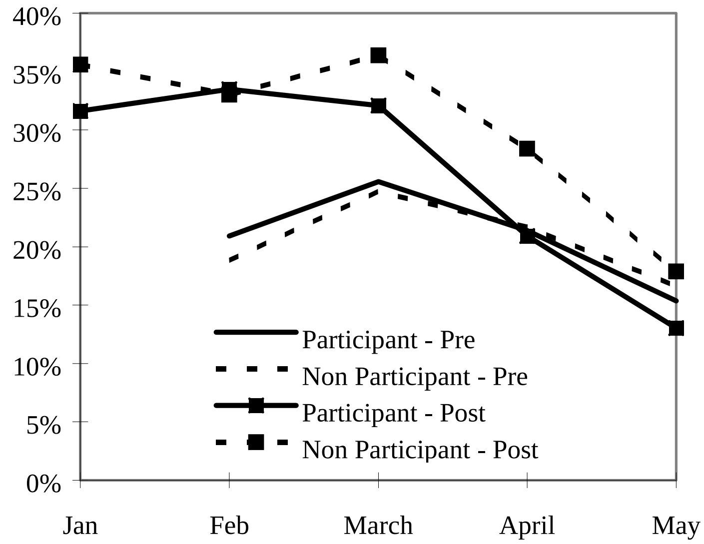


Figure 6. Effect of Program on Overdue Notices

Conclusions and Recommendations

SAVINGS POTENTIAL

Estimated savings potentials[10] for Zone 935 and 917 are distributed as shown in Figures 7 and 8.

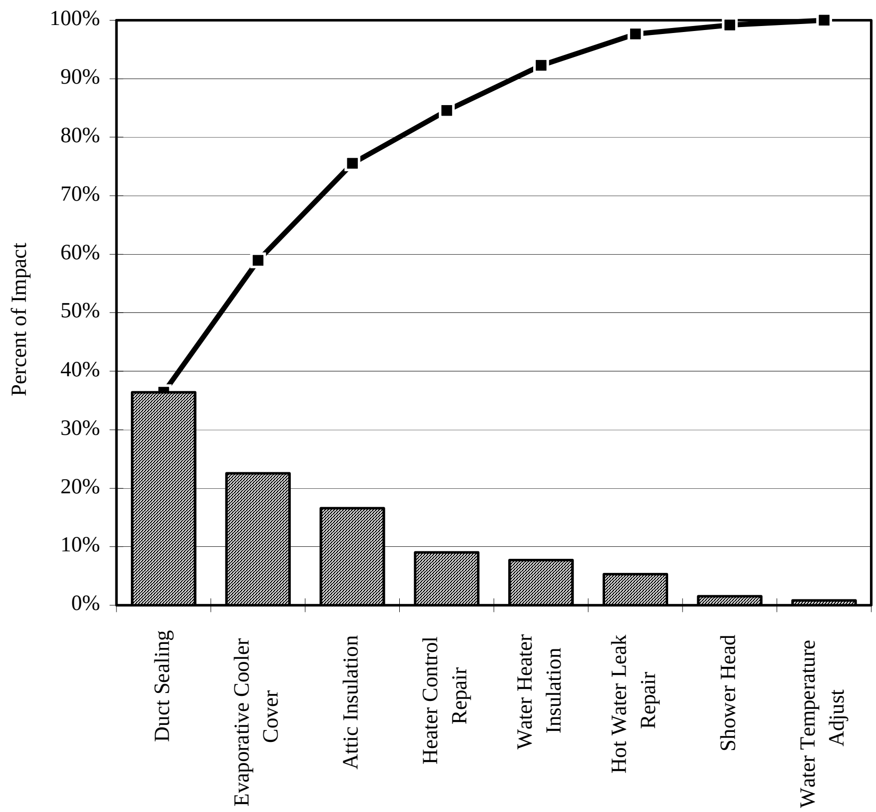


Figure 7. Estimate of Measure Effectiveness Applied to Zone 935 High-Use DAP Homes (percent of potential savings)

[10] Estimates based on installation technician data.

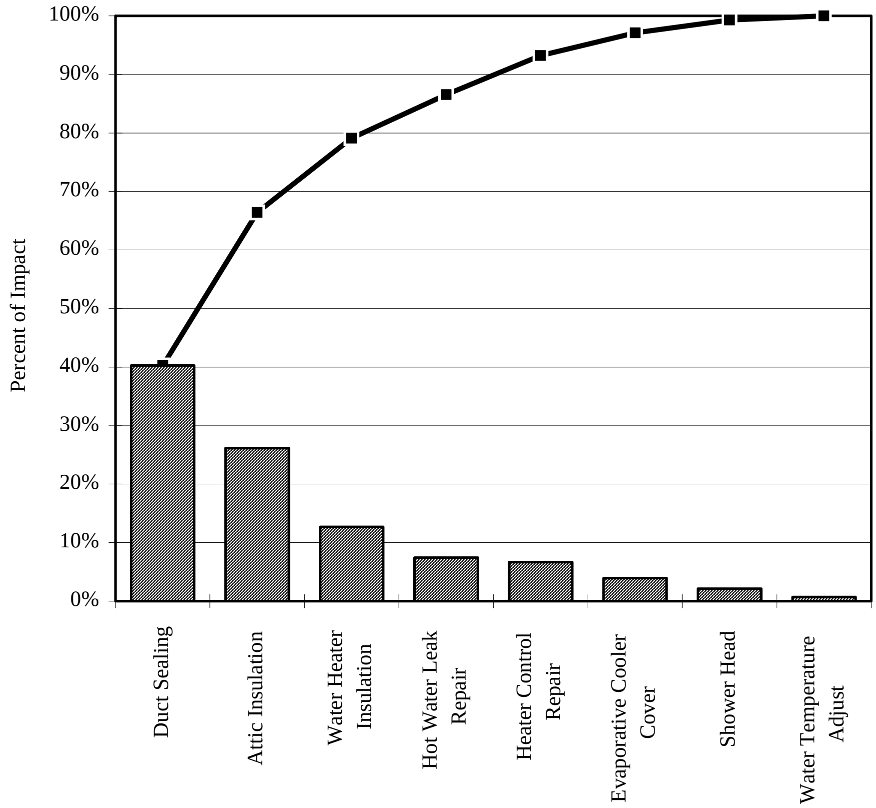


Figure 8. Estimate of Measure Effectiveness Applied to Zone 917 High-Use DAP Homes (percent of potential savings)

Estimated savings potentials[11] from repairable base use efficiency problems are concentrated in hot water measures especially water heater wrap and repair of leaking hot water. This data suggests that a program designed to install water heater wraps on homes where the customer reports no water heater wrap could be effective. Hot water leaks may be a viable target for high base use customers.

MEASURE COST BENEFIT RATIO

The cost benefit ratio for each measure was calculated based on estimated costs, lifetimes and savings. The results are shown in Table 13

[11] Estimates based on installation technician data.

Table 13 Cost Benefit Ratio for Low Income Customers with Normalized Annual Consumption Greater Than 790 Therms

Measure	Engineering Estimate (therms)	Potential Installations	Life of Measure (years)	Lifetime Savings (therms)	Lifetime Savings[12] (customer $)	Measure Cost	Cost per therm
Duct Sealing*	97	60%	20	1944	$ 1,050	$ 495	$ 0.25
Duct Sealing w/o Safety Repairs*	97	30%	20	1944	$ 1,050	$ 295	$ 0.15
Evaporative Cooler Cover*	50	72%	10	503	$ 271	$ 35	$ 0.07
Attic Insulation*	190	14%	20	3795	$ 2,049	$ 612	$ 0.16
Attic Insulation without venting*	190	7%	20	3795	$ 2,049	$ 528	$ 0.14
Heater Control Repair*	24	60%	10	242	$ 131	$ 9	$ 0.04
Water Heater Insulation	17	74%	5	84	$ 45	$ 27	$ 0.32
Hot Water Leak Repair	41	21%	5	203	$ 110	$ 30	$ 0.15
Shower Head	8	30%	5	41	$ 22	$ 22	$ 0.55
Water Temp. Adjust	3	40%	1	3	$ 2	$ 4	$ 1.13

* Applicable to heating climates only (climates similar to Zone 935)

[12] at $0.54 per therm.

COST BENEFIT POTENTIAL FOR PROGRAM DESIGNS

Low income weatherization program design involves many factors, including: Recruitment, Qualification, Measure Selection, Client Selection, Technician Interaction. Selections for three of these factors are shown in Figure 9.

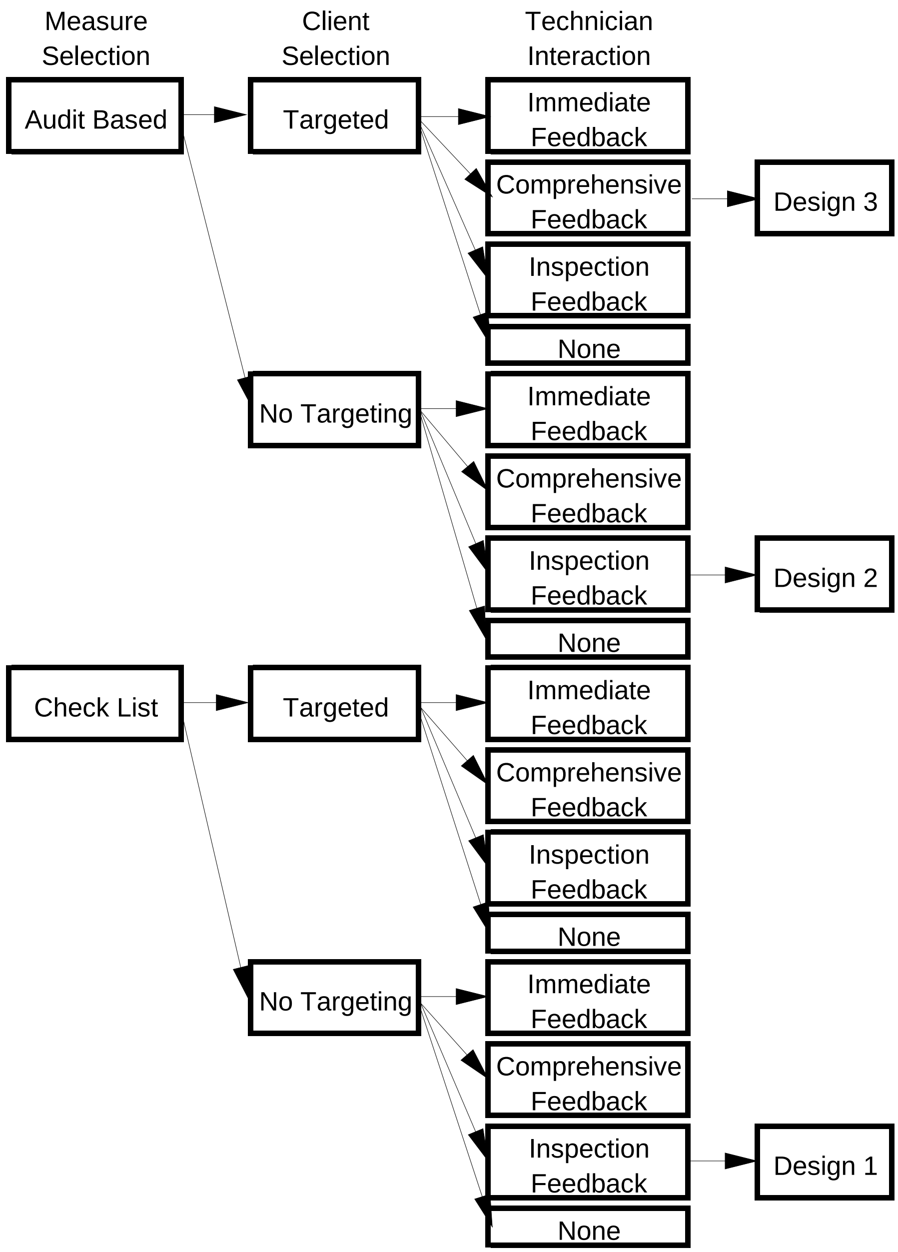


Figure 9. Three Factors Affecting Program Design

There are pros and cons to all the selections within the three factors displayed. Checklist based measure selection reduces the time and expertise needed to choose the measures for a particular residence. Audit based selections should produce more energy savings per installation dollar since the measures are customized to each home.

Non-targeted client selection results in the largest client availability. Targeting reduces the number of clients to those with the highest energy savings potential (or other criteria). When targeting precedes recruitment and qualification, the recruitment and qualification costs are reduced.

The potential positive effect of no technician interaction is that administrative time and effort are reduced. Basing technician feedback on inspections improves the effectiveness of the measures installed. Comprehensive and timely feedback (one to two weeks) further improves the confidence and competence of the technicians. Immediate feedback provides the most effective control over measure effectiveness. It also reduces the training period for new technicians.

Four potential program designs are compared. Since the selection of measures is somewhat independent of program design, this comparison uses a fixed set of measures (pilot measures costing less than $0.25 per therm). The four designs are:

Design 1 -- A typical California DAP design with an installation visit and a follow up visit for additional work (attic insulation for example) if applicable.

Design 2 -- A program with an audit, an installation visit, and a follow up visit for additional work if applicable.

Design 3 -- A targeted program with phone screening, an installation visit, a follow up visit if applicable, and a computerized feedback system.

Design 4 -- A single visit version of Design 3. This design eliminates the first installation visit and does all installations in a single visit based on phone screening information.

The following analyses and assumptions, based on prior experience, are made:

1. The measure selection methodology is actually a continuum from every house receiving any measure that applies (Checklist) to the most sophisticated application of all available data (Adjusted Forensic Analysis or AFA). AFA is an interactive[13] analysis that uses measurements at the house[14], information obtained from the client, historical weather data, and historical consumption data for that residence.

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[13] each of the pieces of data are fit together in a least error approach to estimate the energy savings and cost for each measure in a prioritized order. Each piece of data can be challanged by the other pieces of data. A simple example is that the projected savings from the measures cannot exceed the historical consumption.

[14] such as blower door measured air leakage, Duct Blaster™ measured duct leakage, leakage location by pressure diagnostics, furnace efficiency measurements, etc.

- Design 1 is a "shotgun" checklist. This is assumed to result in 100% application of every measure where it can be applied regardless of its cost effectiveness for that location.

- Design 2 is an audit based on physical measurements at the house that produces a prioritized list that is not interactively adjusted to other data. This is assumed to result in application of measures to homes only when they will be cost effective according to physical measurements and historical weather data. Because of the lack of adjustment it is assumed to result in misapplication 20% of the time.

- Designs 3 and 4 use a telephone screening tool based on information obtained from the client, historical weather data, and historical consumption for that residence. This screening produces a prioritized list that is interactively adjusted to the consumption and weather data. This is assumed to result in the misapplication 10% of the time.

2. Client selection is also a continuum from no selection (all clients) to selection of some percentile based on historical energy consumption.

    - Design 1 uses no selection. This is assumed to result in a potential energy savings proportional to the mean energy consumption. The mean energy consumption of this low income population is 382 therms per year.

    - Design 2 uses no selection. This is assumed to result in a potential energy savings proportional to the mean energy consumption. The mean energy consumption of this low income population is 382 therms per year.

    - Designs 3 and 4 use historical energy consumption data for each residence and target the program to clients within the top 5% of annual consumption. This is assumed to result in the potential energy savings identified in this pilot. That is 1664 lifetime therms for customers with an annual energy consumption of more than 790 therms (mean 1105).

3. Technician interaction is a continuum from minimum feedback (you still have a job and get a paycheck) to feedback as the job is being done. Generally higher level feedback reduces traditional training requirements and provides higher quality work.

    - Design 1 uses inspection feedback. Inspection feedback is pass/fail feedback (with reasons). The feedback is delayed until after the inspection takes place. This results in a time lag of more than a month on most jobs. In this analysis, this is assumed to result in a 50% realization of energy savings potential[15].

    - Design 2 also uses inspection feedback.

    - Designs 3 and 4 use comprehensive feedback on most aspects of the technician performance. This feedback is facilitated through an Artificial Intelligence program on a computer. The feedback is specific to each job and occurs within one week. A portion of this was simulated in the pilot by manual review of data from each job. In

[15] Studies in the early 1980's showed realization rates dropped to 30% when inspection only feedback was used.

this analysis this is assumed to result in a 90% realization rate of energy savings potential.

4. The analysis is based on pilot data from Area 935. All measures applied in the pilot are assumed to be available in these three designs.

5. Recruitment and qualification are assumed to take place as follows:

   - Design 1 uses standard Gas Company recruitment and qualification at an average cost of $50 per recruit.

   - Design 2 uses standard Gas Company recruitment and qualification at an average cost of $50 per recruit.

   - Designs 3 and 4 first target the high use customers ($10 per recruit), then both recruit and screen them at a cost of $45 per recruit.

The cost effectiveness of each design is shown in Table 14.

Table 14 Program Design Effectiveness - Four Designs

	Design 1	Design 2	Design 3	Design 4
Costs				
Targeting			$ 10.00	$ 10.00
Recruitment	$ 50.00	$ 50.00		
Audit		$ 50.00		
Phone Screening			$ 45.00	$ 45.00
Fixed Cost Installation 1	$ 100.00	$ 100.00	$ 100.00	
Installation 1	$ 36.82	$ 12.73	$ 36.82	$ 36.82
Follow up	$ 382.67	$ 132.29	$ 382.67	$ 382.67
Feedback	$ 10.00	$ 10.00	$ 50.00	$ 50.00
Total	$ 579.49	$ 345.02	$574.49	$474.49
Consumption and Savings				
Mean Consumption (therms)	382	382	1105	1105
Lifetime Savings Potential (therms)	575	575	1664	1664
Proper Selection	100%	80%	90%	90%
Realization Rate	50%	50%	90%	90%
Lifetime Benefit (therms)	288	230	1348	1348
Lifetime Customer Benefit ($ @ $0.54 per therm)	$ 155.32	$ 124.26	$ 727.85	$ 727.85
Cost Benefit Ratio				
Lifetime Cost ($ per therm)	$2.01	$1.50	$0.43	$.035

RECOMMENDATIONS

Considering the results of this pilot program and the experience with low income weatherization in other states, Proctor Engineering Group recommends that providers of these services:

1. expend the majority of their low income weatherization effort on the customers that have the highest energy consumption,
2. target the programs at high use customers,
3. include effective[16] duct sealing as a significant portion of the program,
4. provide immediate feedback to field technicians to ensure their increased competence and confidence,
5. include hot water leak repair in the program,
6. investigate gas furnace upgrade (fan off temperature, heat rise, etc.) as a possible measure[17], and
7. investigate a streamlined one visit program design.

[16] While it may seem unnecessary to point out that ineffective duct sealing is of no value, duct sealing is often integrated into programs in external appearance only.

[17] This measure was not included in this pilot partially because of the lack of experienced technicians in this area.

Appendix A Population Analysis

Table 15 shows the percentage of low income customers in each three digit zip code that fall into the top quartile of gas energy consumption. Locations identified in the left hand portion of the table have a greater than average percentage of high use customers.

Table 15. Usage intensity by location

Zip Code	Locals in Top Quartile	Zip Code	Locals in Top Quartile	Zip Code	Locals in Top Quartile	Zip Code	Locals in Top Quartile
935	59%	908	33%	915	22%	900	19%
932	52%	936	32%	926	21%	907	19%
937	50%	924	30%	931	21%	916	19%
933	45%	911	30%	918	20%	902	18%
925	37%	934	25%	906	20%	912	15%
910	37%	922	24%	903	20%	927	14%
923	34%	**917**	24%	914	19%	928	13%
913	34%	930	23%	905	19%	904	12%

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Table 16 shows the number low income customers in each three digit zip code that fall into the top quartile of gas energy consumption.

Table 16. Distribution of high gas energy consumption customers by location (based on a total low income population of 1.3 million households)

Zip Code	Homes in Top Quartile (thousands)	Zip Code	Homes in Top Quartile (thousands)	Zip Code	Homes in Top Quartile (thousands)	Zip Code	Homes in Top Quartile (thousands)
900	225.2	926	50.1	914	21.2	915	9.1
917	125.5	922	43.7	916	19.2	918	8.3
932	116.6	906	37.6	911	17.4	933	8.3
925	101.1	907	33.3	912	13.8	931	6.8
913	83.2	924	31.9	936	13.5	905	5.7
902	73.8	934	28.9	927	13.4	904	2.9
935	72.5	910	26.0	903	12.5	908	0.7
923	61.5	930	25.5	928	10.4	937	0.1

Table 17 displays the heating and base consumption percentiles.

Table 17. Heating and Base Consumption Percentiles
(heating based on 65% of the customers that have some heating use)

Heating Percentile	Annual Heating Therms	Base Percentile	Annual Base Therms
10	0	10	63
20	12	20	117
30	27	30	163
40	43	40	206
50	62	50	248
60	86	60	293
70	115	70	345
80	156	80	409
90	223	90	514

Appendix B Sample Attrition

The pilot project was designed for 500 installations between May and September of 1996. It was desired that the analysis be completed by mid-February 1997. This would have provided post-retrofit billing data for both summer months and a limited number of winter months. Additional winter data could only be available if the February 1997 deadline were relaxed. Recruitment and qualification were much slower than expected. In the end these difficulties reduced the sample size to 215 homes, with a mean completion date in September of 1996. This significantly reduced the summer billing data. In the final analysis we were able to calculate credible savings data on 185 out of the 215 treated homes.