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Southern California Blower Door Breakpoint Study Target Sample Selection

Submitted to:
Southern California Edison
And
Southern California Gas Company

Final Report

October, 1993

Submitted by:
Proctor Engineering Group

Creators of CheckMe!®

Southern California Blower Door Breakpoint Study Target Sample Selection

INTRODUCTION

Southern California Edison and Southern California Gas Company have committed to a study of blower door weatherization for low income customers. The Southern California Blower Door Breakpoint Study will answer questions key to the design of future Southern California weatherization programs. The primary purpose of this study is to determine where (which houses or apartments) blower door guided weatherization (BGW) would be cost effective. A scientifically valid test to make that determination has been started. The background literature search has been completed and reported. This document summarizes progress on sample selection. Following this phase, a carefully controlled field test will be conducted. The field test will include pre-retrofit/post-retrofit measurement and evaluation.

SUMMARY

This report provides a profile of the portion of Southern California Edison and Southern California Gas Company's residential customer base that is served by both utilities and is on Low Income Rate Assistance (LIRA). The analyses determines that portion of electric and gas bill that increases in the summer and winter months, termed Seasonal Energy Cost (SEC), which is dominated by air conditioning in the summer and space heating in the winter. The methodology for determining SEC is contained in Appendix B.

Figure 1 shows the continuum of Seasonal Energy Cost from high to low for low income residential customers.

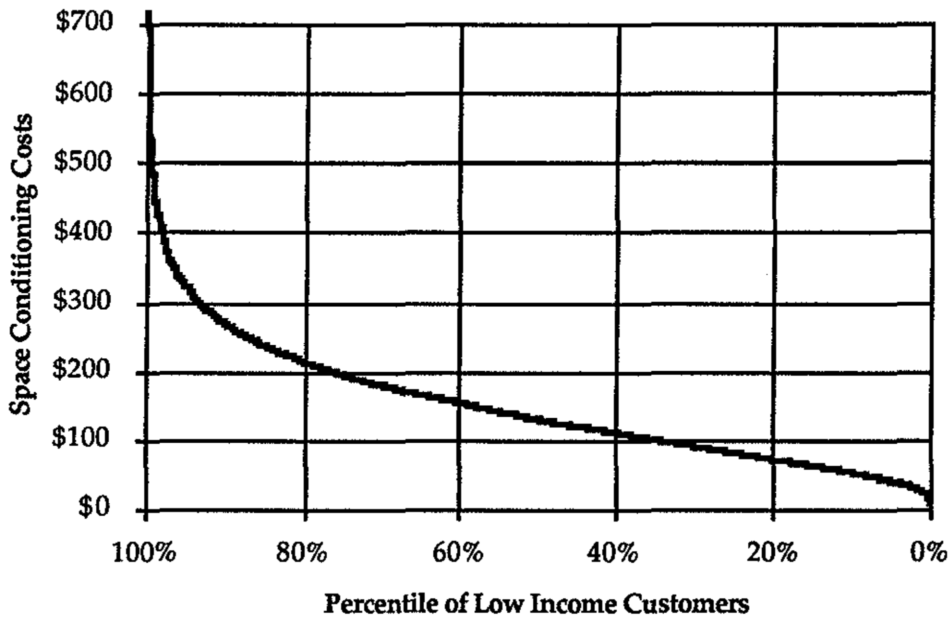

Figure 1. Annual Space Conditioning Cost Profile of Low Income Customers
(Electric only customers excluded)

Sample Selection

Since it is prohibitive to test BGW technology on every possible combination of housing type in the area, and since the purpose of this study is to determine the break point between where blower door guided weatherization (BGW) is sufficiently beneficial and where it is not, the test will be limited to a group that can help establish the economics of this form of weatherization. This group is the customers with combined space conditioning costs higher than the calculated breakpoint.

For the sample selection, the breakpoint was set at $357 (annual space conditioning cost). This is based on the following assumptions:

1) Based on field testing, the maximum expected savings from BGW on homes with ducted space conditioning systems is 20%.
   Note: homes without ducted systems would save substantially less.
2) The desired simple payback is 7 years or less.
3) The incremental cost of BGW including duct sealing is $500.
   ($500 ÷ 7 years ÷ 20% = $357 per year)

Approximately 3% of the sample paid over $357 for space conditioning, as shown in Figure 2.

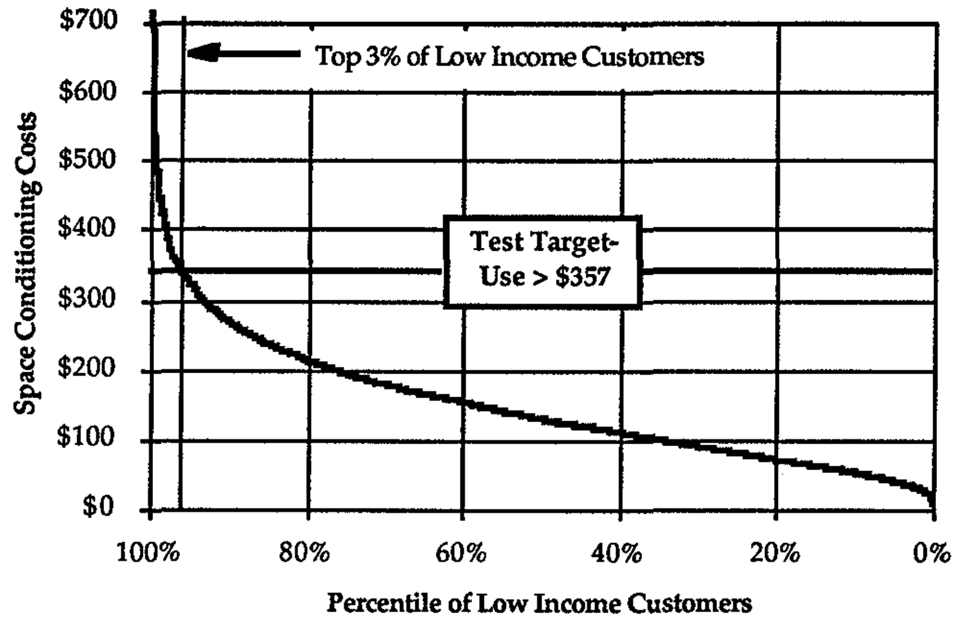

Figure 2. Breakpoint Test Target Customers

The characteristics of these customers and the characteristics of the low income customers as a whole are detailed in Appendix A of this report.

Customer Use by Fuel and Season

Customers with high Seasonal Energy Use can be categorized by fuel and season. Gas heat alone exceeds $200 on 56% of the customers and electric cooling alone exceeds $200 on 50% of the customers. The detailed breakdown is shown in Figure 3.

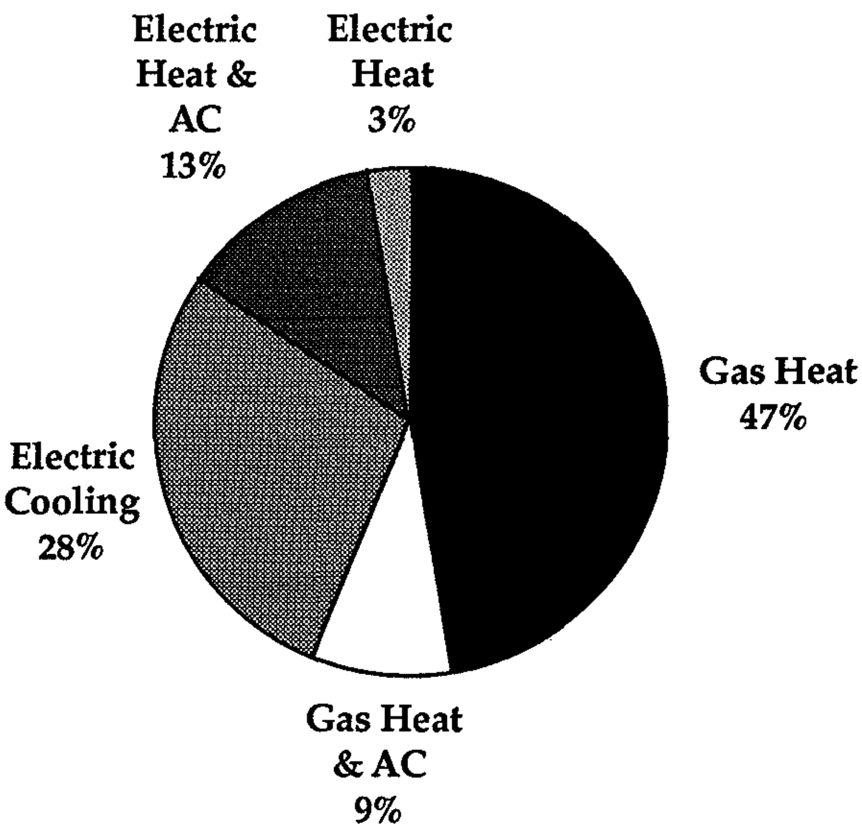

Figure 3. Space Conditioning Fuel Cost in Excess of $200

While the sample for this investigation was selected from Low Income Rate Assistance customers common to both the gas and electric utilities, 16% of the targeted customers exhibited use patterns of electric heated customers. This illustrates the need to determine the cost profile for electric only LIRA customers.

Target Customer Location

These high use target customers are disproportionally located in the agricultural towns of the Central Valley and Hemet. (See Figure 4.) These areas are neither the coolest nor hottest areas served by both utilities. (Cooling degree days ≈ 1850 and heating degree days ≈ 2500). The combination of building characteristics, occupancy, and climate creates a high percentage of high use customers among the low income population.

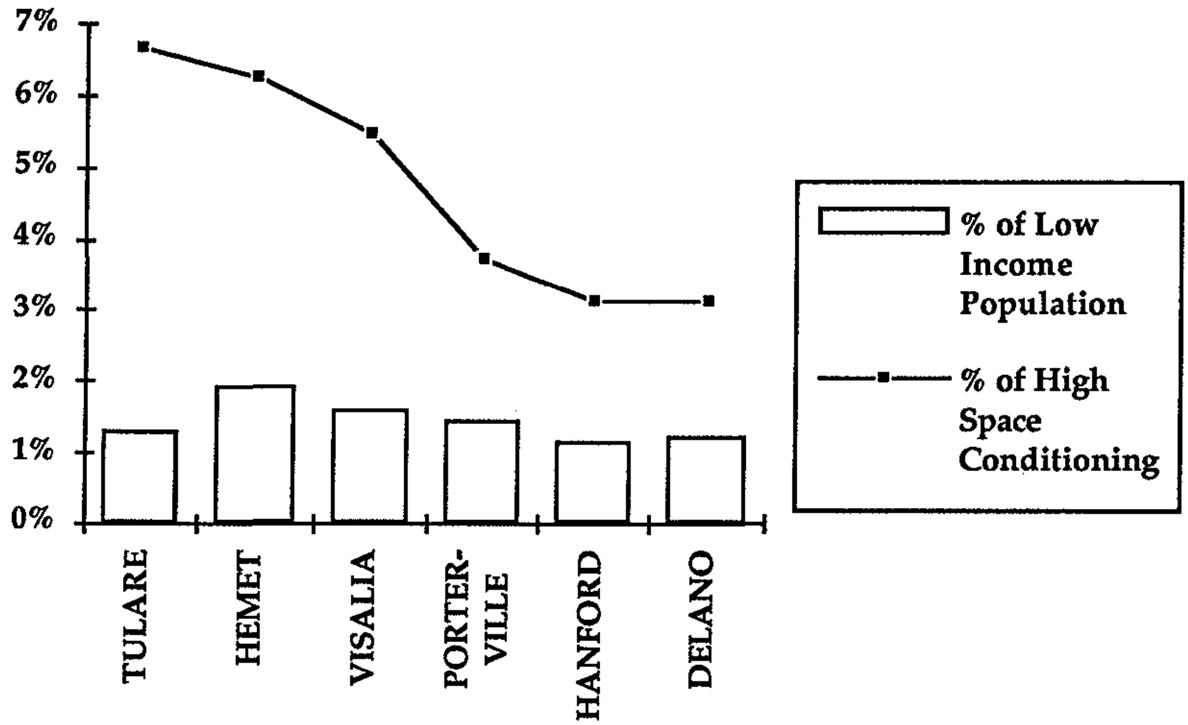

Figure 4. Towns with a High Percentage of High Use Customers among the Low Income Population

Next Steps

The next phase of this project involves the following tasks:

1) Determine the characteristics of the test customers and the population.
2) Determine the cost profile of electric only low income customers.
3) Finalize the research plan, based on building, customer, and climate characteristics.

The housing type and other characteristics (occupancy, etc.) of the test group is being determined by a search of Southern California Gas weatherization records. This data will be compared with similar data for the low income population to determine the final test sample.

Southern California Edison is now obtaining a large sample of electric only LIRA customers for cost profile analysis by Proctor Engineering Group.

Proctor Engineering Group has discussed potential test methodologies with Edison and the Gas Company, community groups, and researchers. The tentative work plan is attached in Appendix C. The final test plan will be based on the housing occupancy and climate characteristics now being determined by Southern California Gas.

Appendix A
Characteristics of Low Income and Target Sample

Patterns of energy consumption and the geographical mix of low income customers in this sample were investigated.

TOTAL GAS AND ELECTRIC CONSUMPTION

Electric consumption for the typical LIRA customer in this sample is substantially less than the Edison residential population average [annual electric use of 4336 kWh for the sample compared to a population average of 8137 kWh (*Southern California Edison Residential Appliance End-Use Survey, Collection of Residential Appliance Time-Of-Use Energy Load Profiles, 1991 Results*)]. Gas use for the sampled LIRA customers is closer to the Gas Company average [sample annual gas use of 472 therms compared to 588 therms for the population (*The Gas Company Fact Sheet - Spring 1993*)].

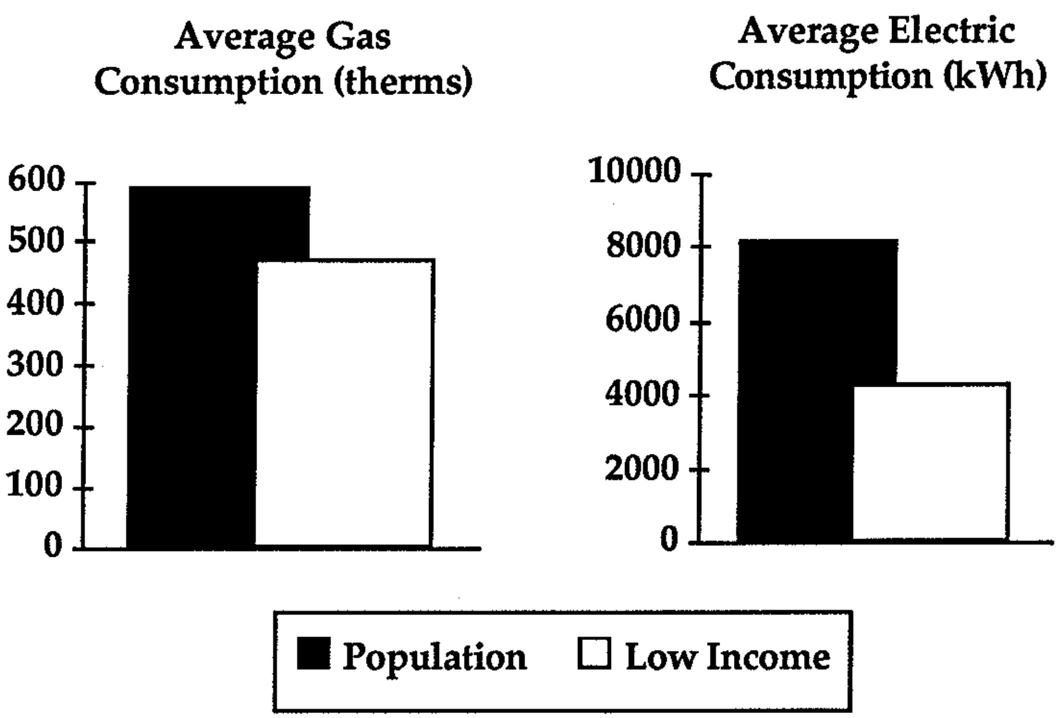

Figure 5. Average Residential Energy Use
(all end uses)

SEASONAL GAS AND ELECTRIC CONSUMPTION

Seasonal gas and electric consumption statistics for the population sample and the target group are tabulated in Table A.

Table A. Seasonal Consumption			
		Low Income Sample n=15389	High Use Sample n=510
Winter Electric	**Mean**	**289**	**811**
	Std. Dev.	*336*	*926*
Winter Gas	**Mean**	**114**	**347**
	Std. Dev.	*110*	*180*
Summer Electric	**Mean**	**569**	**1673**
	Std. Dev.	*470*	*849*

GEOGRAPHIC LOCATION OF LOW INCOME AND TARGETED CUSTOMERS

The location of the sampled low income customers and the location of high use customers is compared in Table B.

92.105A **Table 1 Location of Low Income Sample and High Use Target Population (by %)**

City	Low Income	Space Conditioning > $357		City	Low Income	Space Conditioning > $357
TULARE	1.3	6.7		UPLAND	0.6	0.6
HEMET	1.9	6.3		BLOMNG	0.5	0.6
VISALI	1.6	5.5		BEAUMO	0.5	0.6
SAN BD	5.0	4.7		OJAI	0.4	0.6
PRTERV	1.5	3.7		YUCA V	0.2	0.6
DELANO	1.2	3.1		NORCO	0.1	0.6
HANFOR	1.2	3.1		LINDSA	0.1	0.6
PALMDA	0.4	2.8		MNTERY	1.2	0.4
LOSANG	8.2	2.6		BELLFL	0.5	0.4
FONTAN	3.0	2.6		HUNT B	0.5	0.4
MRNO V	1.4	2.6		FARMVI	0.4	0.4
LAPUEN	2.8	2.4		ARCADI	0.3	0.4
YUCAIP	0.8	2.2		29 PAL	0.2	0.4
SUN CI	0.6	2.0		CSTAME	0.2	0.4
COMPTO	3.1	1.8		BREA	0.1	0.4
ONTARI	2.0	1.8		LACRSN	0.1	0.4
PERRIS	1.2	1.8		REDLAN	0.1	0.4
SIMI V	0.7	1.8		WILDOM	0.1	0.4
GLENDO	0.5	1.8		NUEVO	0.1	0.4
PLMDES	0.0	1.8		R MIRA	0.0	0.4
HOMELA	0.5	1.6		BALDWN	2.1	0.2
LANCAS	0.2	1.6		VENTUR	1.7	0.2
W COVI	1.3	1.4		POMONA	1.6	0.2
COVINA	1.2	1.4		STABAR	1.5	0.2
INGLWO	1.9	1.2		ORANGE	1.2	0.2
CORONA	0.7	1.2		WHITTI	1.0	0.2
BLYTHE	0.1	1.2		DOWNEY	0.9	0.2
PALMSP	0.1	1.2		NORWAL	0.9	0.2
SANTAA	3.1	1.0		MAYWOO	0.7	0.2
ALHAMB	1.6	1.0		TORRAN	0.7	0.2
HIGHLA	0.6	1.0		EL MON	0.7	0.2
EXETER	0.2	1.0		SANGAB	0.7	0.2
CRESTL	0.1	1.0		LAKEWO	0.6	0.2
ROSEME	0.8	0.8		STAPAU	0.6	0.2
AZUSA	0.4	0.8		MONROV	0.5	0.2
WOODLA	0.3	0.8		IRVINE	0.4	0.2
MURRIE	0.3	0.8		MSN VI	0.4	0.2
DESHTS	0.3	0.8		NWBURY	0.4	0.2
MTCLAI	0.2	0.8		EARLMA	0.3	0.2
CTHDRL	0.1	0.8		CHINO	0.3	0.2
RIALTO	1.3	0.6		MIRALO	0.2	0.2
PICORI	1.1	0.6		ROWL H	0.2	0.2
LA HAB	0.9	0.6		ARTESI	0.2	0.2

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Table 1 Location of Low Income Sample and High Use Target Population (by %)

City	Low Income	Space Conditioning > $357		City	Low Income	Space Conditioning > $357
LOMITA	0.2	0.2		LOMALN	0.1	0.0
ALTADE	0.2	0.2		CLARMO	0.1	0.0
LKFORE	0.2	0.2		JSHUAT	0.1	0.0
CYN CT	0.2	0.2		S ELMN	0.1	0.0
CABAZO	0.2	0.2		LAG BC	0.1	0.0
MOJAVE	0.2	0.2		PLACNT	0.1	0.0
NPORTB	0.1	0.2		MONTRO	0.1	0.0
CYPRES	0.1	0.2		TUSTIN	0.1	0.0
STRATM	0.1	0.2		CALCIT	0.1	0.0
TIPTON	0.1	0.2		PIXLEY	0.1	0.0
ROSAMO	0.0	0.2		LA PAL	0.1	0.0
LKAROW	0.0	0.2		PASADE	0.1	0.0
SAUGUS	0.0	0.2		ARMONA	0.1	0.0
MCFRLA	0.0	0.2		IVANHO	0.1	0.0
LITLER	0.0	0.2		LA VER	0.1	0.0
OXNARD	3.6	0.0		STANTO	0.1	0.0
SO GAT	1.2	0.0		CALIME	0.1	0.0
FULERT	1.1	0.0		DUARTE	0.1	0.0
HUNTPA	0.8	0.0		BUENA	0.1	0.0
LAWNDA	0.8	0.0		WALNUT	0.1	0.0
STAMNI	0.8	0.0		GOSHEN	0.0	0.0
CULVER	0.6	0.0		TERABE	0.0	0.0
HAWTHO	0.6	0.0		BELLGD	0.0	0.0
BELL	0.6	0.0		COLTON	0.0	0.0
PARAMO	0.6	0.0		LOSALM	0.0	0.0
RDNDOB	0.5	0.0		PIRU	0.0	0.0
CARSON	0.5	0.0		SOMIS	0.0	0.0
GARDEN	0.5	0.0		BANNIN	0.0	0.0
WSTMNS	0.4	0.0		FRAZEP	0.0	0.0
CAMARI	0.4	0.0		MALIBU	0.0	0.0
HACNDA	0.4	0.0		CERRIT	0.0	0.0
MANBEA	0.4	0.0		DIMOND	0.0	0.0
SANDIM	0.3	0.0		MENTON	0.0	0.0
CUDAHY	0.3	0.0		VILLA	0.0	0.0
COMMER	0.3	0.0		BALBOA	0.0	0.0
FILLMO	0.3	0.0		BRADBU	0.0	0.0
GRDNGR	0.3	0.0		LAKEVI	0.0	0.0
LYNWOO	0.2	0.0		LONG B	0.0	0.0
FTN VL	0.2	0.0		SURFSI	0.0	0.0
HAWGRD	0.2	0.0		VALENC	0.0	0.0
MOORPA	0.2	0.0		VENICE	0.0	0.0
GOLETA	0.2	0.0				
TEMECU	0.2	0.0				

Appendix B Methodology

This analysis consists of drawing a random sample, calculating the SEC, sorting and compiling the results.

SAMPLE SELECTION

The initial sample included 32,965 LIRA customers that The Gas Company was able to match with LIRA customers supplied by Edison. The analysis is based on the energy use in two minimum use billing periods as an estimate of the base use for that fuel. In order to use this methodology a number of screens must first be applied to the data. The screens and their effect on the sample size are shown in Table C. In the end the sample was reduced to 15,389 households (47% of the original sample). The necessary use of these screens in this quick analysis may introduce some bias, however this bias is small in comparison with the usefulness of the results.

Table C Percentage of Households Eliminated by Screens

	Edison	Gas Company
Zeros in data	<1%	2%
Estimates	N/A	9%
Two lowest readings not within ± 20%	29%	24%
Net Utility by Utility	70%	65%
Combined Net	47%	

ESTIMATING SEASONAL ENERGY COST

The use (the Daily Base) that is not attributable to space conditioning (heating and cooling) and other seasonally variable end-uses was estimated from spring and fall data. The Daily Base was calculated as the minimum average daily use from the Spring or Fall. The Daily Base includes average lighting, refrigeration, clothes drying, cooking, water heating, etc.

The energy use for the summer billing periods were summed to total summer use. Summer seasonal energy use was computed as the total summer use minus the Daily Base times the number of days in the summer.

The summer seasonal electric use for these households includes air conditioning and any change in refrigerator use or other electrical appliances. For households without air conditioning this number will be small. The electric summer cooling cost was estimated as the summer seasonal electric use times the marginal LIRA rate (12¢ per kWh).

Winter seasonal electric use includes space heating and changes in lighting or other electrical appliances. For households without electric heating this number will be small. The cost was estimated based on a marginal rate of 12¢ per kWh.

In the winter the seasonal gas use includes space heating and changes in gas cooking, water heating, or other gas appliance use. For households without gas heat, this seasonal use is small. The gas heating cost was estimated by multiplying the seasonal use times the marginal LIRA rate (60.9¢ per therm).

For this sample selection no weather normalization was used. Data obtained in the final study will be weather normalized.

Appendix C 1992 Work Plan

Based on meetings in 1992, a preliminary work plan was developed and is summarized below. **THE FINAL RESEARCH PLAN WILL BE PRODUCED BASED ON THE RESULTS OF THE WORK NOW PROGRESSING AT SOUTHERN CALIFORNIA EDISON AND SOUTHERN CALIFORNIA GAS COMPANY AS WELL NEW PROCEDURES AND MONITORING EQUIPMENT NOW AVAILABLE.**

SUMMARY

The **first step** is to make sure that the meetings held so far have fleshed out the primary question that will guide the study. In an attempt to draw out further questions, and clarify present ones, Proctor Engineering summarized and presented the results of previous blower door studies. Drawing on past experience is crucial in focusing the work of the present study.

Step two is determining which low income customers the study will target. Since it is prohibitive to test BGW technology on every possible combination of housing type in the area, the test will be limited to a group that can help establish the economics of this form of weatherization. Determining who to target (the "test stratum") involves compiling heating and cooling energy use data for the low income customer population, and from this data establishing the various levels of consumption of each customer group. The test stratum is a group of low income customers that fall within a certain energy use range. The stratum will be selected with anticipated savings large enough for accurate measurement.

In the **third step** the characteristics of this stratum is investigated and compared with the general population. Test houses will be selected which represent some significant portion of the low income housing stock. A sample will be constructed of a size projected to produce statistically accurate results. The data collected in steps two and three will make this projection possible. Based on the building types in the final sample, the measurement technique will be adjusted as necessary.

Step four determines a strategy for estimating cooling energy savings on low income units with compressor based air conditioning. While it is possible to measure the change in cooling energy use with a pre-/post-weatherization test, such tests have not been undertaken in any significant proportion. In addition occupant behavior associated with cooling is far more variable than in heating. As a result it is necessary to monitor not only energy use but also interior temperatures when investigating changes in cooling. An alternative would be to improve the existing knowledge of infiltration under cooling conditions. With that knowledge, an improved estimate of the cooling energy savings effect of BGW could take place. It is recommended that mechanisms of infiltration in hot weather be investigated with the assistance of EPRI. The existing Ventilation Consortium could possibly fund a portion of this work.

Steps five through eight, comprise the bulk of this study. These steps will measure the change in heating energy consumption due to BGW. In the **fifth step**, equipment is installed to measure infiltration, furnace run time, inside and outside temperatures. This equipment will record the use of the heating equipment in very short time increments for accurate data analysis. Approximately six weeks will be required for this initial data gathering period.

In each dwelling, the in-situ efficiency of the heating system will be measured at the time of the equipment installation. While long term tracer gas measurements will give a good indication of the long term ventilation rate, they will not give any information on how those ventilation rates vary with time of day and outside temperatures. For this reason a smaller sample of the houses will receive additional monitoring equipment capable of determining the level of pollutants in the dwelling.

Test houses will be divided into three matched groups. (NOTE THAT LATER DISCUSSIONS INCLUDED A TWO GROUP METHOD AS A POSSIBLE ALTERNATIVE) The first group will receive BGW, the second will receive Southern California Edison (SCE) expanded weatherization, and the third will be a comparison group. All test houses will be previously weatherized under one of the two utility programs. **This test method will determine the incremental value of BGW and SCE expanded weatherization over standard practice. However, it will not determine the relative merits of either alternative relative to standard practice.** This design has evolved as a method of cost reduction. **Step six** is the test weatherization of the structure. Half of all the weatherization done in the test will be inspected to insure that it represents proper application of the technique.

A six week period of data accumulation follows weatherization. In **step seven** the equipment will be read and removed.

In the succeeding analysis (**Step eight**), the following questions will be addressed:

1) What is the weather normalized annual energy savings for the houses in the study?
2) What is the projected incremental costs for these two weatherization technologies?
3) What are the projected savings in residences of similar construction that utilize other heating systems, with other efficiencies and other fuels than the ones tested.

The Southern California Blower Door Breakpoint Study will determine the incremental value of two forms of weatherization (Blower Door Guided Weatherization and Southern California Edison Expanded Weatherization) in the selected usage strata. It will make a good estimate of the incremental value of these forms of weatherization for low income customers in other usage strata when the building stock is similar.

DISCUSSION

Step 1. Determining the Question

The initial question for this study has been posed in various forms including:

- When, where, and how is blower door guided weatherization cost effective in Southern California compared to alternative forms of weatherization used for low income customers?
- In what houses or units will it be worthwhile to do blower door guided weatherization? For example are single family units built before 1950 with gas floor furnaces in Los Angeles a good location for this form of weatherization?

In order to answer these questions for the varied housing stock in Edison and Gas Company service areas the housing stock that are occupied by low income customers in these areas must first be determined. This housing stock can be described by a number of parameters:

1) Climate Zone (Severe, Moderate, Mild, Heating, Cooling, Heating and Cooling)
2) Date of construction
3) Single Family, Duplex/Triplex, Multi Family
4) Centrally ducted heating or cooling systems
5) Type and cost of heating and cooling energy source
6) Efficiency of heating and cooling system

One approach would be to apply blower door guided weatherization in each of the possible combinations of these variables and meter the change in energy use. The primary problems with that approach are that it would require a very large sample and it would have a very high cost.

Step 2. Determining the Energy Use Characteristics of the Low Income Population

From the discussions that have taken place it appears that the primary purpose of this study is to determine where (which houses or apartments) blower door guided weatherization would be cost effective. Examination of the population of low income customers served by the two utilities will find a continuum of energy consumption from high to low. This is illustrated in Figure 1. Values in Figure 1 are for illustrative purposes only the actual energy use profile of low income customers will be determined in step two.

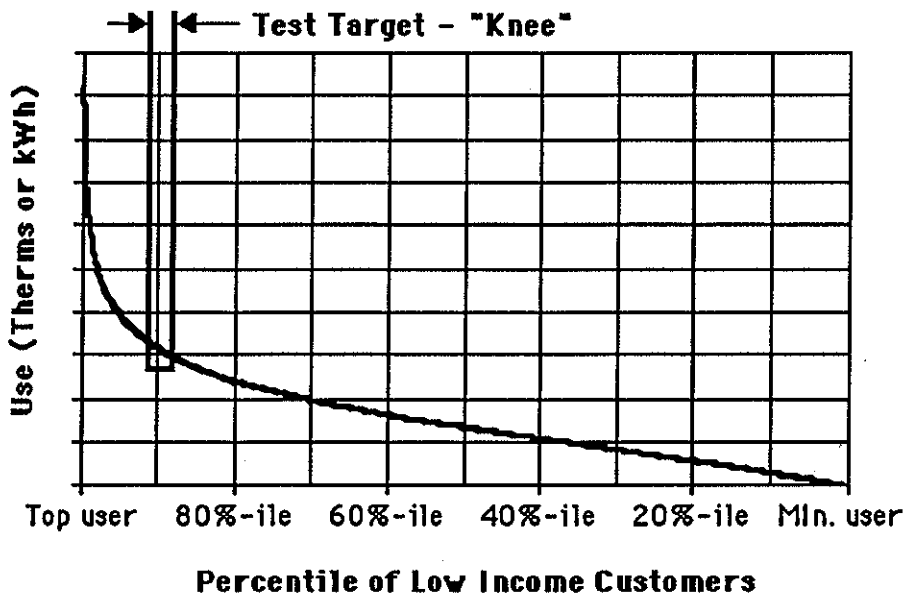

Figure 1. Illustration of Annual Energy Use Profile of Customers

Since the purpose of this study is to determine the break point between where blower door guided weatherization (BGW) is sufficiently beneficial and where it is not, it is not necessary to determine how beneficial it is for every situation. We suggest that the test be run near the probable break point. By determining the if BGW is effective for customers at one level of consumption, it can be argued that customers that use more than that level of use will be more cost effective. In addition calculations can estimate the level below which BGW is likely to not be cost effective.

Step 3. Determining the Housing and Climate Characteristics of the Test Customers and the Population

Once the target for the test is determined the housing type and other characteristics (occupancy, climate zone, etc.) of that group will be determined and compared with similar data for the low income population. It is likely that some combinations are more prevalent in the test target group. When these combinations represent some significant portion of the overall population they will be included in the final sample.

The statistical significance of a measured difference in energy use is dependent on the sample size, the variability of the data and the desired confidence level. Statistical issues of sample size and confidence will initially be addressed in this step of the study.

Step 4. Determining the Cooling Savings Estimation Strategy

BGW should result in reduced infiltration (and reduced duct leakage on centrally ducted systems). Infiltration mechanisms and effects have been investigated primarily in cold climates and in single family housing. Less is known about infiltration in moderate climates, and far less is known about infiltration under cooling conditions.

This lack of knowledge under cooling conditions is partially a result of the difficulty in measuring infiltration under those conditions. While a theoretical basis has been established for estimating the cooling load due to infiltration, the actual infiltration rates in cooling have not been significantly studied. This is particularly true for multi family buildings. If the analysis of the target customer indicates that there are significant customers with cooling load large enough to justify a program, then the infiltration effect of blower door guided weatherization should be studied on a sample of these buildings.

Three approaches are examined: pre-/post- monitoring, passive ("long term") tracer gas measurements, and short term ("real time") tracer gas measurements.

PRE-/POST-WEATHERIZATION MONITORING

Because of high variability in occupant thermostat control behavior in cooling and the desire to apply the results to a wide range of housing stock, the first approach, pre-/post-weatherization monitoring, would require extensive monitoring of temperatures and other variables.

LONG TERM (PFT) TRACER GAS MEASUREMENT

The second approach, long term tracer gas measurement has the advantages of relatively low cost and direct measurement of the dilution of a known "pollutant" over time. Long term tracer gas measurement utilizes a Per Fluorocarbon Tracer (PFT) source that releases a PFT at a known rate. This PFT is an intentional "pollutant" into the home. Small tubes placed strategically in the home soak up the PFT in activated charcoal particles. Analysis of the amount of PFT in the charcoal after the test period determines the average rate of dilution that occurred. PFT results are influenced by variables that are often unknown such as door and window openings. In the summer, this is a particular problem since ventilation may be a major source of cooling.

We propose to use a two mode analysis of PFT data for the heating portion of this study. Details of this analysis are contained in a later section of this work paper. A two mode analysis is possible when two modes (such as cooling and ventilation) dominate the test period. Additionally two mode analysis requires knowledge of two additional items; the percentage of time that the modes occur, the relationship between the two ventilation rates, or both ventilation rates. Because of the uncertainties associated with this PFT measurements in cooling, the alternative of "real time" tracer gas testing is recommended.

SHORT TERM (REAL TIME) TRACER GAS MEASUREMENT

Only the third approach, "real time" tracer gas measurement, is likely to provide adequate information on infiltration during hot weather. Real Time Tracer Gas (RTTG) utilizes a tracer such as SF/6 either with constant injection at a known rate, or injected to obtain a known initial level. Concentration of the gas is measured over a sequence of time periods and the dilution rate is determined.

The primary advantage of RTTG is that it is far more accurate than other methods in determining the true ventilation rate at the time of the test. In addition, it is possible to determine in multiple tests the ventilation rates under multiple conditions. By this method even short term ventilation problems can be detected. RTTG's primary disadvantage is its cost. This cost disadvantage may be mitigated by cooperation with EPRI in their existing test program.

Both PFT and RTTG can utilize multiple test gasses for multiple zone systems. Multi family buildings and single family buildings with attics are both multi zone systems.

It is our recommendation that real time tracer gas measurements be undertaken with the assistance of EPRI.

Step 5. Metering Equipment Installation and Initial One-Time Tests

The purpose of this study is to gather and analyze data necessary to calculate the "breakpoint" for BGW under a variety of circumstances. Accomplishing that analysis is dependent on determining the heating (and cooling) energy use, the efficiency of the heating (and cooling) appliance, and the infiltration rate under heating and cooling conditions. Together these pieces of information make calculations for situations other than those tested possible.

Heating energy use will be monitored by a single device (the Synertech S-100) that records furnace run time, indoor temperature, and outdoor temperature. Heating system efficiency will be measured with Forced Air Signature Test (FAST) for forced air systems, and through steady state efficiency testing coupled with modeling for non-forced air systems. Infiltration rates will be measured with a long term tracer gas methodology. For a smaller sample of units an onsite monitor will record the level of Carbon Dioxide on a real time basis.

THREE CHANNEL MONITOR

This monitoring system is the least expensive system that gives adequate information for a scientifically accurate short term evaluation. It is applicable to measurement of usage reductions on appliances that have fixed input rates.

Operation

The three channels will record the critical parameters of event start time, event end time, outside temperature, and inside temperature. The temperature data is collected every minute and averaged to the hour. This information provides high quality results because each cycle can be analyzed. The old hourly method of analysis creates data variations because cycles overlap into different hours. This new equipment can be downloaded once at the end of the project.

The use of this device can be summarized as:

1) Primary Application:
This method is very good for a rapid analysis of changes in use of gas and electric resistance furnaces.

2) Requirements:
The analysis will require at least four weeks of cold weather before and four weeks of cold weather after the weatherization is done. It is necessary that the analysis be confined to time periods when the inside temperature is nearly independent of the outside temperature.

3) Analysis:
The first step of the analysis is determination of inside temperature independence. This is shown in Figure 2. The second step regresses the run time data against the outside temperature for data in the analysis range. This is shown in Figure 3 for both before and after weatherization.

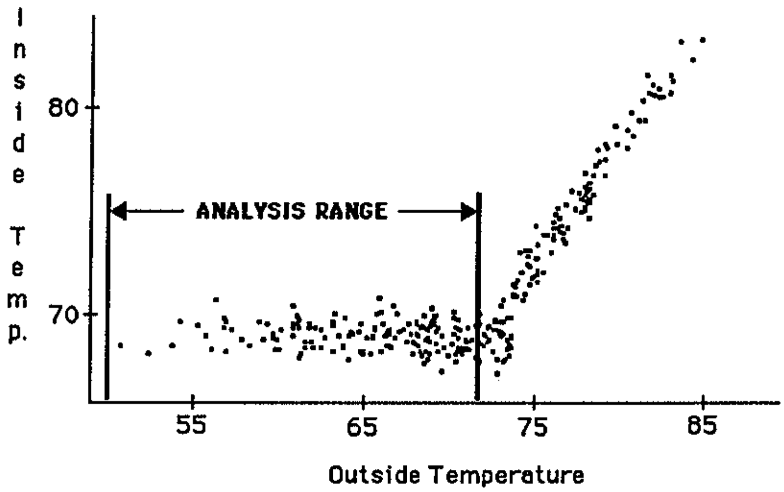

Figure 2. Determining Analysis Range by Independence of Inside Temperature

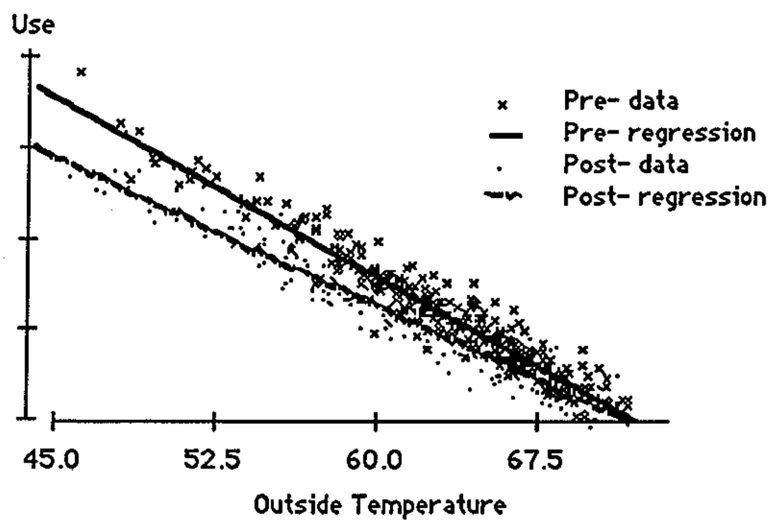

Figure 3. Establishing the Savings from the Retrofit by Regression

4) Historical Applications:
An earlier version of this methodology is being used by Oak Ridge National Laboratory with the assistance of Synertech Corporation for the fuel oil study component of the National Weatherization Assistance Program Evaluation.

5) Sample Size:
The initial estimate of sample size* to determine a 10% savings ± 5% with a 90% confidence is:

- 50 Comparison Group Homes
- 50 Southern California Edison Expanded Weatherization Homes
- 50 Blower Door Guided Weatherization Homes

* based on a standard deviation in use of 15%. The standard deviation of homes in the area to be studied will be determined prior to the start of the study and sample sizes adjusted.

FORCED AIR SIGNATURE TEST

This test procedure accurately determines the actual installed furnace efficiency. It is utilized in this case to make accurate determination of heating load (as opposed to heating energy use) possible.

Operation

FAST is a short term test that measures furnace input and output over whole cycles and determines how the efficiency of the furnace changes with cycle length and other critical variables. Development of FAST is detailed in "The Development of a Field Furnace Efficiency Test: A More Accurate Prediction of Seasonal Efficiency" by the author, Fifth International Energy Program Evaluation Conference, Chicago, Ill. 1991.

LONG TERM (PFT) TRACER GAS MEASUREMENT

Long term tracer gas measurement has the advantages of relatively low cost and direct measurement of the dilution of a known "pollutant" over time. This technique is described under Step 4, "Determining the Cooling Savings Estimation Strategy."

We propose a two mode analysis of PFT data for the heating portion of this study. For units with centrally ducted heating systems, the ventilation rate will be significantly different when the unit is on and when it is off. This is due to the fact that duct leaks significantly increase the ventilation rate of the structure. In this analysis, the relationship between the two ventilation rates will be estimated based on one time measurements of duct leakage. Additionally the three channel monitor will determine the percentage each mode of operation existed during the test period.

For single family structures, the PFT test will utilize two or three zones (living area, attic, and crawlspace).

Step 6. Weatherization of Test Units

This step will require a high degree of coordination in order to be accomplished in the proper time frame. In addition it is essential that the work done on the houses represents a reasonable approximation of what can be accomplished with these weatherization techniques. For this reason half of the units will be inspected.

Steps 7 & 8. Data Retrieval and Analysis

In the final steps the data is downloaded from the three channel monitor via an RS-232 port. FAST data and long term tracer gas results are integrated into the final analysis.

