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1996 & 1997 Measure Retention Study Residential Weatherization Retrofit Incentive (RWRI) Program

Submitted to
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Study ID No. 990

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1996 & 1997 RESIDENTIAL WEATHERIZATION RETROFIT INCENTIVE PROGRAM

STUDY ID NO. 990

EXECUTIVE SUMMARY

Background

The California Demand Side Management Advisory Committee (CADMAC) measurement and evaluation (M&E) Protocols require Retention Studies for specific program years on a program by program basis. The purpose of these studies is to collect data to determine the retention and effective useful life (EUL) of the primary measures specific to each program. This involves measuring the proportion of measures still in place and operational since their initial installation. This information provides the basis for development of *ex post* EULs. The *ex post* EULs are then statistically compared with *ex ante* EULs.

The current study is a Retention Study for the 1996 & 1997 Residential Weatherization Retrofit Incentive Program (RWRI) operated by San Diego Gas and Electric Company (SDG&E).

Program protocols require that Retention Studies evaluate the top 10 measures or 50% of the estimated resource value (whichever number of measures is less). Under this protocol the primary measures for the current study are:

- Attic insulation
- Infiltration

Study Methodology

The sample plan for the current study was designed to maximize the representative measurement of the two primary measures of the RWRI Program (attic insulation and infiltration). To this end, an analysis of program participation database was conducted. It was determined that all program households had at least one infiltration measure installed, while only 17% (n=769) households had attic insulation installed. Therefore, the sample was first randomly sorted by households with attic insulation and then by infiltration measure. This provided a sample more representative of the primary measures determined for the current study. A sample of 350 customers from program years 1996 and 1997 were then surveyed by telephone (a copy of the survey can be found in Appendix A) from the sorted sample listing.

The primary retention measurement is the proportion of measures that are in place and operational. This is derived from survey information by analyzing frequencies and means by each or combined measures. The EUL estimation methodology from the previous RWRI study (Megdal and Associates, March 1, 1999) was adopted to provide both continuity and comparability. This study estimated EULs by calculating the expected median from an exponential model, given the average length of time since installation and the average surviving retention rate

Key Findings

Nearly all (99%) of the attic insulation and 90% of the infiltration measures remained in place (standard deviations = 0.08 and 0.22, respectively). Confidence intervals were calculated at an 80% confidence interval, with $\alpha = 0.2$. Calculated ex post EULs were in excess of ex ante EULs, as follows:

	Ex Ante	*Ex Post*	**Recommended** *Ex Post*
Attic Insulation	20 Years	316 Years	20 Years
Infiltration	10 Years	19 Years	10 Years

The confidence interval for the *ex post* EUL estimate for attic insulation was 155 years to 2,605 years. This range does not include the *ex ante* estimate of 20 years. Per the M&E Protocols the *ex post* EUL would normally be adopted where the *ex ante* estimate is not within the 80% confidence interval. However, a more conservative approach, and the one recommended in the current study, is to adopt the *ex ante* EUL estimate. The model clearly validates that the expected EUL is at least this value. Similarly, the confidence interval for the *ex post* EUL estimate for infiltration measures was 16 years to 24 years. The *ex ante* EUL (10 years) again was not within this range. A conservative approach recommends adopting the *ex ante* EUL estimate for this measure.

INTRODUCTION

Background

Standardized protocols for demand-side management (DSM) evaluation were developed in California through the cooperative efforts of utility DSM evaluation experts, interested parties, regulatory staff, and outside consultants working through the California Demand Side Management Advisory Committee (CADMAC). The measurement and evaluation (M&E) protocols serve as the basis for the measurement of *ex post* energy savings achieved by energy efficiency programs, whose measurement determines the shareholder incentives to be received by the utility due to the utility's performance in obtaining these savings.

The M&E Protocols require Retention Studies at a specified number of years after the program year (depending on the program). The purpose of these studies is to collect empirical data to determine the effective useful life (EUL) for the measures representing the top 50% of resource benefits. These studies involve measuring the proportion of measures still in place that remain operational and effective. These data along with considerations of time since program participation provide the basis for development of the *ex post* EUL. The *ex post* EUL is then compared statistically with the *ex ante* EUL at an 80% confidence level, as mandated by the M&E Protocols.

The current study is the Measure Retention Study for SDG&E's 1996 and 1997 Residential Weatherization Retrofit Incentives Programs (RWRI) and meets the requirements specified in Table 8A and Table 9A of the M&E Protocols. The program provides subsidized weatherization services to residential customers. The current study examined program measures that met the "top 50% of resource benefits" requirement of the M&E Protocols on Table 9A. The measures included in this study were[1]:

1996	% TRC	TRC	Installed Measures
Attic Insulation	29%	$421,769.12	694
Infiltration	33%	$475,828.88	3,908
Total =>	**62%**	**$897,598.00**	**4,602**
1997			
Attic Insulation	19%	$23,542.87	75
Infiltration	50%	$60,563.62	531
Total =>	**69%**	**$84,106.49**	**606**

[1] Data Source SDG&E

Program Overview

San Diego Gas & Electric's RWRI program was part of their DSM Replacement Bid Pilot. To meet the California Public Utility Commission's goal for DSM bidding, SDG&E contracted with SESCO to operate the RWRI program. As part of the program, SESCO offered free conservation improvements to selected homes. The program operated as approved by the CPUC on February 8, 1995 in Application 94-08-038. SESCO targeted customers based upon customer consumption history. The conservation measures installed included: attic and ceiling insulation, weatherstripping, caulking, outlet insulation, sealing by-passes, low-flow showerheads, water heater and pipe wraps, and compact fluorescent lights. The intent of the program was to reduce heating and cooling losses, resulting in energy savings for customers and the utility.

Methodology

Per M&E Protocols, a goal of 350 surveys was established for the current study. About 17% of the program participants had attic installation installed and all of the participants had at least one infiltration measure installed. To ensure representation across the primary measures, all of the attic insulation participants were randomly sorted. Then the remaining participants were randomly sorted. This second group of customers was then appended to the first sample. CIC Research, who conducted the telephone portion of the survey, was told to sample the participants in that order. This maximized the representativeness of the primary measure data.

The current study's approach and protocols were designed to meet the challenges presented in obtaining retention information years after participation, while ensuring a high quality data and customer service. This was accomplished through a carefully designed survey instrument and the use of well-trained interviewers with many years of experience in providing utility customer services. Data collection and analysis were conducted under established Protocols. Protocols were also established and implemented to ensure proper customer service and working relationships with SDG&E.

A simple, straightforward survey was designed and implemented to minimize participant confusion and obtain accurate, representative data. To this end, it was assumed that all of the infiltration measures that could be installed, were installed. In this manner, respondents had only to provide how much of the infiltration measures currently needed replacement and for how long. This greatly facilitated the interpretation of survey results and prompted respondents to provide more and better quality data. In about fifteen questions, respondents could provide no data. The current study handled this missing data in two ways. In the first step, respondents were called back and prompted for 'best estimates'. If this step failed to obtain a response, missing data were substituted with the average age and percentage of non-missing data. Retention and age data were then re-calculated with this additional substituted data.

The primary retention measurement was the proportion of measures that remained in place and operational. The retention information, along with considerations of time since program participation, provided the basis for development of the *ex post* EUL. The *ex post* EUL was then statistically compared with *the ex ante* EUL.

Effective Useful Life (EUL) Analysis

The purpose of EUL Analysis is to determine an *ex post* EUL estimate that is then compared to the *ex ante* EUL estimate. The *ex ante* EULs for the current study measures was 20 years and 10 years (attic insulation and infiltration, respectively). Measure retention data and survey responses (surviving percentage and age) were the basis for development of the *ex post* EUL estimates. Of course the best measurement of EUL would utilize retention measurements that occurred long enough after installation, to be likely to capture the median life (i.e., achieving a retention rate of 50 percent or less). This study, however, does not have that luxury.

Many energy-efficiency retention studies examine energy efficiency equipment as being either there or not. This dichotomous scale allows the possibility of using classical survival analysis techniques. Insulation and infiltration, however, can have partial retention. They are not necessarily either there or not, as is the case for many efficiency equipment measures. This range of possible retention estimates means that techniques that rely on 0-1 measurement are not appropriate. This makes classical survival analysis an inappropriate technique.

A common model form in classical survival analysis is an exponential failure model. Though we do not have a 0-1 measurement that allows for classic survival analysis, we can still use an exponential model. One of the primary advantages of using an exponential model is that it provides a simple assessment of the median and, therefore, makes EUL prediction relatively straightforward. With these advantages, an exponential model was selected to predict the EULs in the previous RWRI Retention Study. The current study adopted this EUL methodology for the same reasons. In addition, it provides continuity and comparability between the two studies and facilitates additional analyses and review. The basis of this classic exponential failure model is shown below:

The exponential survival function is: $S(t) = e^{-\lambda t}$
The mean survival time is then $1 / \lambda$.
Defining the EUL as the median creates the following equation: $S(t) = e^{-\lambda t} = 0.5$
Solving for t = EUL, *obtains*: $EUL = - \ln (0.5) / \lambda$

Observing S in a sample with average measure age t can then be used to solve the survival function for $\lambda = \ln (S) / t$. Substituting into the previous equation provides the formula for predicted EUL, as follows:

Predicted EUL = (t * ln (0.5)) / ln (S), *where*: S = survival proportion

The predicted EUL (*ex post* EUL) was compared to the *ex ante* EUL to derive the EUL realization rates. The resulting formula is: EUL Realization Rate = *ex post* EUL / *ex ante* EUL

Confidence intervals

The confidence intervals were then estimated using the predicted EUL equation and the confidence interval upper and lower limits for *S* and *t*. The confidence interval calculations are based upon well-accepted formulas that are used to estimate confidence intervals for sampling error. The retention estimates are means and are, therefore, point estimates. As such, the calculation of the confidence level was based on the formula for confidence intervals for point estimates. This formula is as follows:

Lower interval = mean - t * (SD / √n)
Upper interval = mean + t * (SD / √n)

where:

t = score for statistical significance
SD = standard deviation
n = sample size

Study Findings

Nearly all of the attic insulation (99%) and infiltration measures (90%) remained in place and operational. Confidence intervals were calculated at an 80% confidence interval, with an alpha of 0.20 (as directed by the M&E Protocols). Both *ex post* EULs were in excess of the *ex ante* EULs, as follows:

	Ex Ante	***Ex Post***	**Recommended *Ex Post***
Attic Insulation	20 Years	316 Years	20 Years
Infiltration	10 Years	19 Years	10 Years

The confidence interval for the *ex post* EUL estimate for attic insulation was 155 years to 2,605 years. This range does not include the *ex ante* estimate of 20 years. In practice, the *ex post* EUL would normally be adopted where the *ex ante* estimate is not within the 80% confidence interval (M&E Protocols). However, a more conservative approach, and the one recommended in the current study, is to adopt the *ex ante* EUL estimate. The model clearly validates that the expected EUL is at least this value. Similarly, the confidence interval for the *ex post* EUL estimate for infiltration measures was 16 years to 24 years. The *ex ante* EUL (10 years) again was not within this range, as well. Once again, the most conservative approach is a recommendation to adopt the *ex ante* EUL estimate for this measure.

M&E PROTOCOLS TABLE 6

FOR

1996 & 1997 RESIDENTIAL WEATHERIZATION RETROFIT

INCENTIVES PROGRAM

MARCH 2001

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TABLE 6 for RESIDENTIAL WEATHERIZATION RETROFIT INCENTIVE RETENTION STUDIES for 1996 & 1997

Item 1		Item 2	Item 3	Item 4		Item 5	Item 6		Item 7	Item 8
Study Measure	End Use	*Ex Ante* EUL	*Ex Post* EUL From Study	*Ex Post* EUL For Earnings	Recommend *Ex Ante* EUL	*Ex Post* EUL Standard Error[1]	80% Confidence Interval Lower Bound	80% Confidence Interval Upper Bound	*Ex Post* EUL p-Value	EUL Realization Rate (*Ex Post/Ex Ante*)
Attic Insulation	Space Conditioning	20 Years	316 Years	316 Years	20 Years	SD for Retention Estimate: 0.07963 (Mean = 0.9919)	155 Years	2,605 Years	<0.05	15.8
Infiltration	Space Conditioning	10 Years	19 Years	19 Years	10 Years	SD for Retention Estimate: 0.22074 (Mean = 0.9042)	16 Years	24 Years	<0.05	1.90

[1]Confidence Intervals

	% Surviving Measures		Age of Surviving Measures	
	Attic Insulation	Infiltration	Attic Insulation	Infiltration
Mean =	0.9919	0.9042	3.700	2.801
n =	161	350	161	350
SD =	0.07963	0.22074	0.599	1.824
Confidence Interval =	0.0080578	0.01514993	0.0605727	0.1252108
Lower Bound =	0.98	0.89	3.639	2.675
Upper Bound =	1.00	0.92	3.760	2.926

M&E PROTOCOLS TABLE 7

FOR

1996 & 1997 RESIDENTIAL WEATHERIZATION RETROFIT

INCENTIVES PROGRAM

MARCH 2001

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M&E PROTOCOLS TABLE 7

DATA QUALITY AND PROCESSING DOCUMENTATION

1996 & 1997 Residential Weatherization Retrofit Incentive Program

March 2001

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B. RETENTION STUDIES

1. Overview Information

a. **Study title and study ID: 1996 & 1997 Residential Weatherization Retrofit Incentives Program, Study ID No. 990.**

b. **Program, program year(s), and program description (design):** RWRI Program for the 1996 and 1997 program years. The program is designed to provide assistance for weatherization measurements to be added to residential customers' households.

c. **End uses and measures covered:** Weatherization measures: Attic insulation and infiltration.

d. **Methods and Models Used:**

1.) EUL is the result of calculating the expected median from an exponential model given the average length of time since installation and the average retention rate at the time. The model is as follows (a more detailed explanation can be found on page 2 of this report):

Predicted EUL = (a * ln(0.5)) / ln(s)

where:

a = average measure age
s = survival proportion.

2.) As the retention estimates are means, confidence interval calculations are based on the point estimate formula given below:

Lower interval = mean - t * (SD / √n)
Upper interval = mean + t * (SD / √n)

where:

t = score for statistical significance
SD = standard deviation
n = sample size

e. **Analysis sample size:** As shown in table below:

Program Year	Measure	# of Customers in Program	# of Installations In Program	Sample Frame	# of Measures In Sample Frame	Study Date
1996	Attic Ins.	3,908	694	142	142	April - 98
	Infiltration	3,908	3,908	264	305	April - 98
1997	Attic Ins.	531	75	19	19	April - 98
	Infiltration	531	531	37	45	April - 98
Both Years	Attic Ins.	4,439	769	161	161	April - 98
	Infiltration	4,439	4,439	350	350	April - 98

2. Database Management

a. **Data sources:** The data came from the following sources:

- Customer name, address, telephone number, installed measures, and participation date from the program tracking database.
- Attic insulation and infiltration measures were determined through a telephone survey (described in the report section entitled Sampling and Data Collection).

The data were merged to form the dataset for the econometric analysis leading to the estimated Effective Useful Life.

b. **Data attrition:** The goal was to achieve a sample of 350 completed surveys for the combined programs years (1996 and 1997).

SDG&E RWRI Study
Final Dialing Results
April 2000

Call Result	Number	Percent
Completed interviews	**350**	**23.2**
Answering machine	102	6.8
Refusals	46	3.1
Callbacks	28	1.9
No answer	58	3.8
Number not in service	533	35.4
Wrong number	155	10.3
Business number	128	8.5
Other language	10	0.7
Busy number	34	2.2
No knowledge of program	58	3.8
Blocked number	5	0.3
	1,507	**100.0%**

c. **Data quality checks**: The data sets for the regression analysis were merged in SPSS by the appropriate key variables. Counts of the data set before and after the merges were verified to ensure accurate merging.

d. **All data collected:** All collected data for these analyses were utilized.

3. Sampling

a. **Sampling procedures and protocols:** A goal of 350 completed surveys was established. All of the program participants had at least one infiltration measure installed, while only 17% of participants had attic insulation installed. Therefore, all of the attic insulation participants (n=769) were randomly sorted separately and the remaining participants were then randomly sorted. The two files were then appended to each other, with the randomly sorted list of attic insulation participants first. CIC Research was then instructed to sample the customers in that order. See the section of the report entitled Sampling and Data Collection and section 2.b, above, for a detailed description of call responses.

b. **Survey information:** A copy of the SDG&E RWRI telephone survey is attached at the end of the report. The survey response rate was 23%. Nearly half of the program participants (46%) had "out of service" or "wrong numbers". This probably indicates a fairly high turnover of participants in the RWRI program population.

c. **Statistical descriptions:** Key variables consisted of: the average age of currently installed measures and the proportion of measures still in place.

4. Data Screening and Analyses

a. **Outliers and missing data points:** No outliers. Missing variables were substituted with the average removed measure age or retention percentage (n = 15). This was the most conservative approach to handling these data.

b. **Background variables:** Not applicable

c. **Screened data:** Not applicable

d. **Model statistics:** See M&E Protocol Table 6.

e. **Specification:** Measure failures were independent, as none of the attic insulation measures coincided with an infiltration measure failure. An exponential survival model was used in conjunction with these data (see section 1.d, above).

1) **Heterogeneity:** Not applicable.
2) **Omitted factors:** None omitted.

f. **Error in measuring variables:** Not applicable.
g. **Influencing data points:** None.
h. **Missing** data: None
i. **Precision:** The calculation for the standard error is based on the expectation of the second-derivative matrix for the log-likelihood function.

MEASURE RETENTION SURVEY

FOR

1996 & 1997 RESIDENTIAL WEATHERIZATION RETROFIT

INCENTIVES PROGRAM

MARCH 2001

STUDY ID NO. 990

Homeowner Insulation and Infiltration Study
April 2000

Hello. This is _____, I am calling on behalf of San Diego Gas & Electric Company. They want to know if the energy-efficiency measures installed in your home a few years ago are still in place. Have I reached the residence at (address)?

(**If no, terminate the survey and thank customer**).

A. Am I speaking to the person in your household who is most knowledge about the energy-efficiency measures that were installed?

1 yes (CONTINUE)
2 no (ASK TO SPEAK TO THAT PERSON, RESCHEDULE IF NECESSARY)

1. (**ATTIC INSULATION**:) Thinking about your home's attic insulation. Has any remodeling, new construction, or major damage caused any of the insulation to be removed?
FROM CONTACT SHEET

1 yes (CONTINUE)
2 no (SKIP TO Q2)

1a. Approximately what percentage would you say was removed? _____ %

1b. When was the attic insulation removed? _____ (**MONTH**) & _____ (**YEAR**).

2. (**INFILTRATION**:) Thinking about the weatherstripping, caulking, and insulation around your doors, windows, and plumbing. Does any of it currently need to be replaced?
FROM CONTACT SHEET

1 yes (CONTINUE)
2 no (TERMINATE SURVEY AND THANK CUSTOMER)

2a. Approximately what percentage needs to be replaced? _____ %

2b. When did you notice it needed replacement? _____ (**MONTH**) & _____ (**YEAR**).

(TERMINATION MESSAGE)

"Thank you very much for your time and cooperation."