Final Report

Measure Retention Study – 1996 & 1997 Residential Weatherization Programs (RWRI) Study Id No. 991

Submitted to San Diego Gas & Electric Company

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Megdal & Associates

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by

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Executive Summary

Background and Study Method

The California Demand Side Management Advisory Committee (CADMAC) measurement and evaluation (M&E) Protocols require Retention Studies at specific retention years depending on the program. The purpose of the Retention Study is to collect data to determine the retention and effective useful life (EUL) for the primary measures in the program. This involves measuring the proportion of measures still in place, operational, and effective. The retention information along with considerations of time since program participation provide the basis for development of the *ex post* EUL. The *ex post* EUL is then statistically compared with *the ex ante* EUL.

This study is the Measure Retention Study for the 1996 and 1997 Residential Weatherization Retrofit Incentives Programs (RWRI) operated by San Diego Gas & Electric Company (SDG&E). This report includes the tables required by the measurement and evaluation (M&E) protocols[1].

The measures included in this study were the primary measures for the RWRI programs. These are: Attic and ceiling insulation, and Infiltration measures.

The sampling plan was designed to meet the M&E Protocol requirements. Telephone surveys were completed with 200 households with attic insulation and 399 with infiltration measures.

The primary retention measurement is the proportion of measures that are in place and operational. This is derived from survey information by analyzing means of the participant retention data by measure. The Effective Useful Life (EUL) analysis came from calculating the expected median from linear regression model based upon annual participation retention rates within a created time-series cross-sectional model developed from the telephone survey responses. Other EUL models were tested to include: a simple exponential model, and Lifereg survival analysis.

[1] *Prepared Testimony of Kevin C. McKinley, Chair, California DSM Measurement Advisory Committee (CADMAC) in the 1998 Annual Earnings Assessment Proceeding (AEAP) Before the Public Utilities Commission of the State of California*, September 8, 1998, pp. 11.

Findings

The sample sizes and retention estimates are provided in Table ES.1. Retention for attic insulation was found to be 97.96% at the 9th year evaluation. Retention for infiltration measures was found to be 72.15%.

Table ES.1 Retention Findings

Attic insulation	**N**	**Mean**	**Standard Deviation**
Duration	194	8.76	1.1852
Retention rate	195	97.96	11.9615
Infiltration	**N**	**Mean**	**Standard Deviation**
Duration	375	7.54	2.0949
Retention rate	399	72.15	31.6648

The *ex post* EUL estimates from the exponential model, *ex ante* EULs, and recommendations are summarized in Table ES.2.

Table ES.2 EUL Estimates and Recommendations

	Attic Insulation	**Infiltration**
Ex ante EUL	20 years	10 years
Ex post EUL	185 years (Linear regression)	18 years (Linear regression) 13 years (Regression with duration squared)
Ex Post EUL recommended	20 years (*Ex ante* more reasonable & test duration not long enough.)	10 years (*Ex ante* within confidence interval of duration squared analyses.)
80% Confidence Interval at 20% p-value	136 to 287 years (Linear regression)	16.5 to 19.6 years (Linear regression)

All of the EUL models tested with the attic insulation data found extremely high EUL estimates. The retention measurement at the 9th year is still less than half this measures *ex ante* EUL. The non-linear expected nature of survival functions (see Section 2.5 for further detail on this issue) and this still early measurement is not providing enough retention loss data to properly establish the likely functional form and estimate a reliable EUL. Given this, we are recommending using the ex ante EUL of 20 years as a conservation estimate. At the 9th year attic insulation retention is still over 97.96% according to this study.

The 9th year data provides much more information for estimating the EUL for infiltration. The *ex ante* EUL for infiltration is 10 years. The retention rate has also dropped to 72.15% by the 9th year. A multi-question approach with inquiries for dates when infiltration was either removed/replaced or noticed in need of replacement allowed the creation of annual participant retention rates within a time-series cross-sectional dataset development.

Linear regression using this dataset found an *ex post* EUL for infiltration of 18 years. Though the overall statistics would at first glance appear stronger for the linear model, the regression model that utilized duration-squared bears a functional form more akin to the non-linear nature expected and seen thus-far in the data. This specification provided an *ex post* EUL of 13 years. A conservative error bound at the 80% confidence level as required by the M&E Protocols, however, includes the 10-year ex-ante estimate. Given this, we recommend using the *ex-ante* 10 year infiltration EUL for this program as a conservative estimate.

1.0 Introduction

1.1 Project 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). These measurement and evaluation (M&E) protocols are the standardized expectations for DSM evaluation which serve as the basis for the measurement of *ex post* energy savings caused 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 the Retention Study is to collect data to determine the empirical effective useful life (EUL) for the measures representing the top 50% of resource benefits[2]. This involves measuring the proportion of measures still in place, operational, and effective. The retention information along with considerations of time since program participation provide the basis for development of the *ex post* EUL. The *ex post* EUL is then statistically compared with the *ex ante* EUL at an 80% confidence level[3].

This study is the Measure Retention Study for the 1996 and1997 Residential Weatherization Retrofit Incentives Programs (RWRI) operated by San Diego Gas & Electric Company (SDG&E). It meets the requirements of the fourth year retention studies specified in Table 8A and Table 9A of the M&E Protocols. This report also presents Tables 6 and 7 as required by the M&E Protocols as modified according to CADMAC testimony on September 8, 1998.[4]

The RWRI program provided subsidized weatherization services to residential customers. The Study examined program measures that allowed for meeting

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2 *Prepared Testimony of Kevin C. McKinley, Chair, California DSM Measurement Advisory Committee (CADMAC) in the 1998 Annual Earnings Assessment Proceeding (AEAP) Before the Public Utilities Commission of the State of California*, September 8, 1998, pp. 11.

3 Ibid, pp. 16.

4 *Prepared Testimony of Kevin C. McKinley, Chair, California DSM Measurement Advisory Committee (CADMAC) in the 1998 Annual Earnings Assessment Proceeding (AEAP) Before the Public Utilities Commission of the State of California,* September 8, 1998.

the "top 50% of resource benefits" requirement of the M&E Protocols on Table 9A. To ensure surpassing this criteria, there are two categories of measures which are examined in this study: attic and ceiling insulation, and infiltration measures.

Figure 1.1 displays the percentage of electric savings for these measure categories versus others for 1996. Figure 2 provides the same information for 1997. Figure 3 provides the distribution of therm savings in 1996 while Figure 4 displays this for 1997. Measures included in this study constitute between 76% to 85% of the energy savings in any year or fuel type.

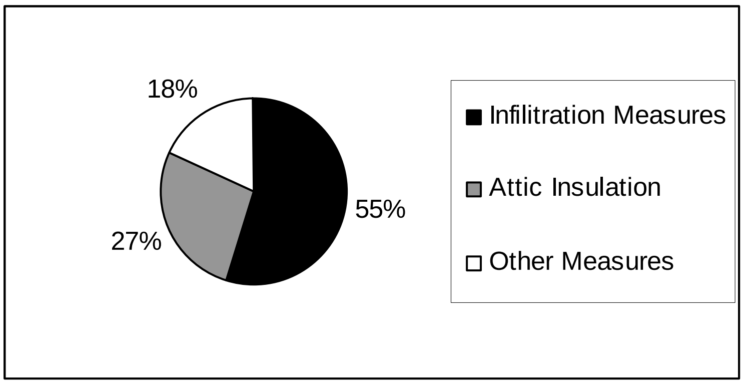


Figure 1.1 1996 RWRI Distribution of kWh Savings

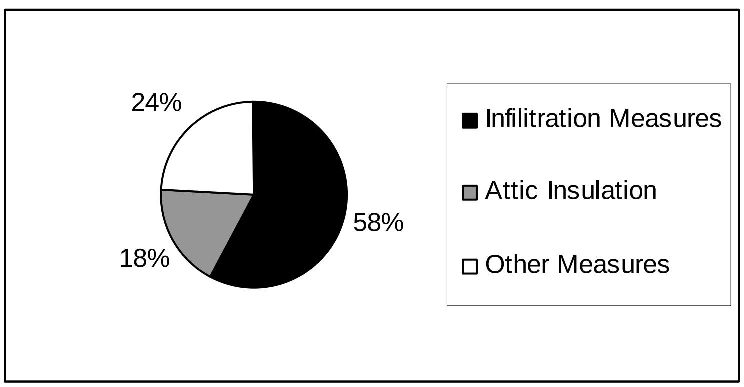


Figure 1.2 1997 RWRI Distribution of kWh Savings

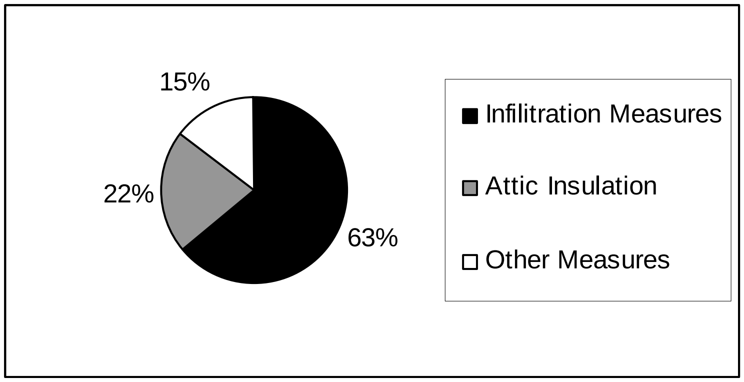


Figure 1.3 1996 RWRI Distribution of Therm Savings

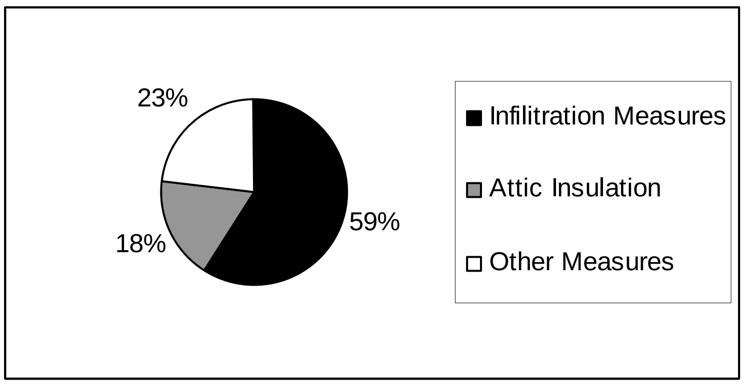


Figure 1.4 1997 RWRI Distribution of Therm Savings

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 of the site visit data by measure. The retention information along with considerations of time since program participation provide the basis for development of the *ex post* EUL. The *ex post* EUL is then statistically compared with *the ex ante* EUL.

A telephone survey instrument was designed to provide the most reliable information that could be obtained on the retention of attic insulation and infiltration measures many years after program installation. There were several components within the survey designed to increase the ability of the analysis of this data to reliably ascertain effective retention. The primary elements of this is by including not only whether it had to be replaced but also whether it is in need of replacement and when it was replaced or noticed that it was in need of replacement. Another important aspect for retention studies is in targeting the treated home rather than the occupant during program for the survey inquiry.

1.2 Program Overview

San Diego Gas & Electric's RWRI program was part of their DSM Replacement Bid Pilot as a result of meeting the California Public Utility Commission's goal for DSM bidding. SDG&E contracted with SESCO to operate the RWRI program whereby 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.

1.3 Report Overview

Section 1 has provided an overview of the project, being completed with this overview of the report itself. Section 2 presents the methodology of the study. The last section, Section 3, presents the study findings including information on the sample, measure retention estimates, and the effective useful life examination (EUL). The last subsection of Section 3 also presents a summary of the documentation protocols as required in Table 7, and the reporting protocols as required in Table 6 of the revised M&E Protocols. The body of the report is followed by appendices that contain the survey instrument; and the datasets and documentation for the study (in accordance with the M&E Protocols).

2.0 Methodology

2.1 Measurement Issues

Retention Measurement

One of the primary objectives of this study was to answer the questions: "Is the measure still in place?; Is it operational?; and Is it still effective?". This is in accordance with the M&E Protocols' definition of a Measure Retention Study:

> "An assessment of (a) length of time the measure(s) installed during the program year are maintained in operating condition; and (b) the extent to which there has been a significant reduction in the effectiveness of the measure(s)."[5]

The methodology selected was based upon these needs, understanding the differences between a measure retention study and a persistence study, and developing a workable methodology for conducting a telephone survey to gather the data to answer this question.

This study was designed only as a measure retention study and not a persistence study. Only a few practitioners with significant experience in conducting persistence studies understand the differences between these two types of studies. One of the primary differences after the studies are conducted lies in their acceptable uses. Given that this study is a measure retention study, the results should only be used as a measure retention study (unless further adjustments and examinations are made).

An example of an improper use of a measure retention study would be to use its results along with prior impact evaluation. This improper use of the retention results could yield a double-counting of losses. As an example, suppose a program database indicated that 100 low flow showerheads should have been installed. Then an impact evaluation is conducted one year post-participation. This impact evaluation finds 97 showerheads installed (or implicitly accounts for this loss in a lower realization rate in a billing analysis such as a 97% realization rate). Then suppose two years later a retention study is done and finds 90 showerheads in place and operational. If the study were conducted as a measure retention study only, using as its baseline the program database, the retention study would find a loss of 10 showerheads (100-90) or a 90% retention. This could be an accurate measure retention estimate.

[5] Measure Retention Study definition from page A-7 of the March 1998 edition of the California Measurement & Evaluation (M&E) Protocols.

However, if the retention study results were applied to the impact evaluation's savings to estimate savings still being achieved, there would be a double-count of the 3% loss. The persistence retention rate would need to be re-estimated as 93% (90/97) in order to be applied to the impact savings estimate. Of the 10 showerheads not in place at the time of the retention study, three are in the program database but were never actually installed and seven were the retention loss in the form of persistence from the impact evaluation.

As this study is a measure retention study, and not a persistence study, it did not gather data on usage or analyze data measuring potential long-term participant spillover (market transformation for participants), as doing so could cause confusion to readers of the report.

Effective Useful Life Measurement

The second primary objective of this study is to assess *ex post* effective useful life (EUL). This assessment primarily lies upon analysis of the retention information. The telephone survey also included follow-up questions for cases of removal and for respondents answering that the measure is in need of replacement as to when this occurred or was noticed. This allowed the analysis to be examined as not just two points in time but also as retention over the full time period since installation.

2.2 Survey Instrument and Protocols

The telephone survey was designed to meet all the demands discussed above that are necessary to create a reliable retention and EUL analysis for insulation and infiltration measures. Yet, a short and straight-forward survey was also a desired design parameter. This was accomplished in a two-page survey instrument.

The procedure for the telephone survey was to call the participant and double-check they were at the same address before initiating the survey. If the phone number was no longer valid or they were at a different address, then a look-up was made for the current telephone number at the participating address. The residents of these homes were then called to participate in the survey. The survey was worded to be applicable to both residents who had been participants and those who moved into homes that were retrofitted. The survey then also established that new residents had moved into the retrofitted home and when this occurred. This procedure was developed to help ensure that the resulting analysis from the data gathered would not be biased due to movement in and out of retrofitted homes over the last nine (9) years.

The short survey then asked survey respondents whether they have removed or replaced any weatherstripping, caulking, and insulation around the doors, windows, outlets, and plumbing since 1996. If so, they were asked what percent was replaced or removed and when this occurred. The survey also allowed them to provide multiple years that they may have done this. This is used to measure infiltration retention.

The survey then followed with similar questions about remaining weatherstripping and caulking if any of it needed replacing, what percent, and when they noticed it needed replacing. This second series of questions allows the survey to additional consider operational retention for the infiltration measures.

The last series of survey questions asked residents about removing or replacing attic insulation for those homes that received attic/ceiling insulation measures. Again the survey asked whether this occurred, if so what percentage was removed/replaced, and then when this occurred.

The survey instrument is provided as Appendix A to this report

2.3 Sampling

Random sampling is the easiest way to insure generalizability of the results to the overall population. It is also the easiest to use and to explain. Given this, random sampling is an important part of the sampling plan.

Almost all participating homes received infiltration measures. Less than one-fifth of the homes needed and received attic or ceiling insulation. This means that simple random sample of the participants would obtain far too few sample points to analyze attic insulation retention. So a stratified sampling plan was developed to ensure adequate coverage of attic insulation participants and infiltration measures with and without attic insulation to be weighted so each type is properly represented in the infiltration analysis.

The measure counts, sampling goals, and number of completion sample points are shown in Table 2.1.

Table 2.1 Measure Counts, Sampling Goals, and Sample Completes

Measures	Program Participant Count	% of Population
Infiltration	4,375	98%
Attic/ceiling insulation	768	17%
Measures	**Sample Goals**	
Infiltration & attic insulation	198	
Infiltration & no attic insul.	150	
Infiltration total	348	
Attic insulation total	200	
Measures	**Completed Samples**	
Infiltration & attic insulation	199	
Infiltration & no attic insul.	199	
Infiltration total	398	
Attic insulation total	200	
Total sample	399	

2.4 Analysis for Retention Estimates

Many of the retention equipment studies examine whether or not the piece of equipment is still in place and operational. Contrary to this, all the primary measures of the RWRI programs could be totally there, partially there or not there at all. It is not an all or nothing possibility.

Insulation and infiltration measures could have part of the installed measure removed. The instrument accounted for this by asking what percent was removed, replaced, or needing replacement. Instead of a dichotomous variable retention for these measures are interval data from zero to 100%.

The retention that is both in place and operation is 100% minus the sum of the percentage removed or replaced and the percentage that needs to be replaced.

2.5 Effective Useful Life Analysis

The purpose of the EUL analysis is to create an *ex post* EUL estimate that is then compared to the *ex ante* EUL estimate. The *ex ante* EULs for this study are 10 years for infiltration and 20 years for attic insulation as such in Table 2.3.

Table 2.3 *Ex Ante* EULs for Primary RWRI Measures

Measures	*Ex Ante* EUL
Attic insulation	20 years
Infiltration	10 years

The measure retention percentage and the answers to when the insulation measures were removed/replaced or needed to be replaced are the basis for development of the *ex post* estimate of Effective Useful Life (EUL). We recognize that the best measurement of EUL would utilize retention measurement 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. The M&E Protocols calls for a 9th year retention study for these programs, with this study to include development of an *ex post* EUL and a comparison of the *ex post* EUL to the *ex ante* EUL by measure.

Many energy efficiency retention studies examine energy efficiency equipment as being either there or not. This dichotomous scale allows the possibility of the most common classical survival analysis techniques. These techniques originated in the medical field where the concern was for mortality or whether someone contracted the studied disease. These outcomes are dichotomous, they either occur or not and can be measured as zero or one events.

Insulation and infiltration can have partial retention and we have measured these as interval data. This is the dependent variable of interest.

The EUL exam for each measure examined EUL estimates from three methods. The M&E Protocol definition of EUL, as modified according to CADMAC testimony on September 8, 1998, is:

> "An estimate of the median number of years that the measures installed under the program are still in place and operable."[6]

The methods selected had to be able to provide an estimation of retention (our dependent variable) at a fitted/forecasted retention at the 50% or median useful life.

The three methods tested were:

1. An exponential failure model as was used in the 4th year retention study for the 1994, 1995, 1996, and 1997 RWRI program years.
2. A general linear regression based with duration as the independent variable and a second model with the independent variables as duration

[6] *Prepared Testimony of Kevin C. McKinley, Chair, California DSM Measurement Advisory Committee (CADMAC) in the 1998 Annual Earnings Assessment Proceeding (AEAP) Before the Public Utilities Commission of the State of California,* September 8, 1998, p. 20.

and duration-squared (due to an expected inflection point in the retention rate).

3. A survival analysis using the LIFEREG procedure in SAS® specifically designed to estimate censored hazard functions with interval dependent variables.

A summary of each of these methods is provided below along with a synopsis of their advantages and disadvantages. The final estimate is selected based upon its reasonableness, and likely reliability given its robustness in utilizing the data available.

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 it straight forward to predict the effective useful life (EUL). This simple model has been selected in 4th year studies due to its ability to provide estimates with very few failures in the retention database. (The survival techniques were found to not be solvable, no convergence, given few failures and little variation in the data.) At the same time, this simplistic model does not make use of the full cross-section time-series and interval dependent variable data available in this 9th year study.

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:

$$\text{EUL} = -\ln(0.5)/\lambda$$

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 us with the formula for the predicted EUL as follows:

$$\text{Predicted EUL} = [t \ln(0.5)] / \ln(S) \quad \text{where S=survival proportion}$$

The predicted EUL (*ex post* EUL) is compared to the *ex ante* EUL to derive the EUL realization rates. This is expressed as:

EUL Realization Rate = *Ex Post* EUL/*Ex Ante* EUL

Confidence intervals are then estimated using the predicted EUL equation and the confidence interval upper and lower limits for S and t.

The telephone survey for this study was designed to collect a maximum of interval and time-series data by asking percentages removed/replaced and when these actions occurred. From these responses a full time-series cross-sectional data set could be created that had interval measures of operational retention that varied over time for participating homes. For example, if someone said that they replaced 40% of their infiltration in 2000 and they noticed in 2004 that another 20% needed replacement then observations for operational retention were created for each year from 1996 through 2005. In this example, the operation infiltration retention was 100% from 1996 until 2000, 60% from 2000 through 2004 and 40% in 2005. A full time-series cross-sectional analysis dataset from the cross-section survey responses was developed for all survey participants for attic insulation and for infiltration measures.

The time-series cross-sectional dataset with an interval dependent variable allowed linear regression models to be tested. This provides considerably more data to be used to analyze and estimate the median life than the simple exponential models used in prior studies. It is also provides a much finer interpretation to a dependent variable that is interval rather than dichotomous. It does, however, require forecasting outside the bounds of the observed data, particularly in the case of the longer lasting attic insulation measure. There is also no guarantee that a solution will be able to be derived.

Two regression models were tested for both measure categories. One was a simple linear model based upon duration and the second contained both duration and duration squared. The squared term was tested to find and represent the inflection point for the expected change in the rate of retention over time. These models appear as follows:

$$OR_{it} = B_0 + B_1 Dur_{it} + e_i$$

where:

OR_{it} = Operational retention (remove/replaced and needing to be replaced for infiltration measures) for customer "i" in time "t"

B_0 = Intercept

Dur_{it} = Duration for customer "i" at time "t".

e_i = Statistical error term, for unexplained variance.

$$OR_{it} = B_0 + B_1 Dur_{it} + B_2 Dur\_Sq_{it} + e_i$$

where:

OR_{it} = Operational retention (remove/replaced and needing to be replaced for infiltration measures) for customer "i" in time "t"

B_0 = Intercept

Dur_{it} = Duration for customer "i" at time "t".

Dur_Sq_{it} = $Dur_{it} * Dur_{it}$, duration squared for customer "i" at time "t".

e_i = Statistical error term, for unexplained variance.

The median for the EUL for a dichotomous measure is viewed as when 50% of the equipment is still there and operational and 50% is no longer there or operational. The interval data for these measures could occur when 50% of the homes have zero insulation while 50% have 100% operational retention or when all homes have 50% retention or other combinations that equate to an overall mean of 50% operational retention. The EUL value is then derived from the regression model results for at what duration does the mean operational retention equal 50%.

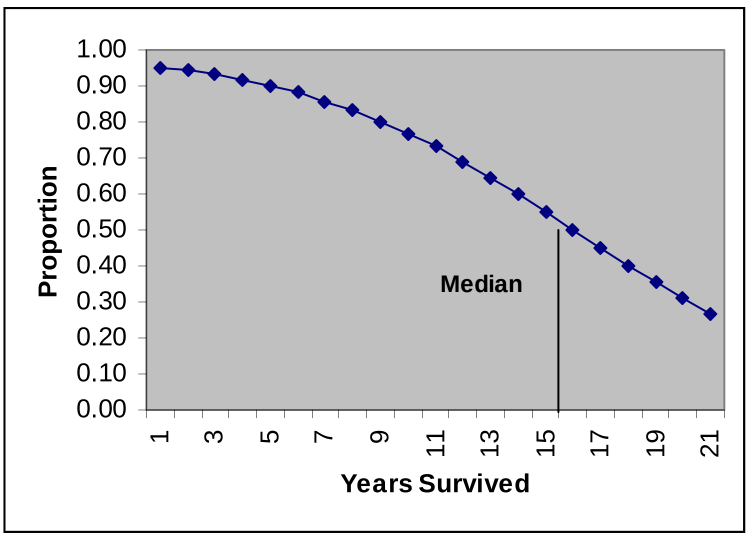
The 80% confidence interval for the regression-based EUL estimate is derived by using 1.645 times the standard error of the coefficient estimate(s). The confidence interval is then the duration that equates to a 50% dependent variable at plus and minus this confidence interval around the regression estimate.

Expectations and observations suggest that a likely lifetime pattern would consist of little loss in the early years and increasing loss (hazard probability) as the measure approaches its expected life, with a flattening hazard occurring thereafter. The logistic function is one that would often fit this pattern, relying upon a logistic function of time and the EUL. This is written as:

$$F(Z_i) = 1\text{-}[1/(1 + e^{-(t + \text{EUL})\ b})$$

The survival function with an EUL of 15 (and b as 0.2) would appear as shown in Figure 2.1.

Figure 2.1 Logistic Survival Function with EUL=15 and b=0.2



The best estimation of this function would occur when all participants have removed/replaced all of the efficiency measure. This would allow estimation of the full functional form to occur from the data observed. However, we seldom have this luxury as the estimation of the EUL (survival statistics) is normally desired sometime earlier in order to make decisions about future investments.

Unless the data collection occurs after all participants have no operational retention, there is always data for which we do not know when and how quickly retention loss will occur. We do not have complete data for the longer duration occurrences. This is right censored data as we do not have complete data for the right side of the distribution. Survival analysis techniques were developed to handle censored data on the variable of interest and to still obtain an efficient and reliable estimate.

The early survival analysis methods were designed for dichotomous variables. For many years, however, standard survival methods have been available that use maximum likelihood to estimate parametric regression models with censored survival data. The Lifereg procedure in SAS® provides a standard estimation package to undertake this analysis using several different common functional forms. Lifereg was used in this study with tests for a log-normal, Weibull, and an exponential survival distribution functional form.[7]

The Lifereg procedure produces estimated quantile values for each observation. The 50% quantile provides the values used to derive the median by taking the mean of these across the output dataset observations. Chi-square statistics are provided for the overall lifereg analysis and for the variables. Standard errors are produced by the Lifereg procedure and standard deviations are produced as the means are calculated for the 50% quantile.

[7] These models, techniques, and SAS® procedures for this modeling are well described in *Survival Analysis Using the SAS® System: A Practical Guide* by Dr. Paul D. Allison, SAS® Institute, 1995.

3.0 Findings and Results

3.1 Sample Disposition and Weighting

The samples were drawn, checked, and provided for recruitment as planned. The recruiting occurred according to the protocols, resulting in the necessary completed sample points and ensuring that new residents within retrofitted homes are surveyed.

The call disposition for the infiltration sample is provided in Table 3.1. Table 3.2 provides the call dispositions for the attic insulation sample.

Table 3.1 Call Disposition for Infiltration Sample

Call Result	Number	Percent
Completed interviews	***200***	***22.5%***
Number not in service	197	22.1%
Wrong number/wrong address	147	16.5%
Other language	18	2.0%
Business number/fax/modem/cell phone	24	2.7%
Refusal	39	4.4%
Busy number	14	1.6%
No answer	63	7.1%
Answering machine	147	16.5%
Callback	14	1.6%
Respondent never available	6	0.7%
Apartment Complex	21	2.4%
Total	**890**	**100.0%**

Table 3.2 Call Disposition for Attic Insulation Sample

Call Result	Number	Percent
Completed interviews	***200***	***22.6%***
Number not in service	210	23.8%
Wrong number/wrong address	147	16.6%
Other language	18	2.0%
Business number/fax/modem/cell phone	34	3.8%
Refusal	36	4.1%
Busy number	17	1.9%
No answer	97	11.0%
Answering machine	91	10.3%
Callback	18	2.0%
Respondent never available	2	0.2%
Apartment Complex	14	1.6%
Total	**884**	**100.0%**

Analysis was conducted separately for attic insulation from infiltration measures. The attic insulation sample was taken from a simple random sample and required no weighting.

A much smaller proportion of participants had attic insulation than infiltration. Almost all participants had infiltration measures. The infiltration sample was a combination of the entire attic insulation sample that had infiltration plus a random sample of infiltration participants that did not have attic insulation. This provided the highest sample numbers at the lowest cost. This method meant that those with attic insulation in this combination comprise a much higher percentage than would have occurred with a strictly random sample of infiltration participants. In order for the analysis of infiltration to represent the program population weighting had to better balance these two types of infiltration sample. Where there was no attic insulation the weight for the infiltration analysis was set to one (1). For those with both attic insulation and infiltration the weight was set at 0.351968. This allowed the infiltration analysis for these observations to properly represent the combined measure group proportion in the program infiltration population.[8]

[8] This was derived from the ratio of the percentages in the population compared to the percentages in the sample. The percent of participants that have both attic insulation and infiltration compared to the total with infiltration is 17.6%. The same percentage for the attic insulation and infiltration sample compared to the total sample with infiltration is 49.9%. The ratio of 17.6%/49.9% provides the weight used for the sample with both, 0.351968.

3.2 Retention Findings

The complete survey dataset was cleaned within an Excel© spreadsheet. There was an initial read of this information into a SAS® dataset. This dataset was further cleaned to remove customer identification and to allow for enclosure with the datasets and programs provided with this report. This SAS® dataset was then used for further analysis and the creation of more sophisticated datasets as needed. SAS® was used to obtain measure counts, frequencies, computing retention means by measure with weighting as needed, and obtaining statistics for other analyses. (Appendix B provides the names and sequences of all analysis datasets and programs, along with a copy of the datasets and programs as required by the M&E Protocols.)

One-hundred (100%) minus the percent removed/replaced for attic insulation is a participant's retention rate. This varied from zero to 100. Duration was conservatively measured in the cross-sectional dataset (that used for the simple exponential model) as the number of years between installation and the date the respondents said at least some of the attic insulation was removed or replaced. If no attic insulation was removed or replaced, the duration was measured as years since installation until the survey was conducted.

The means (and weighted mean for infiltration) of the survey estimates are the overall measure retention estimates. The mean attic insulation rate is 97.96%. The mean duration is 8.76 years. The mean retention rate and duration, along with their standard deviations, for attic insulation is provided in Table 3.3.

Table 3.3 Retention Findings

Attic insulation	**N**	**Mean**	**Standard Deviation**
Duration	194	8.76	1.1852
Retention rate	195	97.96	11.9615
Infiltration	**N**	**Mean**	**Standard Deviation**
Duration	375	7.54	2.0949
Retention rate	399	72.15	31.6648

For infiltration measures the participant retention rate is 100% minus the percent removed/replaced and minus that which wasn't removed or replaced but is identified as needing to be replaced. This varied from zero to 100.[9] Duration was conservatively measured in the cross-sectional dataset (that used

9 There were a few cases where participants appeared to misunderstand the question and over reported the needing to be replaced figure. Any participant's retention rate was limited to being between zero and 100%.

for the simple exponential model) as the number of years between installation and the average of the dates[10] reported by the respondents for when at least some of the infiltration was removed/replaced or found to be needing replacement. If no infiltration was removed/replaced or found to be needing replacement, the duration was measured as years since installation until the survey was conducted.

The infiltration retention rate (the mean of the participant retention rates from these two types of in-place and operational rates) was 72.15%. The average duration at approximately nine years is 7.54 years. These rates and their standard deviations are reported in Table 3.3 above.

3.3 Effective Useful Life (EUL) Analyses for Infiltration Measures

As discussed in Section 2 on methodology, there were three methods tested for providing reliable EUL estimates for the median, 50% retention rate. These were:

1. An exponential failure model as was used in the 4th year retention study for the 1994, 1995, 1996, and 1997 RWRI program years.
2. A general linear regression based with duration as the independent variable and a second model with the independent variables as duration and duration-squared (due to an expected inflection point in the retention rate).
3. A survival analysis using the LIFEREG procedure in SAS® specifically designed to estimate censored hazard functions with interval dependent variables.

The exponential model was used to calculate the predicted EUL as described in Section 2.5. Recall the equation for the predicted ex post EUL is as follows:

Predicted EUL = $[t \ln(0.5)] / \ln(S)$ where S=survival proportion

The input and predicted EUL results are provided in Table 3.4. A spreadsheet was used to calculate the predicted EUL. However, the formula is simple enough that with the input in Table 3.4 (average retention rate and average duration) the predicted EUL could be produced on a hand-held calculator.

10 Up to five different years were taken as repeated removal/replacement dates for infiltration and another year was collected for those saying that some of the infiltration needed to be replaced.

Table 3.4 Input and Predicted EUL Results from Exponential Model for Infiltration

Average Retention Rate	Average Duration Observed	*Ex Post* Predicted EUL
72.2%	7.5 years	16 years
Standard Deviation	**Standard Deviation**	
31.66	2.09	

An estimate of the confidence intervals for the EUL estimates is derived in a three step process. These steps are:

1. Calculate the confidence intervals for the retention estimate.
2. Calculate the confidence interval for duration.
3. Estimate the low interval EUL confidence number by using the low interval level for retention with the low interval level for duration in the exponential model to obtain maximum low interval. Do the same with the high level to obtain the high interval EUL confidence number.

The confidence interval calculations in steps one and two 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 is straight forward based on the formula for confidence intervals for point estimates. This formula is as follows:

$$\text{Mean} - t\,(sd/\sqrt{N}) < \text{Mean} < \text{Mean} + t\,(sd/\sqrt{N})$$

where:

t = score representing desired level of statistical significance
sd = standard deviation
N = sample size

Table 6 of the M&E Protocols requires the confidence interval be produced for the 80 percent level.[11]

Using the three step process described above, conservative estimates (wide span) of the EUL confidence intervals were made. The *ex post* EUL confidence interval estimates are presented in Table 3.5.

[11] *Prepared Testimony of Kevin C. McKinley, Chair, California DSM Measurement Advisory Committee (CADMAC) in the 1998 Annual Earnings Assessment Proceeding (AEAP) Before the Public Utilities Commission of the State of California*, September 8, 1998, pp. 6.

Table 3.5 *Ex Post* Infiltration EUL Confidence Interval Estimates from Simple Exponential Model

	Confidence Interval* *Ex Post* EUL	
		to
Infiltration	14.7 years	17.6 years

* 80% Confidence interval α=20%.

The above estimate required an assumption of desired level of statistical significance, α. This is setting our Type I error, the risk of rejecting a true hypothesis. There is a trade-off between the degree we are willing to accept a Type I error (rejecting a true hypothesis) and that associated with a Type II error, the error of failing to reject an hypothesis when it is actually false. This α is the p-value required by Table 6 of the M&E Protocols.[12]

The confidence interval for the infiltration EUL as estimated by the simple exponential model is from 14.7 years to 17.6 years. SDG&E's ex ante estimate for infiltration for the RWRI program is 10 years. This estimate clearly exceeds that estimate.

Using the standard deviation of the estimate to develop confidence intervals generally measures sampling error. In general, what is measured is if the exact same measurement tool is used, the confidence level provides us the probability of falling within the interval in repeated samples or, similarly, the probability that the results for the population as a whole would be within the interval around the results found for the sample. This is the standard measurement and use of confidence intervals.

A measurement of the confidence interval does not measure the overall accuracy of the estimate. This is because there are generally two types of possible errors. These are:

1. Sampling error
2. Measurement error

The confidence interval allows us to measure possible sampling error. There is no readily available and accepted measurement to assess measurement error. (Measurement error is the error from the tool or technique used for the measurement or that the hypothesized model is not the one and only true model for the process being examined.)

There are three likely sources of potential measurement error within this estimate. These are: (1) Estimating EUL based upon right censored data

[12] Ibid.

without controlling for this fact; (2) Asking recall for a period of years within a telephone survey; and (3) Obtaining accurate operational retention estimates from residential telephone survey respondents. The instrument and conservative assumptions on duration have attempted to minimize measurement error for items two and three. The other methods examined do a better job of utilizing all the data available and examining the right censored nature of the data.

The second method tested could be conducted due to the creation of detailed dates of removal/replacement/operational status from the telephone surveys and using this via a series of computer programming to create a time-series cross-sectional dataset. (A summary description of the set-up of the observations in this dataset is provided in Section 2.5 above.)

Regression models were run with the dependent variable being the participant retention as it varied over time based upon the two different infiltration retention questions. Two models were tested (as described in Section 2.5). One had only the duration as the independent variable and the other had duration and duration squared. The regression results are shown in Table 3.6.

Table 3.6 Infiltration Retention Regression Results

	Intercept	**Duration** (measured in days)	**Duration Squared**
Linear model- $	101.75	-0.0079	
t-value	132.82	19.11	
Std error of estimate	0.7661	0.000413	
R-Squared	0.0886		
With duration-squared	99.789	-0.003669	-0.00000135
t-value	98.37	2.46	2.95
Std error of estimate	1.014	0.00149	0.00000046
R-Squared	0.0908		

The median EUL estimated by the linear model is a fitted value where the equation equals 50%. This involves solving the equation 50=101.7535719 - 0.0079003*x where x is duration in days. **The infiltration EUL estimate from the linear regression is 17.94 years.**

Using the standard error of the estimate provided by the regression output, multiplying by 1.645 to derive the 80% confidence level at α=20% provides the confidence interval shown in Table 3.7. This is 16.5 to 19.6 years for the linear infiltration regression model.

The median EUL estimated by the regression model with duration squared involves solving the equation 50=99.78935609 – (0.00366939*x) –

(0.00000135*x^2) where x is duration in days. **The infiltration EUL estimate from the regression with duration squared is 13.3 years.**

Following the conservation three-step process for determining the confidence interval for the duration squared model as used in the simple exponential model provides an EUL confidence interval of 9.9 to 22.4 years.

Table 3.7 *Ex Post* Infiltration EUL Confidence Interval Estimates from the Regression Models

	Confidence Interval* *Ex Post* EUL	to
Linear regression	16.5 years	19.6 years
Regression with duration-squared	9.9 years	22.4 years

* 80% Confidence interval α=20%.

The time-series cross-sectional dataset created through both research design and analysis programming, along with the 9-year period for potential change that has occurred, has allowed survival analysis models to be conducted that do reach convergence. This is a significant improvement over what was possible with the 4th year retention data. The results are presented in Table 3.8.

Though survival analysis results were obtainable in this study, the results vary by orders of magnitude depending upon the assumed distribution. A longer duration period of observation might help provide further evidence for selecting a distributional form. Without further research evidence to support the selection of the distribution, we recommend relying upon the regression results rather than the survival analysis.

The regression results provide reasonable estimates, use all of the data available (time-series cross-sectional), and are more defensible and stable than the survival analysis results. The 9th year retention study demonstrates that the RWRI infiltration retention is meeting or exceeding the *ex ante* estimate of 10 years.

Linear regression using this dataset found an *ex post* EUL for infiltration of 18 years. Though the overall statistics would at first glance appear stronger for the linear model, the regression model that utilized duration-squared bears a functional form more akin to the non-linear nature expected and seen thus-far in the data. This specification provided an *ex post* EUL of 13 years. A conservative error bound at the 80% confidence level as required by the M&E Protocols, however, includes the 10-year ex-ante estimate. Given this, we recommend using the *ex-ante* 10 year infiltration EUL for this program as a conservative estimate.

Table 3.8 Infiltration Lifereg Survival Analysis Results

	Intercept	Duration (measured in days)	Scale	Weibull shape
Log-normal distribution - $	0.7136	0.1674	0.0712	
Std error of estimate	0.0223	0.0027	0.0034	
Chi-Square	1025	3727		
Estimated value at 50% quantile = 7.8 years with se of 0.459				
	Intercept	**Duration** (measured in days)	**Scale**	**Weibull shape**
Weibull distribution - $	4.2454	0.0341	0.2928	3.415
Std error of estimate	0.0612	0.0072	0.0184	0.2144
Chi-Square	4815	22		
Estimated value at 50% quantile = 81.6 years with se of 2.112				
	Intercept	**Duration** (measured in days)	**Scale**	**Weibull shape**
Exponential distribution - $	4.0606	0.0476	1.0	1.0
Std error of estimate	0.219	0.0263	0	0
Chi-Square	344	3		
Estimated value at 50% quantile = 58.2 years with se of 4.73				

3.4 Effective Useful Life (EUL) Analyses for Attic Insulation Measures

As discussed in Section 2 on methodology, there were three methods tested for providing reliable EUL estimates for the median, 50% retention rate. These were:

1. An exponential failure model as was used in the 4th year retention study for the 1994, 1995, 1996, and 1997 RWRI program years.
2. A general linear regression based with duration as the independent variable and a second model with the independent variables as duration and duration-squared (due to an expected inflection point in the retention rate).
3. A survival analysis using the LIFEREG procedure in SAS® specifically designed to estimate censored hazard functions with interval dependent variables.

The exponential model was used to calculate the predicted EUL as described in Section 2.5. Recall the equation for the predicted ex post EUL is as follows:

$$\text{Predicted EUL} = [t \ln(0.5)] / \ln(S) \quad \text{where S=survival proportion}$$

The input and predicted EUL results for attic insulation are provided in Table 3.9. A spreadsheet was used to calculate the predicted EUL. However, the formula is simple enough that with the input in Table 3.9 (average retention rate and average duration) the predicted EUL could be produced on a hand-held calculator.

Table 3.9 Input and Predicted EUL Results from Exponential Model for Attic Insulation

Average Retention Rate	Average Duration Observed	***Ex Post*** **Predicted EUL**
97.96%	8.76 years	211 years
Standard Deviation	**Standard Deviation**	
11.96	1.185	

An estimate of the confidence intervals for the EUL estimates is derived in a three step process. These steps are:

1. Calculate the confidence intervals for the retention estimate.
2. Calculate the confidence interval for duration.
3. Estimate the low interval EUL confidence number by using the low interval level for retention with the low interval level for duration in the exponential model to obtain maximum low interval. Do the same with the high level to obtain the high interval EUL confidence number.

The confidence interval calculations in steps one and two 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 is straight forward based on the formula for confidence intervals for point estimates. This formula is as follows:

$$\text{Mean} - t\,(sd/\sqrt{N}) < \text{Mean} < \text{Mean} + t\,(sd/\sqrt{N})$$

where:

t = score representing desired level of statistical significance
sd = standard deviation
N = sample size

Table 6 of the M&E Protocols requires the confidence interval be produced for the 80 percent level.[13]

Using the three step process described above, conservative estimates (wide span) of the EUL confidence intervals were made. The *ex post* EUL confidence interval estimates are presented in Table 3.10.

Table 3.10 *Ex Post* Attic Insulation EUL Confidence Interval Estimates from Simple Exponential Model

	Confidence Interval* *Ex Post* EUL	
		to
Attic insulation	190 years	642 years

* 80% Confidence interval α=20%.

The above estimate required an assumption of desired level of statistical significance, α. This is setting our Type I error, the risk of rejecting a true hypothesis. There is a trade-off between the degree we are willing to accept a Type I error (rejecting a true hypothesis) and that associated with a Type II error, the error of failing to reject an hypothesis when it is actually false. This α is the p-value required by Table 6 of the M&E Protocols.[14]

The confidence interval for the infiltration EUL as estimated by the simple exponential model is from 190 years to 642 years. SDG&E's *ex ante* estimate for attic insulation for the RWRI program is 20 years. The combination of the 9th year retention exam being less than half of the expected EUL and the simple exponential model obviously produce unreasonable estimates.

Using the standard deviation of the estimate to develop confidence intervals generally measures sampling error. In general, what is measured is if the exact same measurement tool is used, the confidence level provides us the probability of falling within the interval in repeated samples or, similarly, the probability that the results for the population as a whole would be within the interval around the results found for the sample. This is the standard measurement and use of confidence intervals.

A measurement of the confidence interval does not measure the overall accuracy of the estimate. This is because there are generally two types of possible errors. These are:

1. Sampling error

[13] *Prepared Testimony of Kevin C. McKinley, Chair, California DSM Measurement Advisory Committee (CADMAC) in the 1998 Annual Earnings Assessment Proceeding (AEAP) Before the Public Utilities Commission of the State of California*, September 8, 1998, pp. 6.

[14] Ibid.

2. Measurement error

The confidence interval allows us to measure possible sampling error. There is no readily available and accepted measurement to assess measurement error. (Measurement error is the error from the tool or technique used for the measurement or that the hypothesized model is not the one and only true model for the process being examined.)

There are three likely sources of potential measurement error within this estimate. These are: (1) Estimating EUL based upon right censored data without controlling for this fact; (2) Asking recall for a period of years within a telephone survey; and (3) Obtaining accurate operational retention estimates from residential telephone survey respondents. The instrument and conservative assumptions on duration have attempted to minimize measurement error for items two and three. The other methods examined do a better job of utilizing all the data available and examining the right censored nature of the data.

The second method tested could be conducted due to the creation of detailed dates of removal/replacement status from the telephone surveys and using this via a series of computer programming to create a time-series cross-sectional dataset. (A summary description of the set-up of the observations in this dataset is provided in Section 2.5 above.)

Regression models were run with the dependent variable being the participant retention as it varied over time based upon the percent removed/replaced and when this occurred. Two models were tested (as described in Section 2.5). One had only the duration as the independent variable and the other had duration and duration squared. The regression results are shown in Table 3.11.

The median EUL estimated by the linear model is a fitted value where the equation equals 50%. This involves solving the equation $50=101.397017 - 0.0007476*x$ where x is duration in days. **The attic insulation EUL estimate from the linear regression is 184.6 years.**

Using the standard error of the estimate provided by the regression output, multiplying by 1.645 to derive the 80% confidence level at α=20% provides the confidence interval shown in Table 3.12. This is 136 to 287 years for the linear infiltration regression model.

The duration squared regression model does not even provide reasonable regression coefficients from which to estimate a EUL. The duration coefficient is positive and greater than the negative coefficient on duration squared.

Table 3.11 Attic Insulation Retention Regression Results

	Intercept	Duration (measured in days)	Duration Squared
Linear model- $	100.397	-0.0007476	
t-value	334.48	4.61	
Std error of estimate	0.30016	0.00016	
R-Squared	0.011		
With duration-squared	99.6556	0.000852	-0.00000051
t-value	251.06	1.46	2.85
Std error of estimate	0.3969	0.00058	0.00000018
R-Squared	0.0157		

Table 3.12 *Ex Post* Infiltration EUL Confidence Interval Estimates from the Regression Models

	Confidence Interval* *Ex Post* EUL	
	to	
Linear regression	136 years	287 years
Regression with duration-squared	Unreasonable coefficients	

* 80% Confidence interval α=20%.

Again, the 9th year retention exam being less than half of the expected EUL has obviously caused even the regression analysis to produce unreasonable estimates.

The time-series cross-sectional dataset created through both research design and analysis programming, along with the 9-year period for potential change that has occurred, has allowed survival analysis models to be conducted that do reach convergence. This is a significant improvement over what was possible with the 4th year retention data. The results are presented in Table 3.13.

Though survival analysis results were obtainable in this study, the results vary by orders of magnitude depending upon the assumed distribution. A longer duration period of observation might help provide further evidence for selecting a distributional form. Without further research evidence to support the selection of the distribution, we do not recommend relying upon the results from the survival analysis.

RWRI's *ex ante* estimate for attic insulation is 20 years. The simple exponential analysis and the linear regression analysis both product estimates around 200 years. This 9th year retention study is almost half the EUL assumed but the loss in retention is less than 3%. We, therefore, recommend accepting the *ex ante* estimate of 20 years as a conservative estimate.

Table 3.13 Attic Insulation Lifereg Survival Analysis Results

	Intercept	**Duration** (measured in days)	**Scale**	**Weibull shape**
Log-normal distribution - $	1.0589	0.1265	0.0038	
Std error of estimate	0.0055	0.0006	0.0002	
Chi-Square	37127	41732		
Estimated value at 50% quantile = 8.9 years with se of 0.003				
	Intercept	**Duration** (measured in days)	**Scale**	**Weibull shape**
Weibull distribution - $	4.598	0.0008	0.0212	47.2533
Std error of estimate	0.0112	0.0013	0.0015	3.4014
Chi-Square	169907	0.37		
Estimated value at 50% quantile = 99.2 years with se of 0.181				
	Intercept	**Duration** (measured in days)	**Scale**	**Weibull shape**
Exponential distribution - $	4.5705	0.0028	1.0	1.0
Std error of estimate	0.576	0.065	0	0
Chi-Square	63	0.0		
Estimated value at 50% quantile = 68.6 years with se of 5.66				

3.5 Required Protocol Tables

This subsection provides the summary tables as required in the M&E Protocols. Table 3.14 provides the summary documentation for data quality and processing as required in Table 7 of the M&E Protocols.

Table 3.14 Data Quality and Processing Documentation Protocol Table 7B

Protocol Table Item #	
	Overview Information
1a. Study Title & ID	Measure Retention Study for 1996/1997 Residential Weatherization Retrofit Incentives Programs for SDG&E
1b. Program, years, & descrip.	Residential Weatherization Retrofit Incentives Program [1996 and 1997] Assistance provided for weatherization measures to be added to residential customers' homes.
1c. End uses & measures	End Use: Space conditioning Study measures: Attic insulation and Infiltration
1d. Methods & models	Telephone survey analysis produced participant retention estimates. Means of these are measure retention estimates. Three models tested for EUL estimates: simple exponential, linear and duration-squared regression models on annual time-series cross-sectional data, and Lifereg survival analysis with 3 distribution assumptions. See Section 2 for further methods discussion. See Section 3 for further discussion on models and findings.
1e. Analysis sample sizes	Customers & measure installation (No. of participant homes): Attic insulation = 768 Infiltration = 4,375
	Sample sizes: Attic insulation = 200 Infiltration = 200
	Data collection: August 2005
	Database Management
2a. Data sources	Program tracking databases provided information for sampling pool used as recruiting database for telephone survey. Telephone survey conducted as described in Section 2.
2b. Data attrition	Telephone look-up for all addresses where program telephone number does not connect to retrofitted home address. Call disposition reports provided in Tables 3.1 and 3.2 of report. Completion rate of 22.5% for infiltration and 22.6% for attic insulation.
2c. Data quality checks	Initial database with survey responses contained several customer fields from database and from several questions in telephone survey set-up. These were used to check line-up and data entry coordination.
2d. Collected data not used	None

	Sampling	
3a. Sampling procedures	Random sampling of customers with infiltration strata consisting of those with and without attic insulation. Sampling plan: Attic insulation = 200; Of these 150 have infiltration; Additional infiltration with no attic insulation = 198.	
3b. Survey information	Survey instrument provided in Appendix A. It is described in Section 2. Call disposition reports provided in Tables 3.1 and 3.2 of report. Small rate of refusal so no action taken for possible correction: just over 4%.	
3c. Statistical descrip.	Retention findings based on mean of telephone survey estimate by measure. EUL estimates from regression model of time-series cross-sectional dataset created for annual participant retention rates. See Section 3.4.	
	Data Screening and Analysis	
4a. Outliers	There were a few customers that misinterpreted the inter-relationship between the infiltration question on removed/replaced versus those where this has not occurred but needs to be replaced. Those where their total loss was greater than 100% was truncated to 100% for a non-negative (zero) retention rate.	
4b. Background var.	Move-in residents to previously retrofitted homes examined. No changes necessitated to analysis.	
4c. Screened data	No screening, all data utilized.	
4d. Model statistics	Attic Insulation: Intercept: 100.397 Duration coefficient: -0.0007476 EUL: 185 years See Section 3.4 for detail & other models tested.	Infiltration: Intercept: 99.789 Duration coefficient: -0.003669 Duration-Squared coefficient: -0.00000135 EUL: 13 years See Section 3.4 for detail & other models tested.
4e. Specification	Predicted EUL from solving: 50= Intercept + Duration coeff*x for attic insulation and from iterative testing on: Intercept + Duration coeff*x + Duration SQ coeff*x^2 for infiltration. See Section 3.4 for further detail.	
4e1 Heterogeneity	Residential program with no heterogeneity considered.	
4e2 Omitted Factors	No omissions.	
4f Error	The greatest data difficulty is with not enough time since installation for more complete data to estimate functional form for survival. This also created issues with right censored data. Potential measurement error, though survey wording and procedures attempted to minimize this, surrounds asking recall for a period of years within a telephone survey and being able to obtain accurate operational retention estimates from residential telephone survey respondents.	
4g Influential data points	Few complete loss of retention which created right censored data.	
4h Missing data	Few missing data. Mean from other relevant responses substituted for missing data so as not to lose the observation for the analysis.	
4i Precision	Confidence levels computed. Forecasting outside of data bounds and right censored data still creating unreasonable estimates in many cases.	

Table 3.15 provides a reporting summary of the study results as required in Table 6 of the M&E Protocols.

Table 3.15 Data Quality and Processing Documentation Protocol Table 6

Protocol Table Item #	
	Overview Information
1. Studied measure & end-use	Attic insulation and infiltration for heating and cooling.
2. *Ex ante* EUL	Attic insulation: 20 years Infiltration: 10 years
3. *Ex post* EUL	Attic insulation: 185 years (Linear regression) Infiltration: 13 years (Regression with duration squared)
4. *Ex Post* to be used	Attic insulation: 20 years (*Ex ante* more reasonable.) Infiltration: 10 years (*Ex ante* within confidence interval of analysis estimate.)
5. EUL Standard Error	Attic insulation: 0.000162 on duration $ of -0.00075 (Linear regression) Infiltration: 0.001492 on duration $ of -0.003669 and 0.00000046 on duration-squared $ of -0.00000135 (Regression with duration-squared)
6. 80% Confidence Interval	Attic insulation: 136 years to 287 years (Linear regression) Infiltration: 9.9 years to 22.4 years (Regression with duration-squared, conservative CI based on max of both.)
7. p-Value	20%
8. Realization Rate	1.0
9. Like measures	None

Appendix A. Telephone Survey

Homeowner Insulation and Infiltration 9-Year Retention Study
SDG&E 1996 & 1997 RWRI Program

Hello. This is ____________, I am calling on behalf of San Diego Gas & Electric Company. They want to know if energy-efficiency measures installed in your home several years ago are still in place.

1. Have I reached the residence at _[ADDRESS]?

(IF NO, THEN CHECK “WRONG ADDRESS”. TERMINATE.
“I’m sorry but I must have the wrong number. Thank you for your time.”

IF NO, FAX #, OR DISCONNECTED THEN: PHONE LOOK-UP FOR TELEPHONE NUMBER AT ADDRESS. THEN BACK INTO CALL LIST.)

a. Yes – (CONTINUE)

2. RECORD IF CONTINUED FROM ORIGINAL PHONE # OR LOOK-UP #.
   a. ORIGINAL PHONE #
   b. New Resident -- LATER LOOK-UP NUMBER USED

3. Are you the person in your household who is most familiar with your home’s energy efficiency?
   a. Yes (CONTINUE)
   b. No (ASK TO SPEAK TO THAT PERSON AND REPEAT INTRO BEFORE CONTINUING)
   c. No one is most familiar. (SAY:) We have only a few simple questions. Are you one of the heads of the household? (IF YES, CONTINUE. IF NOT, ASK TO SPEAK TO ONE AND REPEAT INTRO.)

4. SDG&E sponsored a program in 1996 and 1997 where weatherstripping, insulation or attic insulation was installed in your home. Were you or your family living at this residence in 1996 (nine years ago)?
   a. Yes (SKIP Q5)
   b. No

5. Can you tell me what month and year you moved to this address?
   a. ________ Month _________ Year

(IF Q4 = NO, SAY BEFORE CONTINUING:)

Even though you did not live in your home in 1996, we'd like to ask you a couple of questions about those items.

[IF INFILTRATION=1 CONTINUE, ELSE SKIP TO Q12]
According to our records your home received weatherstripping, caulking, and insulation around the doors, windows, outlets, and plumbing.
(IF Q4 = NO, SAY:) Since you moved in,

6. Have you had to replace any of that weatherstripping, caulking, or insulation?
   a. Yes
   b. No (SKIP TO Q9)

7. What percent of that weatherstripping or caulking have you had to replace?
   ____%

8. Can you tell me in what year or years you did that? (TAKE UP TO THREE DIFFERENT YEARS)
   i. ______ ______ ______

9. Of that which hasn't been replaced, has any of it come out or worn out and needs to be replaced?
   a. Yes (CONTINUE)
   b. No (SKIP TO Q12)

10. What percentage or the weatherstripping or caulking needs to be replaced?
   i. ______%

11. Can you tell me about what year and month you first noticed that some it needed to be replaced?
   a. _________ Year ________ Month

[IF ATTIC=1 CONTINUE, ELSE SKIP TO COMPLETION]
According to our records the home at this address received attic insulation as part of that same program in 1996 or 1997.

12. We need to know whether any of the attic insulation has been removed or replaced. This could happen if your home was remodeled, if you've gotten a new roof, if insulation was damaged by rain, when moving storage items in the attic or for other reasons. Has any of your home's attic insulation been removed or replaced since 1996 (or since you moved in)?
   a. Yes
   b. No (SKIP TO COMPLETION)
   c. Don't know (SKIP TO COMPLETION)

13. What percentage of the attic insulation was removed or replaced? ______%

14. Can you tell me in what year or years this occurred? (TAKE UP TO THREE DIFFERENT YEARS)
    i. ______ ______ ______

Those are all of my questions. Thank you very much for your time and assistance.

Appendix B. Datasets and Documentation

This study was specifically designed to be as simple and straight forward as possible. As the analysis progressed, the steps and programs were continually refined in order to accomplish this goal. The result was the development of small set of concise data analysis steps. The use of these steps, and copies of the programs are provided in this Appendix. The datasets, SAS© programs, and Excel© spreadsheets are provided on diskette at the end of this Appendix. Following the description contained below, the work should be easily replicable.

Flow of Datasets and Analysis Programs

A step-by-step schematic of the use of datasets and analysis programs is presented in Figure B.1. This diagram also indicates the complete flow of the material provided and the type of material (dataset and type, program and type). This diagram can be used with the datasets and programs provided on diskette to replicate all of the results discussed in this report.

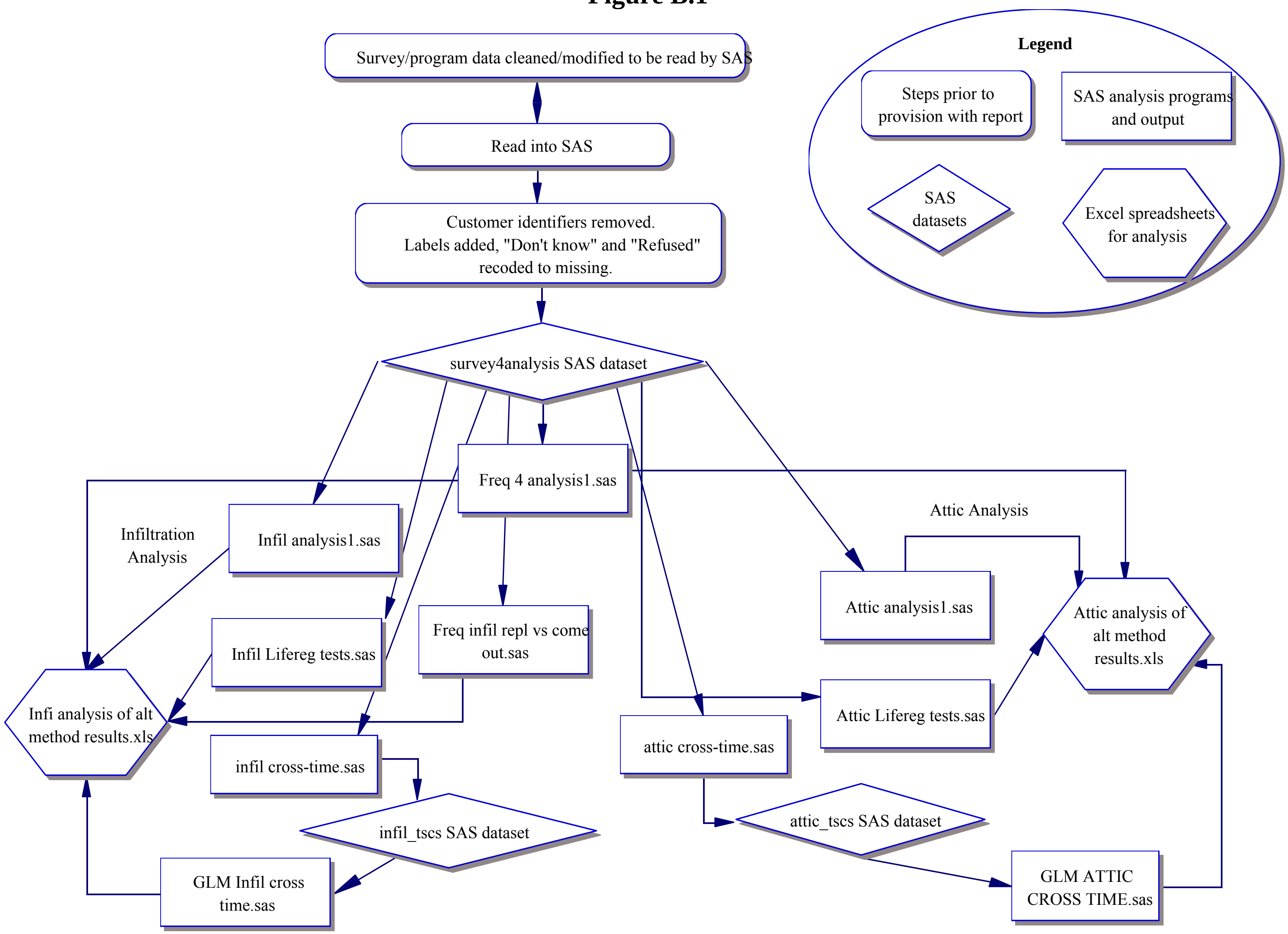
Printed copies of each of the SAS© programs and Excel© spreadsheets are provided in the pages following the flow chart. They are provided in the order that they are used.

Set-Up Reminders for Replication

The SAS© and Excel© programs are the exact ones used for this study. A few minor changes will need to be made to replicate the work.

SAS© programs contain LIBNAME statements and FILENAME statements in the beginning of the programs to tell the program where to find datasets and where to place datasets. These will need to be changed to reflect the folder set-up being used in the replication.

Figure B.1


Legend
Steps prior to provision with report
SAS analysis programs and output
SAS datasets
Excel spreadsheets for analysis
Survey/program data cleaned/modified to be read by SAS
Read into SAS
Customer identifiers removed. Labels added, "Don't know" and "Refused" recoded to missing.
survey4analysis SAS dataset
Freq 4 analysis1.sas
Infiltration Analysis
Infil analysis1.sas
Infil Lifereg tests.sas
Freq infil repl vs come out.sas
Infi analysis of alt method results.xls
infil cross-time.sas
infil_tscs SAS dataset
GLM Infil cross time.sas
Attic Analysis
Attic analysis1.sas
Attic analysis of alt method results.xls
Attic Lifereg tests.sas
attic cross-time.sas
attic_tscs SAS dataset
GLM ATTIC CROSS TIME.sas