Retention Study of Pacific Gas & Electric Company's 1994 and 1995 Appliance Energy Efficiency Programs

1994-1995 Residential Air Conditioning Ninth Year Retention

PG&E Study ID number: 384cR2

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Measurement and Evaluation
Customer Energy Management Policy, Planning &
Support Section
Pacific Gas and Electric Company
San Francisco, California

All inquiries should be directed to:

Jay Luo
Revenue Requirements
Pacific Gas and Electric Company
P. O. Box 770000, Mail Code B9A
San Francisco, CA 94177

NINTH YEAR RETENTION STUDY FOR PG&E'S 1994 AND 1995 RESIDENTIAL AEI PROGRAM AIR CONDITIONING TECHNOLOGIES

Purpose of Study

This study was conducted in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholders Earnings from Demand-Side Management Programs", as adopted by California Public Utilities Commission Decision 93-05-063, revised March 1998, Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-052.

This study measures the effective useful life (EUL) for all energy efficient air conditioning technologies for which rebates were paid in 1994 and 1995 by Pacific Gas & Electric Company's (PG&E's) Residential Appliance Efficiency Incentive (RAEI) Program.

Methodology

The Protocols assert the purpose of a retention study is to collect data on the fraction of installed measures in place and operable in order to produce a revised estimate of its EUL. The ultimate goal is to estimate the EUL (or the median number of years that the measure is still in place and operable), which can be realized by identifying the measure's survival function. For this study, the survival function describes the percentage of measures installed that are still operable and in place at a given time. Survival analysis is the process of analyzing empirical failure/removal data in order to model a measure's survival function. As much as possible, we have attempted to employ classical survival analysis techniques to our study approach.

Our overall approach consists of four analysis steps that were used to estimate each of the studied measures' EULs:

1. ***Compile summary statistics*** on the raw retention data.

2. ***Visually inspect*** the retention data. By calculating the cumulative percentage of equipment that had failed in a given month, and plotting this percentage over time, an empirical survival function emerged.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, we estimated a trend line using standard linear regression techniques. We attempted to model the trend as a linear and an exponential function. In each case, we plotted the resulting trend line and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting trend line to estimate the EUL.

4. ***Develop a survival function*** using classical survival techniques. Using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System," we modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we plotted the

resulting distribution and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting survival function to estimate the EUL.

Final Results

The final study results are based on the rebated air conditioner failure and removal data modeled using the gamma distribution. This method was chosen for several reasons. The model based on gamma distribution was both the best fit and the minimum EUL model (and thus a conservative estimate) and allowed interval censored data which permitted us to use data points from the fourth year study without needing to re-contacting them in 2003. This increased the number of points used in the model thus increasing its robustness. The gamma survival distribution was also selected because it forecasts curve shapes that are intuitively expected over time.

The EUL estimate from this study is 33.0 years, which rejects the ex ante EUL at the 80% confidence interval and thus allows PG&E to extend the EUL estimate used in their claim to its maximum value of 20 years. As a result the program realization rate, which is the ratio of the ex ante and ex post estimates, is 111%. These results are summarized in the table below.

PG&E's 1994 and 1995 Residential Appliance Efficiency Incentives Program
Summary of Ex Post Effective Useful Life Estimates
Air Conditioning End Use

Program		Study Results					Ex Post	Realization
Year	End Use	Ex Ante	Upper	Median	Lower	Ex Post	Claimed	Rate
1994/1995	Air Conditioning	18	34.9	33.0	31.0	33	20	111%

Regulatory Waivers

No regulatory waivers were filed for this study.

NINTH YEAR RETENTION STUDY FOR PG&E'S 1994 & 1995 RESIDENTIAL AEI PROGRAM AIR CONDITIONING TECHNOLOGY

PG&E Study ID#: 384cR2

FINAL REPORT

Submitted to

Beatrice Mayo
Market Planning and Research
Pacific Gas & Electric Co.
245 Market Street
P0 Box 770000
San Francisco, CA 94105

Prepared by

QUANTUM CONSULTING INC.
2001 Addison Street
Suite 300
Berkeley, CA 94704

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TABLE OF CONTENTS

ATTACHMENTS

LIST OF EXHIBITS

1. EXECUTIVE SUMMARY

This section presents a summary of the ninth year retention study results of Pacific Gas & Electric Company's (PG&E's) Residential Appliance Efficiency Incentive (RAEI) Program for air conditioning technologies. The retention study described in this report covers air conditioning technologies installed at residential accounts that had rebates paid during 1994 and 1995.

1.1 PROTOCOL REQUIREMENTS

This study was conducted under the rules specified in the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols).[1] This evaluation has endeavored to meet all Protocol requirements.

The retention study results in ex post effective useful lives for the high efficiency air conditioning measure, and a comparison of realization rates from the ex ante to ex post estimates. The definition of the effective useful life (EUL), provided in Appendix A, Measurement Terms and Definitions, of the Protocols is: "an estimate of the median number of years that the measures installed under the program are still in place and operable".

The Protocols require high efficiency air conditioning measures to be studied for the RAEI program. This study focuses only on residential air conditioning measures for which rebates were *paid* during calendar year 1994 and 1995. The Protocols also require that two Program Years, 1994 and 1995, be combined and that the studies be conducted on the schedule for Program Year 1994. The Protocols state that combining the two studies "should increase the accuracy of the survival function and decrease the cost of completing the retention studies." Furthermore, "the retention studies shall include data from participant groups from two or more sequential years to increase the robustness of the sample and to allow for the estimation of a survival function for a number of different measures." Because the 1994 air conditioner program is virtually identical to the 1995 air conditioner program, the Protocol's suggestion to combine the two studies will greatly enhance the accuracy of the retention study, without incurring additional cost.

1.2 STUDY APPROACH OVERVIEW

As stated above, the Protocols assert the purpose of a retention study is to collect data on the fraction of installed measures in place and operable (i.e., measures that had not failed or been replaced) in order to produce a revised estimate of its EUL. The ultimate goal is to estimate the EUL (or the median number of years that the measure is still in place and operable), which can be realized by identifying the measure's survival function. For this study, the survival function describes the percentage of measures installed that are still operable and in place at a given time. Survival analysis is the process of analyzing empirical failure/removal data in order to

[1] California Public Utilities Commission Decision 93-05-063, Revised March 1998, Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-052.

model a measure's survival function. As much as possible, we have attempted to employ classical survival analysis techniques to our study approach.

Our overall approach consists of four analysis steps that were used to estimate each of the studied measures' EULs:

1. ***Compile summary statistics*** on the raw retention data.

2. ***Visually inspect*** the retention data. By calculating the cumulative percentage of air conditioners that had failed in a given month, and plotting this percentage over time, an empirical survival function emerged.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, we estimated a trend line using standard linear regression techniques. We attempted to model the trend as a linear and an exponential function. In each case, we plotted the resulting trend line and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting trend line to estimate the EUL.

4. ***Develop a survival function*** using classical survival techniques. Using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System," we modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we plotted the resulting distribution and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting survival function to estimate the EUL.

1.3 STUDY RESULTS FOR REBATED AIR CONDITIONERS

Based on extensive analysis of the retention data, we recommend that PG&E revise the estimate for the EUL from the ex ante EUL estimate of 18 years and set the ex post EUL at 20 years for the rebated air conditioners. Out of the 712 surveys completed (310 from the fourth year study and 402 from the ninth year study), only 7 units had failed and 3 had been removed for other reasons (including one natural disaster). Failures and removals were not modeled separately for air conditioners since there were too few removals to build a distinct model. Exhibit 1-1 presents the various model results for the rebated air conditioners.

Exhibit 1-1
Summary of Study Results for Rebated Air Conditioners

		Analysis Methods		
Approach	**Model**	**Median EUL**	**Upper Bound**	**Lower Bound**
Summary Statistics	Exponential	452	-	-
Trendlines	Linear	194	205	184
	Exponential	389	409	369
LIFEREG	Exponential	399	461	338
	Logistic	41.4	51.1	31.6
	Log-Normal	123.7	169.0	78.3
	Weibull	36.3	44.2	28.4
	Gamma	33.0	34.9	31.0

At this time, the survival function modeled with the gamma distribution provides the best fit for the data. The EUL for this model is 33 years. The lower bound for this model is 31 years and thus the current ex ante EUL of 18 years cannot be confirmed at the 80% confidence level. The gamma model was also coincidentally the minimum EUL model. The maximum EUL survival model was based on the exponential distribution and had a EUL of 399 years.

1.4 FINAL RESULTS

The final study results are based on the rebated air conditioner failure and removal data modeled using the gamma distribution. This method was chosen for several reasons. The model based on gamma distribution was both the best fit and the minimum EUL model (and thus a conservative estimate) and allowed interval censored data which permitted us to use data points from the fourth year study without needing to re-contacting them in 2003. This increased the number of points used in the model thus increasing its robustness. The gamma survival distribution was also selected because it forecasts curve shapes that are intuitively expected over time.

The EUL estimate from this study is 33.0 years, which rejects the ex ante EUL at the 80% confidence interval and thus allows PG&E to extend the EUL estimate used in their claim to its maximum value of 20 years. As a result the program realization rate, which is the ratio of the ex ante and ex post estimates, is 111%. These results are summarized in Exhibit 1-2.

Exhibit 1-2
Final Ex Post EUL Estimate

Program		**Study Results**					**Ex Post**	**Realization**
Year	**End Use**	**Ex Ante**	**Upper**	**Median**	**Lower**	**Ex Post**	**Claimed**	**Rate**
1994/1995	Air Conditioning	18	34.9	33.0	31.0	33	20	111%

2. INTRODUCTION

This report summarizes the retention study of Pacific Gas & Electric Company's (PG&E's) Residential Appliance Efficiency Incentive (RAEI) Program for air conditioning technologies. The evaluation effort includes all air conditioning technologies installed at residential accounts that had rebates paid during 1994 and 1995.

2.1 THE RESIDENTIAL APPLIANCE EFFICIENCY INCENTIVE PROGRAM

The RAEI Program offered fixed rebates to customers who installed split or packaged air conditioners meeting specific electric energy-efficiency requirements. The rebates were paid through the Residential Central Air Conditioner Rebate Program. The Rebates ranging from $100 to $1,200 were paid for air conditioners with Seasonal Energy Efficiency Ratios (SEERs) ranging from 11 to 16+. The programs assumed that customers were in the process of replacing their existing air conditioners, and offered the incentive to influence them to purchase more efficient models.

2.2 STUDY REQUIREMENTS

The retention study described in this report covers all air conditioning measures installed at residential accounts, as determined by PG&E's Marketing Decision Support System (MDSS) sector code, that were included under the RAEI programs and for which rebates were *paid* during calendar year 1994 and 1995.

This study was conducted under the rules specified in the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols).[2] This evaluation has endeavored to meet all Protocol requirements.

The retention study results in an ex post effective useful life for air conditioning equipment, and a comparison of the realization rate from the ex ante to ex post estimate. The definition of the effective useful life, provided in Appendix A, Measurement Terms and Definitions, of the Protocols is:

Effective Useful Life (EUL) – An estimate of the median number of years that the measures installed under the program are still in place and operable.

2.2.1 Studied Measures

The Protocols require high efficiency air conditioning measures to be studied for the RAEI program. This study focuses only on residential air conditioning measures for which rebates were *paid* during calendar year 1994 and 1995.

[2] California Public Utilities Commission Decision 93-05-063, Revised March 1998, Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-052.

2.2.2 Combining Program Years

The Protocols also require that two Program Years, 1994 and 1995, be combined and that the studies be conducted on the schedule for Program Year 1994. The Protocols state that combining the two studies "should increase the accuracy of the survival function and decrease the cost of completing the retention studies." Furthermore, "the retention studies shall include data from participant groups from two or more sequential years to increase the robustness of the sample and to allow for the estimation of a survival function for a number of different measures."

Because the 1994 air conditioner program is virtually identical to the 1995 program, the Protocol's suggestion to combine the two studies will greatly enhance the accuracy of the retention study, without incurring additional cost.

2.2.3 Accepting Ex Post EULs

The Protocols state that "the estimated ex post measure EULs that result from the retention study will be compared to the ex ante EUL estimates. Hypothesis testing procedures will be used to determine if the estimated ex post measure EUL is statistically significantly different from the ex ante measure EUL. If the estimated ex post measure EUL is significantly different than the ex ante measure EUL, the estimated ex post measure EUL will be used. Otherwise, the ex ante estimate will continue to be used. Hypothesis testing will be conducted at the 20% significance level."

2.2.4 Objectives

The research objectives are therefore as follows

- Collect data to determine if rebated air conditioners are in place and operable.
- Calculate the ex post EUL, and the realization rates from ex ante to ex post.
- Complete tables 6 and 7 of the Protocols.

2.3 STUDY APPROACH OVERVIEW

As stated above, the Protocols assert the purpose of a retention study is to collect data on the fraction of installed measures in place and operable in order to produce a revised estimate of its EUL. The ultimate goal is to estimate the EUL (or the median number of years that the measure is still in place and operable), which can be realized by identifying the measure's survival function. For this study, the survival function describes the percentage of measures installed that are still operable and in place at a given time. At any given time, the hazard rate is the rate at which measures fail or are removed. Survival analysis is the process of analyzing empirical failure/removal data in order to model a measure's survival function. As much as possible, we have attempted to employ classical survival analysis techniques to our study approach.

Our overall approach was to apply survival analysis to our collected retention data in order to develop a survival function. Some of the common survival functions take on the logistic cumulative distribution function. Although there is no documentation to support the ex ante survival function assumptions, discussions with the authors of the Protocols indicated that the ex ante EULs are based on a logistic survival function.

However, the form of the logistic survival function assumed by the Protocol authors is *not* the commonly used form of the logistic model. Generally, in survival analysis, the log-logistic model is used, which is a special form of the logistic distribution. Other commonly used survival functions are based on the exponential, Weibull, lognormal, and gamma distributions. For this retention study, we have examined each of these distributions. We have used the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System[3]," in order to estimate the survival functions based on the retention data.

An important issue to keep in mind for this analysis is the definition of survival. Recall that the EUL is defined as the median number of years that the measures installed under the program are still in place and operable. Therefore, to "survive", a measure must not have been removed or have failed.

Our overall approach consists of four analysis steps that were used to estimate the EUL for rebated air conditioners:

1. ***Compile summary statistics*** on the raw retention data. This step illustrated that even after nine years it is difficult to determine the survival rate of the air conditioners since there are still so few "failures".

2. ***Visually inspect*** the retention data. By calculating the cumulative percentage of equipment that had failed in a given month, and plotting this percentage over time, an empirical survival function emerged.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, we estimated a trend line using standard linear regression techniques. We attempted to model the trend as a linear and an exponential function. In each case, we plotted the resulting trend line and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting trend line to estimate the EUL.

4. ***Develop a survival function*** using classical survival techniques. Using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System," we modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we plotted the resulting distribution and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting survival function to estimate the EUL.

The details surrounding each of these steps are provided in Section 3.

[3] Allison, Paul D., "Survival Analysis Using the SAS System, A Practical Guide", SAS Institute, NC, 1995.

2.4 REPORT LAYOUT

This report is divided into four sections, plus attachments. *Sections 1 and 2* are the *Executive Summary* and the *Introduction*. *Section 3* presents the *Methodology* of the evaluation. *Section 4* presents the detailed results and a discussion of important findings. *Attachment 1* provides the Protocol Tables 6B and 7B. *Attachment 2* provides final version of the survey instrument implemented for the data collection portion of this study.

3. METHODOLOGY

This section provides the specifics surrounding the methods used to conduct the Retention Study for the 1994 and 1995 Pacific Gas & Electric Company (PG&E) Residential Appliance Efficiency Incentive (RAEI) Program for air conditioning technologies. It begins with a brief overview of the study objectives and methodology. This is followed by a detailed discussion on the sampling plan for the Retention Study. From there, details regarding the study methodology are presented, along with intermediate results from each of the four approaches implemented.

3.1 STUDY OVERVIEW

The objective of the Retention Study was to estimate ex post effective useful lives for each air conditioning measure, and to compare the realization rates from the ex ante to ex post estimates. The definition of the effective useful life, provided in Appendix A, Measurement Terms and Definitions, of the Protocols is:

Effective Useful Life (EUL) – An estimate of the median number of years that the measures installed under the program are still in place and operable.

3.1.1 Failure Types

For air conditioning there are three cases where a unit is considered to have "failed": (1) if the equipment actually failed and was not replaced under warranty[4], (2) if the unit was destroyed by a disaster and not replaced by insurance, and (3) if the unit was removed from the premise for another reason (such as an upgrade to a larger or more efficient unit).

The results of the 402 surveys conducted in 2003 found that only 10 of the air conditioning units had failed. None of the 310 units from the 1999 survey had failed. However, 25 participants stated they had to make a major repair, 8 of which required the compressor to be replaced. Of the 17 units repaired that did not have a compressor replacement, self-reported repair costs ranged from $75 to $4,500.

If a unit was in place and operable at the time of the survey but had previously been repaired it was not considered a failure for the analysis. Even considering these repaired units, only 4.9% of the 712 surveyed participants reported having had a major repair or failure and the median life for a major repair or failure is still 17.4 years.

3.1.2 Data Collection

One survey was fielded for the air conditioning study to capture survival data on rebated air conditioners. This survey was tailored to the original participants (non-movers) who initially purchased the rebated air conditioner and had not moved since this purchase. The air

[4] It should also be noted that the CADMAC allows failed units replaced under warranty to be considered in place and operable.

conditioning units being studied were split and packaged systems that had SEERs ranging from 11 to 16+. The likelihood of an individual moving and taking their air conditioner with them is very small and thus in an effort to insure that the air conditioner unit being discussed with the survey respondent is the rebated unit it was decided to restrict the surveyed population to the original participants.

An equal percentage of the sample was pulled from the 1994 and 1995 rebate years and within these rebate years the sample was drawn proportional to the population. Since the number of rebates paid in 1995 was roughly one fifth of the number paid in 1994 it was necessary to assign weights to the surveyed population by year to the sample would be representative of the entire 1994 and 1995 rebate year programs. Unless otherwise noted, all analysis results were weighted to represent the population.

Data from the fourth year retention study conducted by Xenergy was used to supplement data collected during the ninth year study (none of the units surveyed as of year four had failed). A portion of these participants was re-contacted in the ninth year study to determine the current state of the air conditioning unit. Recontacting participants from the fourth year study can improve the accuracy of the data collected during the ninth year study for units whose failure date is unknown since it can shorten the window of possible failure. All fourth year study points not recontacted in the ninth year study were included in our models as right hand censored data which improves our modeling accuracy by increasing the number of points in the sample.

3.1.3 Analysis Strategy

The overall approach consisted of four analysis steps used to estimate the EUL for rebated air conditioners:

1. ***Compile summary statistics*** on the raw air conditioning retention data.

2. ***Visually inspect*** the retention data. By calculating the cumulative percentage of equipment that had failed in a given month, and plotting this percentage over time, an empirical survival function emerged.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, we estimated a trend line using standard linear regression techniques. We attempted to model the trend as a linear and an exponential function. In each case, we plotted the resulting trend line and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting trend line to estimate the EUL.

4. ***Develop a survival function*** using classical survival techniques. Using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System," we modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we plotted the resulting distribution and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting survival function to estimate the EUL.

Each of these steps will be developed further in the remainder of this section.

3.2 SAMPLE DESIGN

3.2.1 Existing Data Sources

The Retention Study incorporated a variety of data currently available; in particular PG&E's program participation data (Marketing Decision Support System [MDSS]), retention study databases, and other program-related documentation.

- *Program Participant Tracking System*. The participant tracking system data, maintained in PG&E's MDSS, contains vital project and technical information about the measures rebated. In addition, participant contact information is stored in the MDSS.

- *Residential Population CIS*. PG&E residential customer information system (CIS) data was used to obtain contact information as well as to identify movers and non-movers using the date on premise.

- *Program Marketing Data*. PG&E program marketing data contains a detailed description of the installation and rebate program procedures.

- *Fourth Year Retention Study Contacts.* The fourth year retention study contact data provided information regarding the status of the 413 air conditioning units surveyed in 1999. This data was used to supplement data collected during the ninth year study. Re-contacting participants ("recalls") whose units had not failed as of year four can improve the accuracy of the data collected during the ninth year study for units whose failure date is known. However, since analysis on the initial survey completes showed the rate of failure at year nine to be low and the failure dates to be known this additional information provided little value. As a result only 103 of the 413 fourth year contacts were recalled and thus the remaining fourth year study points were incorporated into our models as right hand censored data. This allowed us to improve our modeling accuracy by increasing the number of points included in the sample.

3.2.2 Sample Frame

Preparing the survey sample dataset began with identifying participants who moved since participating in the air conditioning rebate program. Two variables were used to identify movers and non-movers. The participant's last name and telephone number were compared with the corresponding CIS record. If either the name or telephone number was the same in the participant datasets and the CIS then the participant was flagged as a non-mover.

The distribution of the air conditioning participant population by residency status and year of participation is provided in Exhibit 3-1. As illustrated, non-movers make up approximately 65% of the population, while movers make up the remaining 35% of the population. The final air conditioning sample was drawn from the non-mover population since the condition of the air conditioner should be independent from the residency status of the participant. By surveying only non-movers one can achieve a higher level of confidence that the unit located at the participants' residence is the rebated unit.

Exhibit 3-1
Distribution of Air Conditioning Participant Population by Residency Status and Year

Residency Status	Year of Participation	Count	Percent of Population
Mover	1994	1,623	39.9%
Mover	1995	343	8.4%
Non-Mover	1994	3,075	75.6%
Non-Mover	1995	651	16.0%
Total		4,069	100%

All air conditioner rebated through the program were energy efficient split or packaged units with a SEER ranging from 11 to 16+. These levels are represented in the participant population as shown in Exhibit 3-2. Our sample frame was also drawn proportionally to the population distribution.

Exhibit 3-2
Distribution of Air Conditioning Efficiency Level for Participant Population

SEER Level	Count	Percent of Population
11-11.9	1123	19.7%
12-12.9	3647	64.1%
13-13.9	858	15.1%
14-14.9	38	0.7%
15-15.9	19	0.3%
16-16.9	7	0.1%
Total	5,692	100.00%

3.2.3 Data Collection Strategy

One telephone survey was implemented by QC to obtain survival information on energy efficient air conditioners rebated under the 1994 and 1995 program years. The survey fielded was aimed at "Original Participants", or participants that did not move since purchasing the rebated air conditioning unit. A copy of the survey instrument is provided in *Attachment 2*.

The survey was implemented by Quantum's Computer Aided Telephone Interview (CATI) center. The survey was provided in electronic form, along with samples for interviewers to survey. A disposition of the results from the interviews is provided in Exhibit 3-3.

Exhibit 3-3
Air Conditioning Raw Survey Data Disposition

Disposition	Survey Original Participant
Complete	405
Busy/No Answer/Machine	112
Appointment	23
Language Barrier	2
Didn't know about AC	67
Business	32
Quota Full	1574
Refused/Incomplete	153
Bad Number/Wrong Address	92
Duplicate	4
Total	2464

The QC interviewer, who prompted each survey participant to confirm the unit being discussed was the rebated unit, collected equipment survival data. In situations where the survey participant was unable to confirm the unit was the rebated unit, the survey was promptly terminated and the survey respondent was excluded from the analysis. For each air conditioning unit it was determined whether the equipment was still in place and operable. If the equipment was not in place or was not operable, it was determined when it was removed or stopped operating according to the owner's best recollection. Reasons for removal or failure to operate were also collected. If equipment was replaced, it was determined if the equipment was replaced by insurance or under warranty.

Respondents were asked the frequency with which they used their air conditioner, the temperature it was used at, and whether or not they used a programmable thermostat to regulate it. Additionally, they were asked if and how often they changed the filters, had a technician service the unit and cleaned leaves and/or plants away from touching the outside unit. This information along with information regarding any remodeling activities that have taken place, the ownership status of the household dwelling unit and the number of individuals in the household was collected for possible use as covariates in the survival models. This will be discussed in more detail at the end of this section.

3.2.4 Final Distribution

A summary of the final disposition of the air conditioning survey is presented in Exhibit 3-4.

Exhibit 3-4
Air Conditioning Final Sample Disposition

Type and Number of Surveys Conducted		Survey Points Not Used	In Place & Operating	Failed	Total
9th Year Non Recall	302	3	293	6	299
4th / 9th Year Recall	103	0	99	4	103
4th Year Non Recall	310	0	310	0	310
Total	715	3	702	10	712

The ninth year Non Recall survey yielded 299 complete responses, and respondents were placed into the following categories based upon their responses:

- 293 Non Movers confirmed the rebated air conditioner unit and claimed that it was in place and operable at their residence.

- 6 Non Movers confirmed the rebated air conditioner unit and claimed that it had failed or had been removed (as shown in Exhibit 3-5, one additional unit had failed, but was replaced under warranty, so is considered in place and operating).

3 surveys that had initially been dispositioned as completes were later dropped from the analysis since the individual surveyed could not confirm whether the unit being discussed was in fact the rebated unit.

There were 103 Non Movers who were contacted during the fourth year retention study and then re-contacted during the ninth year study. The characteristics of their responses were the following:

- 99 of the Non Movers who had been contacted 5 years ago claimed the air conditioning unit was still in place and operable.

- 4 of the Non Movers indicated that the air conditioners that were in place and operable 5 years ago have now failed.

There were 310 Non Movers who were contacted during the fourth year retention study but not re-contacted in 2003. These points were included as censored data points for the ninth year analysis. All 310 responders contacted as part of the fourth year study claimed the air conditioner was still in place and operable as of 1999.

Prior to analysis, the results from the fourth year and ninth year surveys were combined into one dataset. Each respondent in the dataset was weighted based on their rebate year so the survey data would accurately represent the entire rebated population. Unless otherwise noted, the remainder of this report will present weighted results.

3.3 ANALYSIS OVERVIEW

As discussed in Section 2.3, the purpose of this Retention Study is to collect data on the fraction of air conditioners in place and operable in order to produce a revised estimate of the EUL. The desired result of our approach was to apply survival analysis to our collected retention data in order to develop a survival function for the rebated air conditioners.

Exhibit 3-5
Unweighted Summary Statistics on Retention Sample Data

Population	Number of Surveys Conducted	Number of Units that Failed, were Removed, or Replaced	Number of Units Replaced Under Warranty or by Insurance	Number of Units in Place and Operable	Percent Failed, Removed, Replaced
9th Year Non Recall	299	7	1	293	2.01%
4th / 9th Year Recall	103	4	0	99	3.88%
9th Year Subtotal	402	11	1	392	2.49%
4th Year Non Recall	310	0	0	310	0.00%
Total	712	11	1	702	1.40%

Of the 402 sites sampled in 2003, only 10 of them (2.49% unweighted) had failed.

The analysis performed used SAS to statistically model the survival function of the rebated air conditioners over time. These models use binary indicators to provide information on events (failures or removals), where a "1" indicates that an event has taken place and a "0" indicates that no event has taken place. Dates for each event are also provided, along with covariates that may be helpful in explaining some causal relationships.

There were four main steps in our approach to the air conditioner survival analysis. The four-step approach included the following activities:

1. The first step in the analysis was to compile summary statistics on the raw retention data.

2. Next, we visually inspected the retention data. By calculating the cumulative percentage of equipment that had failed in a given month, and plotting this percentage over time, an empirical survival function emerged.

3. The third step in the analysis was to develop a trend line. Using the survival plots developed in (2) above, we estimated trend lines using standard linear regression techniques. The trend was modeled as a linear and an exponential function. In each case, we plotted the resulting trend line and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting trend line to develop a preliminary estimate of the EUL.

4. The survival functions were modeled using classical survival techniques. Using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System," five different survival distributions were modeled: exponential, log-logistic, log-normal, Weibull, and gamma.

The review of the summary statistics and the visual inspection of the data prior to modeling allow us to uncover any analysis issues that may need to be addressed during the survival analysis. In addition, these earlier steps provided further validation for the results of the survival function. The details surrounding each of these methods are provided below.

3.4 SUMMARY STATISTICS

As discussed above, the first step of our analysis was to compile unweighted summary statistics on the sample retention data. These statistics include:

- the number of sites surveyed;
- the number of units still in place and operable;
- the number of units that had failed;
- the number of failed units that had been replaced under warranty;
- the percentage of units that had failed; and
- the ex ante EUL.

Exhibit 3-5 (in Section 3.3 above) summarizes this data by survey type. As shown in this exhibit, it would be impossible to develop a survival function or an ex post EUL estimate for the fourth year non-recall group because this group exhibited no failures up to the time they were surveyed. Furthermore, the fourth year group that was recalled as part of the ninth year study exhibited only four failures. The ninth year non-recall group exhibited seven failures, with one failure replaced under warranty. This resulted in an overall 2.5 percent failure rate for the ninth year surveyed population. In order to make a more robust sample all subsequent analyses were conducted on the entire sample frame and weighted accordingly, such that our combined analysis dataset would be representative of the population of rebated air conditioners. For the total sample frame, we had enough data on failures to proceed to the next analysis step.

If we make the assumption that the failure rates provided in Exhibit 3-5 are constant over time, then our survival function would take on the exponential distribution, which is one of the most commonly used distributions in survival analysis. Assuming the failures occurred over a 9-year period (measures have been in place for 8.5 to 9.5 years), we estimated the median EUL. Exhibit 3-6 provides the unweighted estimated EULs based on these assumptions.

Exhibit 3-6
Illustrative Ex Post Unweighted EUL Estimates
Based on Exponential Distribution and Conservative Assumptions

Survey Type	Percent Failed, Removed, Replaced	Annualized Failure, Removal, Replacement Rate^	Mean Life*	Median Life*	Ex Ante EUL
Air Conditioners	2.49%	0.28%	362	251	18

^ Includes only 9th Year survey data and assumes failures occur over a 9 year period.
* Assuming a constant failure rate over time.

Even based on the conservative assumption that warrantied equipment counts as a failure, the estimate of median life greatly exceeds the ex ante estimate of EUL.

3.5 VISUAL INSPECTION

For this step, we developed an empirical survival function that was observed from the raw retention data over the first eight to nine years of the measures' lives.

To develop the empirical function, we calculated for each month the percentage of equipment that was in place and operable. Although this appears to be a straightforward calculation, there were two issues that arose:

- The dates associated with failures were not always well populated.
- Not all customers were surveyed over the same length of time.

Missing Failure Dates

Three common terms used in classical survival analysis are "left-hand censoring", "right-hand censoring", and "interval censoring". Left-hand censoring means that it is known that a failure/removal has occurred, but it is unknown when the failure/removal occurred. It is only known that the failure/removal occurred before a certain date.

Right-hand censoring is more common in our data. Right-hand censoring means that at the last time the customer was surveyed, a failure/removal had not occurred, so the time when the equipment will fail or be removed is unknown.

Interval censoring, as the name implies, means that it is known that a failure has occurred during a known interval. If no event has occurred, the interval is assumed to be right-hand censored.

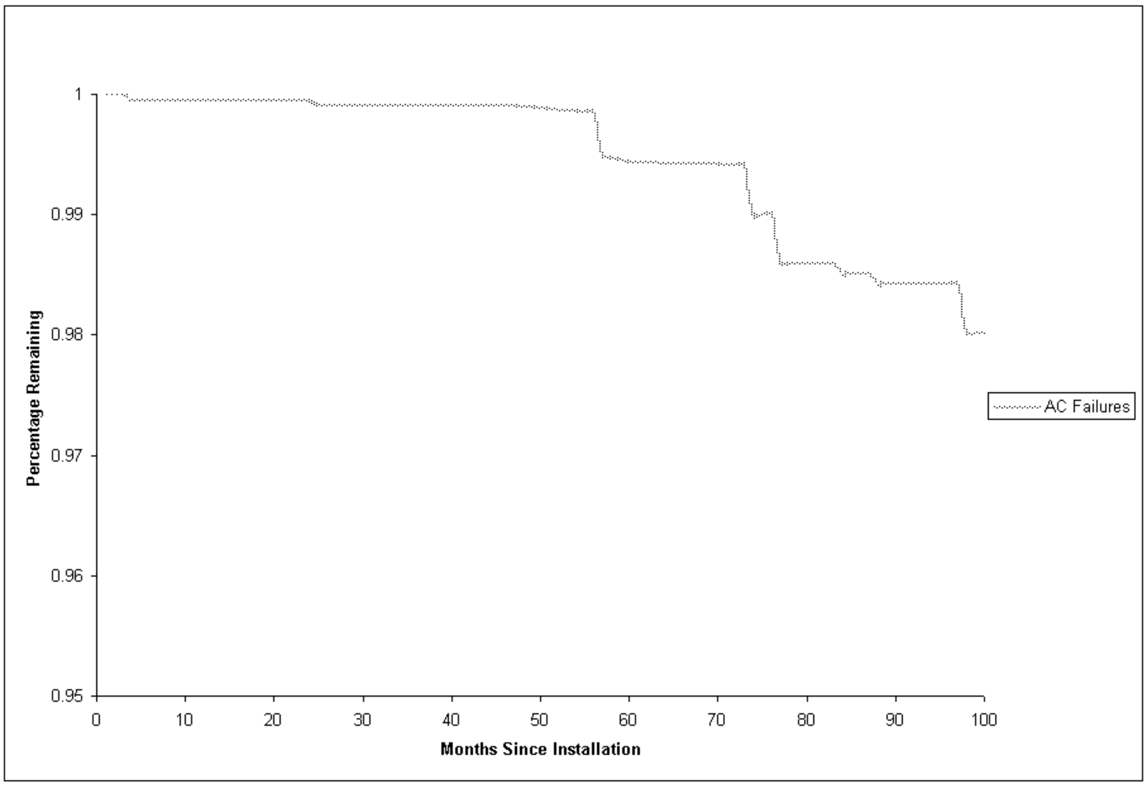
The SAS procedures that are discussed below in Section 3.7 are capable of handling right-hand censored data and in some cases left-hand and interval censored data. But for this more simplistic task, some assumptions were required.

Exhibit 3-7 presents the final empirical survival function developed for the air conditioning dataset. This survival function is based on the following assumptions:

1. For missing failure dates, generate a random date (based on a uniform distribution) between the date the measure was installed and the date the follow-up survey was conducted.

2. To estimate the percentage of equipment operable and in place in month M, do not include the equipment if the survey length is less than month M, regardless if a failure/removal occurred prior to month M.

Exhibit 3-7
Final Empirical Survival Function



Because of assumption 2 above, the empirical data was limited to 100 months. Beyond 100 months, the survival function has several periods of increasing values over time due to the sharp decrease in the number of points available for analysis. For example, the observed increase in failures around month 56 results from the lack of data beyond this time for the fourth year non-recall points. This results in fewer points remaining in the denominator of the percent remaining calculation and thus a perceived higher failure rate at this time.

3.6 TREND LINES

Based on the empirical survival functions presented above, trend lines were developed to estimate the survival functions over the life of the measure, and estimate the measure's EUL. As discussed above, only the first 100 months of the empirical survival functions were used.

Two trend lines were estimated using linear regression:

- The first trend line was assumed to have a linear relationship over time. Therefore, the trend line was developed using a linear regression with the percentage of equipment operable and in place as the dependent variable, and the month as the independent variable.

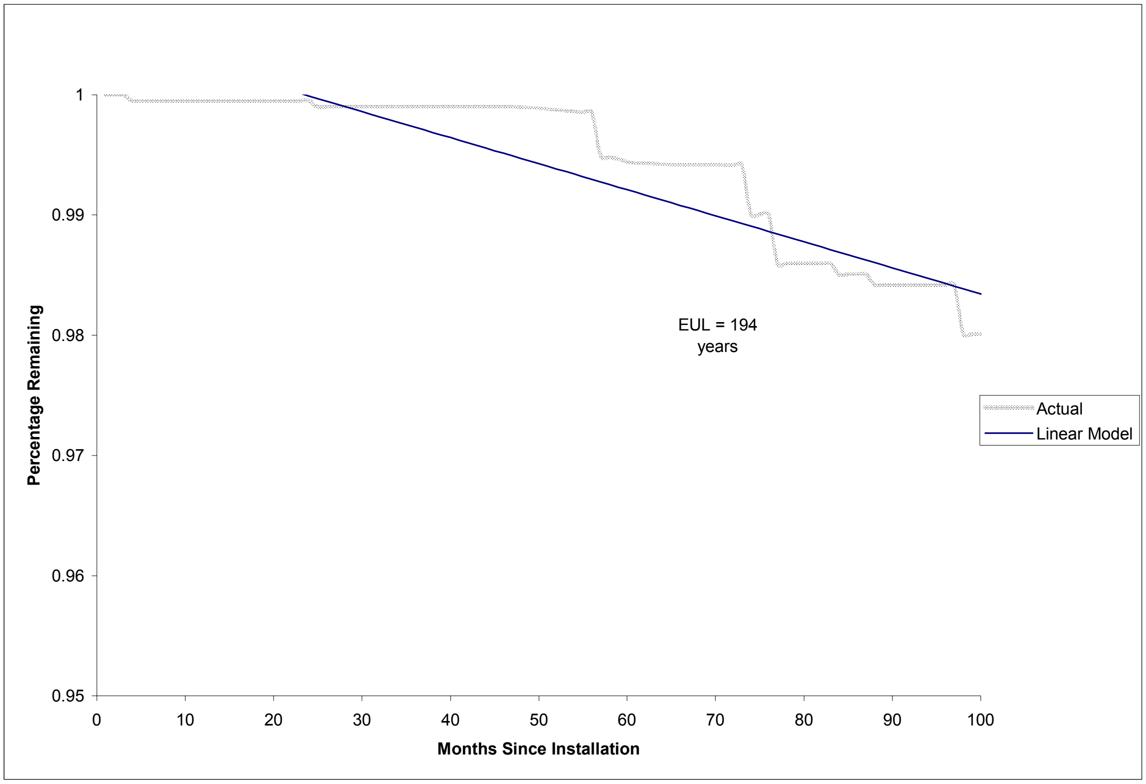
- The second trend line was assumed to follow the exponential distribution, which is one of the most common distributions used in survival analysis. The trend line was also used with linear regression by making a transformation on the percentage of equipment operable and in place. The natural log of the percentage of equipment operable and in place was used as the dependent variable, and the month as the independent variable.

The results of these analyses are provided below.

Linear Trends

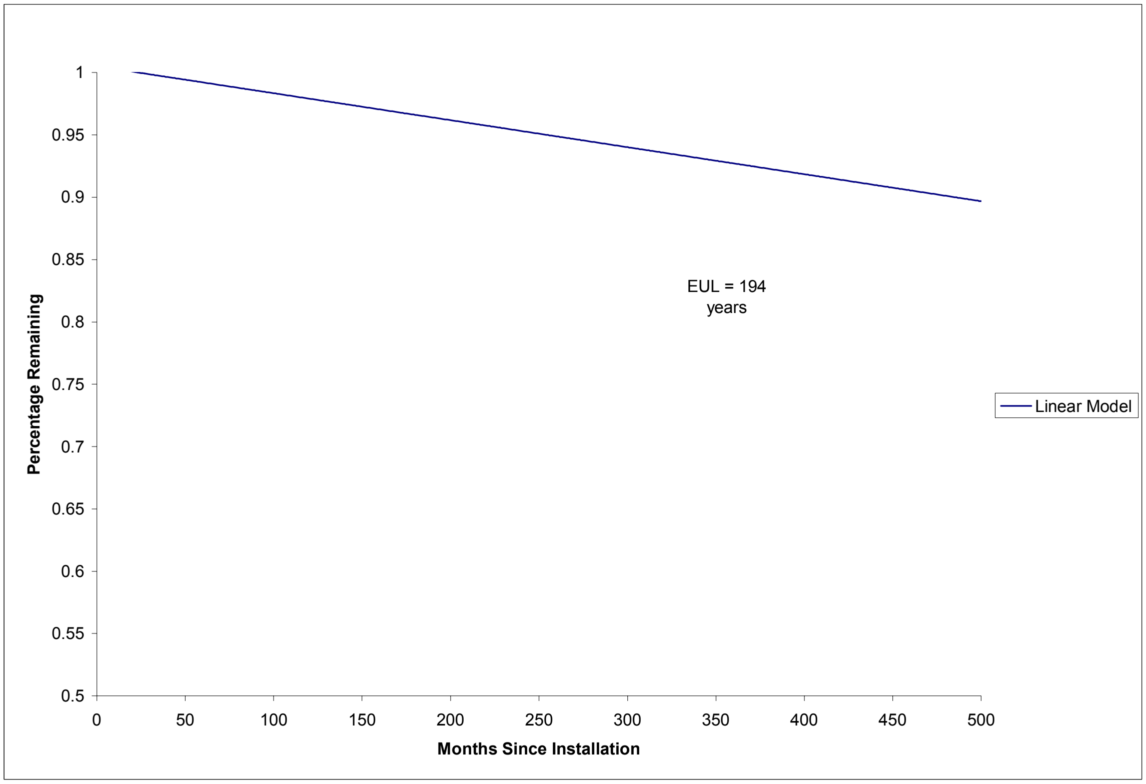
Exhibit 3-8 provides the linear survival functions for the air conditioning failures dataset and compares it to the empirical survival function developed above.

Exhibit 3-8
Comparison of Empirical Survival Function and Linear Trendline
Air Conditioning Failure Dataset



This exhibit illustrates how the linear trendline has difficulty fitting to the empirical function. In the earlier parts of the measure's life the trendline is too steep and starting around month 70 it becomes too flat. The EUL associated with this linear trendline is 194 years which we can assume is an over estimation of the EUL based on the poor fit of the linear trendline over the later years of the measures life. Exhibit 3-9 examines the linear model as it forecasts the survival function over the first 500 months of the air conditioner's life.

Exhibit 3-9
Survival Function Based on a Linear Trendline
Air Conditioning Failures Dataset



Even after 500 months (over 40 years), the model predicts that nearly 90% of the air conditioners will still be in place and operable. This scenario is highly unlikely, suggesting that the distribution does not follow a linear path but instead has a changing rate of failure. Results from more statistically valid methodologies, discussed later in this section, will further illustrate why the linear function is not appropriate. Exhibit 3-10 illustrates how the estimated EUL from the linear trendline is significantly larger than the ex ante. For a linear survival function, the EUL (median life) is calculated as:

EUL = (0.5 – intercept)/slope

Exhibit 3-10
Regression Results of Linear Trendline
and Resulting Ex Post EUL Estimates

Model Description	Intercept	t-Statistic	Slope	t-Statistic	EUL
Linear	1.01	1,701.74	-0.0002	-23.44	194

Clearly, the results of the linear trendline estimate indicate that the ex post EUL estimate is significantly larger than the ex ante estimates (which is 18 years). This result would easily reject the ex ante estimate at the 80 percent confidence level.

Exponential Trends

Exhibit 3-11 provides the resulting survival functions assuming an exponential trend for the air conditioning dataset and compares it to the empirical function developed above, for the first 100 months of the measure's life.

Exhibit 3-11
Comparison of Empirical Survival Function and Exponential Trendline
Air Conditioning Failure Dataset

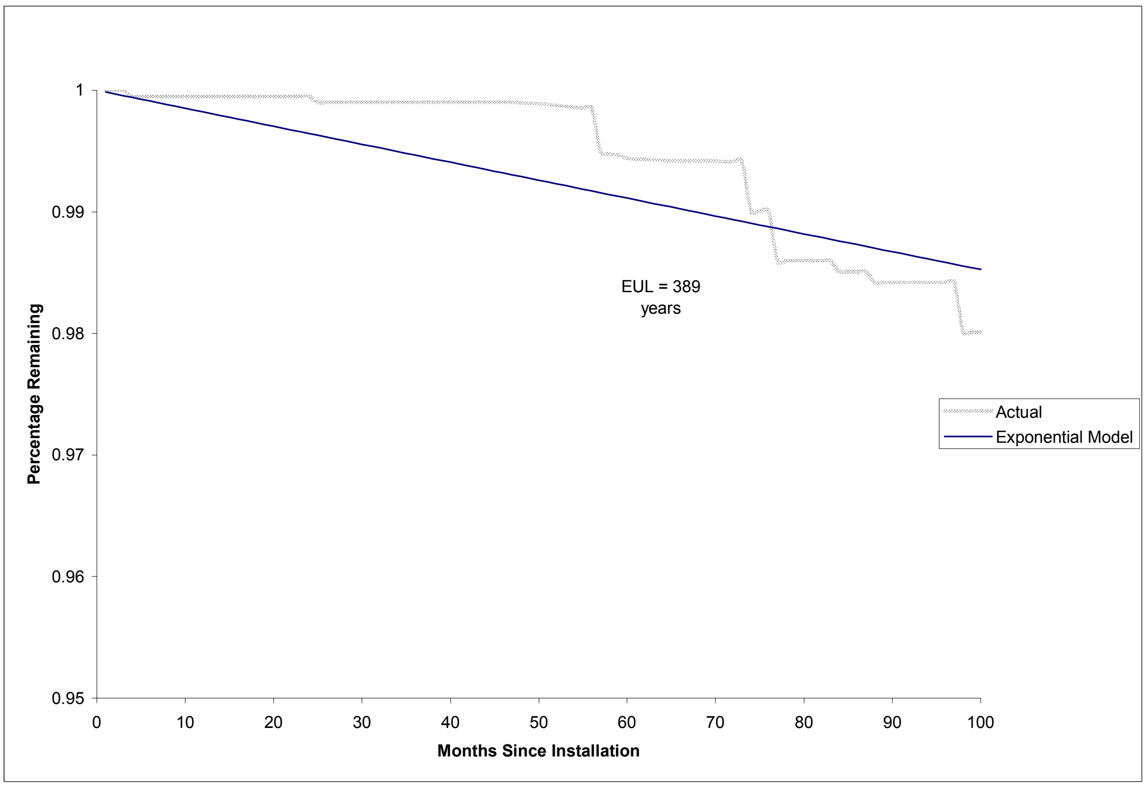
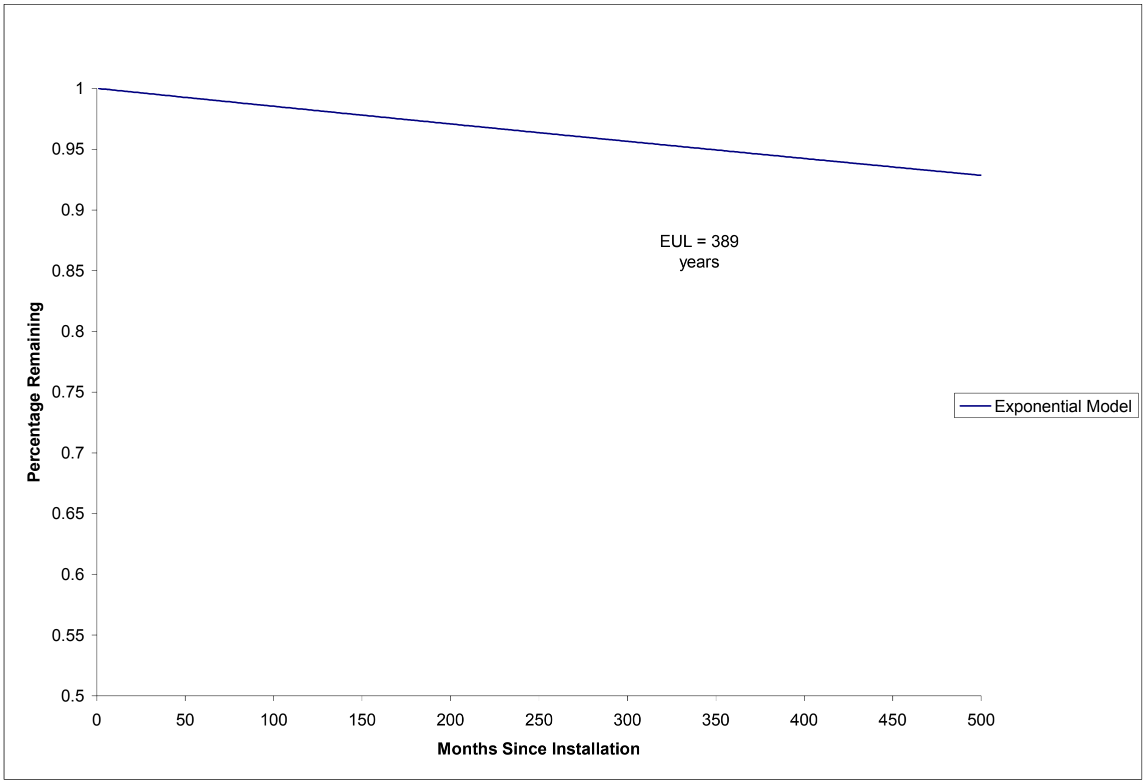


Exhibit 3-12 provides the resulting survival function assuming an exponential trend for the air conditioner dataset over 500 months. Referring back to the linear model (Exhibit 3-9), the differences between the two approaches are more apparent. Due to the constant hazard rate of the exponential model, the curve will flatten out over time, asymptotically approaching zero. The linear model, however, will continue with the same slope until no air conditioners remain.

Exhibit 3-12
Survival Function Based on an Exponential Trendline
Air Conditioner Failure Dataset



The results of the exponential regression along with the corresponding estimated EUL are provided in Exhibit 3-13. For an exponential survival function, the EUL (median life) is calculated as:

EUL = ln(2)/slope

Exhibit 3-13
Regression Results of Exponential Trendline
and Resulting Ex Post EUL Estimates

Model Description	Intercept	t-Statistic	Slope	t-Statistic	EUL
Exponential	0.00	0	0.0001	24.71	389

The result of the exponential trendline estimate is twice the length of the linear trendline estimate. Again, these results indicate the ex post EUL estimate is significantly larger than the ex ante estimate (which is 18 years). These results would easily reject the ex ante estimate at the 80 percent confidence level.

The exponential distribution has some important assumptions that should be addressed. Most importantly, the exponential distribution assumes a constant hazard rate. Although this distribution works well to explain certain data, this assumption is not believed to be valid for appliances such as air conditioners. If this were the case, then study results indicate that energy efficient air conditioners would have an EUL of 389 years.

As we will discuss in more detail in Section 4, this approach is not recommended for the final study results. In addition to the concern of the exponential distribution having properties that are not in line with our expectations, developing a trend line on empirical data in this manner is not optimal. The empirical data is interval and right hand censored, meaning that for some failures, the time of the event is unknown; and it is also unknown when currently operating equipment may fail. This trendline approach does not statistically correct for censored data in the way that classical survival analysis approaches do, as discussed in the following section.

3.7 CLASSICAL SURVIVAL ANALYSIS

This step in our approach is founded on applying classical survival analysis techniques to the retention data in order to develop a survival function. Using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System," we have modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we have plotted the resulting distribution and visually compared it to the empirical functions developed above. Furthermore, we have used the resulting survival function to estimate the EUL.

Some of the same issues we faced when developing the empirical survival function need to be addressed here as well. The problem of right-hand censoring is not an issue for SAS. The LIFEREG procedure, which we used for all of our modeling in this step, is capable of handling right-hand censored data.

SAS is also capable of handling left-hand censored data. In fact, our retention data is actually not left-hand censored, but interval censored. The true definition of left-hand censoring is that we know that an event occurred earlier than some time t, but we don't know exactly when. Interval censoring occurs when the time of failure occurrence is known to be somewhere between two times, but we don't know exactly when. Left censoring can be seen as a special case of interval censoring.

Although the LIFEREG procedure is capable of handling both left and interval censoring, interval censored data is more predictive than left hand censoring. Another commonly used survival analysis procedure in SAS is PHREG. Unfortunately, this procedure cannot handle either left or interval censored data. Therefore, we only conducted our analysis using the LIFEREG procedure.

Another important feature of the LIFEREG procedure is the use of covariates. This feature enabled us to use other predictive variables to help estimate the survival functions. Several covariates were tested for correlation, including owning vs. renting a home, dwelling type, whether a home remodel had occurred, and air conditioning and maintenance habits. None of the covariates tested proved to be statistically significant. Therefore, we did not use covariates in the final models.

Exhibit 3-14 provides the survival functions based on the exponential, logistic, lognormal, Weibull and gamma distributions, estimated for the air conditioning dataset using the LIFEREG procedure and compares these five survival functions with the empirical survival function, over the first 100 months of the measure's life.

Exhibit 3-14
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
Air Conditioning Dataset

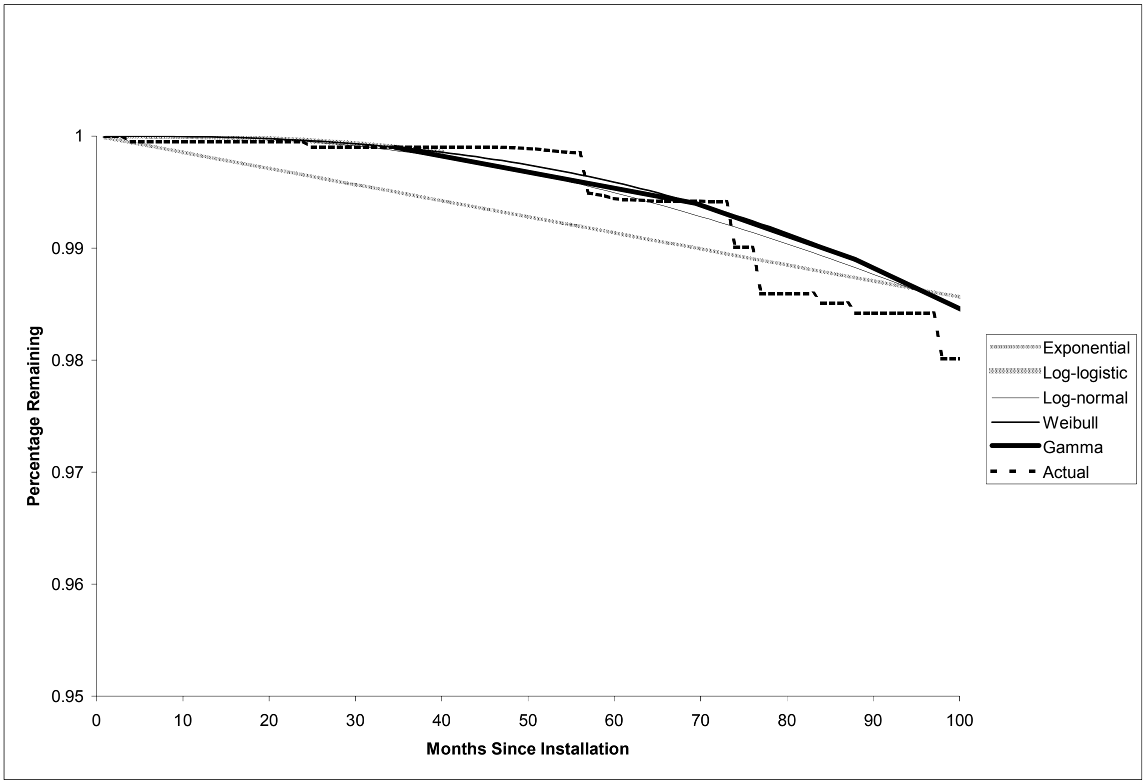


Exhibit 3-15 extends the models produced in LIFEREG to 500 months to examine how the distributions differ over time.

Exhibit 3-15
Exponential, Logistic, Lognormal, Weibull and Gamma Survival Functions
Based on LIFEREG Procedure
Air Conditioning Dataset

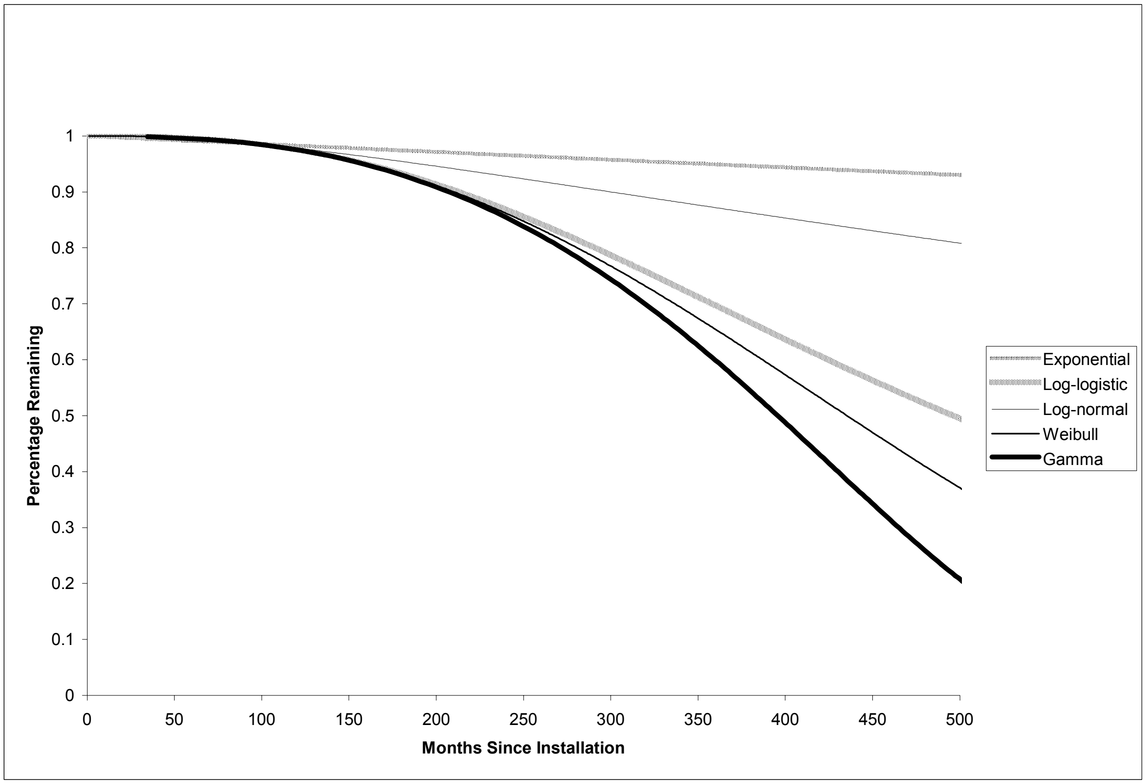


Exhibit 3-15 illustrates how the LIFEREG procedure models the survival function, forecasting out over time. It is likely that the model interprets the empirical data as beginning to "level off", by having a decreasing hazard rate. This interpretation leads the model to forecast somewhat of an asymptotic curve over time for the distributions that are capable of modeling a decreasing hazard rate. This is true for all of the modeled distributions, except for the exponential distribution, which has the property of having a constant hazard rate. That is why we see the exponential distribution deviate from the others: it has a constant hazard rate, while the others are modeled as having decreasing hazard rates over time, as seen in the empirical data.

It is also worth noting that of the five distributions modeled, the gamma distribution is the most adaptive. The LIFEREG procedure models the generalized gamma distribution, which has three parameters. Because this model has at least one more parameter than any of the other distributions, it can take on a wide variety of shapes. In addition, the exponential, Weibull and log-normal distributions are all special cases of the generalized gamma model. But the generalized gamma model can also take on shapes that are unlike any of these special cases. Most importantly, it can have hazard functions with U or bathtub shapes, in which the failure rate (or hazard function) declines, reaches a minimum, and then increases.

Exhibit 3-16 below summarizes the results of the LIFEREG models for the rebated air conditioners. Shown for each model are the parameter estimates and standard errors for every variable included in the model specification. Furthermore, the resulting EUL and its associated standard error are provided.

Exhibit 3-16
Comparison of Survival Model Results
Exponential, Logistic, Lognormal, Weibull and Gamma Models

			Variable			Resulting
Measure	**Model**		**Intercept**	**Scale**	**Shape**	**EUL**
Air Conditioning	Exponential	Parameter Estimate	8.84	1.00	-	**399**
		Standard Error	0.12	0.00	-	62
	Logistic	Parameter Estimate	6.21	0.39	-	**41.4**
		Standard Error	0.18	0.04	-	10
	Log-Normal	Parameter Estimate	7.30	1.25	-	**123.7**
		Standard Error	0.29	0.13	-	45
	Weibull	Parameter Estimate	6.22	0.39	-	**36.3**
		Standard Error	0.19	0.04	-	9
	Gamma	Parameter Estimate	6.14	0.26	1.50	**33.0**
		Standard Error	0.05	0.00	0.00	2

Section 4 provides the recommended results and summarizes all of the results developed in this section.

4. RESULTS

This section presents the final results of the 1994 and 1995 RAEI Retention Study. As discussed in detail in Section 3, the overall approach consists of four analysis steps that were used to estimate the EUL for rebated air conditioners:

1. ***Compile summary statistics*** on the raw retention data.

2. ***Visually inspect*** the retention data.

3. ***Develop a trend line*** from the survival plots.

4. ***Develop a survival function*** using classical survival techniques.

4.1 COMPILE SUMMARY STATISTICS

Although the analysis was conducted on one combined dataset, initial summary statistics were produced for each population. This provided insight on the number and type of events by population group. Exhibit 4-1 presents the percentage of air conditioners that were found to have failed over the study periods (four or nine years depending on the population).

Exhibit 4-1
Unweighted Summary Statistics on Raw Retention Data

Population	Number of Surveys Conducted	Number of Units that Failed, were Removed, or Replaced	Number of Units Replaced Under Warranty or by Insurance	Number of Units in Place and Operable	Percent Failed, Removed, Replaced
9th Year Non Recall	299	7	1	293	2.01%
4th / 9th Year Recall	103	4	0	99	3.88%
9th Year Subtotal	402	11	1	392	2.49%
4th Year Non Recall	310	0	0	310	0.00%
Total	712	11	1	702	1.40%

An unweighted percentage of units that have failed was calculated. From this percentage, an EUL was estimated, assuming a constant failure rate over the life of the measure.

Exhibit 4-2
Illustrative Ex Post Unweighted EUL Estimates
Based on Exponential Distribution and Conservative Assumptions

Survey Type	Percent Failed, Removed, Replaced	Annualized Failure, Removal, Replacement Rate^	Mean Life*	Median Life*	Ex Ante EUL
Air Conditioners	2.49%	0.28%	362	251	18

^ Includes only 9th Year survey data and assumes failures occur over a 9 year period.
* Assuming a constant failure rate over time.

4.2 VISUAL INSPECTION

An empirical survival function was developed from the observed raw retention data for the first eight to nine years of the measures' lives. This empirical survival function showed that at 100 months into the measures life only 2% of the measures had failed. This gave us a good early indication that the expected useful life of the air conditioning measures could be estimated to be longer than the ex ante estimate of 18 years.

4.3 DEVELOP A TREND LINE

Using the empirical functions developed above, a trend line was estimated using standard linear regression techniques. We modeled the trend as a linear and an exponential function (by taking the log of the percentage operable). In each case, we plotted the resulting trend line and visually compared it to the empirical survival function developed above.

The results of the trendline regressions are provided in Exhibit 4-3 for both the linear and exponential models. Also provided in Exhibit 4-3 is the estimated EUL for each model. Clearly, the results of the linear and exponential trendline estimate indicate that the ex post EUL estimates are significantly larger than the ex ante estimates (which are all 18 years). Each of these results would easily reject the ex ante estimate at the 80 percent confidence level.

Exhibit 4-3
Regression Results of Linear and Exponential Trendlines
and Resulting Ex Post EUL Estimates

Model Description	Intercept	t-Statistic	Slope	t-Statistic	EUL
Linear	1.01	1,701.74	-0.0002	-23.44	194
Exponential	0.00	0.00	0.0001	24.71	389

4.4 DEVELOP A SURVIVAL FUNCTION

Using classical survival techniques, we modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we plotted the resulting distribution and visually compared it to the survival plot developed above. Furthermore, we used the resulting survival function to estimate the EUL.

Exhibit 4-4 provides the results of the classical survival analysis. Shown are the model results for each type of distribution modeled and the resulting EUL estimates.

Exhibit 4-4
Comparison of Survival Model Results for Rebated Air conditioners
Exponential, Logistic, Lognormal, Weibull and Gamma Models

Measure	Model		Variable			Resulting
			Intercept	Scale	Shape	EUL
Air Conditioning	Exponential	Parameter Estimate	8.84	1.00	-	**399**
		Standard Error	0.12	0.00	-	62
	Logistic	Parameter Estimate	6.21	0.39	-	**41.4**
		Standard Error	0.18	0.04	-	10
	Log-Normal	Parameter Estimate	7.30	1.25	-	**123.7**
		Standard Error	0.29	0.13	-	45
	Weibull	Parameter Estimate	6.22	0.39	-	**36.3**
		Standard Error	0.19	0.04	-	9
	Gamma	Parameter Estimate	6.14	0.26	1.50	**33.0**
		Standard Error	0.05	0.00	0.00	2

4.5 FINAL RESULTS

Exhibit 4-5 summarizes the estimated EULs from the survival analysis and the corresponding model. The median EULs are provided, along with the upper and lower confidence bounds, based on the 80 percent confidence interval.

Exhibit 4-5
Comparison of All Model Results
Summary Statistics, Linear and Exponential Trendlines
and Linear, Exponential, Logistic, Lognormal, Weibull and Gamma Survival Models

		Analysis Methods		
Approach	Model	Median EUL	Upper Bound	Lower Bound
Summary Statistics	Exponential	251	-	-
Trendlines	Linear	194	205	184
	Exponential	389	409	369
LIFEREG	Exponential	399	461	338
	Logistic	41.4	51.1	31.6
	Log-Normal	123.7	169.0	78.3
	Weibull	36.3	44.2	28.4
	Gamma	33.0	34.9	31.0

4.6 RECOMMENDATIONS

Based on our extensive analysis of the retention data, we believe that there is sufficient evidence to alter the claimed EUL for air conditioning measures from the ex ante EUL of 18 years to an ex post of 20 years (the maximum measure life considered under PG&E's Annual Earnings Assessment Proceedings [AEAP]). The best fitting model using classical survival analysis techniques is based on the gamma distribution and produced statistically significant results indicating an ex post EUL of 33 years. The best fitting model, was also the minimum EUL model. The maximum EUL model, based on the exponential distribution, has an EUL of 399 years.

The results based on the summary statistics are not recommended, as they based solely on the overall failure rate observed during the study period. In addition, the results based on the trendlines are not recommended, as they are based on a number of assumptions, as discussed earlier. One of the primary reasons both of these methods are not recommended is that they are not capable of explicitly handling interval and right hand censored data, as the LIFEREG procedure is. Therefore, the recommended results are based on the classical survival analysis using the LIFEREG procedure.

The EUL estimate from this study is 33.0 years, which rejects the ex ante EUL at the 80% confidence interval and thus allows PG&E to extend the EUL estimate used in their claim to its maximum value of 20 years. As a result the program realization rate, which is the ratio of the ex ante and ex post estimates, is 111%. These results are summarized in Exhibit 4-6.

Exhibit 4-6
Final Ex Post EUL Estimate

Program		Study Results					Ex Post	Realization
Year	End Use	Ex Ante	Upper	Median	Lower	Ex Post	Claimed	Rate
1994/1995	Air Conditioning	18	34.9	33.0	31.0	33	20	111%

APPENDIX 1

PROTOCOL TABLES 6B AND 7B

NINTH YEAR RETENTION STUDY FOR PG&E'S 1994 & 1995 RESIDENTIAL AEI PROGRAM SPACE CONDITIONING TECHNOLOGY

PG&E STUDY ID # 384cR2

This Attachment presents Tables 6B and 7B for the above referenced study as required under the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols), as adopted by the California Public Utility Commission (CPUC) Decision 93-05-063, Revised March 1998 Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-052.

The Table 7B synopsis of analytical methods applied follows Protocol Table 6B.

Protocol Table 6.B
Results of Retention Study
PG&E 1994 & 1995 Residential Space Conditioning Ninth Year Retention
Study ID # 384cR2

		Item 2		Item 3	Item 4	Item 5	Item 6		Item 7	Item 8	Item 9
Studied Measure Description	**End Use**	**Ex Ante EUL**	**Source of Ex Ante EUL**	**Ex post EUL from Study**	**Ex Post EUL to be used in Claim**	**Ex Post EUL Standard Error**	**80% Conf. Interval Lower Bound**	**80% Conf. Interval Upper Bound**	**p-Value for Ex Post EUL**	**EUL Realizat'n Rate (ex post/ex ante)**	**"Like" Measures Associated with Studied Measure (by measure code)**
Split CAC SEER: 11-11.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 11-11.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 11-11.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 11-11.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 11-11.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 11-11.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 11-11.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 11-11.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 12-12.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 12-12.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 12-12.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 12-12.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 12-12.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 12-12.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 12-12.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 12-12.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 13-13.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 13-13.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 13-13.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 13-13.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 13-13.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 13-13.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 13-13.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 13-13.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 14-14.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 14-14.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 14-14.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 14-14.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 14-14.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 14-14.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 14-14.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 14-14.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 15-15.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 15-15.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 15-15.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 15-15.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 15-15.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 15-15.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 15-15.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 15-15.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 16-16+,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 16-16+,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 16-16+,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 16-16+,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 16-16+,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a

Split CAC SEER: 16-16+,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 16-16+,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Split CAC SEER: 16-16+,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 11-11.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 11-11.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 11-11.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 11-11.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 11-11.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 11-11.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 11-11.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 11-11.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 12-12.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 12-12.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 12-12.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 12-12.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 12-12.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 12-12.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 12-12.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 12-12.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 13-13.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 13-13.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 13-13.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 13-13.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 13-13.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 13-13.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 13-13.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 13-13.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 14-14.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 14-14.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 14-14.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 14-14.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 14-14.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 14-14.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 14-14.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 14-14.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 15-15.9,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 15-15.9,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 15-15.9,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 15-15.9,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 15-15.9,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 15-15.9,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 15-15.9,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 15-15.9,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 16-16+,1.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 16-16+,2 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 16-16+,2.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 16-16+,3 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 16-16+,3.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 16-16+,4 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 16-16+,4.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 16-16+,5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a
Packaged CAC SEER: 11-11.91.5 Ton	Space Conditiong	18	Advice Filing	33.0	20	1.6	31.0	34.9	<0.0001	111%	n/a

PROTOCOL TABLE 7B

NINTH YEAR RETENTION STUDY FOR PG&E'S 1994 & 1995 RESIDENTIAL AEI PROGRAM SPACE CONDITIONING TECHNOLOGY PG&E STUDY ID # 384CR2

The purpose of this section is to provide the documentation for data quality and processing as required in Table 7B of the California Public Utility Commission (CPUC) Evaluation and Measurement Protocols (the Protocols). The major topics covered in this section are organized and presented in the same order as they are listed in Table 7B for ease of reference and review. For items discussed in detail elsewhere in the report, only a brief summary will be given in this section to avoid redundancy.

1. OVERVIEW INFORMATION

A. Study Title and Study ID Number

Study Title: Ninth Year Retention Study of PG&E's 1994 & 1995 Residential AEI Program Space Conditioning Technology.

Study ID Number: 384cR2

B. Program, Program Year and Program Description

Program: PG&E Residential AEI Program, Space Conditioning Technology.

Program Year: 1994 and 1995

Program Description:

The Residential Appliance Efficiency Incentive (RAEI) Program offered rebates to customers who installed air conditioners meeting specific electric energy-efficiency requirements. Rebates ranging from $100 to $1,200 were paid for air conditioners with SEERs ranging from 11 to 16+ . The programs assumed that customers were in the process of replacing their existing air conditioners, and offered the incentive to influence them to purchase more efficient models.

C. End Uses and/or Measures Covered

Air Conditioners.

D. Methods and Models Used

Our overall approach consists of four analysis steps that were used to estimate the EUL for rebated air conditioners:

1. ***Compile summary statistics*** on the raw retention data. This step immediately illustrated the difficulties posed for analysis since there were so few "failures" over the first five years.

2. ***Visually inspect*** the retention data. By calculating the cumulative percentage of equipment that had failed in a given month, and plotting this percentage over time, an empirical survival function emerged.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, we estimated a trend line using standard linear regression techniques. We attempted to model the trend as a linear and an exponential function. In each case, we plotted the resulting trend line and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting trend line to estimate the EUL.

4. ***Develop a survival function*** using classical survival techniques. Using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System," we modeled the survival function assuming five of the most common survival distributions: exponential, logistic, lognormal, Weibull and gamma. In each case, we plotted the resulting distribution and visually compared it to the survival plot developed in (2). Furthermore, we used the resulting survival function to estimate the EUL.

The details surrounding each of these steps are provided in Section 3 of the report.

E. Analysis Sample Size

The exhibit below provides the final sample disposition used in the study analysis. *Section 3.2* discusses the sample plan in detail.

Final Sample Disposition

Type and Number of Surveys Conducted		Survey Points Not Used	In Place & Operating	Failed	Total
9th Year Non Recall	302	3	293	6	299
4th / 9th Year Recall	103	0	99	4	103
4th Year Non Recall	310	0	310	0	310
Total	715	3	702	10	712

2. DATABASE MANAGEMENT

A. Key Data Elements and Sources

The Retention Study incorporated a variety of data currently available; in particular PG&E's program participation data (Marketing Decision Support System [MDSS]), retention study databases, and other program-related documentation.

- *Program Participant Tracking System*. The participant tracking system data, maintained in PG&E's MDSS, contains vital project and technical information about the measures rebated. In addition, participant contact information is stored in the MDSS.

- *Residential Population CIS*. PG&E residential customer information system (CIS) data was used to obtain contact information as well as to identify movers and non-movers using the date on premise.

- *Program Marketing Data*. PG&E program marketing data contains a detailed description of the installation and rebate program procedures.

- *Fourth Year Retention Study Contacts.* The fourth year retention study contact data provided information regarding the status of the 413 air conditioning units surveyed in 1999. This data was used to supplement data collected during the ninth year study.

In addition, telephone surveys were conducted to support the analysis, as discussed in *Section 3* of the report.

B. Data Attrition Process

All data points that had survey data on a rebated air conditioner were utilized in the analysis. As discussed in *Section 3*, the SAS analysis procedures we implemented were able to handle interval censored data, in the cases when failure dates were not obtainable.

C. Internal Data Quality Procedures

The Evaluation contractor of this project, Quantum Consulting Inc. (QC), has performed extensive data quality control on all retention and follow-up survey data. QC's data quality procedures are consistent with PG&E's internal database guidelines and the guidelines established in the Protocols.

Throughout every step of this project, numerous data quality assurance procedures were in place to ensure that all data used in analysis and all survey data collected was of the highest quality. On questionable responses follow-up phone calls or site visits were made.

D. Unused Data Elements

As shown above in the disposition table, three surveys that had initially been dispositioned as completes were later dropped from the analysis since the individual surveyed could not confirm whether the unit being discussed was in fact the rebated unit.

Otherwise, all data collected specifically for the Evaluation were utilized in the analysis.

3. SAMPLING

A. Sampling Procedures and Protocols

Section 3.2 describes the sample procedures and protocols.

B. Survey Information

The data collection instrument is presented in the *Attachment 2.* The exhibit below provides the final sample disposition, which contains the number of customers that were surveyed.

Final Sample Disposition

Type and Number of Surveys Conducted		Survey Points Not Used	In Place & Operating	Failed	Total
9th Year Non Recall	302	3	293	6	299
4th / 9th Year Recall	103	0	99	4	103
4th Year Non Recall	310	0	310	0	310
Total	715	3	702	10	712

C. *Statistical Descriptions*

Statistics variables that were used in the survival models are presented in *Section 3.* The exhibit below provides the raw summary statistics of the data utilized for the analysis.

Unweighted Summary Statistics on Retention Sample Data

Population	Number of Surveys Conducted	Number of Units that Failed, were Removed, or Replaced	Number of Units Replaced Under Warranty or by Insurance	Number of Units in Place and Operable	Percent Failed, Removed, Replaced
9th Year Non Recall	299	7	1	293	2.01%
4th / 9th Year Recall	103	4	0	99	3.88%
9th Year Subtotal	402	11	1	392	2.49%
4th Year Non Recall	310	0	0	310	0.00%
Total	712	11	1	702	1.40%

4. *DATA SCREENING AND ANALYSIS*

A. *Procedures for Treating Outliers and Missing Data*

All data points that had survey data on a rebated air conditioner were utilized in the analysis. As discussed in *Section 3*, the SAS analysis procedures we implemented were able to handle interval censored data, in the cases when failure dates were not obtainable.

B. *Background Variables*

Due to the nature of this analysis (survival analysis), background variables, such as interest rates, unemployment rates and other economic factors, were not considered to be a necessary component of the analysis.

C. *Data Screen Process*

Again, all data points that had survey data on a rebated air conditioner were utilized in the analysis.

D. Regression Statistics

The regression statistics for the models implemented are provided in *Section 3*.

E. Model Specification

The model specifications are presented in *Section 3*.

F. Measurement Errors

For the survival analysis, the main source of measurement errors is the survey data. Our approach has been to proactively stop the problem before it happens so that statistical corrections are kept to a minimum.

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and mis-coded study variables. In this project, we implemented several controls to reduce systematic bias in the data. These steps include a thorough interviewer training and survey instrument pretest.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased. For the measures that were modeled in the survival analysis, the impact of random unbiased measurement errors was accounted for as part of the overall standard variance in the parameter estimate.

G. Influential Data Points

No diagnostics were used to identify outliers.

H. Missing Data

As discussed in *Section 3*, the SAS analysis procedures we implemented were able to handle interval censored data, in the cases when failure dates were missing. There were no other missing data points, other than failure dates.

I. Precision

The SAS output provided the standard errors for the 50th percentile (or median).

APPENDIX 2

PG&E Residential Space Conditioning Retention Survey
Original Occupant Survey FINAL

Vars Needed for CATI:
Name
Install Year
Install Month
Address
Phone Number(s)
Brand
Brand_Flag
Recall

Hello, this is _______________________, calling from Quantum Consulting on behalf of PG&E. May I speak with (NAME)? (IF THIS PERSON IS AVAILABLE, PROCEED. IF NOT, READ:) May I speak to the head of the household? IF THIS PERSON IS NOT AVAILABLE, GET HIS/HER NAME AND MAKE ARRANGEMENTS TO CALL LATER.

If recall = 1
IF THERE IS SOMEONE TO TALK TO, READ: PG&E is conducting research on certain Central Air Conditioners purchased through their rebate program, to see if they are still working properly. According to PG&E's records there was a central air conditioner purchased for this household in (INSTALL YEAR). You may remember being contacted 5 years ago about this central air conditioner. We are not trying to sell you anything and the survey will take 5 to 10 minutes.

If recall = 0
IF THERE IS SOMEONE TO TALK TO, READ: PG&E is conducting research on certain Central Air Conditioners purchased through their rebate program, to see if they are still working properly. According to PG&E's records there was a central air conditioner purchased for this household in (INSTALL YEAR). We are not trying to sell you anything and the survey will take 5 to 10 minutes.

IF NECESSARY: PG&E is required by law to conduct these surveys to determine the operating status of central air conditioners for which they provided rebates to customers.

SC. SCREENER SECTION

SC1. First, I want to make sure that I reached you at (ADDRESS). Is this your correct address?

1	Yes	SC2
2	No	SC1A
88	Refused	T&T
99	Don't Know	T&T

SC1A. May I have your corrected address?

77	Specify	SC2

NOTE TO INTERVIEWER: Are they close enough to proceed – if yes then go to SC2

SC2. Is (ADDRESS) a home, a place of business, or both?

1	Home (including those that telecommute)	SC3
2	Place of business	T&T
3	Both	SC3
88	Refused	T&T
99	Don't Know	T&T

SC3. Did you move to this address since (INSTALL MONTH) of (INSTALL YEAR)?

1	Yes	SC4
2	No	SC5A
88	Refused	T&T
99	Don't Know	SC4

SC4. Do you know in approximately what year you moved into this residence?

SC4 Year

1	Prior to 1993	SC5B
2	1993	SC5B
3	1994	SC5B
4	1995	SC5B
5	1996	T&T
6	1997	T&T
7	1998	T&T
8	1999	T&T
9	2000	T&T
10	2001	T&T
11	2002	T&T
12	2003	T&T
88	Refused	CA10
99	Don't Know	CA10

SC5A. Do you recall your household purchasing a central air conditioner in (INSTALL YEAR)?

1	Yes	CA1
2	No	T&T
88	Refused	T&T
99	Don't Know	T&T

SC5B. Do you recall your household purchasing a central air conditioner in (SC4 &YEAR)?

1	Yes	CA1
2	No	T&T
88	Refused	T&T
99	Don't Know	T&T

CA. CENTRAL AIR CONDITIONER REBATE ORIGINAL PARTICIPANTS SECTION

I would now like to ask you some questions about this central air conditioner

CA1. Is the air conditioner still in place at (ADDRESS)?

1	Yes	CA2
2	No	CA21
88	Refused	T&T
99	Don't Know	T&T

If BRAND_FLAG = 1 then ask CA2, else ask CA3
CA2. Is the air conditioner a (BRAND)?

1	Yes	CA37
2	No	CA3
88	Refused	CA37
99	Don't Know	CA37

CA3. Do you know what Brand it is?

77	Specify	CA37

88	Refused	CA37
99	Don’t Know	CA37

CA21. What happened to the air conditioner? (DO NOT READ LIST)

1	Broke	CA23
2	Damaged in fire, earthquake, flood or other disaster	CA23
3	Removed it	CA23
4	Installed it at another address	CA23
77	Other (Specify)	CA23
88	Refused	T&T
99	Don’t Know	T&T

CA23. In what year did this happen?

CA23 Year

1	1993	CA24
2	1994	CA24
3	1995	CA24
4	1996	CA24
5	1997	CA24
6	1998	CA24
7	1999	CA24
8	2000	CA24
9	2001	CA24
10	2002	CA24
11	2003	CA24
88	Refused	CA26
99	Don’t Know	CA26

CA24. In what month in &year did this happen?

CA24 Month

1	January	CA26
2	February	CA26
3	March	CA26
4	April	CA26
5	May	CA26
6	June	CA26
7	July	CA26
8	August	CA26
9	September	CA26
10	October	CA26
11	November	CA26
12	December	CA26
13	Spring	CA26
14	Summer	CA26
15	Fall	CA26
16	Winter	CA26
88	Refused	CA26
99	Don’t Know	CA26

IF CA21 = 1 then ask CA26
Else IF CA21 = 2 then skip to CA27
Else IF CA21 = 3, 4, 77 then Skip to CA28

CA26. Was the unit replaced under warranty?

1	Yes	CA29
2	No	CA28
88	Refused	CA28
99	Don't Know	CA28

CA27. Was the unit replaced through insurance?

1	Yes	CA29
2	No	CA28
88	Refused	CA28
99	Don't Know	CA28

CA28. Was the unit replaced?

1	Yes	CA29
2	No	CA32
88	Refused	CA32
99	Don't Know	CA32

CA29. Was it replaced with an air conditioner of the same efficiency or higher?

1	Lower Efficiency	CA30
2	Same Efficiency	CA30
3	Higher Efficiency	CA30
88	Refused	CA30
99	Don't Know	CA30

IF CA21 = 3,4 or 77 and CA23 = 9, 10 or 11 then ask CA30, else skip to CA32
CA30. On a scale of 1 to 5 how influential was the Energy Crisis of 2001 on your decision to replace the unit you purchased in (INSTALL YEAR)?

1	Extremely Influential	CA31
2	Very Influential	CA31
3	Somewhat Influential	CA31
4	Slightly Influential	CA31
5	Not Influential	CA31
88	Refused	CA31
99	Don't Know	CA31

CA31. Did you receive a rebate from PG&E for the new air conditioner?

1	Yes	CA32
2	No	CA32
88	Refused	CA32
99	Don't Know	CA32

IF CA21 = 4 then ask CA32,
ELSE IF CA21=3 or 77 then ask CA34,
Else Skip to CA36a

CA32. To the best of your knowledge, is the new location of the air conditioner somewhere in central or northern California?

1	Yes	CA34
2	No	CA33a
88	Refused	CA34
99	Don't Know	CA34

CA33a. What state is the air conditioner now in?

77	Specify	CA33b
88	Refused	CA33b
99	Don’t Know	CA33b

CA33b. What city/area is the air conditioner now in?

77	Specify	CA34
88	Refused	CA34
99	Don’t Know	CA34

CA34. Was the air conditioner still in good working condition when you removed it?

1	Yes	CA35
2	No	CA35
88	Refused	CA35
99	Don’t Know	CA35

CA35. Why did you remove your air conditioner?

1	Remodeled	CA36a
2	Needed Larger Unit	CA36a
3	Needed Smaller Unit	CA36a
4	Didn’t like Unit	CA36a
5	Had Major Repair Problems	CA36b
6	Had Minor Repair Problems	CA36b
7	Was Given better Unit	CA36a
8	Wanted more Energy Efficient Unit	CA36a
77	Other (Specify)	CA36a
88	Refused	CA36a
99	Don’t Know	CA36a

CA36a. Have you had any problems with the air conditioner? (DO NOT READ)
(NOTE TO INTERVIEWERS – If repairs probe major or minor)

1	Yes - Needed Major Repairs	CA36b
2	Yes - Needed Minor Repairs	CA36b
3	No	CA40
77	Specify	CA36b
88	Refused	CA36b
99	Don’t Know	CA36b

CA36b. Did you ever have to replace the compressor?
(NOTE TO INTERVIEWERS – The compressor is the most important motor driven device in the outdoor component of the central air-conditioning system.)

1	Yes	CA36e
2	No	CA36c
88	Refused	CA36c
99	Don’t Know	CA36c

CA36c. What was the approximate cost of the repairs?

77	Specify	CA36e
88	Refused	CA36d
99	Don’t Know	CA36d

CA36d. What was the approximate cost of the repairs? (READ ALL)

1	Less than $100	CA36e
2	$100-200	CA36e
3	$200-$400	CA36e
4	$400-$700	CA36e
5	More than $700	CA36e
77	Specify	CA36e
88	Refused	CA36e
99	Don’t Know	CA36e

CA36e. In what year did this repair occur?
(NOTE TO INTERVIEWERS – If multiple repairs occurred get the year of the biggest repair)

CA36e Year

1	1993	CA36f
2	1994	CA36f
3	1995	CA36f
4	1996	CA36f
5	1997	CA36f
6	1998	CA36f
7	1999	CA36f
8	2000	CA36f
9	2001	CA36f
10	2002	CA36f
11	2003	CA36f
88	Refused	CA40
99	Don’t Know	CA40

CA36f. In what month or season in &year did this happen?

CA36f Month

1	January	CA40
2	February	CA40
3	March	CA40
4	April	CA40
5	May	CA40
6	June	CA40
7	July	CA40
8	August	CA40
9	September	CA40
10	October	CA40
11	November	CA40
12	December	CA40
13	Spring	CA40
14	Summer	CA40
15	Fall	CA40
16	Winter	CA40
88	Refused	CA40
99	Don’t Know	CA40

CA37. Is the air conditioner still in good working condition?

1	Yes	CA38a
2	No	CA38a
88	Refused	CA38a
99	Don’t Know	CA38a

CA38a. Have you had any problems with the air conditioner? (DO NOT READ)

1	Needed Major Repairs	CA38b
2	Needed Minor Repairs	CA38b
3	No	CA40
77	Specify	CA38b
88	Refused	CA38b
99	Don't Know	CA38b

CA38b. Have you had to replace the compressor?
(NOTE TO INTERVIEWERS – The compressor is the most important motor driven device in the outdoor component of the central air-conditioning system.)

1	Yes	CA38e
2	No	CA38c
88	Refused	CA38c
99	Don't Know	CA38c

CA38c. What was the approximate cost of the repairs?

77	Specify	CA38e
88	Refused	CA38d
99	Don't Know	CA38d

CA38d. What was the approximate cost of the repairs? (READ ALL)

1	Less than $100	CA38e
2	$100-200	CA38e
3	$200-$400	CA38e
4	$400-$700	CA38e
77	Specify	CA38e
88	Refused	CA38e
99	Don't Know	CA38e

CA38e. In what year did this repair occur?
(NOTE TO INTERVIEWERS – If multiple repairs occurred get the year of the biggest repair)

CA38e Year

1	1993	CA38f
2	1994	CA38f
3	1995	CA38f
4	1996	CA38f
5	1997	CA38f
6	1998	CA38f
7	1999	CA38f
8	2000	CA38f
9	2001	CA38f
10	2002	CA38f
11	2003	CA38f
88	Refused	CA40
99	Don't Know	CA40

CA38f. In what month or season in &year did this happen?

CA38f Month

1	January	CA40
2	February	CA40
3	March	CA40
4	April	CA40
5	May	CA40

6	June	CA40
7	July	CA40
8	August	CA40
9	September	CA40
10	October	CA40
11	November	CA40
12	December	CA40
13	Spring	CA40
14	Summer	CA40
15	Fall	CA40
16	Winter	CA40
88	Refused	CA40
99	Don't Know	CA40

CA40. How often did/do you use your central air conditioner? Would you say it was on…

1	Almost every day of the summer	CA41
2	Most days of the summer	CA41
3	Only on the very hottest days	CA41
77	Specify	CA41
88	Refused	CA41
99	Don't know	CA41

CA41. At what temperature did/do you keep your thermostat during summer days while your home is occupied?

77	Specify	CA42
88	Refused	CA42
99	Don't Know	CA42

CA42. At what temperature do/did you keep your thermostat during summer nights while your home is occupied?

77	Specify	CA43
88	Refused	CA43
99	Don't Know	CA43

CA43. At what temperature do/did you keep your thermostat during summer days while your home is not occupied?

77	Specify	CA43a
88	Refused	CA43a
99	Don't Know	CA43a

CA43a. Do you have a programmable thermostat?

1	Yes	CA43b
2	No	CA44
88	Refused	CA44
99	Don't Know	CA44

CA43b. I'd like to get an idea of how you are using this thermostat to control the temperature of your home. Do you usually adjust the temperature settings on your new thermostat manually or do you program it to adjust automatically at different times of the day?

1	Manual	CA44

2	Program	CA44
88	Refused	CA44
99	Don't Know	CA44

CA44. Did/do you change the air conditioning filters during the summer when you operate your central air conditioner?

1	Yes	CA45
2	No	CA46
88	Refused	CA46
99	Don't Know	CA46

CA45. How often did/do you change the air conditioning filters?

1	Once a summer	CA46
2	Monthly	CA46
3	When they need it	CA46
77	Specify	CA46
88	Refused	CA46
99	Don't Know	CA46

CA46. Did/Do you have a technician come out and check your central air conditioner?

1	Yes	CA47
2	No	CA48
88	Refused	CA48
99	Don't Know	CA48

CA47. How often did/do you have a technician come out and check your central air conditioner?

1	Once a year	CA48
2	Every other year	CA48
3	When we have a problem	CA48
77	Specify	CA48
88	Refused	CA48
99	Don't Know	CA48

CA48. Did/Do you make sure that there were/are no leaves or plants touching your outside air conditioning unit?

1	Yes	CA50
2	No	CA70
88	Refused	CA70
99	Don't Know	CA70

CA50. How often did/do you clean around your outside air conditioning unit?

1	Once a year	CA70
2	Every other year	CA70
3	When we have a problem	CA70
77	Specify	CA70
88	Refused	CA70
99	Don't Know	CA70

Read to All:
Now, we'd like to ask you a few questions about your home.

CA70. To the best of your knowledge has there been any major remodeling or renovation performed at (ADDRESS) since (REBATE YEAR)?

1	Yes	CA71
2	No	CA72
88	Refused	CA72
99	Don't Know	CA72

CA71. During what year did that remodeling occur?

CA71 Year

1	1993	CA72
2	1994	CA72
3	1995	CA72
4	1996	CA72
4	1997	CA72
5	1998	CA72
6	1999	CA72
7	2000	CA72
8	2001	CA72
9	2002	CA72
10	2003	CA72
88	Refused	CA72
99	Don't Know	CA72

CA72. What type of residence do you live in?

1	Single Family Detached Home	CA73
2	Townhouse (also duet home, duplex)	CA73
3	Condo	CA73
4	Apartment (also multifamily, multi-unit)	CA73
5	Mobile Home	CA73
77	Other (specify)	CA73
88	Refused	CA73
99	Don't Know	CA73

CA73. Do you own or rent this residence?

1	Own/buying	CA74
2	Rent/lease	CA74
77	Other (specify)	CA74
88	Refused	CA74
99	Don't Know	CA74

CA74. How many people are in your household, including yourself?

1	1	CA300
2	2	CA300
3	3	CA300
4	4	CA300
5	5	CA300
6	6	CA300
7	7	CA300

8	8	CA300
9	9	CA300
10	10	CA300
11	11	CA300
12	12	CA300
13	13	CA300
14	14	CA300
15	15	CA300
16	16	CA300
17	More than 16	CA300
88	Refused	CA300
99	Don’t Know	CA300

CA300 Goodbye!

Those are all of my questions. Thank you very much for taking the time to participate in this study.