RETENTION STUDY OF PACIFIC GAS & ELECTRIC COMPANY'S 1996 AND 1997 APPLIANCE ENERGY EFFICIENCY PROGRAMS

1996-1997 RESIDENTIAL REFRIGERATION NINTH YEAR RETENTION

PG&E Study ID number: 373 1R2
CALMAC Study ID number: PGE0236.01

January 25, 2006

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Measurement and Evaluation
Customer Energy Efficiency
Policy, Evaluation & Regulatory Requirements Section
Pacific Gas and Electric Company
San Francisco, California

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As part of its Customer Energy Efficiency Programs, Pacific Gas and Electric Company (PG&E) has engaged consultants to conduct a series of studies designed to increase the certainty of and confidence in the energy savings delivered by the programs. This report describes one of those studies. It represents the findings and views of the consultant employed to conduct the study and not of PG&E itself.

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NINTH YEAR RETENTION STUDY FOR
PG&E'S 1996 AND 1997 RESIDENTIAL AEI PROGRAM
REFRIGERATION TECHNOLOGIES
PG&E Study ID number: 373 1R2
CALMAC Study ID number: PGE0236.01

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 refrigeration technologies for which rebates were paid in 1996 and 1997 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 five 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.

5. ***Develop a competing risks model*** that incorporates different distributions for failures and removals. Combining these two distributions results in a survival function used to estimate the EUL.

Final Results

The final study results are based on the rebated refrigerator failure and removal data modeled using the gamma distribution for failures and the log-normal distribution for removals. This method was chosen for several reasons. The competing risks model allows for different events to be modeled with different distributions, while at the same time allowing for interval-censored data. The choice of gamma failure and log-normal removal distributions was made because these distributions fit the rebated refrigerator data the best and they also forecast curve shapes that are intuitively expected over time.

The EUL estimate from this study is 33.4 years, which rejects the ex ante EUL at the 80% confidence interval. Although this estimate rejects the ex ante estimate, the ex post EUL will remain 20 years since this is the maximum measure life considered under PG&E's Annual Earnings Assessment Proceedings (AEAP). Therefore, the program realization rate, which is the ratio of the ex ante and ex post estimates, is one. These results are summarized below.

PG&E's 1996 and 1997 Residential Appliance Efficiency Incentives Program
Summary of Ex Post Effective Useful Life Estimates
Refrigeration End Use

			Study Results			Ex Post	Realization
End Use	Technology	Ex Ante	Upper	Median	Lower	Claimed	Rate
Refrigeration	20 Percent More Efficient	20	34.4	33.4	32.5	20	100%
	25 Percent More Efficient	20	34.4	33.4	32.5	20	100%
	30 Percent More Efficient	20	34.4	33.4	32.5	20	100%

Regulatory Waivers

No regulatory waivers were filed for this study.

NINTH YEAR RETENTION STUDY FOR PG&E'S 1996 & 1997 RESIDENTIAL AEI PROGRAM REFRIGERATION TECHNOLOGY

PG&E STUDY ID#: 373 1R2
CALMAC Study ID#: PGE0236.01

FINAL REPORT

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1. EXECUTIVE SUMMARY

This section presents a summary of the retention study results of Pacific Gas & Electric Company's (PG&E's) Residential Appliance Efficiency Incentive (RAEI) Program for refrigeration technologies. The retention study described in this report covers refrigeration technologies installed at residential accounts that had rebates paid during 1996 and 1997.

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 refrigeration 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 refrigeration measures to be studied for the RAEI program. This study focuses only on residential refrigeration measures for which rebates were *paid* during calendar year 1996 and 1997. The Protocols also require that two Program Years, 1996 and 1997, be combined and that the studies be conducted on the schedule for Program Year 1996. 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 1996 refrigerator program is virtually identical to the 1997 refrigerator 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 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.

[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.

Our overall approach consists of five 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.

5. ***Develop a competing risks model*** that incorporates different distributions for failures and removals. Using the LIFEREG procedure in SAS from (4) above, separate output will be generated for failures and removals. Then, the best fitting distributions for each event will be combined to form one combined survival function.

1.3 STUDY RESULTS FOR REBATED REFRIGERATORS

Based on extensive analysis of the retention data, we recommend keeping the ex ante EUL of 20 years for the rebated refrigerators. Out of the 1,864 surveys completed (588 from the fourth year study and 1,276 from the ninth year study), only 38 units had failed and 97 had been removed (for an un-weighted failure rate of 7.2%). Exhibit 1-1 presents the various model results for the rebated refrigerators. The LIFEREG results presented are for the combined scenario where failures and removals were not modeled separately.

Exhibit 1-1
Summary of Study Results for Rebated Refrigerators

Approach	Model	Median EUL	Upper Bound	Lower Bound
Summary Statistics	Exponential	86	-	-
Trendlines	Linear	32.7	32.7	32.7
	Exponential	41.9	41.9	41.9
LIFEREG	Exponential	43.6	44.3	42.9
	Logistic	47.6	49.2	46.0
	Log-Normal	83.6	87.0	80.1
	Weibull	38.3	39.4	37.2
	Gamma	31.8	32.2	31.3
Competing Risks	Best Fit	33.4	34.4	32.5
	Min EUL	29.3	29.7	28.8
	Max EUL	63.1	66.5	60.1

At this time, the competing risks model provides the best fit for the data. The EUL for this model is 33.4 years with a lower bound of 32.5 years that is higher than the current ex ante EUL of 20 years. In the best-fit competing risks model the failures were modeled using the gamma distribution and the removals were modeled using the lognormal distribution. The minimum EUL was achieved by modeling both the failures and the removals using the gamma distribution. The resulting minimum EUL was 29.3 years with a lower bound of 28.8 years that is also higher than the ex ante EUL. The maximum EUL competing risks model was based on the lognormal distribution for both failures and removals and had an EUL of 63.1 years.

1.4 FINAL RESULTS

The final study results are based on the rebated refrigerator failure and removal data modeled using the gamma distribution for failures and the lognormal distribution for removals. This method was chosen for several reasons. The competing risks model allows for different events to be modeled with different distributions, while at the same time allowing for interval-censored data. The choice of gamma failure and lognormal removal distributions was made because these distributions fit the rebated refrigerator data the best and they also forecast curve shapes that are intuitively expected over time.

The EUL estimate from this study is 33.4 years, which rejects the ex ante EUL at the 80% confidence interval. Although this estimate rejects the ex ante estimate, the ex post EUL will remain 20 years since this is the maximum measure life considered under PG&E's Annual Earnings Assessment Proceedings (AEAP). Therefore, the program realization rate, which is the ratio of the ex ante and ex post estimates, is one. These results are summarized in Exhibit 1-2.

Exhibit 1-2
Final Ex Post EUL Estimate

End Use	Technology	Ex Ante	Study Results			Ex Post	Realization
			Upper	Median	Lower	Claimed	Rate
Refrigeration	20 Percent More Efficient	20	34.4	33.4	32.5	20	100%
	25 Percent More Efficient	20	34.4	33.4	32.5	20	100%
	30 Percent More Efficient	20	34.4	33.4	32.5	20	100%

2. INTRODUCTION

This report summarizes the retention study of Pacific Gas & Electric Company's (PG&E's) Residential Appliance Efficiency Incentive (RAEI) Program for refrigeration technologies. The evaluation effort includes all refrigeration technologies installed at residential accounts that had rebates paid during 1996 and 1997.

2.1 THE RESIDENTIAL APPLIANCE EFFICIENCY INCENTIVE PROGRAM

The RAEI Program offered fixed rebates to customers who installed refrigerators meeting specific electric energy-efficiency requirements. Rebates of $40 to $100 were paid for refrigerators that were 20 to 30 percent more efficient than baseline efficiency standards. The programs assumed that customers were in the process of replacing their existing refrigerators, 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 refrigeration 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 1996 and 1997.

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 refrigeration 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 refrigeration measures to be studied for the RAEI program. This study focuses only on residential refrigeration measures for which rebates were *paid* during calendar year 1996 and 1997.

[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, 1996 and 1997, be combined and that the studies be conducted on the schedule for Program Year 1996. 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 1996 refrigerator program is virtually identical to the 1997 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 refrigerators 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 from PG&E service territory or have failed. Unfortunately, it is likely that the underlying distribution of measures having failed is very different than the distribution of measures being removed.

The results may suggest, for example, that refrigerator failures follow a gamma distribution. The gamma survival function can have an increasing hazard rate over the reasonable life of the refrigerator. In other words, the rate at which refrigerators fail increases over time. This theory is founded on the fact that refrigerators are more likely to fail as they become older.

However, the removal of a refrigerator from PG&E territory is more dependent on human interaction. For example, consider the act of relocating to another state. The participant may either take the refrigerator with them or leave it behind for the new occupant of the home. When the refrigerator is fairly new and in good working condition, the participant is more likely to take the refrigerator with them. On the other hand, as the refrigerator becomes old and approaches the end of its useful life, the participant is more likely to leave the refrigerator behind. This implies that the hazard rate resulting from a refrigerator being removed from PG&E service territory decreases over time. Therefore, it is likely that the survival function of equipment removal differs from the survival function of the equipment failure.

For this study, all of the refrigerators were in place less than ten years at the time the survey was conducted (none were rebated prior to 1996 and the surveys were conducted between September and October of 2005).

Our overall approach consists of five analysis steps that were used to estimate the EUL for rebated refrigerators:

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

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.

5. ***Develop a competing risks model*** that incorporates different distributions for failures and removals. Using the LIFEREG procedure in SAS from (4) above, separate output will be generated for failures and removals. Then, the best fitting distributions for each event will be combined to form one combined survival function. This additional analysis step provided valuable results in our previous retention studies that had not been utilized in prior retention studies. [4]

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

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 versions of the three survey instruments implemented for the data collection portion of this study.

[4] The competing risks model was used both in the ninth year analysis of 1994 and 1995 RAEI programs and the fourth year analysis of 1996 and 1997 RAEI programs.

3. METHODOLOGY

This section provides the specifics surrounding the methods used to conduct the Retention Study for the 1996 and 1997 Pacific Gas & Electric Company (PG&E) Residential Appliance Efficiency Incentive (RAEI) Program for refrigeration 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 five approaches implemented.

3.1 STUDY OVERVIEW

The objective of the Retention Study was to estimate ex post effective useful lives for each refrigeration 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.

There is an additional level of complexity in estimating the EUL for the refrigeration study, because of the incidence of participants moving and taking their refrigerator with them. Operating units that have moved from the original premise to a new premise within PG&E's service territory are considered in place and operable. However, if a unit is moved outside of PG&E territory it is considered to have failed. When estimating the EUL for refrigerators, the following events were considered:

- Was the unit still at its original premise?
- Has the unit been moved to a premise within PG&E's service territory?
- Was the unit still in place and operating?

3.1.1 Failure Types

For refrigeration there are two cases where a unit is considered to have "failed": (1) if the equipment actually failed and was not replaced under warranty[5], and (2) if the unit was moved outside of PG&E's service territory or removed and discarded for any reason. Each of these cases has a different underlying distribution of occurrence. For example, it is likely that actual equipment failures occur very late in life, and have a distribution with an increasing rate of failure, perhaps similar to the Weibull distribution. Units that are moved outside of PG&E's service territory will have a significantly different distribution than equipment failures. Units moved are likely to have a decreasing rate of "failure" over time, not increasing. As the unit

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

becomes older, it is more likely that the owner of the unit may replace it with a more efficient unit or would leave the unit behind during a move. Therefore, modeling this event with a Weibull distribution would be wrong, as a Weibull distribution assumes an increasing failure rate. This is important to note since the majority of "failures" that occur early in life (first 5 years or so) are more likely to occur as a result of the unit being moved. This concept was observed during the course of this study and will be elaborated on later in this section.

3.1.2 Data Collection

As stated above, refrigerators that were removed from PG&E territory as a result of a move were considered to be "failures". As of year nine we expect this type of failure to far outweigh "failures" due to equipment malfunction. In order to get an accurate determination of the current location and operating status of the rebated refrigerator there were three groups of individuals we need to talk to:

- Original Participants (non-movers) - individuals who have purchased the refrigerator in 1996 or 1997 and still reside at the same address,

- Participant Movers - individuals who purchased the rebated refrigerator in 1996 or 1997 and have since moved to a new location (both inside and outside PG&E service territory),

- New Occupants - individuals who have moved into an address for which a rebated refrigerator was purchased in 1996 or 1997.

As a result it was necessary to field three different surveys for the refrigeration study each of which captured the survival data on the rebated refrigerators in a unique way that was tailored to the respondents that were being surveyed.

Before fielding the three surveys, the population of participants was divided into two groups: non-movers and movers. The non-movers were fielded in the Original Participant Survey. From the mover sample, US Search (a professional locator service) was contracted to locate the new address and telephone number of the original occupant who purchased the rebated refrigerator. Based on this information a sample of participants was selected for the Participant Mover Survey. Also selected from the mover sample were New Occupants who currently reside at the address for which the rebated refrigerator was initially purchased (based on CIS data), to make up the sample for the New Occupant Survey.

The samples for all three surveys were drawn proportional to the population; our initial analysis showed that approximately 60% of the participants have not moved as of year nine. For each population, fourth year points were added to increase the total number of points in the Original Participant dataset and thus allow us to improve our modeling accuracy for this population. Unless otherwise noted, all analysis results were weighted to represent the actual rebated refrigerator population.

3.1.3 Analysis Strategy

The overall approach consisted of five analysis steps used that were used to estimate the EUL for rebated refrigerators:

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.

5. ***Develop a competing risks model*** that incorporates different distributions for failures and removals. As discussed earlier in this section, failures and removals have different distributions over time. Competing risks models allow for multiple event types to be modeled at once. The fundamental characteristic of a competing risks model is that if one event type occurs, the individual is removed from risk of all the other event types. Relating this characteristic to this study, if a participant has a refrigerator that fails, then they are no longer part of the equation for the distribution of removals. 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 were 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 Non-Mover Retention Study Contacts.* The fourth year retention study data provided information collected from surveys conducted in 2001 for a total of

588 refrigeration units: 461 refrigeration units surveyed in the Original Occupant Survey, 44 refrigeration units surveyed in the Participant Mover Survey, and 83 refrigeration units surveyed in the New Occupant Survey. These data were used to supplement data collected during the ninth year study.

3.2.2 Sample Frame

Preparing the survey sample dataset began by identifying participants who moved since participating in the refrigeration rebate program. Two variables were created to identify movers and non-movers. The participant's last name and telephone number were compared with the corresponding CIS record. All records where either the last name or telephone number in the participant dataset matched the last name or telephone number in the CIS were flagged as non-movers.

The distribution of the refrigeration participant population by residency status and year of participation is provided in Exhibit 3-1. As illustrated, non-movers make up approximately 60% of the population, while movers make up the remaining 40% of the population. The final refrigeration sample was drawn proportional to the population.

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

Residency Status	Year of Participation	Count	Percent of Population
Mover	1996	12,078	20.1%
Mover	1997	12,160	20.2%
Non-Mover	1996	17,914	29.8%
Non-Mover	1997	18,037	30.0%
Total		60,189	100%

The three different levels of energy efficiency for that were included in the 1996 and 1997 refrigeration programs were 20%, 25%, and 30% more energy efficient than standards. 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 Efficiency Level for Participant Population

Efficiency Level	Count	Percent of Population
20%	23,073	38.3%
25%	23,922	39.7%
30%	13,194	21.9%
Total	60,189	100%

3.2.3 Data Collection Strategy

Three telephone surveys were implemented by QC to obtain survival information on energy efficient refrigerators that were rebated under 1996 and 1997 program years. The first survey to be fielded was aimed at "Original Participants", or participants that did not move since purchasing the rebated refrigerator. The second survey to be fielded was aimed at "Participant Movers" whose rebated refrigerators either failed or were removed prior to their move, were sold or given away at the time of their move or were taken along to their new home. Customers who were contacted as part of the Participant Mover survey and who indicated during the first few questions that they had left the fridge at their old address were thanked for their time and the survey was terminated[6]. Finally, the "New Occupants" survey was fielded. The New Occupants were residential customers that were believed to have moved into a home where a rebated refrigerator had been purchased. Copies of all three survey instruments are provided in A*ppendix 2*.

All three of the surveys were implemented by Quantum's Computer Aided Telephone Interview (CATI) center. Surveys were 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
Disposition of Refrigeration Telephone Surveys

Disposition	Original Participants		Participant Movers		New Occupants	
Complete	800	26.4%	250	18.2%	250	9.9%
Busy/No Answer/Machine	865	28.5%	323	23.5%	642	25.5%
Appointment	77	2.5%	110	8.0%	157	6.2%
Language Barrier	90	3.0%	26	1.9%	119	4.7%
Didn't know about Refrigerator/Rebate/etc.	80	2.6%	132	9.6%	0	0.0%
Business/Rental	26	0.9%	29	2.1%	47	1.9%
Quota Full/Never Dialed	700	23.1%	0	0.0%	0	0.0%
Refused/Incomplete	201	6.6%	163	11.9%	225	8.9%
Bad Number/Wrong Address/Wrong date	191	6.3%	240	17.5%	572	22.7%
Non-Movers	~	0.0%	7	0.5%	~	0.0%
No Refrigerator at Address	~	0.0%	~	0.0%	505	20.1%
Left it at old address	~	0.0%	93	6.8%	~	0.0%
Total Sample	3,030	100%	1,373	100%	2,517	100%

The QC interviewer collected survival data on the rebated refrigerators from the survey participants and requested those who were unable to confirm that the unit was the rebated unit to locate the make and model number. Matching this information to the make and model number from the participation records allowed the interviewer to confirm the refrigerator in question was the rebated unit and continue on with the survey.

For each refrigerator, it was determined whether (1) the equipment was still installed within PG&E's service territory, and (2) if it was operable. If the equipment was not in place or was

[6] Information on these types of customers was gathered during the New Occupant survey.

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 under warranty or by insurance. If the refrigerator was removed, interviewers attempted to determine the present location of the refrigerator. Respondents were asked if and how often they checked the seals and cleaned the coils on their refrigerators. This information along with information regarding any kitchen 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.

3.2.4 Final Distribution

A summary of the final disposition of the three surveys is presented in Exhibit 3-4.

Exhibit 3-4
Refrigeration Final Sample Disposition

Type and Number of Surveys Conducted		Survey Points Not Used	In Place & Operating today	Good Condition as of last date seen	Failed	Removed	Total
Original Participant	1,261	2	1,191	29	26	13	1,259
9th year points	800	2	735	29	23	11	798
4th year points	461	0	456	0	3	2	461
Participant Mover	294	4	168	41	4	77	290
9th year points	250	4	132	41	3	70	246
4th year points	44	0	36	0	1	7	44
New Occupant	333	18	289	11	8	7	315
9th year points	250	18	206	11	8	7	232
4th year points	83	0	83	0	0	0	83
Total	1,888	24	1,648	81	38	97	1,864

The **ninth year Original Participant Survey** yielded **800** complete responses with the following characteristics:

- 23 of the rebated refrigerators failed and were not replaced under warranty or by insurance. Of these:
  - 19 broke.
  - One was in storage but needed major repairs.
  - Three were sold, recycled, or disposed of and were in bad condition.
- 11 of the rebated refrigerators were removed from PG&E's service territory.
  - Three of these refrigerators were sold, given away or moved to another known address outside of PG&E's service territory.
  - Eight were recycled or disposed of but were in good working condition at the time of removal.

- 29 of the Original Participants surveyed were included in the analysis population as right-hand censored data although the rebated refrigerator was no longer in their possession. Each of these refrigerators was in good working condition as of the date it was last seen and thus the censoring date used in analysis for these units corresponds to the date the refrigerator was last in their possession.
  - 23 of these rebated refrigerators were sold to another individual or moved to another address within the PG&E service territory.
  - One was removed due to damage but covered by insurance.
  - Five broke but were covered by a warrantee.
- 735 of the rebated refrigerators were still in place and operating as of the date surveyed.
- Two Original Participants were removed from the analysis population because they returned the rebated refrigerator.

From the **fourth year Original Participant Survey** an additional **461** complete survey responses that were not re-contacted during the course of the ninth year study were also included in the final analysis dataset. These responses had the following characteristics:

- Three of the rebated refrigerators had failed, none of which were replaced under warranty or by insurance.
- Two of the rebated refrigerators were removed from PG&E's territory. One refrigerator is still owned by the Original Participant, and is still operable, but was placed at a second home outside of PG&E's service territory. The other refrigerator was, according to the respondent, sold or given away somewhere in California, but outside of central or northern California. The unit was operable up to the date of removal.

The original contact information from the program tracking database for 3,000 participants who were flagged as movers was sent to US Search to obtain current contact information. From this population, US Search was able to successfully return 1,373 records with usable phone numbers. These 1,373 records were used as the sample for the **ninth year Participant Mover Survey**. This population yielded **250** completed surveys with the following characteristics:

- Three of the rebated refrigerators failed and were not replaced under warranty or by insurance.
- 70 rebated refrigerators were removed from PG&E's service territory. Of these:
  - 62 were taken by the Participant Mover to their new home located outside of PG&E's service territory.
  - Six were sold or given away to an individual residing outside of PG&E's service territory.
  - Two were disposed of, but at the time were still in good working condition.
- 41 of the Participant Movers surveyed were included in the analysis population as right-hand censored data although the rebated refrigerator was no longer in their possession

at the time of the survey. Each of these refrigerators was in good working condition as of the date it was last seen by the participant and thus the censoring date used in analysis for these units corresponds to the date the refrigerator was last in their possession. Of these:

  - 33 were sold or given away to a new location within PG&E's service territory.
  - 8 were sold or given away to an unknown location. Because we were unable to identify whether these 8 were within or outside of PG&E service territory they were included in the model as censored data as of the date they were last seen.

- 132 of the rebated refrigerators were in the Movers' possession within PG&E service territory and were still in good working condition.

- Four Participant Movers were removed from the Participant Mover dataset because they reported leaving the rebated refrigerator at their old address.

From the **fourth year Mover Participant Survey** we were able to include **44** complete survey responses that were not re-contacted during the course of the ninth year study. These responses had the following characteristics:

- 36 of the Participant Movers indicated that the refrigerator was still operable in PG&E's service territory.

- Seven of the Participant Movers removed their refrigerator from PG&E's service territory.

- One Participant Mover claimed that the rebated refrigerator had failed.

The sample for the **ninth year New Occupant** survey was composed of 2,518 individuals who moved into a residence for which a rebated refrigerator was purchased. This survey yielded **250** complete responses with the following characteristics:

- 206 New Occupants were able to identify the rebated refrigerator and reported that it was in still place and operable at their residence.

- Eight of the New Occupants surveyed reported that the rebated refrigerator was present at their current residence when they moved in, however had since failed.
  - Of these, six broke and two were in bad condition and needed major repairs. None of these refrigerators were replaced under warranty or by insurance.

- Seven New Occupants reported that the rebated refrigerator was present at their current residence when they moved in, however had since been removed from PG&E's service territory. Of these:
  - One of these refrigerators was sold or given away outside of PG&E's service territory.
  - Six were recycled or disposed of but were operable at the time of removal.

- 11 of the New Occupants surveyed were included in the analysis population as right-hand censored data although they no longer had the rebated refrigerator in their possession (but confirmed the refrigerator presence in the residence when they moved in). The censoring date used in analysis for these units corresponds to the date the refrigerator was last in the New Occupants possession.
  - Ten of these rebated refrigerators were sold to another individual or moved to another address within the PG&E service territory but were in good working condition as of the date it was last seen.
  - One broke but was covered under warrantee.

- 18 New Occupants were dropped from the analysis for the following reasons:
  - 17 New Occupants could not verify the rebated refrigerator.
  - One New Occupant participant revealed later on in the survey that the previous owner had taken the refrigerator with them when they moved.

From the **fourth year New Occupant Participant Survey** we were able to include **83** complete survey responses of participants who identified the rebated refrigerator and claimed that it was in place and operable at their residence. These participants were not re-contacted during the course of the ninth year study.

Prior to analysis, the three ninth year and three fourth year study datasets were combined into one analysis dataset. Each respondent was weighted in order to make the final analysis dataset representative of the true rebated refrigerator 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 refrigerators 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 refrigerators. Exhibit 3-5 below presents the number of sampled sites that had one unit that had either failed or been removed.

Exhibit 3-5
Unweighted Summary Statistics on Retention Sample Data

Survey Type	Number of Surveys Conducted	Number of Units that Failed, were Removed, or Replaced	Number of Units Replaced Under Warranty	Number of Units in Place and Operable	Percent Failed, Removed, Replaced
Original Participant	1,259	39	8	1,220	3.10%
Participant Mover	290	81	0	209	27.93%
New Occupant	315	15	1	300	4.76%
Total	1,864	135	9	1,729	7.24%

Of the 1,864 sites sampled, 135 of them (7.2% unweighted) had either a failure or a removal. Nine of the failures were not counted because they were replaced under warranty. It is interesting to note here how few failures or removals have occurred within the non-mover participant population. Of the individuals that still reside at the residence for where the rebated refrigerator was originally purchased, only 26 have experienced failures and 13 have been removed after nine years. The majority of the "failures" that have occurred prior to year nine within the Participant Mover population are a result of the individual moving the rebated refrigerator to a new home outside the PG&E territory (77 of the 81 "failures".)

The analysis that QC implemented used SAS to statistically model the survival function of the rebated refrigerators 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 five main steps in our approach to the survival analysis. Our five-step approach included the following activities:

1. The first step in the analysis was to compile summary statistics on the raw retention data. Although the analysis was performed on one combined dataset, results from each of the three surveys were examined individually to provide insight.

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, lognormal, Weibull, and gamma. Due to censoring restrictions, a partial hazards model was unable to be used in this analysis.

5. Competing risk models were developed to estimate survival functions capable of integrating any two survival distributions for failures and removals. Three models were developed using failure and removal data for rebated refrigerators. The first was the "Best Fit" model, which integrated the best fitting model for the failures and the removals. The second, the minimum EUL model, combined the minimum EUL models for these two events and finally the third, the maximum EUL model did the same for the maximum EUL models. In each case, the resulting distribution was plotted and visually compared it to the survival plot developed in (2). Furthermore, the resulting survival function to was used to estimate the EUL.

Reviewing the summary statistics and visually inspecting the data prior to modeling is beneficial as it often reveals analysis issues that need to be addressed during the survival analysis. In addition, these earlier steps provide 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, or been removed;
- the number of failed units that had been replaced under warranty;
- the percentage of units that had failed, or been removed; and
- the ex ante EUL.

If we make the assumption that the failure/removal 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/removals 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 for the combined dataset, for failures only, and for removals only. Participants included in the final analysis dataset from the fourth year study (588 records) were removed so that the assumption of "failures" occurring over a 9-year period was met.

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
Combined	9.38%	1.04%	96	66	20
Failures	2.62%	0.29%	344	239	20
Removals	6.77%	0.75%	133	92	20

^ 4th year survey points were removed and it is assumed that failures and removals occured over 9 years.
* Assuming a constant failure rate over time.

Exhibit 3-6 illustrates that the Median life for the combined event of failures and removals under the assumption of a constant failure rate over time results in a EUL estimate of 66 years, which greatly exceeds the ex ante EUL estimate of 20 years.

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. This task was conducted separately for failures, removals, and the combined distribution.

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 and removals 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.

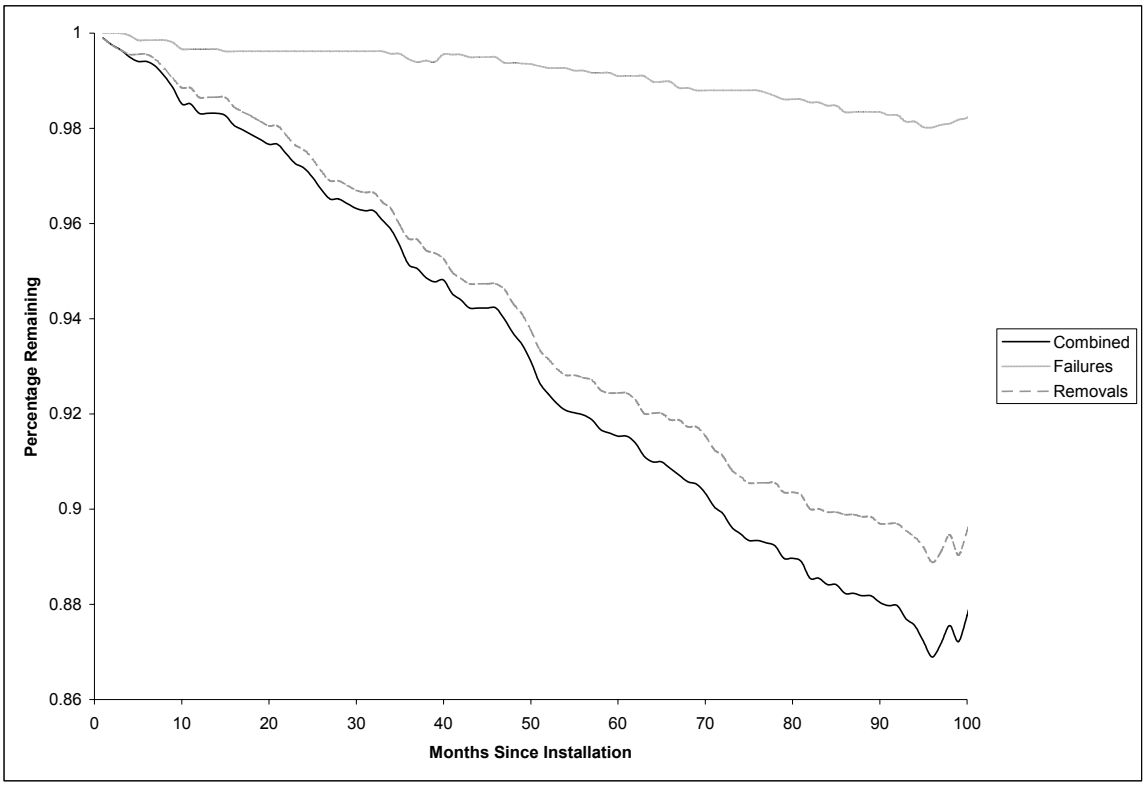
Interval censoring, as the name implies, means that it is known that a failure/removal has occurred during a known interval. If no event has occurred, the interval is assumed to be right-hand censored.

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 combined dataset, failures only, and removals only. This survival function is based on the following assumptions:

1. For missing failure/removal dates, generate a random date (based on a uniform distribution) between the date the refrigerator was purchased 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 were 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. The most significant feature of Exhibit 3-7 is the overwhelming effect on the combined empirical survival function of the removals as opposed to the failures. Up until month 60 there were very few refrigerator failures.

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, the first 100 months of the empirical survival functions were used. This was done for the combined, failure, and removal datasets.

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.

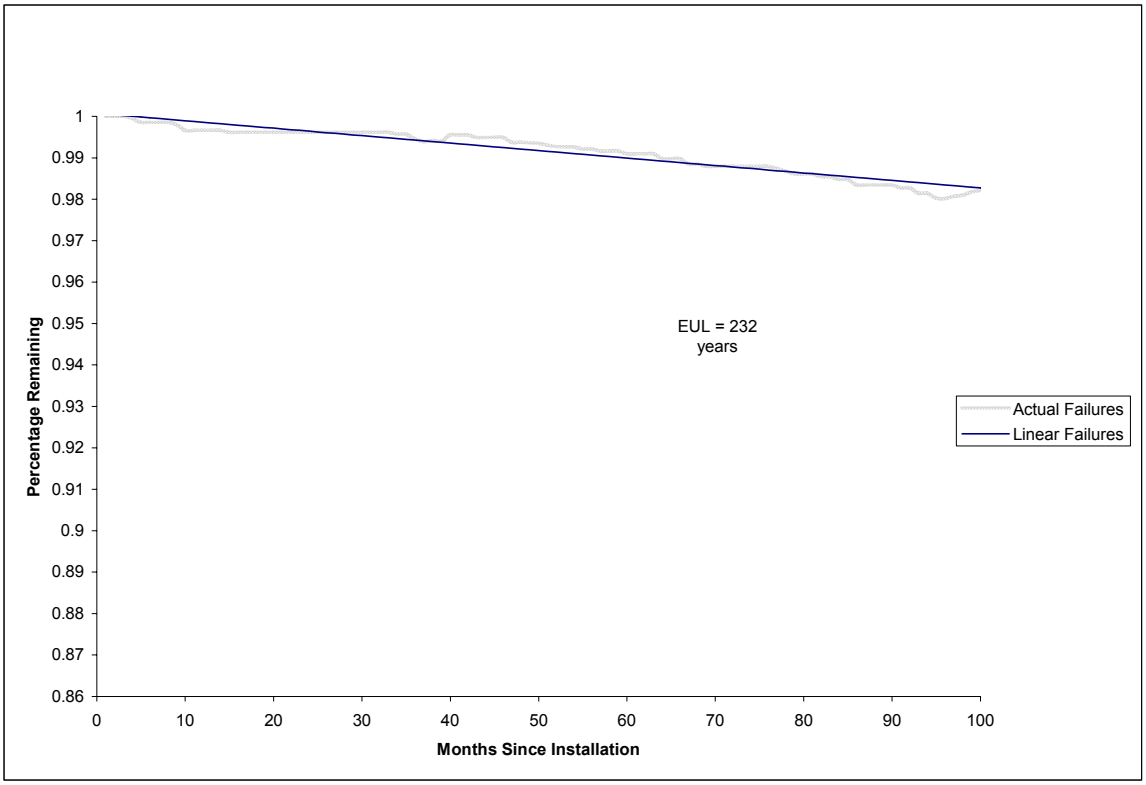
- The second trend line was assumed to follow the exponential distribution, which is one of the most common distributions used in survival analysis. The trend line was also used with linear regression by making a transformation on the percentage of equipment operable and in place. The natural log of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

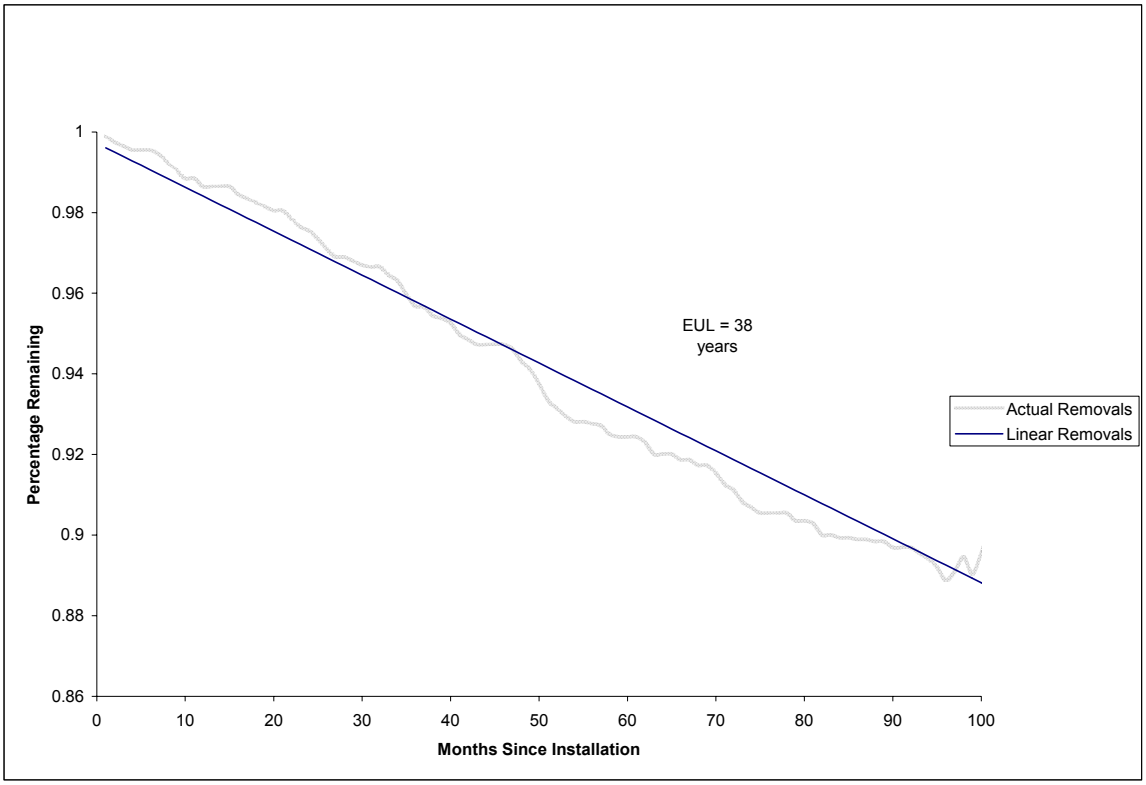
Exhibits 3-8 and 3-9 provide the linear survival functions for the "failures only" and "removals only" datasets and compare them to the empirical survival functions developed above.

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



This exhibit illustrates how the linear trendline has some difficulty fitting to the empirical function for the "failures only" dataset. The EUL associated with this linear trendline for "failures only" is 232 years which we can assume is an over estimation of the EUL based on the poorer fit of the linear trendline over the later years of the measures life. This scenario suggests that the distribution of refrigeration "failures" does not follow a linear path but instead has a changing rate of failure. Exhibit 3-9 examines the linear model as it forecasts the survival function for the "removals only" dataset.

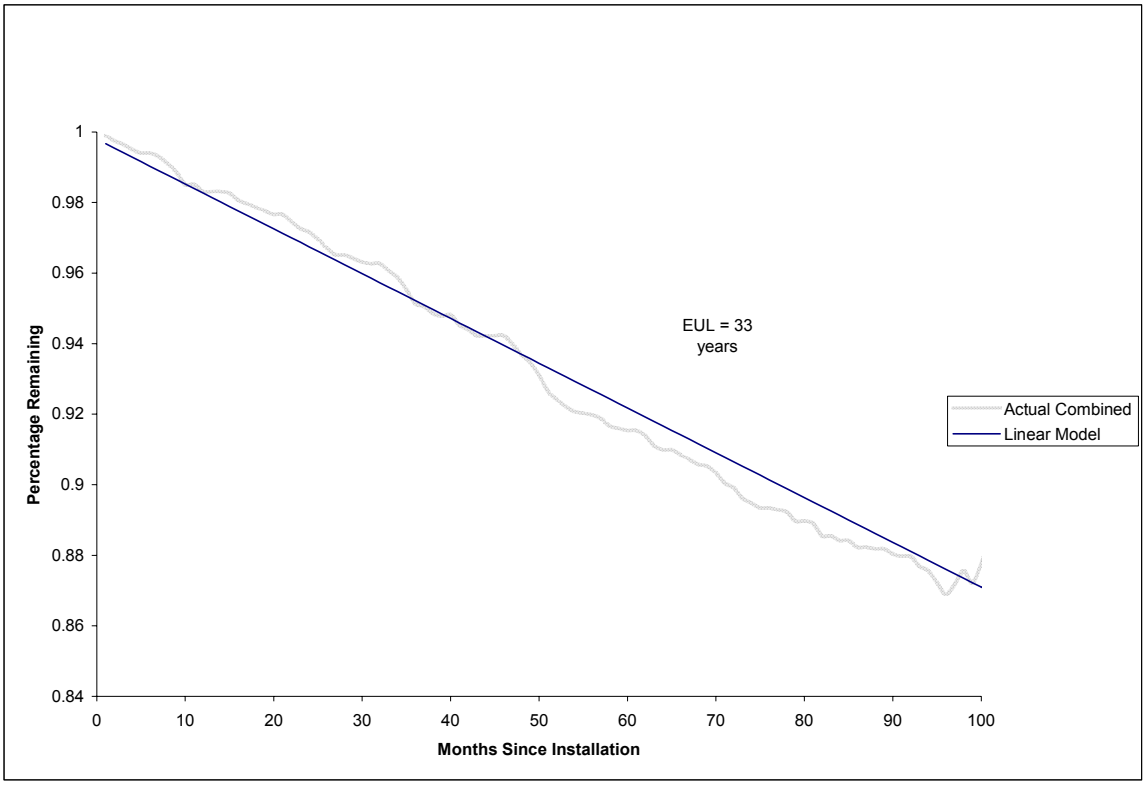
Exhibit 3-9
Comparison of Empirical Survival Function and Linear Trendline
Removals Dataset



The estimated EUL of the Linear Model for "removals only" dataset is 38 years. This result is much more believable than the results presented above for the "failures only" dataset. This is to be expected since over the course of nine years 40% of the population reported moving from the address where they resided when they purchased the rebated refrigerator. Although almost 70% of the individuals surveyed in the ninth year who reported moving said they currently live in the PG&E service territory, this leaves 13% of the population moving outside the PG&E territory, which generates a removal population that is large enough to build a reliable removal model for refrigerators.

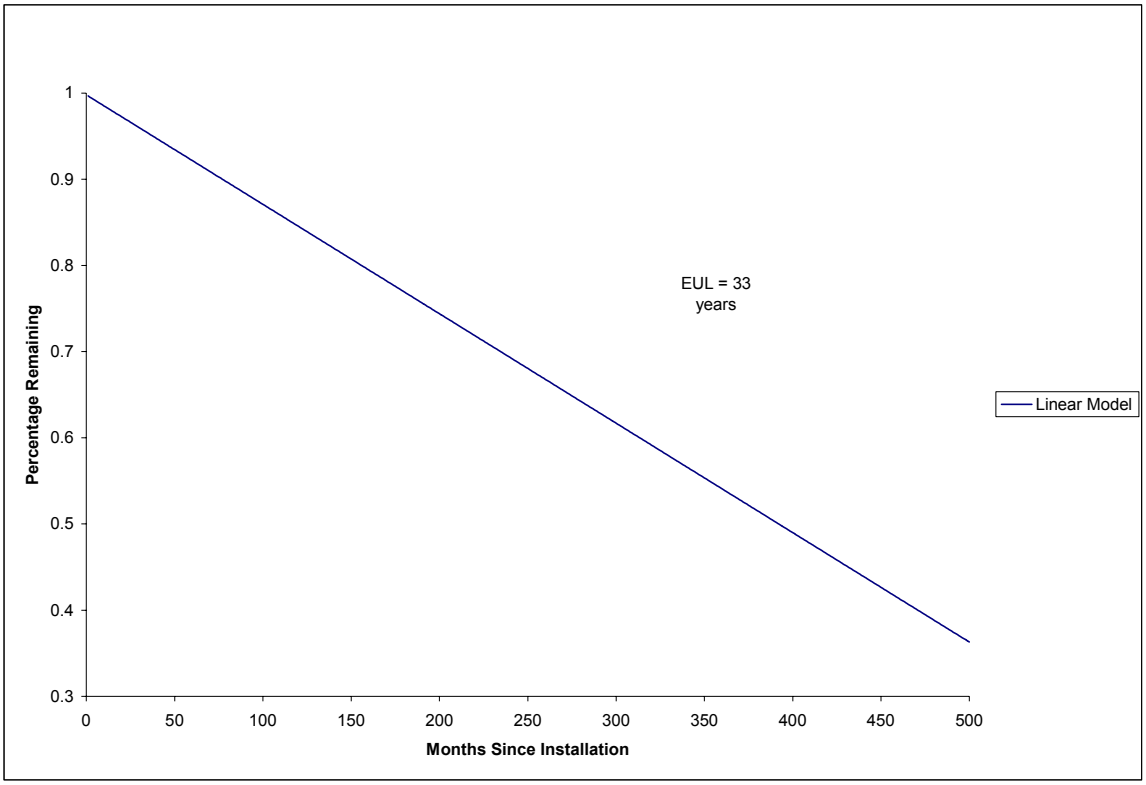
Exhibit 3-10 provides the resulting survival function assuming a linear trend for the combined dataset and compares it with the empirical function developed above, for the first 100 months of the measure's life.

Exhibit 3-10
Comparison of Empirical Survival Function and Linear Trendline
Combined Dataset



This exhibit illustrates how well the linear trend compares to the empirical function during the first nine years of the measure's life. Exhibit 3-11 examines the linear model on the combined dataset as it forecasts the survival function over the first 500 months of the refrigerator's life.

Exhibit 3-11
Survival Function Based on a Linear Trendline
Combined Dataset



Even after 500 months (over 40 years), the model predicts that 36% of the refrigerators are still 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 or removal. A linear distribution indicates that a constant number of failures or removals occur during each period, regardless of the number of units remaining, or the life of the remaining units. Results from more statistically valid methodologies, discussed later in this section, will further illustrate why the linear function is not appropriate. The estimated EUL of the linear model is 33 years which is nearly double the ex ante, as shown in Exhibit 3-12.

It is also interesting to note the obvious difference in slope that the failure and removal datasets produce. The results of the linear regressions are provided in Exhibit 3-13 for each of the three methods. Also provided in Exhibit 3-12 is the estimated EUL for each measure. For a linear survival function, the EUL (median life) is calculated as:

EUL = (0.5 – intercept)/slope

Exhibit 3-12
Regression Results of Linear Trendline
and Resulting Ex Post EUL Estimates

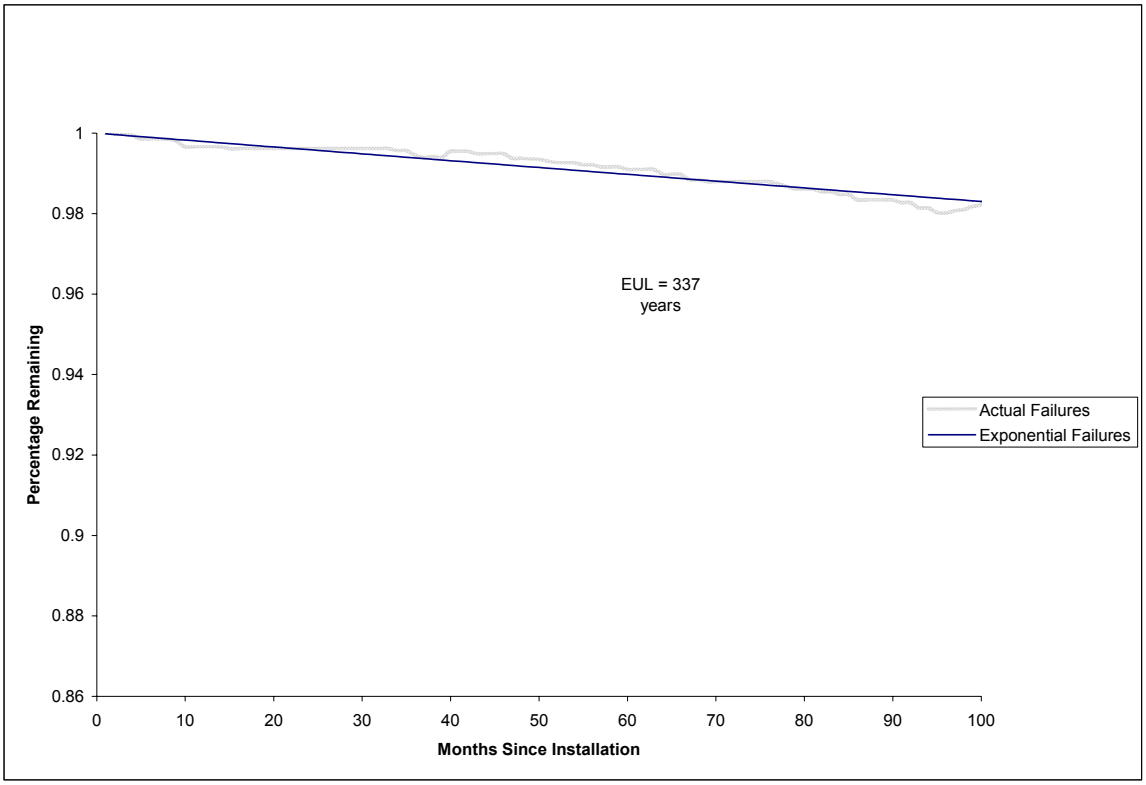
Model Description	Intercept	t-Statistic	Slope	t-Statistic	EUL
Failures Only	1.00	3,691	-0.0002	-42.50	232
Removals Only	1.00	722	-0.0011	-50.65	38
Combined Model	1.00	717	-0.0013	-58.52	33

The results of the linear trendline estimate indicate that the ex post EUL estimate is significantly larger than the ex ante estimates (which are all 20 years). Each of these results would reject the ex ante estimate at the 80 percent confidence level.

Exponential Trends

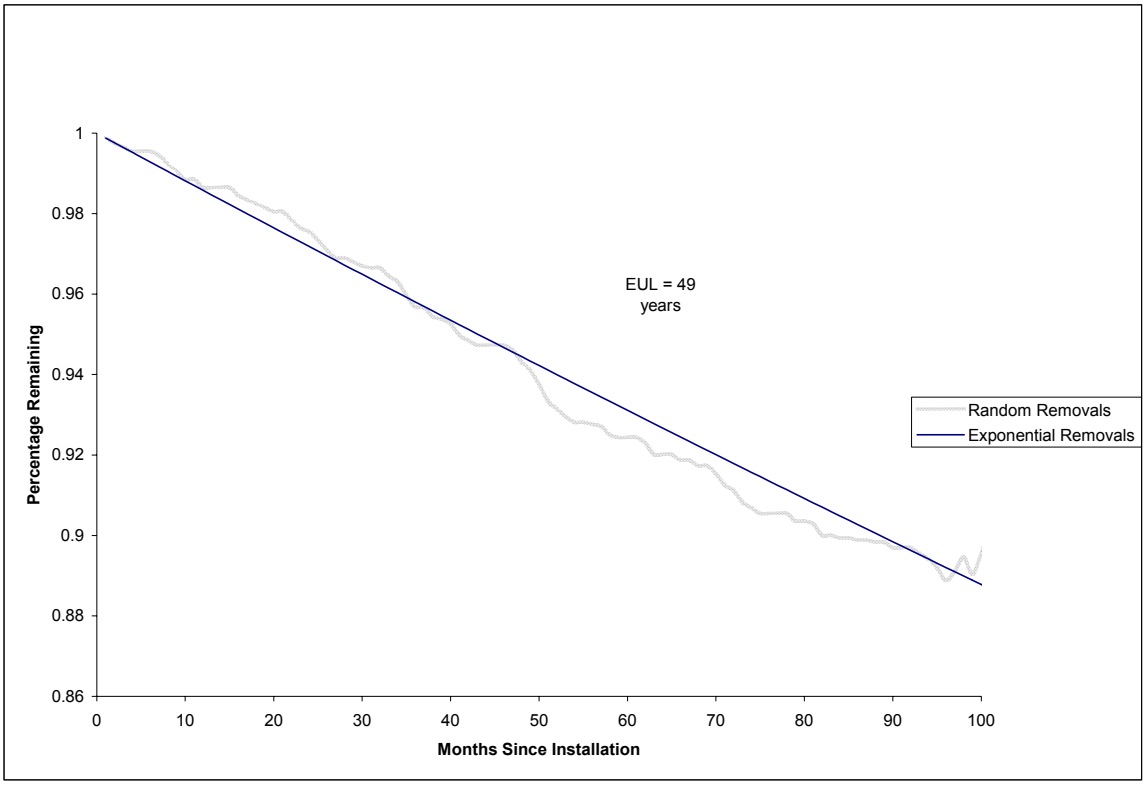
Exhibit 3-13 and 3-14 provide the resulting survival functions assuming an exponential trend for the failure and removal datasets and compare them to the empirical functions developed above, for the first 100 months of the measure's life.

Exhibit 3-13
Comparison of Empirical Survival Function and Exponential Trendline
Failure Dataset



The estimated EUL of the Exponential Model for "failures only" is 337 years. This result is even more unlikely than the result of the Linear Model. It too suggests that the distribution of "failures only" does not follow an exponential path in which the hazard rate is constant and asymptotically approaching zero.

Exhibit 3-14
Comparison of Empirical Survival Function and Exponential Trendline
Removal Dataset



The estimated EUL of the Exponential Model for "removals only" is 49 years.

Similarly, Exhibit 3-15 provides the exponential survival function, and compares it to the empirical survival function for the combined dataset. This exhibit illustrates how the exponential trend seems to slightly underestimate the percentage of refrigerators remaining during the first 50 years of the measure's life at which point the relationship begins to reverse and the trendline begins to overestimate the percent remaining.

Exhibit 3-15
Comparison of Empirical Survival Function and Exponential Trendline
Combined Dataset

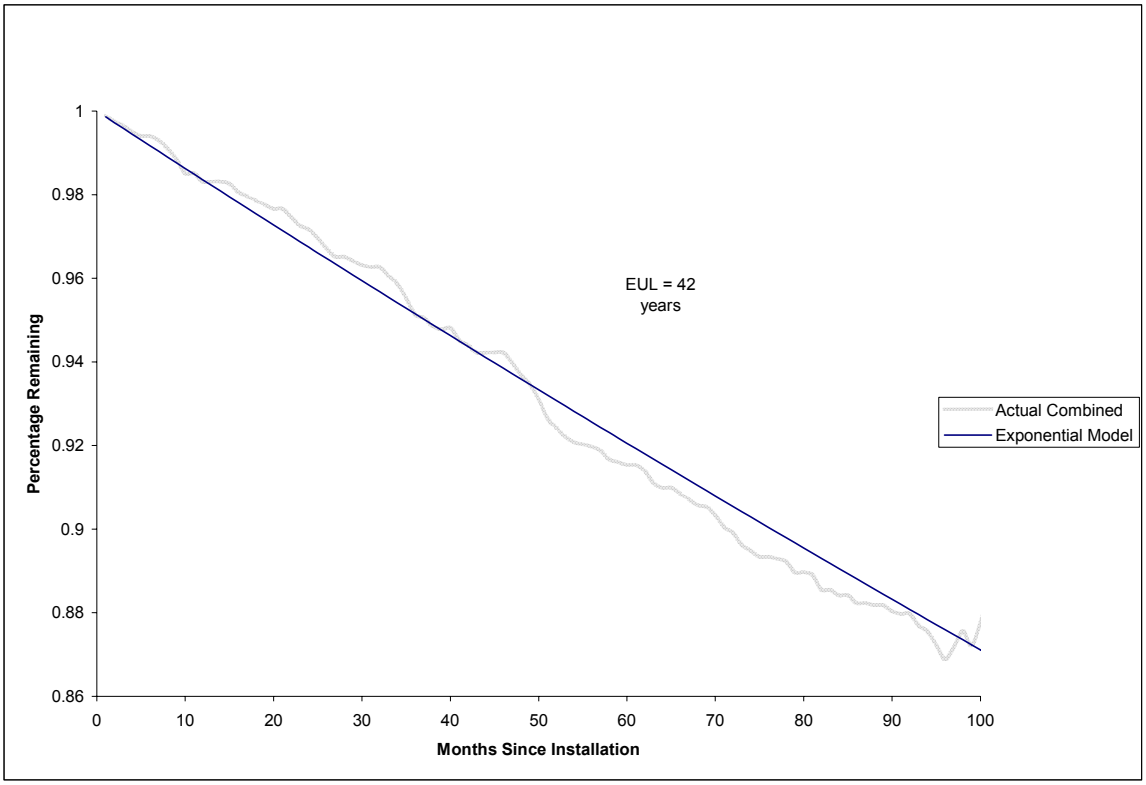
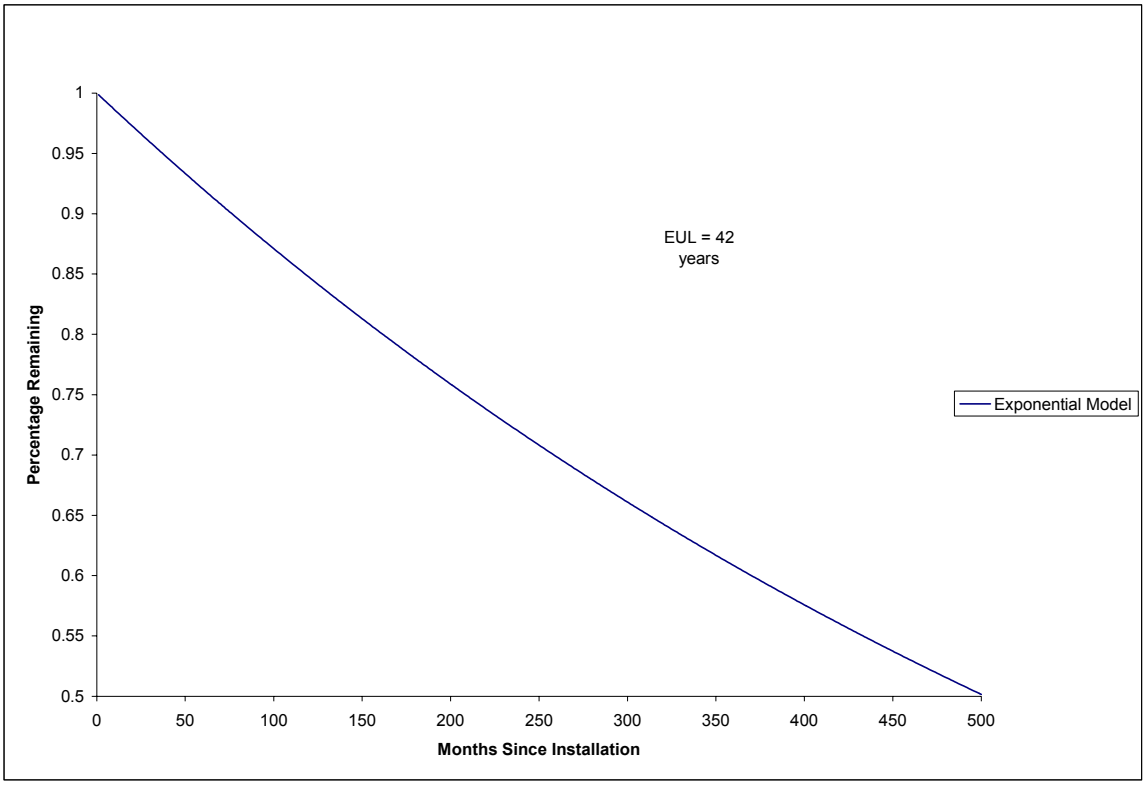


Exhibit 3-16 provides the resulting survival function assuming an exponential trend for the combined dataset over 500 months. Referring back to the linear model for the removal datasets (Exhibit 3-12), the differences between the two approaches are more apparent. Due to the constant hazard rate of the exponential model, the curve will flatten out over time, asymptotically approaching zero. The linear model, however, will continue with the same slope until no refrigerators remain.

Exhibit 3-16
Survival Function Based on an Exponential Trendline
Combined Dataset



The results of the exponential regressions are provided in Exhibit 3-17 for each of the three models. Also provided in Exhibit 3-17 is the estimated EUL for each model. For an exponential survival function, the EUL (median life) is calculated as:

EUL = ln(2)/slope

Exhibit 3-17
Regression Results of Exponential Trendline
and Resulting Ex Post EUL Estimates

Model Description	Slope	t-Statistic	EUL
Failures Only	0.0002	77.46	337
Removals Only	0.0012	106.47	49
Combined Model	0.0014	121.41	42

The results of the exponential trendline estimates are slightly higher than for the linear trendline estimates. Again, these results indicate that the ex post EUL estimate is significantly larger than the ex ante estimates (which are all 20 years). Each of 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 refrigerators. If this were the case, then study results indicate that energy efficient refrigerators purchased without the program and the removal restrictions of utility service territory would have an EUL of 337 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/removals, 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.

As discussed above, the LIFEREG procedure was used to model the survival function for the rebated refrigerators. Exhibits 3-18 through 3-21 present comparisons of various modeling techniques for the failures only dataset, the removals only dataset, and the combined dataset. This level of detail is shown to develop an understanding of the differences among event types.

Failure Dataset

Exhibit 3-18 provides the survival functions based on the exponential, logistic, lognormal, Weibull and gamma distributions, estimated for the failure 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 3-18
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
Failure Dataset

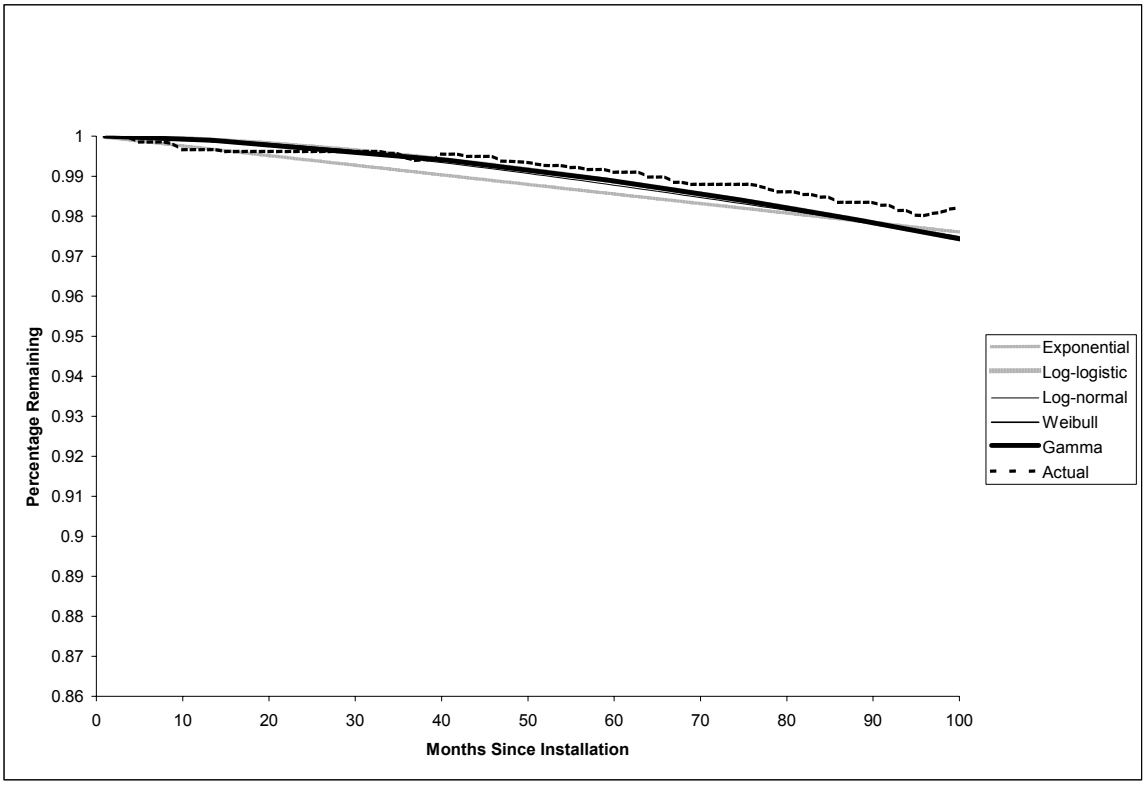


Exhibit 3-18 illustrates that all of the survival functions tend to under-estimate the percentage of remaining equipment beginning around month 40 for the "failures only" dataset. The gamma function seems to do the best job fitting the data in that it has a relatively low rate of failure from months 0 to 40 at which point it begins to increase following the shape of the empirical data.

Removal Dataset

Exhibit 3-19 provides the survival functions based on the exponential, logistic, lognormal, Weibull and gamma distributions, estimated for the removal 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 3-19
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
Removal Dataset

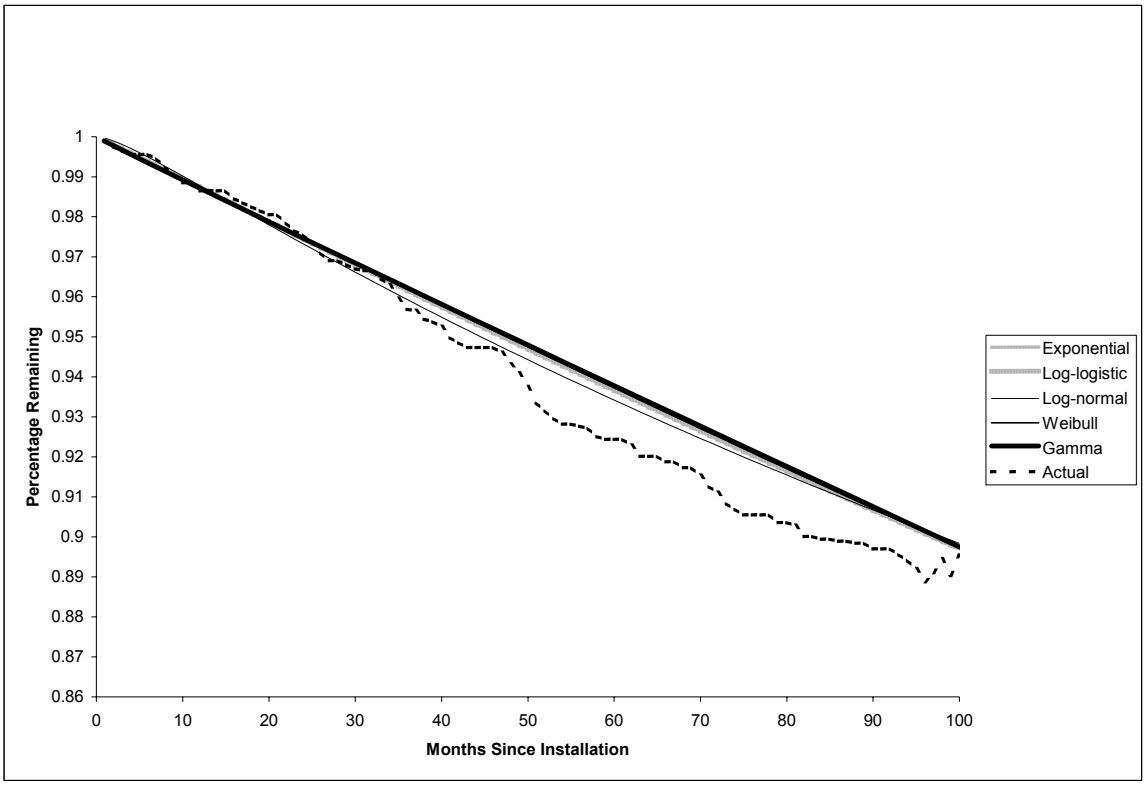


Exhibit 3-19 illustrates that the survival functions tend to over-estimate the percentage of remaining equipment beginning around month 35 for the "removals only" dataset.

Combined Dataset

Exhibit 3-20 provides the survival functions based on the exponential, logistic, lognormal, Weibull and gamma distributions, estimated for the combined 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 3-20
Comparison of Survival Functions
Exponential, Logistic, Lognormal, Weibull and Gamma versus Empirical Function
Combined Dataset

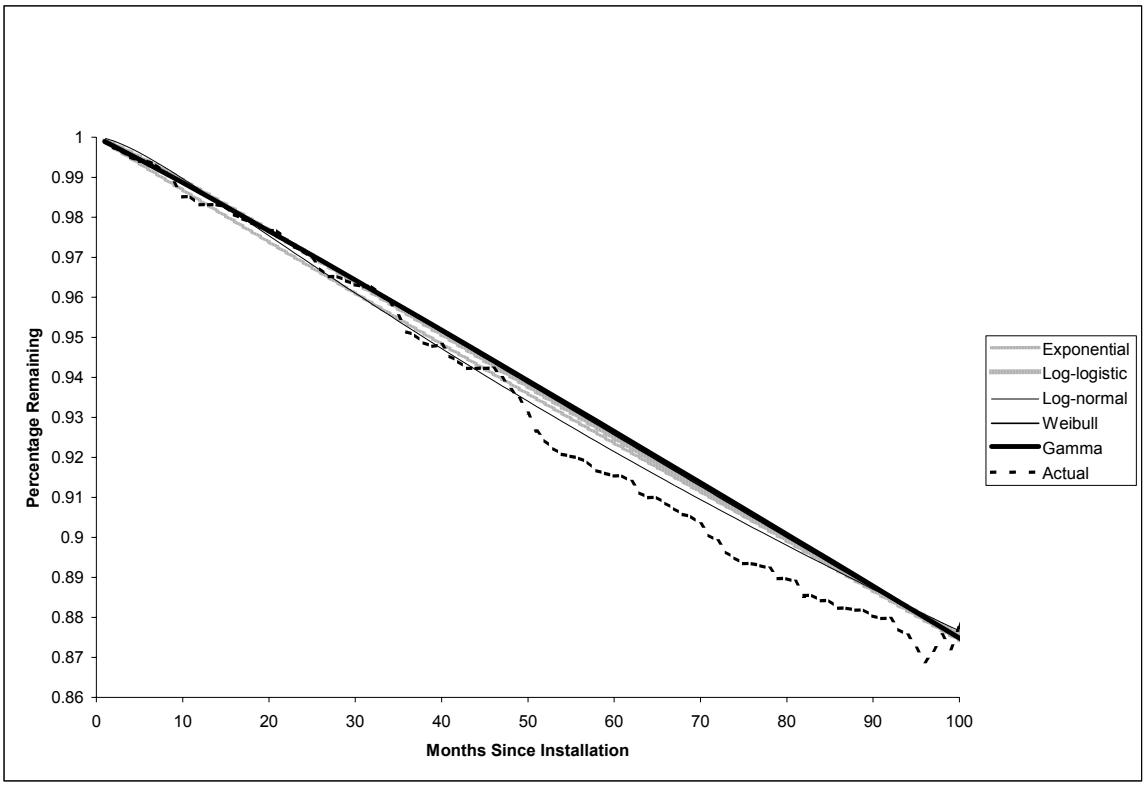


Exhibit 3-20 illustrates that the survival functions for the combined dataset do a fair job estimating the percentage of remaining equipment over the first 100 months of the measures life. Exhibit 3-21 extends the models produced in LIFEREG to 500 months to examine how the distributions differ over time.

Exhibit 3-21
Exponential, Logistic, Lognormal, Weibull and Gamma Survival Functions
Based on LIFEREG Procedure
Combined Dataset

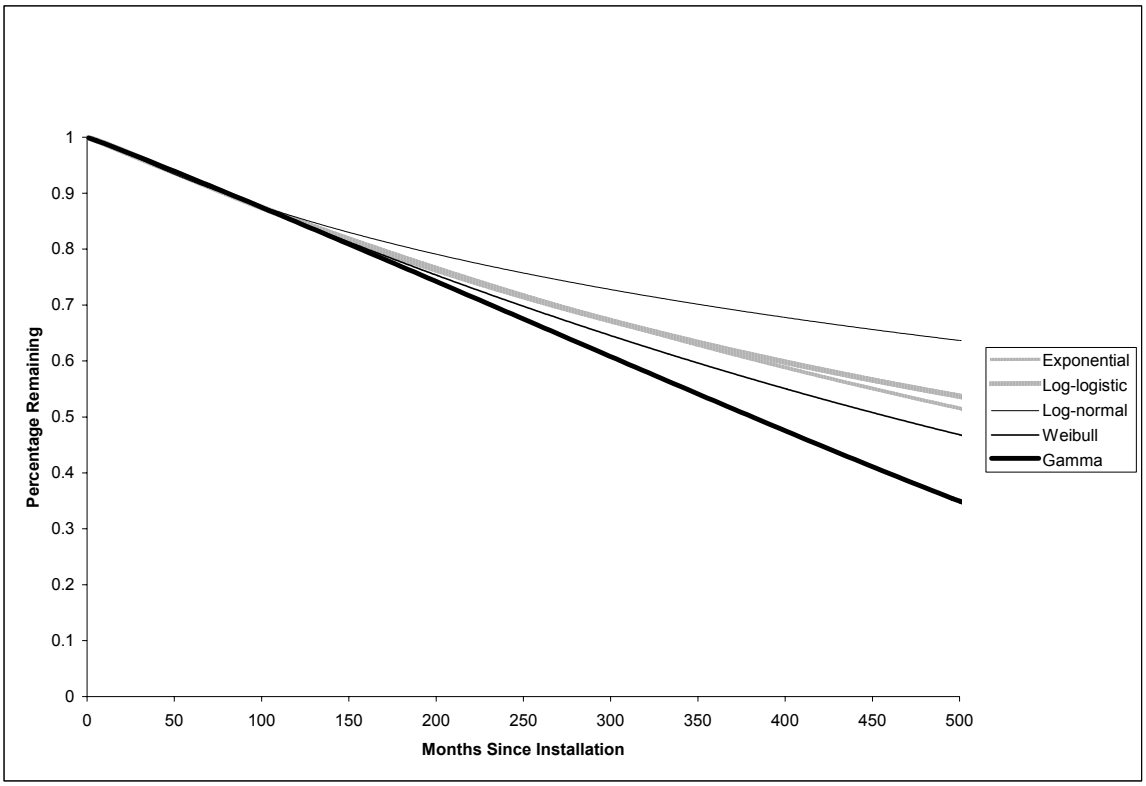


Exhibit 3-21 illustrates how the LIFEREG procedure models the survival function, forecasting out over time. It is likely that the model interprets the empirical data as beginning to "level off", by having a decreasing hazard rate. This interpretation leads the model to forecast somewhat of an asymptotic curve over time for the distributions that are capable of modeling a decreasing hazard rate except the gamma distribution. Even at 500 months we can still not notice the gamma distribution leveling off. The exponential distribution also does not appear to be leveling off by this time, which is a result of the exponential distribution having a constant hazard rate.

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 lognormal 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 3-22 below summarizes the results of the LIFEREG models for the rebated refrigerators. 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 3-22
Comparison of Survival Model Results
Exponential, Logistic, Lognormal, Weibull and Gamma Models

			Variable			Resulting
Measure	**Model**		**Intercept**	**Scale**	**Scale**	**EUL**
Combined	Exponential	Parameter Estimate	6.63	1.00	-	**44**
		Standard Error	0.01	0.00	-	1
	Logistic	Parameter Estimate	6.35	0.90	-	**47.6**
		Standard Error	0.03	0.01	-	1
	Log-Normal	Parameter Estimate	6.91	1.99	-	**83.6**
		Standard Error	0.03	0.02	-	3
	Weibull	Parameter Estimate	6.47	0.93	-	**38.3**
		Standard Error	0.03	0.01	-	1
	Gamma	Parameter Estimate	6.36	0.49	1.96	**31.8**
		Standard Error	0.01	0.00	0.00	0
Failures	Exponential	Parameter Estimate	8.33	1.00	-	**238**
		Standard Error	0.03	0.00	-	7
	Logistic	Parameter Estimate	6.83	0.61	-	**77.2**
		Standard Error	0.07	0.02	-	5
	Log-Normal	Parameter Estimate	8.05	1.76	-	**260.4**
		Standard Error	0.10	0.05	-	26
	Weibull	Parameter Estimate	6.85	0.61	-	**62.8**
		Standard Error	0.07	0.02	-	4
	Gamma	Parameter Estimate	6.72	0.32	1.94	**52.7**
		Standard Error	0.02	0.00	0.00	1
Removals	Exponential	Parameter Estimate	6.83	1.00	-	**53**
		Standard Error	0.01	0.00	-	1
	Logistic	Parameter Estimate	6.70	0.97	-	**67.4**
		Standard Error	0.03	0.01	-	2
	Log-Normal	Parameter Estimate	7.37	2.17	-	**131.8**
		Standard Error	0.04	0.03	-	5
	Weibull	Parameter Estimate	6.81	0.99	-	**52.6**
		Standard Error	0.03	0.01	-	2
	Gamma	Parameter Estimate	6.71	0.42	2.44	**42.2**
		Standard Error	0.01	0.00	0.00	1

Although we feel that the results using the LIFEREG procedure are superior to those based on the trendlines, we do not recommend using this approach for our final results, as will be discussed in more detail in Section 4. The primary reason for this is that the combined LIFEREG model is incapable of differentiating between failures and removals. As we have discussed and the data has shown, the distributions for failures and removals are inherently different. To address this we have developed competing risks models, discussed in the

following section, which are designed to allow for multiple "failure" events and integrate multiple survival distributions into a single function.

3.8 COMPETING RISKS MODEL

The final analysis step, as described in Section 3.3 above, was to develop competing risks models to account for multiple events influencing the survival distribution. The first task in developing competing risks model was to calculate hazard functions for all events. The hazard rate at each time step is simply the derivative of the survival function, or the number of events occurring over that time step divided by the remaining population at that time.

The next task is to create the competing risks model. This is accomplished by combining hazard rates from both failures and removals into one joint probability function.

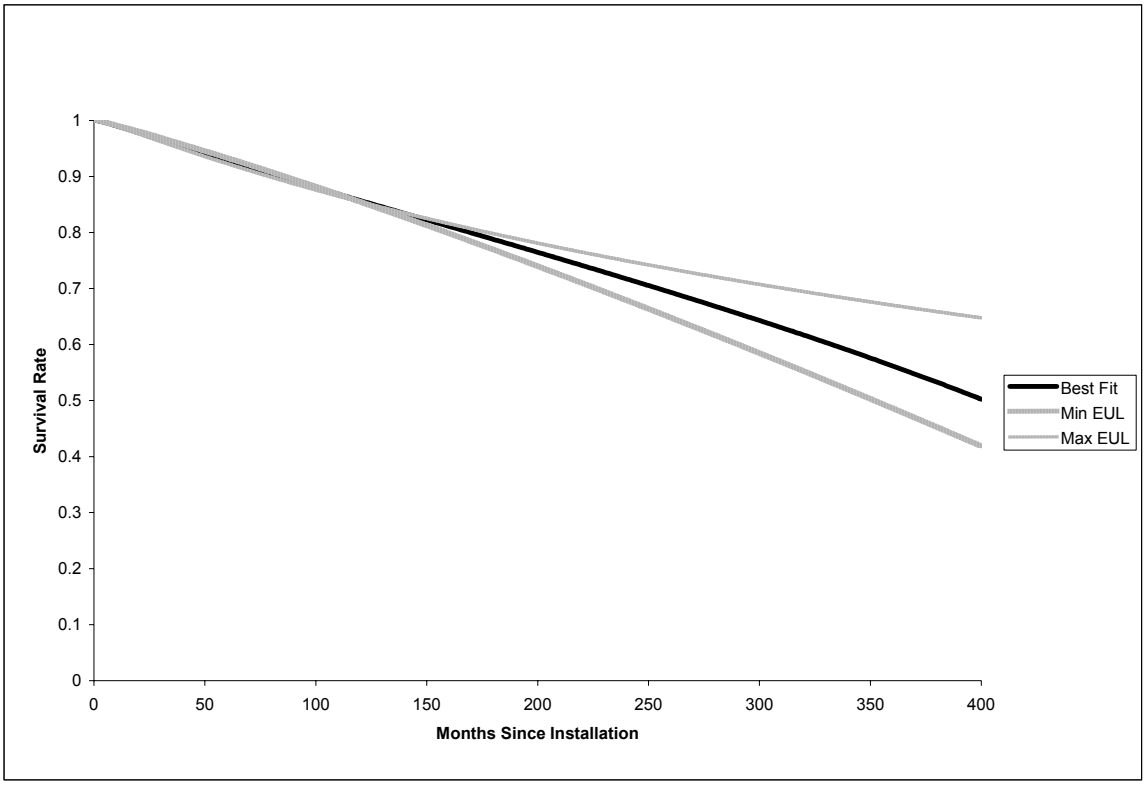
Three different sets of results were generated from this model. The first result contains the best-fitting distribution for each event based on the log-likelihood estimate, which is a parameter output that can be used to judge how well the model fits the actual data. The second SAS result provides the minimum EUL estimate, and the third result provides the maximum EUL estimate. A summary of the different distributions that were chosen for each of the models is presented in Exhibit 3-23.

Exhibit 3-23
Comparison of Distributions Used in the Competing Risks Model

Model Description	Failure Distribution	Removal Distribution
Best Fit	Gamma	Log-Normal
Minimum EUL	Gamma	Gamma
Maximum EUL	Log-Normal	Log-Normal

The resulting survival functions are provided in Exhibit 3-24. For the best fitting model, the gamma distribution was used for failures, and the lognormal distribution was used for removals. The minimum EUL was based on the gamma distribution for both failures and removals. The maximum EUL was created using the lognormal distribution for both failures and removals.

Exhibit 3-24
Comparison of Survival Functions from Competing Risk Model
Using Rebated Refrigerator for Failures and Removals



The EUL predicted by the best fitting model was 33.4 years, almost 70% higher than the ex ante EUL of 20 years. The minimum EUL predicted by the competing risks model was 29.3 years and the maximum was 63.1 years. As shown in the exhibit, the best fit model and the minimum EUL model have similarly shaped distributions over the 400 month time period shown.

Results from the competing risks model are presented in Exhibit 3-25. For each case, the competing risks model EUL prediction is given along with its associated standard error. The properties for the failure and removal distributions (from the LIFEREG procedure in SAS) used to construct each competing risks model are also provided.

Exhibit 3-25
Competing Risks Model Results

Method	Model	Distribution		Variable Intercept	Variable Scale	Variable Scale	Resulting EUL
Best Fit	Combined		Parameter Estimate				**33.4**
			Standard Error				0.74
	Failures	Gamma	Parameter Estimate	6.72	0.32	1.94	**52.7**
			Standard Error	0.02	0.00	0.00	0.9
	Removals	Log-Normal	Parameter Estimate	7.37	2.17	-	**131.8**
			Standard Error	0.04	0.03	-	5.4
Min EUL	Combined		Parameter Estimate				**29.3**
			Standard Error				0.3
	Failures	Gamma	Parameter Estimate	6.72	0.32	1.94	**52.7**
			Standard Error	0.02	0.00	0.00	0.9
	Removals	Gamma	Parameter Estimate	6.71	0.42	2.44	**42.2**
			Standard Error	0.01	0.00	0.00	0.6
Max EUL	Combined		Parameter Estimate				**63.1**
			Standard Error				2.7
	Failures	Log-Normal	Parameter Estimate	8.05	1.76	-	**260.4**
			Standard Error	0.10	0.05	-	25.6
	Removals	Log-Normal	Parameter Estimate	7.37	2.17	-	**131.8**
			Standard Error	0.04	0.03	-	5.4

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 1996 and 1997 RAEI Retention Study. As discussed in detail in Section 3, the overall approach consists of five analysis steps that were used to estimate the EUL for rebated refrigerators:

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.
5. ***Develop competing risk models*** to obtain final results

4.1 COMPILE SUMMARY STATISTICS

Although the analysis was conducted on one combined dataset, initial summary statistics were produced for each survey type. This provided insight on the number and type of events by survey type. For example, the survey results confirm the initial assumption that the Participant Mover group would exhibit a higher proportion of removals.

Exhibit 4-1 presents the percentage of refrigerators that were found to have failed or been removed over the study period.

Exhibit 4-1
Unweighted Summary Statistics on Raw Retention Data

Survey Type	Number of Surveys Conducted	Number of Units that Failed, were Removed, or Replaced	Number of Units Replaced Under Warranty	Number of Units in Place and Operable	Percent Failed, Removed, Replaced
Original Participant	1,259	39	8	1,220	3.10%
Participant Mover	290	81	0	209	27.93%
New Occupant	315	15	1	300	4.76%
Total	1,864	135	9	1,729	7.24%

The raw retention data was then combined to form one analysis dataset. Failures and removals were modeled both as one event and separately so that the differences in the distributions between failures and removals could be examined. An unweighted percentage of units that have failed or been removed was calculated. From this percentage, an EUL was estimated, assuming a constant failure rate over the life of the measure. Exhibit 4-2 presents these results.

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
Combined	9.38%	1.04%	96	66	20
Failures	2.62%	0.29%	344	239	20
Removals	6.77%	0.75%	133	92	20

^ 4th year survey points were removed and it is assumed that failures and removals occured over 9 years.
* Assuming a constant failure rate over time.

4.2 VISUAL INSPECTION

Using the raw retention data, we developed empirical distributions of the combined survival function for failures and removals. The empirical distributions developed illustrated the overwhelming effect the removals had on the combined function as opposed to the failures (as of month 60 there were very few refrigerator failures).

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 each of the three analysis methods. Also provided in Exhibit 4-3 is the estimated EUL for each method. 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 20 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

Measure Description	Intercept	t-Statistic	Slope	t-Statistic	EUL
Linear Distribution					
Combined Model	1.00	717	-0.0013	-58.52	33
Failures Only	1.00	3,691	-0.0002	-42.50	232
Removals Only	1.00	722	-0.0011	-50.65	38
Exponential Distribution					
Combined Model	-	-	0.0014	121.41	42
Failures Only	-	-	0.0002	77.46	337
Removals Only	-	-	0.0012	106.47	49

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 analysis dataset, and for each type of distribution modeled. Furthermore, the resulting EUL estimates are provided.

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

Measure	Model		Variable			Resulting
			Intercept	Scale	Scale	EUL
Combined	Exponential	Parameter Estimate	6.63	1.00	-	**44**
		Standard Error	0.01	0.00	-	1
	Logistic	Parameter Estimate	6.35	0.90	-	**47.6**
		Standard Error	0.03	0.01	-	1
	Log-Normal	Parameter Estimate	6.91	1.99	-	**83.6**
		Standard Error	0.03	0.02	-	3
	Weibull	Parameter Estimate	6.47	0.93	-	**38.3**
		Standard Error	0.03	0.01	-	1
	Gamma	Parameter Estimate	6.36	0.49	1.96	**31.8**
		Standard Error	0.01	0.00	0.00	0
Failures	Exponential	Parameter Estimate	8.33	1.00	-	**238**
		Standard Error	0.03	0.00	-	7
	Logistic	Parameter Estimate	6.83	0.61	-	**77.2**
		Standard Error	0.07	0.02	-	5
	Log-Normal	Parameter Estimate	8.05	1.76	-	**260.4**
		Standard Error	0.10	0.05	-	26
	Weibull	Parameter Estimate	6.85	0.61	-	**62.8**
		Standard Error	0.07	0.02	-	4
	Gamma	Parameter Estimate	6.72	0.32	1.94	**52.7**
		Standard Error	0.02	0.00	0.00	1
Removals	Exponential	Parameter Estimate	6.83	1.00	-	**53**
		Standard Error	0.01	0.00	-	1
	Logistic	Parameter Estimate	6.70	0.97	-	**67.4**
		Standard Error	0.03	0.01	-	2
	Log-Normal	Parameter Estimate	7.37	2.17	-	**131.8**
		Standard Error	0.04	0.03	-	5
	Weibull	Parameter Estimate	6.81	0.99	-	**52.6**
		Standard Error	0.03	0.01	-	2
	Gamma	Parameter Estimate	6.71	0.42	2.44	**42.2**
		Standard Error	0.01	0.00	0.00	1

4.5 DEVELOP COMPETING RISKS MODELS

As discussed in Section 3, competing risks models were developed to incorporate multiple event types having differing distributions into one combined distribution. The model contains three different distribution combinations. The first combination is what we believe to be the best estimate of the actual distribution, based on log-likelihood estimates produced by SAS. The second combination presents the minimum EUL. Conversely, the third combination presents the maximum EUL. Each combination of failures and removals was modeled to develop survival functions as presented in Section 3. The resulting EUL predictions from the competing risks models are presented in Exhibit 4-5.

Exhibit 4-5
Competing Risks Model Results

Method	Model	Distribution		Variable Intercept	Variable Scale	Scale	Resulting EUL
Best Fit	Combined		Parameter Estimate				**33.4**
			Standard Error				0.74
	Failures	Gamma	Parameter Estimate	6.72	0.32	1.94	**52.7**
			Standard Error	0.02	0.00	0.00	0.9
	Removals	Log-Normal	Parameter Estimate	7.37	2.17	-	**131.8**
			Standard Error	0.04	0.03	-	5.4
Min EUL	Combined		Parameter Estimate				**29.3**
			Standard Error				0.3
	Failures	Gamma	Parameter Estimate	6.72	0.32	1.94	**52.7**
			Standard Error	0.02	0.00	0.00	0.9
	Removals	Gamma	Parameter Estimate	6.71	0.42	2.44	**42.2**
			Standard Error	0.01	0.00	0.00	0.6
Max EUL	Combined		Parameter Estimate				**63.1**
			Standard Error				2.7
	Failures	Log-Normal	Parameter Estimate	8.05	1.76	-	**260.4**
			Standard Error	0.10	0.05	-	25.6
	Removals	Log-Normal	Parameter Estimate	7.37	2.17	-	**131.8**
			Standard Error	0.04	0.03	-	5.4

4.6 FINAL RESULTS

Exhibit 4-6 summarizes the estimated EULs from the survival analysis for each analysis dataset and corresponding model. The median EULs are provided, along with the upper and lower confidence bounds, based on the 80 percent confidence interval.

Exhibit 4-6
Comparison of Survival Model Results
Linear, Exponential, Logistic, Lognormal, Weibull and Gamma Models

			Analysis Methods		
Approach	**Model**		**Failures**	**Removals**	**Combined**
Summary	Exponential	Median EUL	306	120	86
Statistics		Upper Bound	-	-	-
		Lower Bound	-	-	-
Trendlines	Linear	Median EUL	232	38	33
		Upper Bound	232	38	33
		Lower Bound	231	38	33
	Exponential	Median EUL	337	49	42
		Upper Bound	343	49	42
		Lower Bound	332	49	42
LIFEREG	Exponential	Median EUL	238	53	44
		Upper Bound	247	54	44
		Lower Bound	229	52	43
	Logistic	Median EUL	77	67	48
		Upper Bound	84	70	49
		Lower Bound	70	65	46
	Log-Normal	Median EUL	260	132	84
		Upper Bound	293	139	87
		Lower Bound	228	125	80
	Weibull	Median EUL	63	53	38
		Upper Bound	68	55	39
		Lower Bound	58	51	37
	Gamma	Median EUL	53	42	32
		Upper Bound	54	43	32
		Lower Bound	51	41	31

Exhibit 4-7 summarizes the estimated EULs from the competing risks model for each analysis dataset and corresponding model. The median EULs are provided, along with the upper and lower confidence bounds, based on the 80 percent confidence interval.

Exhibit 4-7
Comparison of Competing Risks Model Results

Model Output	Failure Distribution	Removal Distribution	EUL	Upper Bound	Lower Bound
Rebated Refrigerator Failure and Removal Data					
Best Fit	Gamma	Log-Normal	33.4	34.4	32.5
Minimum EUL	Gamma	Gamma	29.3	29.7	28.8
Maximum EUL	Log-Normal	Log-Normal	63.1	67	60

4.7 RECOMMENDATIONS

Based on our extensive analysis of the retention data, we believe that the best fitting model for the Expected Useful Life of the rebated refrigerators results from the competing risks analysis.

The results based on the summary statistics are not recommended, as they based solely on the overall failure/removal 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. As we have discussed earlier, we believe that failures and removals have different underlying distributions, which can only be handled using competing risk models. This is yet another reason why the approaches based on the summary statistics and the trendlines are not recommended. This is also the primary reason why the combined data models using the LIFEREG procedure are not recommended.

For these reasons, we recommend using the competing risk model approach. The distributions that provided the best model fit as measured by the log-likelihood estimate resulted in a gamma failure distribution and a lognormal removal distribution. Although the 80% confidence interval based on the best fit competing risks model does not encompass the ex ante EUL of 20 years, the ex post EUL should remain at 20 years since the best fit EUL exceeds the ex ante EUL. 20 years is the maximum measure life considered under PG&E's Annual Earnings Assessment Proceedings [AEAP]. The program realization rate, which is the ratio of the ex ante and ex post estimates, is one. These results are summarized in Exhibit 4-8.

Exhibit 4-8
Final Ex Post EUL Estimate

			Study Results			Ex Post	Realization
End Use	Technology	Ex Ante	Upper	Median	Lower	Claimed	Rate
Refrigeration	20 Percent More Efficient	20	34.4	33.4	32.5	20	100%
	25 Percent More Efficient	20	34.4	33.4	32.5	20	100%
	30 Percent More Efficient	20	34.4	33.4	32.5	20	100%

APPENDIX 1

PROTOCOL TABLES 6B AND 7B

NINTH YEAR RETENTION STUDY FOR PG&E'S 1996 & 1997 RESIDENTIAL AEI PROGRAM REFRIGERATION TECHNOLOGY

PG&E STUDY ID # 373 1R2

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 1996 & 1997 Residential Sector
Residential Refrigeration Ninth Year Retention
Study ID # 373 1R2

		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)**
Refrigerator Rebate, Exceeds Standards by 20%	Refrigeration	20	Advice Filing	33.4	20	0.74	32.5	34.4	<0.0001	100%	n/a
Refrigerator Rebate, Exceeds Standards by 25%	Refrigeration	20	Advice Filing	33.4	20	0.74	32.5	34.4	<0.0001	100%	n/a
Refrigerator Rebate, Exceeds Standards by 30%	Refrigeration	20	Advice Filing	33.4	20	0.74	32.5	34.4	<0.0001	100%	n/a

PROTOCOL TABLE 7B

NINTH YEAR RETENTION STUDY FOR PG&E'S 1996 & 1997 RESIDENTIAL AEI PROGRAM REFRIGERATION TECHNOLOGY PG&E STUDY ID # 373 1R2

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 1996 & 1997 Residential AEI Program Refrigeration Technology.

Study ID Number: 373 1R2

B. Program, Program Year and Program Description

Program: PG&E Residential AEI Program, Refrigeration Technology.

Program Year: 1996 and 1997

Program Description:

The Residential Appliance Efficiency Incentive (RAEI) Program offered fixed rebates to customers who installed refrigerators meeting specific electric energy-efficiency requirements. Rebates of $40 - $100 were paid for refrigerators that were 20 - 30 percent more efficient than baseline efficiency standards. The programs assumed that customers were in the process of replacing their existing refrigerators, and offered the incentive to influence them to purchase more efficient models.

C. End Uses and/or Measures Covered

Refrigerators.

D. Methods and Models Used

Our overall approach consists of five analysis steps that were used to estimate the EUL for rebated refrigerators:

6. ***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.

7. ***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.

8. ***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.

9. ***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.

10. ***Develop a competing risks model*** that incorporates different distributions for failures and removals. This additional analysis step provides valuable results that have not been previously utilized in retention studies.

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 today	Good Condition as of last date seen	Failed	Removed	Total
Original Participant	1,261	2	1,191	29	26	13	1,259
9th year points	800	2	735	29	23	11	798
4th year points	461	0	456	0	3	2	461
Participant Mover	294	4	168	41	4	77	290
9th year points	250	4	132	41	3	70	246
4th year points	44	0	36	0	1	7	44
New Occupant	333	18	289	11	8	7	315
9th year points	250	18	206	11	8	7	232
4th year points	83	0	83	0	0	0	83
Total	1,888	24	1,648	81	38	97	1,864

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 Non-Mover Retention Study Contacts.* The fourth year retention study data provided information regarding the status of the 588 refrigeration units surveyed in 2001 as part of the following surveys: Original Occupant Survey, Participant Mover Survey, and New Occupant Survey. These data were used to supplement data collected during the ninth year study for all three populations.

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 refrigerator 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/removal 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 were made.

D. Unused Data Elements

As shown in the final disposition table above, a total of 24 survey points were collected but not used in the analysis for the following reasons:

- Two Original Participants were removed from the analysis population because they returned the rebated refrigerator.

- Four Participant Movers were removed from the analysis dataset because they reported leaving the rebated refrigerator at their old address. These individuals were inadvertently categorized as completes, and were later re-categorized as incompletes.

- Eighteen New Occupants were dropped from the analysis for the following reasons:

  - Seventeen New Occupants could not verify that they still had the rebated refrigerator.

  - One New Occupant revealed later on in the survey that the previous owner had, in fact, taken the refrigerator with them.

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 today	Good Condition as of last date seen	Failed	Removed	Total
Original Participant	1,261	2	1,191	29	26	13	1,259
9th year points	800	2	735	29	23	11	798
4th year points	461	0	456	0	3	2	461
Participant Mover	294	4	168	41	4	77	290
9th year points	250	4	132	41	3	70	246
4th year points	44	0	36	0	1	7	44
New Occupant	333	18	289	11	8	7	315
9th year points	250	18	206	11	8	7	232
4th year points	83	0	83	0	0	0	83
Total	1,888	24	1,648	81	38	97	1,864

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

Survey Type	Number of Surveys Conducted	Number of Units that Failed, were Removed, or Replaced	Number of Units Replaced Under Warranty	Number of Units in Place and Operable	Percent Failed, Removed, Replaced
Original Participant	1,259	39	8	1,220	3.10%
Participant Mover	290	81	0	209	27.93%
New Occupant	315	15	1	300	4.76%
Total	1,864	135	9	1,729	7.24%

4. DATA SCREENING AND ANALYSIS

A. Procedures for Treating Outliers and Missing Data

An initial data cleaning process found that 24 records out of the preliminary 1,888 completes from the ninth year surveys had been misclassified as completes for a variety of reasons. These records were dropped and all remaining data points on the rebated refrigerators 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/removal 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 refrigerator 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 miscoded 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/removal dates were missing. There were no other missing data points, other than failure/removal dates.

I. Precision

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

APPENDIX 2

1996/1997 PG&E 9th Year Residential Refrigeration Retention Survey

Variables Needed for CATI:
Name
Rebate Year
Address
Phone Number
Brand
Type
Control

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 THERE IS SOMEONE TO TALK TO, READ: PG&E is conducting research on certain refrigerators purchased through their rebate program, to see if they are still working properly.

IF NECESSARY: PG&E is required by law to conduct these surveys to determine the operating status of refrigerators 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	SC9
2	No	SC1A
88	Refused	T&T
99	Don't Know	T&T

SC1A. May I have your corrected address?
NOTE TO INTERVIEWER: Are they close enough to proceed – if yes then go to SC9

77	Specify	SC9

SC9. Did you move to this address in (REBATE YEAR) or later?

1	Yes	SC10
2	No	SC10
88	Refused	T&T
99	Don't Know	T&T

SC10. In what year did you move to this address?

SC10 Year

1	1995	SC11
2	1996	SC11
3	1997	SC11
4	1998	SC11
5	1999	SC11
6	2000	SC11
7	2001	SC11
8	2002	SC11
9	2003	SC11
10	2004	SC11

11	2005	SC11
12	Prior to 1995	T&T (User Box 30)
88	Refused	R9
99	Don’t Know	R9

If Rebate Year = 1997 and SC10=1 then T&T (User Box 30)

SC11. And do you recall the month or time of year?

SC11 Month

1	January	R9
2	February	R9
3	March	R9
4	April	R9
5	May	R9
6	June	R9
7	July	R9
8	August	R9
9	September	R9
10	October	R9
11	November	R9
12	December	R9
13	Spring	R9
14	Summer	R9
15	Fall	R9
16	Winter	R9
88	Refused	R9
99	Don’t Know	R9

IF (SC10 = 1, 2 or 3 and [REBATE YEAR] = 1996) or (SC10 2 or 3 or 4and [REBATE YEAR] = 1997) then ask R9, Else Skip to R10.

R9. Did you purchase a refrigerator for this address during 1996 or 1997, for which you received a rebate from PG&E?

1	Yes	T&T (User Box 30)
2	No	R10
88	Refused	R10
99	Don’t Know	R10

R.HOUSEHOLDS WHERE THERE USED TO BE REFRIGERATOR REBATE PARTICIPANT

READ: I would like to ask you some questions about your refrigerator.

R10. Was there a refrigerator at (ADDRESS) when you moved in?

1	Yes	R12
2	No	R100
88	Refused	R11
99	Don’t Know	R11

R11. When you moved into your home, what best describes how you obtained your refrigerator?

1	We moved our refrigerator from our previous address.	R100
2	We purchased a new refrigerator.	R100
3	Someone gave us a refrigerator.	R100
4	We kept the existing refrigerator from the previous occupant.	R12
5	Our landlord provided us with a refrigerator.	R12
88	Refused	T&T
99	Don't Know	T&T

R12. The value of this study depends upon our ability to determine that we are evaluating the proper rebated refrigerator.

May I please ask you to take a moment and go look at your refrigerator and verify that it is a <%BRAND> ...<%TYPE>?

1	Yes	R13
2	No (Refused to look)	R100
3	The refrigerator is no longer there	R100
88	Refused	R13
99	Don't Know	R13

ASK R100 IF R10 = 2, or R11 = 1, 2, 3, or R12 = 2
Else skip to R300

R100. What is the age of your current refrigerator? (IF MORE THAN ONE, ONLY ASK ABOUT PRIMARY REFRIGERATOR).

1	Enter Years	T&T (User Box 35)
88	Refused	T&T (User Box 35)
99	Don't Know	T&T (User Box 35)

R13. Do you still have this refrigerator?

1	Yes	R37
2	No	R21
88	Refused	R21
99	Don't Know	R21

R21. What happened to the refrigerator? (DO NOT READ LIST)

1	Broke	R23
2	Damaged in fire, earthquake, flood or other disaster	R23
3	Sold it or gave it away	R22
4	Put it at another address I'm responsible for	R23
5	Recycled it	R23
6	Disposed of it / New Fridge Delivery folks took it	R23
7	Still have it	R37
77	Other (Specify)	R23
88	Refused	T&T
99	Don't Know	T&T

R22. Why did you sell or give away your refrigerator away?

1	Remodeled Kitchen	R23
2	Needed Larger Unit	R23
3	Didn't like Unit	R23
4	Had Repair Problems	R23
5	Was Given better Unit	R23
6	Wanted more energy efficient unit	R23

7	Moved from that house and didn’t take it along	R23
77	Other (Specify)	R23
88	Refused	R23
99	Don’t Know	R23

R23. In what year did this happen?

R23 Year

1	1995	R24
2	1996	R24
3	1997	R24
4	1998	R24
5	1999	R24
6	2000	R24
7	2001	R24
8	2002	R24
9	2003	R24
10	2004	R24
11	2005	R24
88	Refused	R26
99	Don’t Know	R26

R24. And do you recall the month or time of &year?

R24 Month

1	January	R25
2	February	R25
3	March	R25
4	April	R25
5	May	R25
6	June	R25
7	July	R25
8	August	R25
9	September	R25
10	October	R25
11	November	R25
12	December	R25
13	Spring	R25
14	Summer	R25
15	Fall	R25
16	Winter	R25
88	Refused	R25
99	Don’t Know	R25

IF [R21 = 3, 5 or 6] and R23 = 7, 8, 9, 10 or 11 then ask R25, else skip to R26

R25. On a scale of 1 to 5 how influential was the energy crisis of 2001 on your decision to buy a new unit?

1	Extremely Influential	R26
2	Very Influential	R26
3	Somewhat Influential	R26
4	Slightly Influential	R26
5	Not Influential	R26
88	Refused	R26
99	Don’t Know	R26

IF R21 = 1 then ask R26
IF R21 = 2, 5 or 6 then ask R27
Else IF R21 = 3, 4, 77 then skip to R28, Else skip to R37

R26. Was the unit replaced under warranty?

1	Yes	R29
2	No	R28
88	Refused	R28
99	Don't Know	R28

R27. Was the unit replaced through insurance?

1	Yes	R29
2	No	R28
88	Refused	R28
99	Don't Know	R28

R28. Was the unit replaced?

1	Yes	R29
2	No	R31
88	Refused	R31
99	Don't Know	R31

R29. Was it replaced with a refrigerator of the same efficiency or higher?

1	Lower Efficiency	R30
2	Same Efficiency	R30
3	Higher Efficiency	R30
88	Refused	R30
99	Don't Know	R30

R30. Did you receive a rebate from PG&E for the new refrigerator?

1	Yes	R31
2	No	R31
88	Refused	R31
99	Don't Know	R31

IF R21 = 1, 2, 6 or 77 then ask R31

R31. How did you dispose of the old refrigerator? Did you … (READ LIST)

1	Recycle it	R35
2	Throw it away	R35
3	Have it removed by the individuals that delivered the new one	R35
77	Other (specify)	R35
88	Refused	R35
99	Don't Know	R35

IF R21 = 3,4,77 then ask R32, Else Skip to R35

R32. To the best of your knowledge, is the new owner or new location of the refrigerator somewhere in central or northern California?

1	Yes	R34
2	No	R33
88	Refused	R35
99	Don't Know	R35

R33. What state is the refrigerator now in?

1	Specify	R34
88	Refused	R34
99	Don’t Know	R34

R34. What city/area is the refrigerator now in?

1	Specify	R35
88	Refused	R35
99	Don’t Know	R35

IF R21 = 3, 5, 6, 77, Then Ask R35

IF R21=1 or 2 THEN SKIP TO R40
IF R21=4 or 7 or R13 = 1, THEN SKIP TO R37

R35. Was the refrigerator still in good working condition when you last had it?

1	Yes	R40
2	No	R36
88	Refused	R40
99	Don’t Know	R40

R36. What problems did you have with the refrigerator? (DO NOT READ)

1	Broken/Needed Major Repair/Too Expensive to Fix	R40
2	Needed Minor Repair	R40
3	Made Noises	R40
4	Leaked	R40
5	Too expensive to operate	R40
77	Specify	R40
88	Refused	R40
99	Don’t Know	R40

Only ask if R13 = 1, or R21=4 or 7

R37. How is the refrigerator currently being used? (READ LIST)

1	As a main refrigerator	R38
2	As a spare or secondary refrigerator	R38
3	Stored unused/unplugged	R38
88	Refused	R38
99	Don’t know	R38

R38. Is the refrigerator still in good working condition?

1	Yes	R40
2	No	R39
88	Refused	R40
99	Don’t Know	R40

R39. What problems have you had with the refrigerator? (DO NOT READ)

1	Broken/Needed Major Repair/Too Expensive to Fix	R40
2	Needed Minor Repair	R40
3	Made Noises	R40
4	Leaked	R40
5	Too expensive to operate	R40
77	Specify	R40
88	Refused	R40

99	Don’t Know	R40

R40. Do you clean the coils on your refrigerator?

(NOTE TO INTERVIEWER: The coils are thin metal tubes typically located on the back of the refrigerator)

1	Yes	R41
2	No	R42
88	Refused	R42
99	Don’t Know	R42

R41. How often do you clean the coils on your refrigerator? (DO NOT READ)

1	Every 6 months	R42
2	Once a year	R42
3	Every few years	R42
4	When they need it	R42
5	Never	R42
88	Refused	R42
99	Don’t Know	R42

R42. Do you check the seals on your refrigerator?
(NOTE TO INTERVIEWER: The seals are located around the doors of the refrigerator)

1	Yes	R43
2	No	R70
88	Refused	R70
99	Don’t Know	R70

R43. How often do you check the seals on your refrigerator? (DO NOT READ)

1	Every 6 months	R70
2	Once a year	R70
3	Every few years	R70
4	When they need it	R70
5	Never	R70
88	Refused	R70
99	Don’t Know	R70

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

R70. To the best of your knowledge has there been any major kitchen remodeling or renovation performed since (REBATE YEAR) at (ADDRESS)?

1	Yes	R71
2	No	R72
88	Refused	R72
99	Don’t Know	R72

R71. During what year did that remodeling occur?

R71 Year

1	1995	R72
2	1996	R72
3	1997	R72
4	1998	R72
5	1999	R72
6	2000	R72

7	2001	R72
8	2002	R72
9	2003	R72
10	2004	R72
11	2005	R72
88	Refused	R72
99	Don’t Know	R72

R72. What type of residence do you live in?

1	Single Family Detached Home	R73
2	Townhouse (also duet home, duplex)	R73
3	Condo	R73
4	Apartment (also multifamily, multi-unit)	R73
5	Mobile Home	R73
77	Other (specify)	R73
88	Refused	R73
99	Don’t Know	R73

R73. Do you own or rent this residence?

1	Own/buying	R74
2	Rent/lease	R74
77	Other (specify)	R74
88	Refused	R74
99	Don’t Know	R74

R74. How many people are in your household, including yourself?

1	Number of people	R99
88	Refused	R99
99	Don’t Know	R99

ASK R99 if (R12 = 88 or 99) AND (R13 = 1 or R21 = 7)
Else skip to R300

R99. Can you go to the refrigerator for me, and verify the Model number for me?

1	Yes – It is (MODEL) Number	R300
2	Can’t Find Model Number	R300
2	No – It is not (MODEL) Number	R300
88	Refused	R300
99	Don’t Know	R300

NOTE TO INTERVIEWER: Here are instructions to aid respondents in finding the location of brand name for commonly installed units through the program.

(IF TYPE IS SIDE BY SIDE READ “You will probably find the model number near the top of the refrigerator section, either on the ceiling or high on the right or left side walls. If not, it could be on the back wall or on the inside of the door.”

IF TYPE IS REFRIGERATOR ON TOP READ “You will probably find the model number near the top of the refrigerator section. Usually it is high on the left side wall. If not, it could be on the inside of the door.”

IF TYPE IS FREEZER IS ON TOP READ “You will probably find the model number near the top of the refrigerator section. Sometimes when the freezer is on top they put the number in the freezer compartment. If not, it could be on the inside of the door.”)

R300 Goodbye!

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

1996/1997 PG&E 9th Year Residential Refrigeration Retention Survey
Original Participant Survey – Non-Movers

Variables Needed for CATI:
Name
Rebate Year
Brand
Type
Address
Phone Number(s)
Control

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 THERE IS SOMEONE TO TALK TO, READ: PG&E is conducting research on certain refrigerators purchased through their rebate program, to see if they are still working properly. We are not trying to sell you anything and the survey will take 5 to 10 minutes.

IF RESPONDENT SAYS THEY HAVE NO REFRIGERATOR REBATED BY PG&E: According to PG&E's records, there was a refrigerator purchased by this household in (REBATE YEAR).

IF NECESSARY: PG&E is required by law to conduct these surveys to determine the operating status of refrigerators 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. Do you recall your household purchasing a refrigerator in (REBATE YEAR)?

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

SC4. Was it a (BRAND)and (TYPE)?

1	Yes	R1

2	No	SC5
88	Refused	SC5
989	Don’t Know	SC5

SC5. Do you recall receiving a rebate from PG&E for the refrigerator you purchased in (REBATE YEAR)?

1	Yes	R1
2	No	T&T
88	Refused	T&T
989	Don’t Know	T&T

R.REFRIGERATOR REBATE PARTICIPANTS SECTION

I would now like to ask you some questions about the refrigerator purchased in (REBATE YEAR)

R1. Is the refrigerator still at (ADDRESS)?

1	Yes	R37
2	No	R21
88	Refused	T&T
99	Don’t Know	T&T

R21. What happened to the refrigerator? (DO NOT READ LIST)

1	Broke	R23
2	Damaged in fire, earthquake, flood or other disaster	R23
3	Sold it or gave it away	R22
4	Put it at another address I’m responsible for	R23
5	Recycled it	R23
6	Disposed of it / New Fridge Delivery folks took it	R23
7	Returned it	R23
8	Put it in Storage	R23
9	Still have it	R37
77	Other (Specify)	R23
88	Refused	T&T
99	Don’t Know	T&T

R22. Why did you sell or give away your refrigerator?

1	Remodeled Kitchen	R23
2	Needed Larger Unit	R23
3	Didn’t like Unit	R23
4	Had Repair Problems	R23
5	Was Given better Unit	R23
6	Wanted more energy efficient unit	R23
77	Other (Specify)	R23
88	Refused	R23
99	Don’t Know	R23

R23. In what year did this happen?

R23 Year

1	1995	R24
2	1996	R24

3	1997	R24
4	1998	R24
5	1999	R24
6	2000	R24
7	2001	R24
8	2002	R24
9	2003	R24
10	2004	R24
11	2005	R24
88	Refused	R26
99	Don’t Know	R26

R24. And do you recall the month or time of &year ?
R24 Month

1	January	R25
2	February	R25
3	March	R25
4	April	R25
5	May	R25
6	June	R25
7	July	R25
8	August	R25
9	September	R25
10	October	R25
11	November	R25
12	December	R25
13	Spring	R25
14	Summer	R25
15	Fall	R25
16	Winter	R25
88	Refused	R25
99	Don’t Know	R25

IF [(R21 = 3 and R22 = 1, 3 or 6) or R21 = 5 or 6 or 8] and R23 = 7, 8, 9, 10 or 11 then ask R25, else skip to R26

R25. On a scale of 1 to 5 how influential was the energy crisis of 2001 on your decision to buy a new unit?

1	Extremely Influential	R26
2	Very Influential	R26
3	Somewhat Influential	R26
4	Slightly Influential	R26
5	Not Influential	R26
88	Refused	R26
99	Don’t Know	R26

IF R21 = 1 or 7 then ask R26
IF R21 = 2, 5 or 6 then ask R27
Else IF R21 = 3,4,8, 77 then skip to R28

R26. Was the unit replaced under warranty?

1	Yes	R29
2	No	R28
88	Refused	R28
99	Don’t Know	R28

R27. Was the unit replaced through insurance?

1	Yes	R29
2	No	R28
88	Refused	R28
99	Don’t Know	R28

R28. Was the unit replaced?

1	Yes	R29
2	No	R31
88	Refused	R31
99	Don’t Know	R31

R29. Was it replaced with a refrigerator of the same efficiency or higher?

1	Lower Efficiency	R30
2	Same Efficiency	R30
3	Higher Efficiency	R30
88	Refused	R30
99	Don’t Know	R30

R30. Did you receive a rebate from PG&E for the new refrigerator?

1	Yes	R31
2	No	R31
88	Refused	R31
99	Don’t Know	R31

IF R21 =1, 2, 77 then ask R31

R31. How did you dispose of the old refrigerator? Did you …(READ LIST)

1	Recycle it	R35
2	Throw it away	R35
3	Have it removed by the individuals that delivered the new one	R35
77	Other (specify)	R35
88	Refused	R35
99	Don’t Know	R35

IF R21 = 3,4,77 then ask R32, Else Skip to R35

R32. To the best of your knowledge, is the new owner or new location of the refrigerator somewhere in central or northern California?

1	Yes	R34
2	No	R33
88	Refused	R35
99	Don’t Know	R35

R33. What state is the refrigerator now in?

1	Specify	R34
88	Refused	R34
99	Don’t Know	R34

R34. What city/area is the refrigerator now in?

1	Specify	R35
88	Refused	R35
99	Don’t Know	R35

IF R21 = 3, 5, 6, 8, 77, Then Ask R35
Else,

IF R21=1 or 2 THEN SKIP TO R40
IF R21=4 , 9 or R1 = 1, THEN SKIP TO R37

R35. Was the refrigerator still in good working condition when you last had it?

1	Yes	R40
2	No	R36
88	Refused	R40
99	Don’t Know	R40

R36. What problems did you have with the refrigerator? (MULTIPLES, DO NOT READ)

1	Broken/Needed Major Repair/Too Expensive to Fix	R40
2	Needed Minor Repair	R40
3	Made Noises	R40
4	Leaked	R40
5	Too expensive to operate	R40
77	Specify	R40
88	Refused	R40
99	Don’t Know	R40

Only ask if R1 = 1, or R21=4 or 9,

R37. How is the refrigerator currently being used? (READ LIST)

1	As a main refrigerator	R38
2	As a spare or secondary refrigerator	R38
3	Stored unused/unplugged	R38
88	Refused	R38
99	Don’t know	R38

R38. Is the refrigerator still in good working condition?

1	Yes	R40
2	No	R39
88	Refused	R39
99	Don’t Know	R39

R39. What problems did you have with the refrigerator? (MULTIPLES, DO NOT READ)

1	Broken/Needed Major Repair/Too Expensive to Fix	R40
2	Needed Minor Repair	R40
3	Made Noises	R40
4	Leaked	R40
5	Too expensive to operate	R40

77	Specify	R40
88	Refused	R40
99	Don’t Know	R40

R40. Do you clean the coils on your refrigerator?
(NOTE TO INTERVIEWER: The coils are thin metal tubes typically located on the back of the refrigerator)

1	Yes	R41
2	No	R42
88	Refused	R42
99	Don’t Know	R42

R41. How often do you clean the coils on your refrigerator? (DO NOT READ)

1	Every 6 months	R42
2	Once a year	R42
3	Every few years	R42
4	When they need it	R42
5	Never	R42
88	Refused	R42
99	Don’t Know	R42

R42. Do you check the seals on your refrigerator?
(NOTE TO INTERVIEWER: The seals are located around the doors of the refrigerator)

1	Yes	R43
2	No	R50
88	Refused	R50
99	Don’t Know	R50

R43. How often do you check the seals on your refrigerator? (DO NOT READ)

1	Every 6 months	R50
2	Once a year	R50
3	Every few years	R50
4	When they need it	R50
5	Never	R50
88	Refused	R50
99	Don’t Know	R50

ASK ALL

Now we’d like to ask you a few questions about your old refrigerator which you replaced in [REBATE YEAR] with the rebated refrigerator.

R50. What was the age of the old refrigerator when it was replaced with the rebated refrigerator?
(NOTE TO INTERVIEWERS: if unit not replaced, get current age, or age at the time last seen)

1	Enter Years	R51
2	Did not own one	R70
88	Refused	R51
99	Don’t Know	R51

R51. Was the old refrigerator still in good working condition at the time it was replaced (IF NEEDED: with the rebated refrigerator)?
(NOTE TO INTERVIEWERS: if unit not replaced, get current condition, or condition at the time last seen)

1	Yes	R70
2	No	R52
88	Refused	R70
99	Don't Know	R70

R52. What problems did you have with the old refrigerator (IF NEEDED: that you replaced with the rebated refrigerator)? (MULTIPLES, DO NOT READ)

1	Broken/Needed Major Repair	R70
2	Needed Minor Repair	R70
3	Made Noises	R70
4	Leaked	R70
5	Too expensive to operate	R70
77	Specify	R70
88	Refused	R70
99	Don't Know	R70

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

If R22=1 then skip to R72

R70. To the best of your knowledge has there been any major kitchen remodeling or renovation performed since (REBATE YEAR) at (ADDRESS)?

1	Yes	R71
2	No	R72
88	Refused	R72
99	Don't Know	R72

R71. During what year did that remodeling occur?

R71 Year

1	1995	R72
2	1996	R72
3	1997	R72
4	1998	R72
5	1999	R72
6	2000	R72
7	2001	R72
8	2002	R72
9	2003	R72
12	2004	R72
13	2005	R72
88	Refused	R72
99	Don't Know	R72

R72. What type of residence do you live in?

1	Single Family Detached Home	R73
2	Townhouse (also duet home, duplex)	R73
3	Condo	R73
4	Apartment (also multifamily, multi-unit)	R73
5	Mobile Home	R73

77	Other (specify)	R73
88	Refused	R73
99	Don’t Know	R73

R73. Do you own or rent this residence?

1	Own/buying	R74
2	Rent/lease	R74
77	Other (specify)	R74
88	Refused	R74
99	Don’t Know	R74

R74. How many people are in your household, including yourself?

1	Number of people	R300
88	Refused	R300
99	Don’t Know	R300

R300 Goodbye!

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

1996/1997 PG&E 9th Year Residential Refrigeration Retention Survey
Original Participant Survey – Movers

Variables Needed for CATI:
Name
Rebate Year
Old STREET
Old CITY
CONTROL NUMBER
Brand
Type
Address
Addr_flag
Phone Number(s)

Hello, this is _____, calling from Quantum Consulting on behalf of Pacific Gas & Electric. May I speak with (NAME)? (IF THIS PERSON IS AVAILABLE, PROCEED. IF NOT, 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 THERE IS SOMEONE TO TALK TO, READ: PG&E is conducting research on certain refrigerators purchased through their rebate program, to see if they are still working properly. According to PG&E's records, there may have been a refrigerator purchased by this household in (REBATE YEAR), which may have been installed at a previous address. 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 refrigerators for which they provided rebates to customers.

SC. SCREENER SECTION

SC1. According to PG&E's records, you purchased a refrigerator in (REBATE YEAR), which may have been installed at (OLD STREET, OLD CITY)? Is this correct?

1	Yes	SC2
2	No – Wrong Address	SC1A
3	No – Didn't purchase fridge	T&T
88	Refused	T&T
99	Don't Know	T&T

SC1A. May I have the address where the refrigerator was originally installed?

NOTE TO INTERVIEWER: Are they close enough to proceed – if yes then go to SC4 else T&T

77	Specify	SC2

SC2. Have you moved since you purchased this refrigerator?

1	Yes	SC4
2	No	T&T (User Box Non-Mover)
88	Refused	T&T
99	Don't Know	T&T

If SC2 = 2 then Output User Box 'Non-Mover'

SC4. Was the refrigerator a (BRAND)(TYPE)?

1	Yes	SC6
2	No	SC5
88	Refused	SC5
99	Don't Know	SC5

SC5. Do you recall receiving a rebate from PG&E for that refrigerator?

1	Yes	SC6
2	No	T&T
88	Refused	T&T
989	Don't Know	T&T

IF ADDR_FLAG = 1 then Ask SC6.

SC6. I would like to verify that I have your correct current address. Is it (ADDRESS)?

1	Yes	SC7
2	No	SC6a
88	Refused	T&T
99	Don't Know	T&T

Ask for all

SC6a. For our records, would you mind providing us with your current zip code?

1	Specify Zip	SC7
88	Refused	SC7a
99	Don't Know	*SC7a*

If SC6 = 1 then Ask SC7

SC7. Do you currently receive your electricity service from Pacific Gas and Electric?

1	Yes	SC10
2	No	SC10
88	Refused	SC10
99	Don't Know	SC10

If SC6 = 2 or Addr_flag = 0 then Ask SC7a
SC7a. Do you currently receive your electricity service from Pacific Gas and Electric?

1	Yes	SC10
2	No	SC10
88	Refused	T&T
99	Don't Know	T&T

SC10. What month and year did you move out of your previous address at (OLD STREET)?

SC10 Year

1	1995	SC11
2	1996	SC11
3	1997	SC11
4	1998	SC11
5	1999	SC11
6	2000	SC11
7	2001	SC11
8	2002	SC11
9	2003	SC11
10	2004	SC11
11	2005	SC11
88	Refused	R1
99	Don't Know	R1

SC11 Month

1	January	R1
2	February	R1
3	March	R1
4	April	R1
5	May	R1
6	June	R1
7	July	R1
8	August	R1
9	September	R1
10	October	R1
11	November	R1
12	December	R1
13	Spring	R1
14	Summer	R1
15	Fall	R1
16	Winter	R1
88	Refused	R1
99	Don’t Know	R1

R.REFRIGERATOR REBATE PARTICIPANTS SECTION

I would now like to ask you some questions about the refrigerator purchased in (REBATE YEAR)

R1. Did you move your refrigerator from (OLD STREET) to your current residence?

1	Yes	R2
2	No	R21
88	Refused	T&T
99	Don’t Know	T&T

R2. Do you still have the refrigerator at your current residence?

1	Yes	R37
2	No	R21
88	Refused	T&T
99	Don’t Know	T&T

R21. What happened to the refrigerator? (DO NOT READ LIST)

1	Broke	R23
2	Damaged in fire, earthquake, flood or other disaster	R23
3	Sold it or gave it away	R22
4	Put it at another address I’m responsible for	R23
5	Recycled it	R23
6	Disposed of it / New Fridge Delivery folks took it	R23
7	Still have it	R37
8	Left it at old address	R35
9	Returned it	R23
77	Other (Specify)	R23
88	Refused	T&T
99	Don’t Know	T&T

R22. Why did you sell or give away your refrigerator away?

1	Remodeled Kitchen	R23
2	Needed Larger Unit	R23
3	Didn’t like Unit	R23
4	Had Repair Problems	R23
5	Was Given better Unit	R23
6	Wanted more energy efficient unit	R23
7	Because we were moving	R23
77	Other (Specify)	R23
88	Refused	R23
99	Don’t Know	R23

R23. In what year did this happen?

R23 Year

1	1995	R24
2	1996	R24
3	1997	R24
4	1998	R24
5	1999	R24
6	2000	R24
7	2001	R24
8	2002	R24
9	2003	R24
12	2004	R24
13	2005	R24
88	Refused	R26
99	Don’t Know	R26

R24. And do you recall the month or time of &year ?

R24 Month

1	January	R25
2	February	R25
3	March	R25
4	April	R25
5	May	R25
6	June	R25
7	July	R25
8	August	R25
9	September	R25
10	October	R25
11	November	R25
12	December	R25
13	Spring	R25
14	Summer	R25
15	Fall	R25
16	Winter	R25
88	Refused	R25
99	Don’t Know	R25

IF [(R21 = 3 and R22 = 1, 3, 6) or R21 = 5 or 6] and R23 = 7, 8, 9, 10 or 11 then ask R25, else skip to R26

R25. On a scale of 1 to 5 how influential was the energy crisis of 2001 on your decision to buy a new unit?

1	Extremely Influential	R26
2	Very Influential	R26
3	Somewhat Influential	R26
4	Slightly Influential	R26
5	Not Influential	R26
88	Refused	R26
99	Don't Know	R26

IF R21 = 1 or 9 then ask R26
IF R21 = 2, 5 or 6 then ask R27
Else IF R21 = 3, 4, 8, 77 then skip to R28, Else Skip to R37

R26. Was the unit replaced under warranty?

1	Yes	R29
2	No	R28
88	Refused	R28
99	Don't Know	R28

R27. Was the unit replaced through insurance?

1	Yes	R29
2	No	R28
88	Refused	R28
99	Don't Know	R28

R28. Was the unit replaced?

1	Yes	R29
2	No	R31
88	Refused	R31
99	Don't Know	R31

R29. Was it replaced with a refrigerator of the same efficiency or higher?

1	Lower Efficiency	R30
2	Same Efficiency	R30
3	Higher Efficiency	R30
88	Refused	R30
99	Don't Know	R30

R30. Did you receive a rebate from PG&E for the new refrigerator?

1	Yes	R31
2	No	R31
88	Refused	R31
99	Don't Know	R31

IF R21 =1, 2, 6, 77 then ask R31

R31. How did you dispose of the old refrigerator? Did you… (READ LIST)

1	Recycle it	R35
2	Throw it away	R35
3	Removed by the individuals who delivered the new refrigerator	R35
77	Other (specify)	R35

88	Refused	R35
99	Don’t Know	R35

IF R21 = 3,4,77 then ask R32, Else Skip to R35

R32. To the best of your knowledge, is the new owner or new location of the refrigerator somewhere in central or northern California?

1	Yes	R34
2	No	R33
88	Refused	R35
99	Don’t Know	R35

R33. What state is the refrigerator now in?

1	Specify	R34
88	Refused	R34
99	Don’t Know	R34

R34. What city/area is the refrigerator now in?

1	Specify	R35
88	Refused	R35
99	Don’t Know	R35

IF R21 = 3, 5, 6, 8, 77, Then Ask R35
Else,
IF R21=1 or 2 THEN SKIP TO R40
IF R21=4 or 7 or R2 = 1, THEN SKIP TO R37

R35. Was the refrigerator still in good working condition when you last had it?

1	Yes	R40
2	No	R36
88	Refused	R40
99	Don’t Know	R40

R36. What problems did you have with the refrigerator? (DO NOT READ)

1	Broken/Needed Major Repair/Too Expensive to Fix	R40
2	Needed Minor Repair	R40
3	Made Noises	R40
4	Leaked	R40
5	Too expensive to operate	R40
77	Specify	R40
88	Refused	R40
99	Don’t Know	R40

If R21 = 8 then ask R95 and R96 and then T&T

R95. Did you rent or own the residence where you left your refrigerator?

1	Own/buying	R96
2	Rent/lease	R96
77	Other (specify)	R96
88	Refused	R96
99	Don’t Know	***R96***

R96. Do you rent or own your current residence?

1	Own/buying	R300
2	Rent/lease	R300
77	Other (specify)	R300
88	Refused	R300
99	Don't Know	***R300***

Only ask if R2 = 1, or R21=4 or 7,

R37. How is the refrigerator currently being used? (READ LIST)

1	As a main refrigerator	R38
2	As a spare or secondary refrigerator	R38
3	Stored unused/unplugged	R38
88	Refused	R38
99	Don't know	R38

R38. Is the refrigerator still in good working condition?

1	Yes	R40
2	No	R39
88	Refused	R40
99	Don't Know	R40

R39. What problems did you have with the refrigerator? (DO NOT READ)

1	Broken/Needed Major Repair/Too Expensive to Fix	R40
2	Needed Minor Repair	R40
3	Made Noises	R40
4	Leaked	R40
5	Too expensive to operate	R40
77	Specify	R40
88	Refused	R40
99	Don't Know	R40

R40. Did/Do you clean the coils on your refrigerator?
(NOTE TO INTERVIEWER: The coils are thin metal tubes typically located on the back of the refrigerator)

1	Yes	R41
2	No	R42
88	Refused	R42
99	Don't Know	R42

R41. How often did/do you clean the coils on your refrigerator? (DO NOT READ)

1	Every 6 months	R42
2	Once a year	R42
3	Every few years	R42
4	When they need it	R42
5	Never	R42
88	Refused	R42
99	Don't Know	R42

R42. Did/Do you check the seals on your refrigerator?
(NOTE TO INTERVIEWER: The seals are located around the doors of the refrigerator)

1	Yes	R43
2	No	R50
88	Refused	R50
99	Don't Know	R50

R43. How often did/do you check the seals on your refrigerator? (DO NOT READ)

1	Every 6 months	R50
2	Once a year	R50
3	Every few years	R50
4	When they need it	R50
5	Never	R50
88	Refused	R50
99	Don't Know	R50

ASK ALL

Now we'd like to ask you a few questions about your old refrigerator which you replaced in [REBATE YEAR].

R50. What was the age of the old refrigerator when it was replaced?
(NOTE TO INTERVIEWERS: if unit not replaced, get current age, or age at the time last seen)

1	Enter Years	R51
2	Did not own one	R70
88	Refused	R51
99	Don't Know	R51

R51. Was the old refrigerator still in good working condition at the time it was replaced?
(NOTE TO INTERVIEWERS: if unit not replaced, get current condition, or condition at the time last seen)

1	Yes	R70
2	No	R52
88	Refused	R70
99	Don't Know	R70

R52. What problems did you have with the old refrigerator? (DO NOT READ)

1	Broken/Needed Major Repair	R70
2	Needed Minor Repair	R70
3	Made Noises	R70
4	Leaked	R70
5	Too expensive to operate	R70
77	Specify	R70
88	Refused	R70
99	Don't Know	R70

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

R70. To the best of your knowledge has there been any major kitchen remodeling or renovation performed since (REBATE YEAR) to either this or your previous address? (Note to interviewer: Remodel should have occurred while they lived at current or previous address)

1	Yes	R71
2	No	R72
88	Refused	R72
99	Don’t Know	R72

R71. During what year did that remodeling occur?

R71 Year

1	1995	R72
2	1996	R72
3	1997	R72
4	1998	R72
5	1999	R72
6	2000	R72
7	2001	R72
8	2002	R72
9	2003	R72
10	2004	R72
11	2005	R72
88	Refused	R72
99	Don’t Know	R72

R72. What type of residence do you live in?

1	Single Family Detached Home	R74
2	Townhouse (also duet home, duplex)	R74
3	Condo	R74
4	Apartment (also multifamily, multi-unit)	R74
5	Mobile Home	R74
77	Other (specify)	R74
88	Refused	R74
99	Don’t Know	R74

R74. How many people are in your household, including yourself?

1	Number of people	R75
88	Refused	R75
99	Don’t Know	R75

R75. Do you own or rent your current residence?

1	Own/buying	R76
2	Rent/lease	R76
77	Other (specify)	R76
88	Refused	R76
99	Don’t Know	***R76***

R76. Did you own or rent the residence you were living in at the time when you purchased the rebated refrigerator?

1	Own/buying	R300
2	Rent/lease	R300
77	Other (specify)	R300
88	Refused	R300
99	Don’t Know	***R300***

R300 Goodbye!

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