RETENTION STUDY OF PACIFIC GAS & ELECTRIC COMPANY'S 1994 AND 1995 COMMERCIAL ENERGY EFFICIENCY PROGRAMS

1994-1995 COMMERCIAL LIGHTING & HVAC NINTH YEAR RETENTION

PG&E Study ID numbers:
Lighting: 310R2 & 324R2
HVAC: 312R2 & 326R2

March 1, 2004

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

Disclaimer of Warranties and Limitation of Liabilities

As part of its Customer Energy Management 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.

Furthermore, the results of the study may be applicable only to the unique geographic, meteorological, cultural, and social circumstances existing within PG&E's service area during the time frame of the study. PG&E and its employees expressly disclaim any responsibility or liability for any use of the report or any information, method, process, results or similar item contained in the report for any circumstances other than the unique circumstances existing in PG&E's service area and any other circumstances described within the parameters of the study.

All inquiries should be directed to:

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

NINTH YEAR RETENTION STUDY FOR PG&E'S 1994 & 1995 COMMERCIAL EEI PROGRAM LIGHTING AND HVAC TECHNOLOGIES PG&E STUDY ID #S: LIGHTING: 310R2 & 324R2 HVAC: 312R2 & 326R2

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 HVAC and lighting energy efficiency technologies for which rebates were paid in 1994 and 1995 by Pacific Gas & Electric Company's (PG&E's) Commercial Energy Efficiency Incentive (CEEI) Programs. Retrofits were performed under three different PG&E programs, the Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customize Incentives (CI) Programs.

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 simply calculating the cumulative percentage of equipment that had failed in a given month, and plotting the percentage over time.
3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, a trend line was estimated using standard linear regression techniques. We modeled the trend as a linear and an exponential function.
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 used the resulting survival function to estimate the EUL.
5. ***Develop competing risks models*** for measures in which the distribution of the failures and removals was different. Using the LIFEREG procedure in SAS from step 4 above, separate output was generated for failures and removals for these measures. Then, the best fitting distributions for each event were combined to form one survival function.

This fifth step was only used for the L23 T-8 measure and the L37/L81 HID measures since the remainder of the measures observed only one failure type during the study period or did not have enough data on the distinct failure types to be able to model them separately.

Study Results

The exhibit below presents the final EULs for the studied and like measures. Provided are the ex ante and ex post EULs, the 80 percent confidence intervals for the ex post results, the final EUL used for the filing claim, and the realization rate.

PG&E's 1994 & 1995 Commercial Energy Efficiency Incentives Program
Summary of Ex Post Effective Useful Life Estimates
Lighting and HVAC End Uses

		Measure	EUL		Upper 80% CL	Lower 80% CL	EUL for Claim	Realization Rate
Measure Description	**Year**	**Code**	**Ex Ante**	**Ex Post**	**Ex Post**	**Ex Post**	**-**	**-**
LIGHTING								
T8 Lamps and Electronic Ballasts								
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXT	1994/1995	**L23**	**16**	**16**	**18**	**13**	**16**	**1.0**
FIXTURE: T-8, 1-LAMP, 4 FT FIXTURE	1994/1995	L9	16	-	-	-	16	1.0
FIXTURE: T-8, 2-LAMP, 4 FT FIXTURE	1994/1995	L10	16	-	-	-	16	1.0
FIXTURE: T-8, 3-LAMP, 4 FT FIXTURE	1994/1995	L11	16	-	-	-	16	1.0
FIXTURE: T-8, 4-LAMP, 8 FT FIXTURE	1994/1995	L12	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 2 FT FIXT	1994/1995	L21	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 3 FT FIXT	1994/1995	L22	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 8 FT FIXT	1994/1995	L24	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 1 31-W T-8 U OR 2 17-W T-8	1994/1995	L69	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 2 31-W T-8 U OR 4 17-W T-8	1994/1995	L70	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 3 31-W T-8 U OR 6 17-W T-8	1994/1995	L71	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 1 32-WATT T-8 LAMP	1994/1995	L72	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 2 32-WATT T-8 LAMPS	1994/1995	L73	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 3 32-WATT T-8 LAMPS	1994/1995	L74	16	-	-	-	16	1.0
FIXTURE: 8-FT T-8 W/EL BLST, 2 8-FT T-8 OR 4 32-W, 4-FT T-8	1994/1995	L75	16	-	-	-	16	1.0
FIXTURE: T-8 FIXTURE, 1-LAMP	1994	L117	16	-	-	-	16	1.0
FIXTURE: T-8 FIXTURE, 2-LAMP	1994	L118	16	-	-	-	16	1.0
FIXTURE: T-8 FIXTURE, 4-LAMP	1994	L120	16	-	-	-	16	1.0
FIXTURE: T-8 LAMP/BLST RETROFIT KIT, 1-LAMP	1994	L121	16	-	-	-	16	1.0
FIXTURE: T-8 LAMP/BLST RETROFIT KIT, 2-LAMP	1994	L122	16	-	-	-	16	1.0
FIXTURE: T-8 LAMP/BLST RETROFIT KIT, 3-LAMP	1994	L123	16	-	-	-	16	1.0
FIXTURE: T-8 LAMP/BLST RETROFIT KIT, 4-LAMP	1994	L124	16	-	-	-	16	1.0
FIXTURE: 8-FT T-8 W/EL BLST, 1 8-FT T-8 OR 2 32-W, 4-FT T-8	1995	L160	16	-	-	-	16	1.0
Optical Reflectors w/ Fluorescent Delamp								
FIXTURE: MODIFICATION/LAMP REMOVAL, 4FT LAMP REMOVED	1994/1995	**L19**	**16**	**17**	**22**	**12**	**16**	**1.0**
FIXTURE: MODIFICATION/LAMP REMOVAL, 2 FT LAMP REMOVED	1994/1995	L17	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/LAMP REMOVAL, 3 FT LAMP REMOVED	1994/1995	L18	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/LAMP REMOVAL, 8 FT LAMP REMOVED	1994/1995	L20	16	-	-	-	16	1.0
HIGH OUTPUT: 2 36 W, T-8 OR 2 40-W, T-10 W/ES BLST	1994/1995	L76	16	-	-	-	16	1.0
HIGH OUTPUT: 2 36 W, T-8 OR 2 40 W, T-10 W/ELEC BLST	1994/1995	L77	16	-	-	-	16	1.0
High Intensity Discharge								
HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	1994/1995	**L37**	**16**	**18**	**24**	**13**	**16**	**1.0**
HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	1994/1995	**L81**	**16**	**18**	**24**	**13**	**16**	**1.0**
HID FIXTURE: INTERIOR, 0-100 WATTS LAMP	1994/1995	L25	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, 101-175 WATTS LAMP	1994/1995	L26	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, 176-250 WATTS LAMP	1994/1995	L27	16	-	-	-	16	1.0
HID FIXTURE: COMPACT, 0-35 WATTS LAMP	1994/1995	L78	16	-	-	-	16	1.0
HID FIXTURE: COMPACT, 36-70 WATTS LAMP	1994/1995	L79	16	-	-	-	16	1.0
HID FIXTURE: COMPACT, 71-100 WATTS LAMP	1994/1995	L80	16	-	-	-	16	1.0
HVAC								
Variable Speed Drive HVAC Fan								
ADJUSTABLE SPEED DRIVE: HVAC FAN, 50 HP MAX	1994/1995	**S22**	**16**	**20**	**25**	**14**	**16**	**1.0**
Water Chiller								
WATER CHILLER: >= 300 TONS, WATER-COOLED	1994/1995	**S11**	**20**	**-**	**-**	**-**	**20**	**1.0**
WATER CHILLER: < 150 TONS, WATER-COOLED	1994/1995	S9	20	-	-	-	20	1.0
WATER CHILLER: >= 150 & < 300 TONS, WATER-COOLED	1994/1995	S10	20	-	-	-	20	1.0
WATER CHILLER: < 150 TONS, AIR-COOLED W/CONDENSER	1994/1995	S12	20	-	-	-	20	1.0
WATER CHILLER: >= 150 TONS, AIR-COOLED W/CONDENSER	1994	S13	20	-	-	-	20	1.0
WATER CHILLER: EARLY REPLACEMENT, > 150 TONS	1995	S16	15	-	-	-	15	1.0
Cooling Tower								
COOLING TOWER	1994/1995	**S15**	**20**	**-**	**-**	**-**	**20**	**1.0**
Energy Management System								
INSTALL HVAC EMS	1994/1995	**204**	**14**	**12**	**16**	**9**	**14**	**1.0**

* Studied Measures are in Bold.

Regulatory Waivers

There were no regulatory waivers filed for this study.

NINTH YEAR RETENTION STUDY FOR PG&E'S 1994 & 1995 COMMERCIAL EEI PROGRAM LIGHTING AND HVAC TECHNOLOGIES

PG&E STUDY ID#S: LIGHTING: 310R2 & 324R2
HVAC: 312R2 & 326R2

FINAL REPORT

Prepared for

Rafael Friedmann
Pacific Gas & Electric Co.
245 Market Street
San Francisco, CA 94105

Prepared by

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

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1. EXECUTIVE SUMMARY

This section presents a summary of the ninth year retention study results of Pacific Gas & Electric Company's (PG&E's) Commercial Energy Efficiency Incentive (CEEI) Program for lighting and HVAC technologies. The retention study described in this report covers all HVAC and lighting technologies installed at commercial accounts, as determined by the Marketing Decision Support System (MDSS) sector code, that were included under the RE, REO, and CI programs and for which rebates were *paid* during calendar years 1994 and 1995.

1.1 PROTOCOL REQUIREMENTS

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

The retention study results in ex post effective useful lives for each lighting and HVAC measure, and a comparison of 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: "an estimate of the median number of years that the measures installed under the program are still in place and operable".

Although there are dozens of measures installed under the Lighting and HVAC programs, the Protocols only require a subset of the measures be studied. The Protocols require the utilities to study either "the top ten measures, excluding measures that have been identified as miscellaneous (per Table C-9), ranked by the net resource value or the number of measures that constitutes the first 50% of the estimated resource value, whichever number of measures is less". For consistency, we will refer to the studied measures as the "Top 50% Measures" throughout this report.

The Protocols state that "measures not included in the … retention studies will be divided into two groups: 'like measures' and 'other measures.' Like measures are defined by the Protocols as measures that are believed to be similar to measures included in the retention studies. We have classified all groups of like measures with similar applications, operating conditions, and operating loads.

Exhibit 1-1 presents the list of studied measures and associated like measures covered under this retention study. In addition, Exhibit 1-1 provides the percent of net resource benefit attributable to each studied measure.

[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.

Exhibit 1-1
Mapping of Like Measures

Program and Technology Group	Studied Measures	Percent of Total Net Resource Benefit 1994	1995	Measure Grouping: Like Measures
LIGHTING END USE				
Retrofit Express Program				
T8 Lamps and Electronic Ballasts	L23	21%	27%	L9 - L12, L21, L22, L24, L69 - L75, L117 - L124, L160
Optical Reflectors w/ Fluor. Delamp	L19	19%	15%	L17, L18, L20, L76 - L77
High Intensity Discharge	L37, L81	7%	7%	L25, L78 - L80, L26, L27
HVAC END USE				
Retrofit Express Program				
Adjustable Speed Drive HVAC Fan	S22	1%	1%	N/A
Water Chiller	S11	2%	0%	S9, S10, S12, S13, S16
Cooling Tower	S15	2%	0%	N/A
Customized Incentives Program				
Energy Management System	S204	4%	6%	N/A

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.

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 simply calculating the cumulative percentage of equipment that had failed in a given month, and plotting the percentage over time.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, a trend line was estimated using standard linear regression techniques. We modeled the trend as a linear and an exponential function.

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 used the resulting survival function to estimate the EUL.

5. ***Develop competing risks models*** for measures in which the distribution of the failures and removals was different. Using the LIFEREG procedure in SAS from step 4 above,

separate output was generated for failures and removals for these measures. Then, the best fitting distributions for each event were combined to form one survival function. This fifth step was only used for the L23 T-8 measure and the L37/L81 HID measures since the remainder of the measures observed only one failure type during the study period or did not have enough data on the distinct failure types to be able to model them separately.

1.3 STUDY RESULTS

The recommended results for the L23 T-8 measure (T-8 lamps and electronic ballasts) and the L37/L81 HID measures (high intensity discharge fixtures >=176 and 251-400) are based on the competing risks models. Of the three models created, the best-fit model is the model of choice. This model is based upon the combination of unique distributions for each event type chosen based upon the maximum of the Log-likelihood estimate generated during the LIFEREG procedure in SAS. For the L19 measure (delamping), the S22 measure (adjustable speed drives), and the 204 measure (energy management systems) the recommended results are based on the best fitting LIFEREG procedure results since there were no competing failure types for any of these measures. For the S11 and S15 measures (chillers and cooling towers, respectively) too few failures had occurred (1 for each measure) for reliable models to be built and thus no study results were generated.

Exhibit 1-2 presents the recommended ex post estimates of the EUL. Because each of the analysis techniques did not provide results that were statistically significantly different from the ex ante results, measured at the 80 percent confidence interval, all of the ex post EULs are based on the ex ante estimates. Also presented are the final study results, and the corresponding upper and lower 80 percent confidence interval. Finally, the program realization rates are provided, which are the ratios of the ex ante and ex post estimates. For all measures, the realization rate is one; i.e., the ex post EULs fully corroborates using the ex ante EUL values.

Exhibit 1-2
Final Ex Post EUL Estimates

End Use	Technology	Measure	Ex Ante	Study Results Upper	Study Results Median	Study Results Lower	Ex Post	Realization Rate
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	16	22.3	17.0	11.8	16	100%
	T8 Lamps and Electronic Ballasts	L23	16	18.4	15.5	12.6	16	100%
	High Intensity Discharge	L37&L81	16	23.5	18.2	12.8	16	100%
HVAC	Chiller	S11	20	-	-	-	20	100%
	Cooling Tower	S15	20	-	-	-	20	100%
	ASD	S22	16	25.2	19.5	13.8	16	100%
	EMS	204	14	15.8	12.3	8.9	14	100%

Exhibit 1-3 presents the final EULs for the studied and like measures. Provided are the ex ante and ex post EULs, the 80 percent confidence intervals for the ex post results, the final EUL used for the filing claim, and the realization rate.

Exhibit 1-3
Final EUL Estimates
For Studied and Like Measures

		Measure	EUL		Upper 80% CL	Lower 80% CL	EUL for Claim	Realization Rate
Measure Description	**Year**	**Code**	**Ex Ante**	**Ex Post**	**Ex Post**	**Ex Post**	**-**	**-**
LIGHTING								
T8 Lamps and Electronic Ballasts								
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXT	1994/1995	**L23**	**16**	**16**	**18**	**13**	**16**	**1.0**
FIXTURE: T-8, 1-LAMP, 4 FT FIXTURE	1994/1995	L9	16	-	-	-	16	1.0
FIXTURE: T-8, 2-LAMP, 4 FT FIXTURE	1994/1995	L10	16	-	-	-	16	1.0
FIXTURE: T-8, 3-LAMP, 4 FT FIXTURE	1994/1995	L11	16	-	-	-	16	1.0
FIXTURE: T-8, 4-LAMP, 8 FT FIXTURE	1994/1995	L12	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 2 FT FIXT	1994/1995	L21	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 3 FT FIXT	1994/1995	L22	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 8 FT FIXT	1994/1995	L24	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 1 31-W T-8 U OR 2 17-W T-8	1994/1995	L69	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 2 31-W T-8 U OR 4 17-W T-8	1994/1995	L70	16	-	-	-	16	1.0
FIXTURE: 2 FT T-8 W/EL BLST, 3 31-W T-8 U OR 6 17-W T-8	1994/1995	L71	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 1 32-WATT T-8 LAMP	1994/1995	L72	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 2 32-WATT T-8 LAMPS	1994/1995	L73	16	-	-	-	16	1.0
FIXTURE: 4 FT T-8 W/ELEC BLST, 3 32-WATT T-8 LAMPS	1994/1995	L74	16	-	-	-	16	1.0
FIXTURE: 8-FT T-8 W/EL BLST, 2 8-FT T-8 OR 4 32-W, 4-FT T-8	1994/1995	L75	16	-	-	-	16	1.0
FIXTURE: T-8 FIXTURE, 1-LAMP	1994	L117	16	-	-	-	16	1.0
FIXTURE: T-8 FIXTURE, 2-LAMP	1994	L118	16	-	-	-	16	1.0
FIXTURE: T-8 FIXTURE, 4-LAMP	1994	L120	16	-	-	-	16	1.0
FIXTURE: T-8 LAMP/BLST RETROFIT KIT, 1-LAMP	1994	L121	16	-	-	-	16	1.0
FIXTURE: T-8 LAMP/BLST RETROFIT KIT, 2-LAMP	1994	L122	16	-	-	-	16	1.0
FIXTURE: T-8 LAMP/BLST RETROFIT KIT, 3-LAMP	1994	L123	16	-	-	-	16	1.0
FIXTURE: T-8 LAMP/BLST RETROFIT KIT, 4-LAMP	1994	L124	16	-	-	-	16	1.0
FIXTURE: 8-FT T-8 W/EL BLST, 1 8-FT T-8 OR 2 32-W, 4-FT T-8	1995	L160	16	-	-	-	16	1.0
Optical Reflectors w/ Fluorescent Delamp								
FIXTURE: MODIFICATION/LAMP REMOVAL, 4FT LAMP REMOVED	1994/1995	**L19**	**16**	**17**	**22**	**12**	**16**	**1.0**
FIXTURE: MODIFICATION/LAMP REMOVAL, 2 FT LAMP REMOVED	1994/1995	L17	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/LAMP REMOVAL, 3 FT LAMP REMOVED	1994/1995	L18	16	-	-	-	16	1.0
FIXTURE: MODIFICATION/LAMP REMOVAL, 8 FT LAMP REMOVED	1994/1995	L20	16	-	-	-	16	1.0
HIGH OUTPUT: 2 36 W, T-8 OR 2 40-W, T-10 W/ES BLST	1994/1995	L76	16	-	-	-	16	1.0
HIGH OUTPUT: 2 36 W, T-8 OR 2 40 W, T-10 W/ELEC BLST	1994/1995	L77	16	-	-	-	16	1.0
High Intensity Discharge								
HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	1994/1995	**L37**	**16**	**18**	**24**	**13**	**16**	**1.0**
HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	1994/1995	**L81**	**16**	**18**	**24**	**13**	**16**	**1.0**
HID FIXTURE: INTERIOR, 0-100 WATTS LAMP	1994/1995	L25	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, 101-175 WATTS LAMP	1994/1995	L26	16	-	-	-	16	1.0
HID FIXTURE: INTERIOR, 176-250 WATTS LAMP	1994/1995	L27	16	-	-	-	16	1.0
HID FIXTURE: COMPACT, 0-35 WATTS LAMP	1994/1995	L78	16	-	-	-	16	1.0
HID FIXTURE: COMPACT, 36-70 WATTS LAMP	1994/1995	L79	16	-	-	-	16	1.0
HID FIXTURE: COMPACT, 71-100 WATTS LAMP	1994/1995	L80	16	-	-	-	16	1.0
HVAC								
Variable Speed Drive HVAC Fan								
ADJUSTABLE SPEED DRIVE: HVAC FAN, 50 HP MAX	1994/1995	**S22**	**16**	**20**	**25**	**14**	**16**	**1.0**
Water Chiller								
WATER CHILLER: >= 300 TONS, WATER-COOLED	1994/1995	**S11**	**20**	**-**	**-**	**-**	**20**	**1.0**
WATER CHILLER: < 150 TONS, WATER-COOLED	1994/1995	S9	20	-	-	-	20	1.0
WATER CHILLER: >= 150 & < 300 TONS, WATER-COOLED	1994/1995	S10	20	-	-	-	20	1.0
WATER CHILLER: < 150 TONS, AIR-COOLED W/CONDENSER	1994/1995	S12	20	-	-	-	20	1.0
WATER CHILLER: >= 150 TONS, AIR-COOLED W/CONDENSER	1994	S13	20	-	-	-	20	1.0
WATER CHILLER: EARLY REPLACEMENT, > 150 TONS	1995	S16	15	-	-	-	15	1.0
Cooling Tower								
COOLING TOWER	1994/1995	**S15**	**20**	**-**	**-**	**-**	**20**	**1.0**
Energy Management System								
INSTALL HVAC EMS	1994/1995	**204**	**14**	**12**	**16**	**9**	**14**	**1.0**

* Studied Measures are in Bold.

The remainder of this report will present our analysis methodology and the results from each of the five analysis steps.

2. INTRODUCTION

This report summarizes the retention study of Pacific Gas & Electric Company's (PG&E's) Commercial Energy Efficiency Incentive (CEEI) Program for lighting and HVAC technologies. The evaluation effort includes customers who were paid rebates in 1994 and 1995. Technologies installed under the paid year 1994 and 1995 CEEI Program were covered by three separate program options: the Retrofit Express (RE) Program, the Retrofit Efficiency Options (REO) Program and the Customized Incentives (CI) Program.

2.1 THE RETROFIT EXPRESS PROGRAM

The RE program offered fixed rebates to customers who installed specific electric energy-efficient equipment. The program covered the most common energy saving measures and spans lighting, air conditioning, refrigeration, motors, and food service. Customers were required to submit proof of purchase with these applications in order to receive rebates. The program was marketed to small- and medium-sized commercial, industrial, and agricultural customers. The maximum rebate amount, including all measure types, was $300,000 per account. No minimum amount was required to qualify for a rebate.

Lighting and HVAC end-use rebates were offered in the program for the following technologies:

Lighting Technologies

Halogen lamps

Compact fluorescent lamps

T-12 and T-8 fluorescent lamps

Compact fluorescent lamps and LED's

Electronic ballasts

T-8 and T-10 lamps and electronic ballasts

High-intensity discharge (HID) fixtures

Occupancy sensors, bypass or delay timers, photocells, and time clock controls

Removal of lamps and ballasts

HVAC Technologies

High-efficiency central air-conditioning units in various capacity ranges

Variable speed drive HVAC fans

High-efficiency package terminal air-conditioning units

Programmable thermostats, bypass timers, and electronic timeclocks

Reflective window film

Water chillers of various capacity ranges

Direct evaporative cooler units, evaporative condensers, and evaporative cooler towers

2.2 THE RETROFIT EFFICIENCY OPTIONS PROGRAM

The REO program targeted commercial, industrial, agricultural, and multi-family market segments most likely to benefit from these selected measures. Customers were required to submit calculations for the projected first-year energy savings along with their application prior to installation of the high efficiency equipment. PG&E representatives worked with customers to identify cost-effective improvements, with special emphasis on operational and maintenance measures at the customers' facilities. Marketing efforts were coordinated amongst PG&E's divisions, emphasizing local planning areas with high marginal electric costs to maximize the program's benefits.

The REO program did not include any lighting measures. Nine HVAC technologies, however, were included, which can be summarized into four general technology groups, described below:

Technology

Variable frequency drive supply fans

Installation of high efficiency water chillers

Variable air volume supply systems, which replace constant air volume supply systems

Evaporative cooling towers

2.3 THE CUSTOMIZED INCENTIVES PROGRAM

The Customized Incentives program offered financial incentives to CIA customers who undertook large or complex projects that save gas or electricity. These customers were required to submit calculations for projected first-year energy impacts with their applications prior to installation of the project. The maximum incentive amount for the Customized Incentives program was $500,000 per account, and the minimum qualifying incentive was $2,500 per project. The total incentive payment for kW, kWh, and therm savings was limited to 50 percent of direct project cost for retrofit of existing systems. Since the program also applied to expansion projects, the new systems incentive was limited to 100 percent of the incremental cost to make new processes or added systems energy efficient. Customers were paid 4¢ per kWh and 20¢ per therm for first-year annual energy impacts. A $200 per peak kW incentive for peak demand impacts required that savings be achieved during the hours PG&E experiences high power demand.

Due to significant documentation and analysis involved in Customized Incentives program measures, however, rebates for a number of 1992 and 1993 measures were delayed for payment until 1994 or 1995. This evaluation covers those measures where rebates were paid in 1994 or 1995.

As a result of program design, the measures installed were similar to or the same as those for the RE program, but were installed in larger and more complex projects. The Lighting measures are the same as those described above for the RE program. For HVAC, the following technologies were rebated in 1994 and 1995:

Technology
HVAC variable speed drive
High efficiency chiller
Energy Management Systems (EMS)
Other miscellaneous Customized Incentives HVAC measures, which included:

- Installation of various energy efficient motors
- Installation of various HVAC controls
- Various technologies (i.e., precoolers and economizers) added to increase overall system efficiency

2.4 STUDY REQUIREMENTS

The retention study described in this report covers all HVAC and lighting technologies installed at commercial accounts, as determined by the Marketing Decision Support System (MDSS) sector code, that were included under the RE, REO, and CI programs and for which rebates were *paid* during calendar year 1994 and 1995.

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

The retention study results in ex post effective useful lives for each lighting and HVAC measure, and a comparison of 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.

2.4.1 Studied Measures

Although there are dozens of measures installed under the Lighting and HVAC programs, the Protocols only require a subset of the measures be studied. The Protocols refer to the studied measures as the "Top 10 or Top 50% Measures", which is defined as:

Top 10 or Top 50% Measures – The utility should select the top ten measures, excluding measures that have been identified as miscellaneous (per Table C-9), ranked by the net resource value or the number of measures that constitutes the first 50% of the estimated resource value, whichever number of measures is less.

For the 1994 CEEI Program, the number of measures that constitutes the first 50% of the estimated resource value is five and for the 1995 CEEI Program it is only four. For consistency, we will refer to these measures throughout the report as the "Top 50% Measures."

[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.

For the 1994 and 1995 CEEI Program, HVAC and Lighting comprise the studied end-uses. Among these end-uses, the following measures shown in Exhibit 2-1 are identified as the "Top 50% Measures", as defined above.

Exhibit 2-1
Top 50% Measures for Paid Year 1994 and 1995

Paid Year	MDSS Measure Codes	Measure Description	% of Net Resource Benefit	Cummulative % of Net Resource Benefit
1994	L23	FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXTURE	21.1%	21%
	L19	FIXTURE: MODIFICATION/LAMP REMOVAL, 4 FT LAMP REMOVED	18.9%	40%
	204	INSTALL HVAC EMS	4.1%	44%
	L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	3.7%	48%
	L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	3.5%	51%
1995	L23	FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXTURE	26.7%	27%
	L19	FIXTURE: MODIFICATION/LAMP REMOVAL, 4 FT LAMP REMOVED	15.2%	42%
	L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	7.2%	49%
	204	INSTALL HVAC EMS	6.0%	55%

In addition to studying the measures identified in Exhibit 2-1, PG&E decided to study three additional HVAC measures for program years 1994 and 1995 and one additional Lighting measure for program year 1995. These additional measures along with their net resource benefit are shown in Exhibit 2-2. Adding these measures brings the cumulative net resource benefit up to 56% in 1994 and 57% in 1995.

Exhibit 2-2
Other Studied Measures for Paid Year 1994 and 1995

Paid Year	MDSS Measure Codes	Measure Description	% of Net Resource Benefit	Cummulative % of Net Resource Benefit
1994	S15	COOLING TOWER	2.3%	54%
	S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	1.9%	55%
	S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	0.6%	56%
1995	S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	1.4%	56%
	S15	COOLING TOWER	0.2%	57%
	S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	0.0%	57%
	L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	0.0%	57%

2.4.2 Like Measures

The Protocols state that "measures not included in the … retention studies will be divided into two groups: 'like measures' and 'other measures.' Like measures are defined by the Protocols as:

> **Like Measures** – measures that are believed to be similar to measures included in the retention studies.

We have classified all groups of like measures with similar applications, operating conditions, and operating loads. Exhibit 2-3 presents the mapping of studied measures to like measures.

Exhibit 2-3
Mapping of Like Measures

Program and Technology Group	Studied Measures	Percent of Total Net Resource Benefit 1994	Percent of Total Net Resource Benefit 1995	Measure Grouping Like Measures
LIGHTING END USE				
Retrofit Express Program				
T8 Lamps and Electronic Ballasts	L23	21%	27%	L9 - L12, L21, L22, L24, L69 - L75, L117 - L124, L160
Optical Reflectors w/ Fluor. Delamp	L19	19%	15%	L17, L18, L20, L76 - L77
High Intensity Discharge	L37, L81	7%	7%	L25, L78 - L80, L26, L27
HVAC END USE				
Retrofit Express Program				
Adjustable Speed Drive HVAC Fan	S22	1%	1%	N/A
Water Chiller	S11	2%	0%	S9, S10, S12, S13, S16
Cooling Tower	S15	2%	0%	N/A
Customized Incentives Program				
Energy Management System	204	4%	6%	N/A

The Protocols require that "like measures adopt the same percent adjustment [or realization rate] for the measure effective useful lives of the similar studied measures . . . to adjust their ex ante measure effective useful lives."

Other measures are defined as:

> **Other Measures** – measures that are different from the measures included in the retention study.

Therefore, other measures consist of all HVAC and Lighting measures that are not classified as either studied or like measures. The Protocols require that, for other measures, the ex ante estimate of the effective useful life will be adjusted by the average percentage adjustment [or realization rate] of all the studied measures within that end use."

2.4.3 Combining Program Years

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

Because the Top 50% Measures for the 1995 Program Year are a subset of the 1994 Top 50% Measures, the Protocol's suggestion to combine the two studies will greatly enhance the accuracy of the retention study, without incurring additional cost.

2.4.4 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."

2.4.5 Objectives

The research objectives are therefore as follows:

- Collect data on the fraction of the measures that are in place and operable, for all studied measures.
- For each studied measure, calculate the ex post EUL, and the realization rates from ex ante to ex post.
- For each like measure, calculate the ex post EUL, based on a transferred realization rate from the studied measures.
- For each remaining HVAC and lighting measure, calculate the ex post EUL, based on the average realization rate from all studied and like measures.
- Complete tables 6 and 7 of the Protocols.

2.5 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 for each of the studied measures. 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. It is this distribution that we used in our analysis. 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 for each of our studied measures.

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

There is much literature to suggest, for example, that electronic ballast failures follow an exponential distribution. The exponential survival function has a constant hazard rate. In other words, the rate at which electronic ballasts fail is constant over time. This belief is founded on the fact that electronic devices are likely to fail at any point in time with equal probability. Because electronic ballasts may have anywhere from 30 to 120 parts, plus more than twice as many solder joints as there are parts, it is likely that the ballast may also fail at any point in time, with equal probability.[4]

However, the removal of an electronic ballast is more dependent on human interaction. For example, consider the act of remodeling, or upgrading the system as new technologies emerge. Both of these actions are likely to occur in the latter stage of the equipment's life. However, if the customer is not satisfied with the technology, the removal may occur early on in the equipment's life. Whatever the case may be, it is likely that the survival function of equipment removal differs from the survival function of the equipment failure.

These reasons have led us to develop a competing risks model that accounts for varying distributions for each event type. The LIFEREG procedure in SAS is used to generate output for each unique event type (failures and removals). This output is then used to generate a competing risks model that produces a survival function that is comprised of the best fitting distribution for each event type.

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

[4] Energy User News, Vol. 23 No. 10, October 1998. Electronics, Energy Products and Life-Cycle Costing, pp. 28.

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. For the S11 Chiller and S15 Cooling Tower measures, it was sufficient to only look at the raw data, because all but one of the sampled equipment was still in place and operable for each measure.

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 emerges.

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 modeled 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 competing risks models*** for measures in which the distribution of the failures and removals was different. Using the LIFEREG procedure in SAS from step 4 above, separate output was generated for failures and removals for these measures. Then, the best fitting distributions for each event were combined to form one survival function. This fifth step was only used for the L23 T-8 measure and the L37/L81 HID measures since the remainder of the measures observed only one failure type during the study period or did not have enough data on the distinct failure types to be able to model them separately.

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

2.6 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 and finally *Attachment 2* provides copies of the Lighting and HVAC retention audit instruments.

3. METHODOLOGY

This section provides the specifics surrounding the methods used to conduct the Retention Study for the 1994 and 1995 Pacific Gas & Electric Company (PG&E) Commercial Energy Efficiency Incentive (CEEI) Programs. It begins with 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 SAMPLE DESIGN

3.1.1 Existing Data Sources

PG&E's 1994 and 1995 first year CEEI program impact evaluations established "retention panels" of approximately 350 sites in 1994 and 250 sites in 1995 for the Lighting and HVAC end uses. At each of these sites the rebated equipment was documented by make, model, and location. The total combined data collection effort resulted in a panel of over 300 Lighting, and over 350 HVAC sites. As part of the fourth year retention study, 304 of these customers were contacted, and retention data was collected either over the phone or on-site. During the fourth year retention study for the 1996 and 1997 program years, additional retention data was collected on 1994 and 1995 participants in anticipation of aiding this ninth year study.

Altogether, retention data had been collected on a total of 455 1994 and 1995 sites that had installed at least one of the studied measures. Because many of the customers in the original retention panels did not install studied measures, the sample frame of customers being studied was opened to all 1994 and 1995 participants to increase the robustness of the analysis.

Exhibit 3-1 provides the available sample frame for each studied measure, along with the number of sites that have existing retention data.

Exhibit 3-1
Available Sample Frame and Sites with Existing Retention Data by Studied Measure

Measure Code	Measure Description	Participant Population (1994/95 MDSS)	Total Sites Previously Contacted
L19	FIXTURE: MODIFICATION/LAMP REMOVAL, 4 FT LAMP REMOVED	2,100	71
L23	FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXTURE	4,290	156
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	490	76
L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	188	44
S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	14	12
S15	COOLING TOWER	45	38
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	115	22
S204	INSTALL HVAC EMS	108	36
TOTAL		7,350	455

3.1.2 Sample Design Overview

For this retention study, an attempt was made to recontact all 455 sites previously contacted. Furthermore, this sample frame was supplemented with the entire lighting and HVAC population of sites with studied measures.

The objective of the sample design was to collect retention data on as many of the HVAC measures as possible, as they had a limited sample frame. A goal was set of having retention data on 50 sites for each measure, including previously collected retention data if a site could not be recontacted. For some measures, this goal was clearly unachievable due to the limited sample frame.

Similarly for the L37 measure, which had a limited sample frame, a goal was set of obtaining retention data on 50 sites.

For the L81 measure, a goal of 150 sites was set, which would be more than sufficient to obtain a statistically significant result, and is approximately 30% of the available sample frame, and thus achievable from a data collection standpoint.

For the remaining L19 and L23 measures, which have large sample frames, a goal of 300 was set. This was felt to be more than sufficient to obtain a statistically significant result.

3.1.3 Final Distribution

For the most part, these sampling goals were achieved. Because there is some overlap in measures being installed at the same site, particularly with the L23 and L19, some measures exceeded their sample goal. Exhibit 3-2 below provides the final sample disposition, which includes the number of sites with available retention data used for this study.

Exhibit 3-2
Final Sample Disposition

Measure Code	Measure Description	Participant Population (1994/95 MDSS)	Total Sites Previously Contacted	Total Sites Contacted with Retention Data
L19	FIXTURE: MODIFICATION/LAMP REMOVAL, 4 FT LAMP REMOVED	2,100	71	295
L23	FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXTURE	4,290	156	349
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	490	76	176
L37	HID FIXTURE: INTERIOR, >= 176 WATTS LAMP	188	44	57
S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	14	12	12
S15	COOLING TOWER	45	38	45
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	115	22	43
S204	INSTALL HVAC EMS	108	36	54
TOTAL		7,350	455	1,031

3.1.4 Data Collection Strategy

The data collection effort surrounding the survival analysis included a combination of telephone and on-site surveys. When possible, these data were gathered using telephone surveys, with alternate data collection using on-site audits where installations were too complex to be supported by self-reported data. In general, on-sites were required for many of the lighting end use installations, while HVAC equipment survival was more readily verified using the telephone interview only. The following outlines the data collection procedures.

An auditor contacted each site by telephone to assess whether an on-site audit was necessary, or if a telephone survey would suffice. If the auditor determined that the information could be obtained over the telephone, the auditor conducted the telephone survey immediately, or at the customer's earliest convenience. If an on-site audit was deemed necessary, and the participant was willing, an appointment was scheduled and an auditor visited the site.

Equipment survival data were collected by the auditor, who prompted each site contact to locate the retention technologies using information available from the retention panels (when available). At that time, information was recorded regarding the success or failure in locating the panel-specified equipment.

For each unit of equipment in the retention panel, it was determined whether (1) the equipment was still installed, and (2) if it was operable. If the equipment was not in place or was not operable, it was determined when it was removed or stopped operating according to the owner or operators best recollection. Reasons for removal or failure to operate were also collected. If equipment was replaced, it was determined if the equipment was replaced with a standard, equivalent or higher efficiency technology. Finally, it was determined if replaced equipment was done so under warranty.

3.2 ANALYSIS OVERVIEW

As discussed in Section 2.4, the purpose of a retention study is to collect data on the fraction of measures in place and operable in order to produce a revised estimate of its 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 each of the studied measures.

Before attempting to estimate a survival function for a given measure, we first evaluated the data collected to see if there was enough data to support an estimate. For this step, for each studied measure, we compiled summary statistics on the raw retention data, and visually inspected the empirical survival function that we observed over the first eight to nine years.

Next we used the empirical survival function to forecast the survival function using basic linear regression techniques. We analyzed both a linear trend, as well as an exponential trend (which is one of the most common forms of a survival function).

Next, we used classical survival analysis techniques to develop a survival function. This analysis was performed using the SAS System and the SAS companion guide, "Survival Analysis Using the SAS System." As part of this step, we attempted to model the survival function using five of the most commonly used survival distributions: exponential, logistic, lognormal, Weibull and gamma.

Finally, we constructed Competing Risks models for measures in which the distribution of the failures and removals was different. This technique allows us to create a single optimal model in situations where failures are most appropriately modeled using one distribution, while removals are better represented by another distribution. Three different competing risks scenarios were developed for each measure: a best-fit model that matched the best fitting distributions (based on the Log-likelihood estimator in SAS), a minimum EUL model, and a maximum EUL model. Statistical methods are employed to determine which distribution best fits the data.

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.
3. ***Develop a trend line*** from the survival plots.
4. ***Develop a survival function*** using classical survival techniques.
5. ***Develop competing risks models*** that model each event with a different distribution.

The details surrounding each of these methods are provided below.

3.3 SUMMARY STATISTICS

As discussed above, the first step of our analysis was to compile summary statistics on the sample retention data. For each measure in our sample, these statistics include:

- the number of units installed at the site;
- the number of units still operable and in place;
- 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.

The California DSM Measurement Advisory Committee (CADMAC) subcommittee on persistence has agreed that failed equipment that is replaced under warranty should be counted as if it is still operable and in place. Exhibit 3-3 summarizes this data at the measure level.

Exhibit 3-3
Summary Statistics on Retention Sample Data

End Use	Technology	Measure	# of Sites Contacted	Units	Total Number of Units	Number of Units that Failed or were Removed	Number of Units in Place and Operable	Percent Failed or Removed
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	295	Lamps	45,376	2251	43,125	4.96%
	T8 Lamps and Electronic Ballasts	L23	349	Ballasts	47,722	7081	40,641	14.84%
	High Intensity Discharge (>=176)	L37	57	Fixtures	863	77	786	8.92%
	High Intensity Discharge (251-400)	L81	176	Fixtures	3,378	320	3,058	9.47%
HVAC	ASD	S22	43	Drives	104	10	94	9.62%
	Chiller	S11	12	Chillers	15	1	14	6.67%
	Cooling Tower	S15	45	Towers	48	1	47	2.08%
	EMS	204	54	Systems	57	16	41	28.07%

Exhibit 3-3 clearly demonstrates that for the S11 Chiller and S15 Cooling Tower measures, it will be difficult to develop a survival function or an ex post EUL estimate. Both of these measures exhibited only one failure or removal in the sample. With such limited data on failures, a reliable survival function cannot be developed nor can an ex post EUL estimate. Because of this, no further analysis was conducted on the S11 Chiller and S15 Cooling Tower measures. The ex ante estimate was assumed for the ex post estimate of the EUL for these two measures.

Even though the S11 Chiller measure did exhibit a 6.67 percent failure/removal rate, this is based on a sample of only one failure/removal in 15. Similarly, the S15 Cooling Tower measure exhibited a 2.08 percent failure/removal rate, which was based on a sample of only one failure/removal in 48. Even if we were to assume a constant rate of failure/removal over a nine year period (a conservative estimate of the number of years of data collection), we would still obtain an ex post estimate that greatly exceed the ex ante, which is usually 20 years for both S11 Chiller measures and S15 Cooling Tower measures.

For the other six measures (L23 T8, L37 HID >=176W, L81 HID 251-400W, L19 Delamping, S22 ASD, and 204 EMS), we had enough data on failures to proceed to the next analysis step.

If we make the assumption that the failure/removal rates provided in Exhibit 3-3 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 nine year period, we can estimate the median EUL. Section 4 provides the results of estimating the EULs based on these assumptions for the data collected in the 2003 survey (limiting our data to the 2003 survey data allows us to meet the assumption that all failures/removals are equally distributed over a nine year period).

It is important to note that during some of the follow-up surveys (which were done either on-site or over the phone by an experienced auditor), it was not always possible to identify the exact equipment that was included in the retention panel. In some cases we were unable to identify the exact amount of equipment at the facility, which sometimes lead to larger or smaller estimates of equipment in place and in operation.

Because we obtained counts of the number of units that had failed or been removed, we could verify the unit counts in the retention panel. This was done by adding the number of units found to be in place and operable, to the number of units that had failed or been removed. In the cases where the number of verified units was smaller than the number of units in the retention panel, we conducted our analysis on only the number that we verified during the survey.

3.4 VISUAL INSPECTION

For this step, we developed an empirical survival function that was observed from the raw retention data over the first nine years of the measures' lives. As discussed above, this task was conducted for all measures, regardless of the amount of failures or removals in the sample data.

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 has occurred during a known interval. If no event has occurred, the interval is assumed to be right-hand censored.

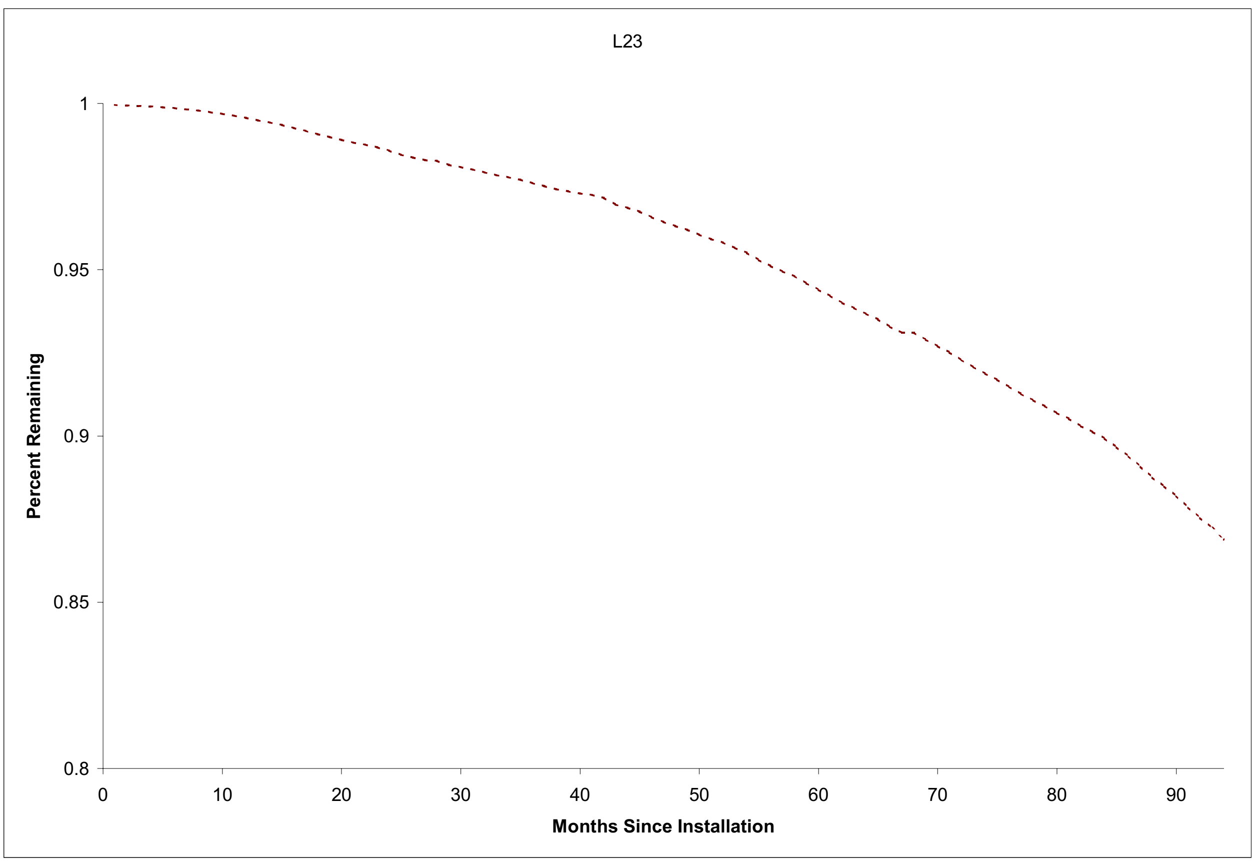
The SAS procedures that are discussed below in Section 3.6 are capable of handling right-hand censored data and in some cases left-hand and interval censored data. But for this more simplistic task, some assumptions were required.

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

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

Exhibit 3-4 provides an example of a derived empirical survival function the L23 T8 measure, over the first eight years of the measure's life:

Exhibit 3-4
Final Empirical Survival Function
for all Studied Lighting Measures



3.5 TREND LINES

Based on the empirical survival functions presented above, a trend line was developed to estimate the survival function over the life of the measure, and estimate the measure's EUL. Only the first 100 months of the empirical survival functions were used, as retention data were only gathered over the first eight to nine years of the measures' life. This was done for all of the Lighting and HVAC measures although the validity of the models for the S11 Chiller and S15 Cooling Tower technologies is questionable since both measures only reported one failure during the study period.

Two trend lines and corresponding EULs were estimated using linear regression as follows:

- 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. For a linear survival function, the EUL (median life) is calculated as:

  EUL = (0.5 – intercept)/slope

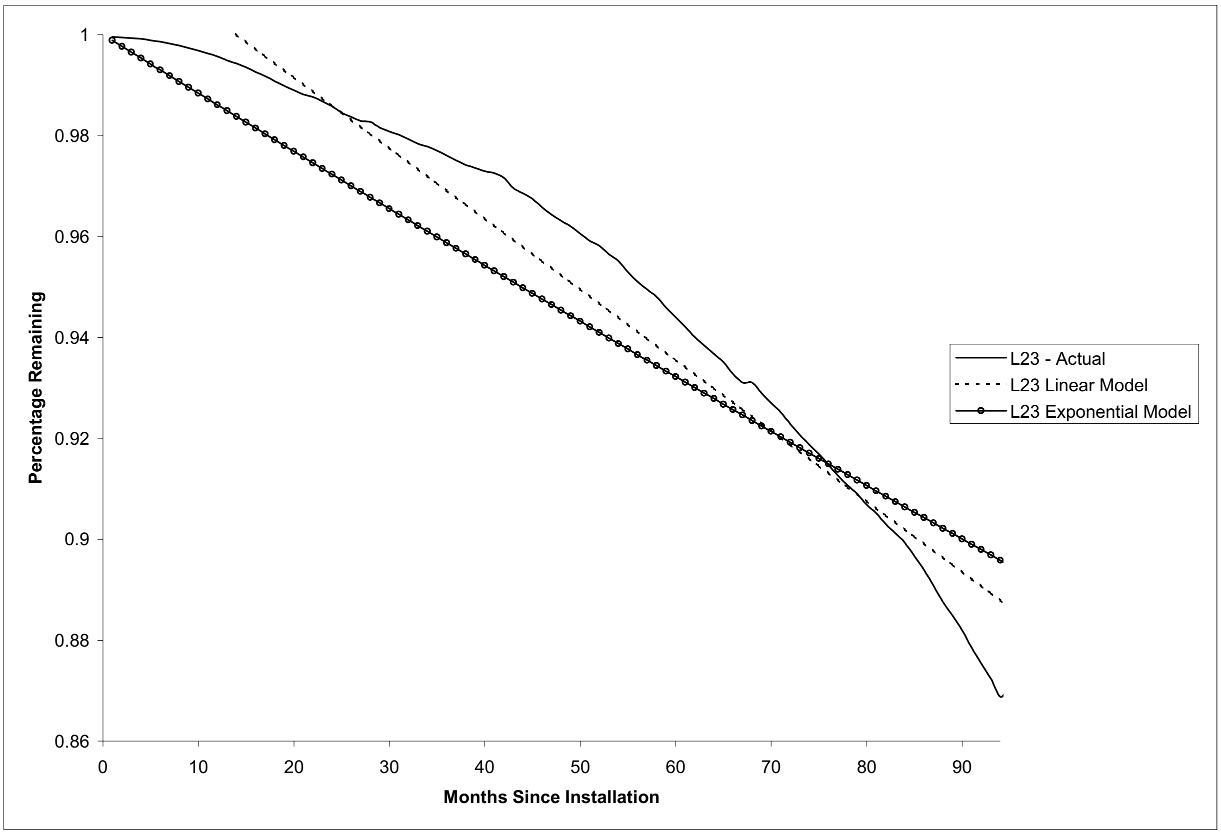
- The second trend line was assumed to follow the exponential distribution, which is one of the most common distributions used in survival analysis. The trend line was also used with linear regression by making a transformation on the percentage of equipment operable and in place. The natural log of the percentage of equipment operable and in place was used as the dependent variable, and the month as the independent variable. Although the exponential distribution is appropriate for many survival functions, we have doubts about the applicability of the exponential distribution to this data due to the very small hazard rate. Because the exponential distribution asymptotically approaches zero, and the fact that the initially low hazard rates will remain constant, this distribution produces some very large EUL estimates. For an exponential survival function, the EUL (median life) is calculated as:

  EUL = ln(2)/slope

For this and all further analyses steps discussed, the L37 and L81 HID measures were combined to allow for a more robust model to be built due to the increased number of data points available for modeling. The protocols also allow for grouping of "like measure", for this reason of increased reliability. It was also found from the analyses steps above, that these two HID measures exhibited similar empirical survival functions, and had similar summary statistics.

Exhibit 3-5 provides an example for the L23 (T8 lamp replacing T12) measure, comparing the linear and exponential survival functions with the empirical function developed above, for the first eight years of the measure's life. This exhibit illustrates how the two trend lines compare to the empirical function during the earlier parts of the measure's life.

Exhibit 3-5
Comparison of Empirical Survival Function and Linear Trendline
L23 T8 Measure



The resulting EULs based on the linear and exponential survival function developed are presented in Section 4.

It is important to note that 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 many technologies. 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.

3.6 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 in 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 L23 T8 Fixtures, L19 Delamping, L37/L81 HID (>=176W/251-400W), S22 ASD and 204 EMS measures.

Exhibit 3-6 provides an example for the L23 T8 measure, comparing the empirical survival function over the first 8 years of the measure's life, to the estimated survival functions based on the exponential, logistic, lognormal and Weibull distributions, using the LIFEREG procedure. For the L23 T8 measure, the survival model based on the gamma distribution would not converge and thus it was dropped from the analysis.

Exhibit 3-6
Comparison of Survival Functions
Exponential, Logistic, Lognormal, and Weibull versus Empirical Function
L23 T8 Measure

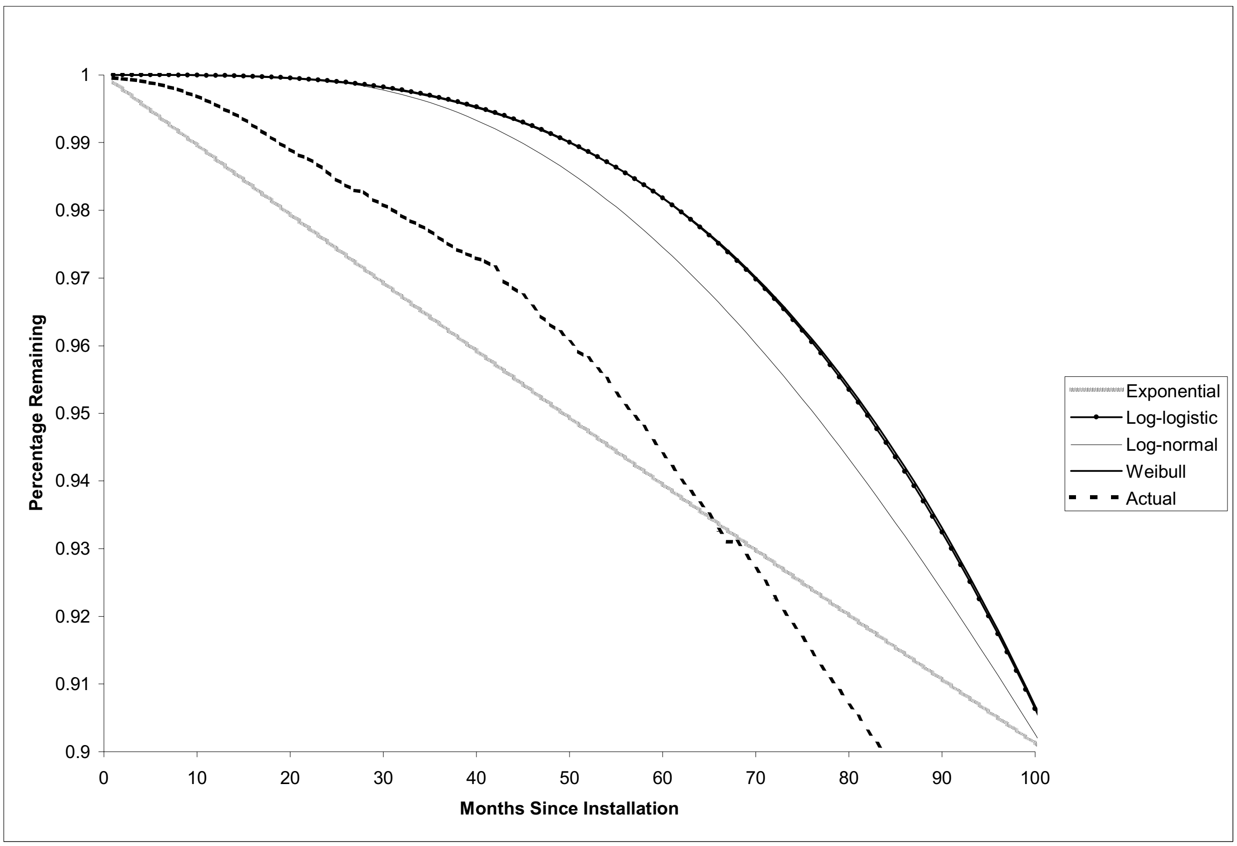
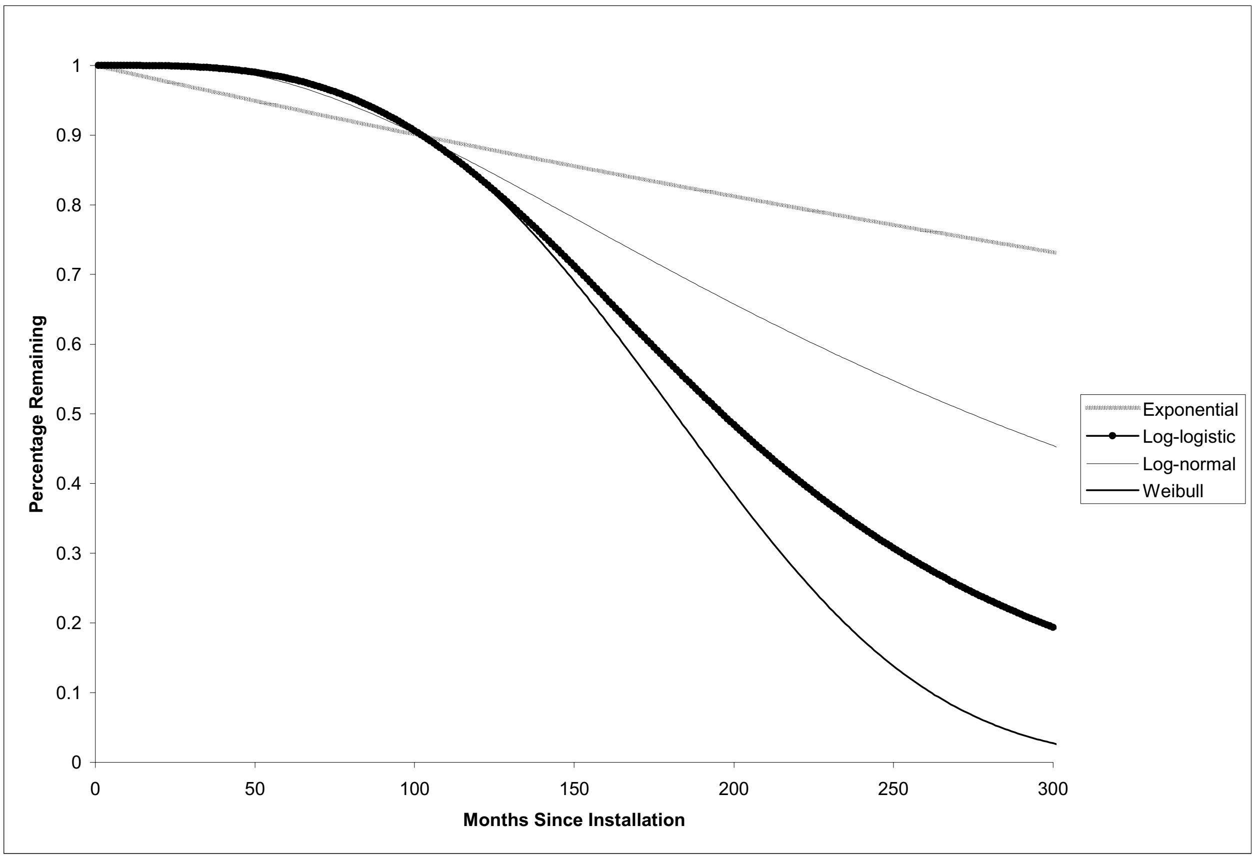


Exhibit 3-7 provides forecasts generated by these four survival functions over the first 300 months of the measures life for the L23 T8 measure.

Exhibit 3-7
Exponential, Logistic, Lognormal, and Weibull Survival Functions
Based on LIFEREG Procedure
L23 T8 Measure



Section 4 summarizes all of the results of the LIFEREG models.

It should be noted that the standard errors developed by the LIFEREG model, that were directly output by SAS were adjusted to account for intra-site correlation issues, because the failure and removal rates associated with measures installed at the same site are correlated. For example, when a removal occurs, it is likely that many measures are removed at once. To a lesser extent, failures are correlated since they may all come from the same manufacturing lot, they are all likely to be installed under the same circumstances, and they are also used in a similar manner. Attachment 1, Protocol Table 7B, discusses the development of standard errors in more detail.

3.7 COMPETING RISKS MODELS

The final analysis step, as described in Section 3.2 above, was to develop competing risks models to account for multiple events influencing the survival distribution. The first task in developing competing risks models was to calculate hazard functions for all events individually. 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 output were generated from this model. The first output contains the best-fitting distribution for each event based on the log-likelihood estimate, which is a parameter output by SAS used to judge how well the model fits the actual data. The second output provides the minimum EUL estimate, and the third output provides the maximum EUL estimate. A summary of the different distributions that were chosen for each of the models is presented in Exhibit 3-8. The L19 Delamping measure only experienced one event type during this study, excluding it from the competing risks models. The S22 ASD and 204 EMS measures were also excluded from the competing risks analysis since they had too few different event types to make the distribution of failures versus removals distinct. As a result the competing risks analysis was performed only on the L23 T8 and L37/L81 HID measures.

Exhibit 3-8
Comparison of Distributions used in the Competing Risks Model

		Distribution	
Measure	**Method**	**Failures**	**Removals**
L23 T8	Best Fit	Log Logistic	Weibull
	Min EUL	Weibull	Weibull
	Max EUL	Exponential	Exponential
L37 and L81 HID	Best Fit	Log Logistic	Weibull
	Min EUL	Gamma	Gamma
	Max EUL	Exponential	Log-Normal

The resulting survival functions for the L23 T8 measure are provided in Exhibit 3-9. For the best-fitting model, the Log Logistic distribution was selected for failures and the Weibull distribution was selected for removals.

Exhibit 3-9
Resulting Survival Functions from the Competing Risks Model
L23 T8 Measure

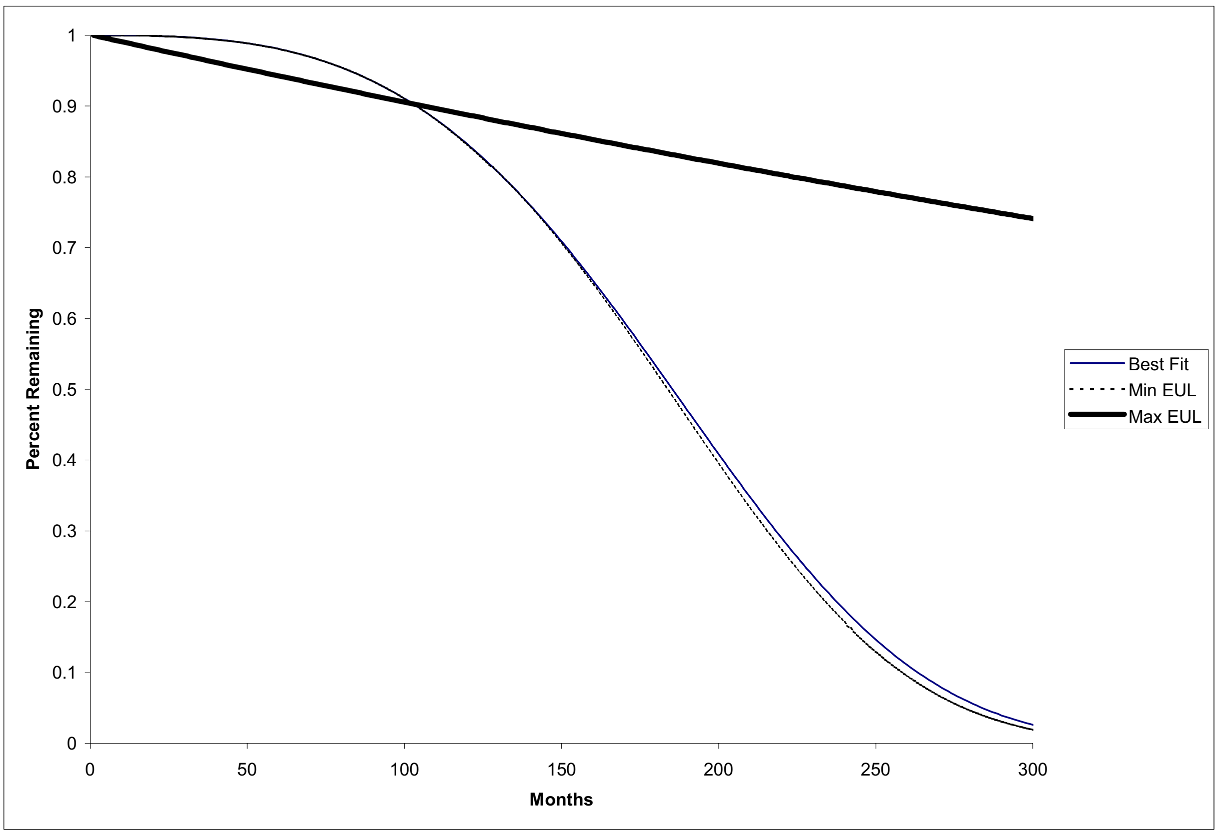


Exhibit 3-10 presents the results from the competing risks models in tabular format for the L23 T8 measure. For each case, the competing risks model EUL prediction is given along with its associated standard error. The properties for the event distributions (from the LIFEREG procedure in SAS) used to construct each competing risks model are also provided.

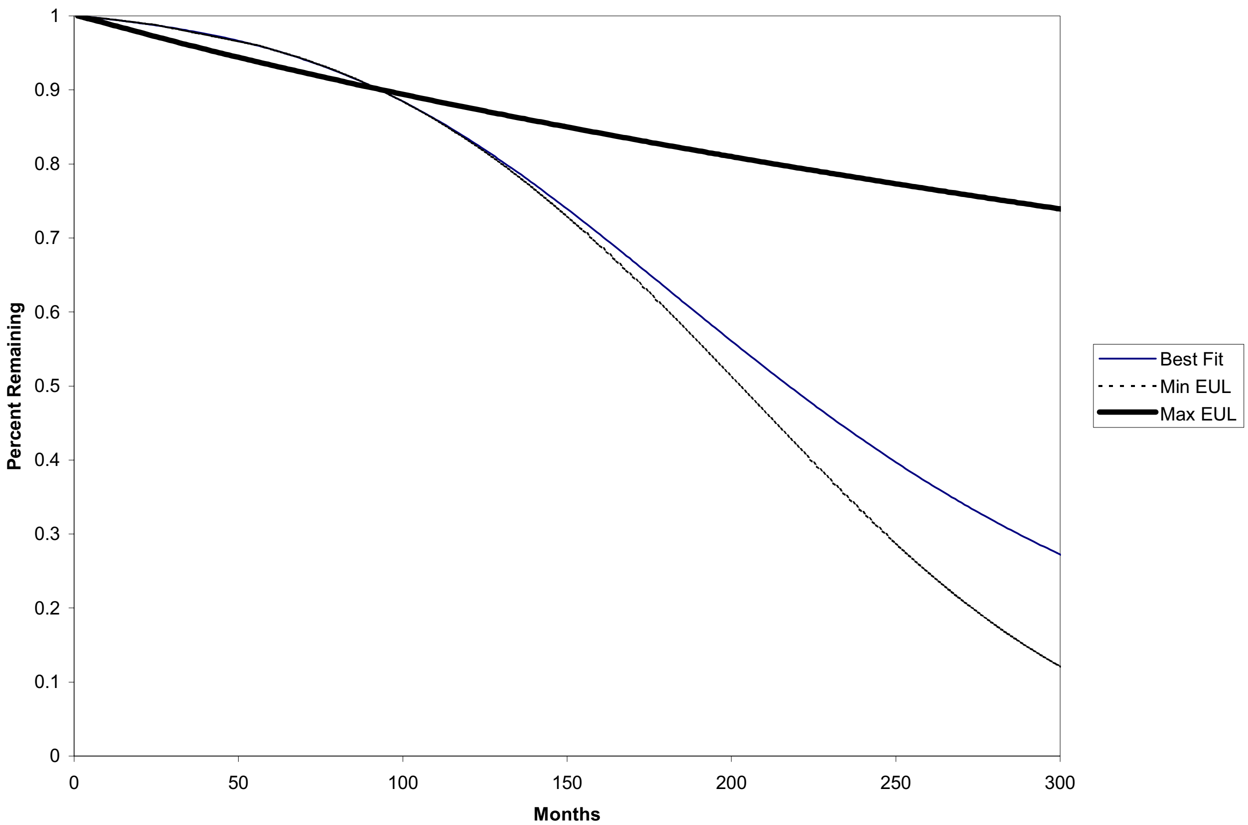
Exhibit 3-10
Results from Competing Risks Models
L23 T8 Measure

Measure	Method	Model			Variable Intercept	Variable Scale	Resulting EUL
L23	Best Fit	Combined		Parameter Estimate	-	-	**15.5**
				Standard Error	-	-	2.25
		Failures	Log Logistic	Parameter Estimate	5.67	0.38	**23.4**
				Standard Error	0.03	0.01	5.45
		Removals	Weibull	Parameter Estimate	5.44	0.25	**17.6**
				Standard Error	0.02	0.01	2.85
L23	Min EUL	Combined		Parameter Estimate	-	-	**15.3**
				Standard Error	-	-	2.26
		Failures	Weibull	Parameter Estimate	5.67	0.38	**21.1**
				Standard Error	0.03	0.01	4.41
		Removals	Weibull	Parameter Estimate	5.44	0.25	**17.6**
				Standard Error	0.02	0.01	2.85
L23	Max EUL	Combined		Parameter Estimate	-	-	**57.8**
				Standard Error	-	-	7.31
		Failures	Exponential	Parameter Estimate	7.41	1.0000	**95.6**
				Standard Error	0.02	0.0000	15.7
		Removals	Exponential	Parameter Estimate	7.83	1.00	**145.4**
				Standard Error	0.02	0.00	28.7

As the exhibit shows, there is a wide variation in the EUL from the minimum to the maximum. The actual range is 15.3 years for the minimum EUL and 57.8 years for the maximum EUL, with the best fit being very close to the minimum EUL with an EUL of 15.5 years.

Exhibit 3-11 provides the competing risks results for the L37/L81 HID measures. Again, for the best-fitting model, the Log Logistic distribution was selected for failures and the Weibull distribution was selected for removals.

Exhibit 3-11
Resulting Survival Functions from the Competing Risks Model
L37/L81 HID Measure



The detailed results from the competing risks models for the L81 HID measure are presented in Exhibit 3-12. Again, the competing risks model EUL prediction is provided along with the underlying assumptions.

Exhibit 3-12
Results from Competing Risks Models
L37/L81 HID Measure

Measure	Method	Model			Variable: Intercept	Variable: Scale	Resulting EUL
L37 & L81	Best Fit	Combined		Parameter Estimate	-	-	**18.2**
				Standard Error	-	-	4.19
		Failures	Log Logistic	Parameter Estimate	5.48	0.32	**20.0**
				Standard Error	0.07	0.02	4.4
		Removals	Weibull	Parameter Estimate	7.11	0.88	**74.0**
				Standard Error	0.22	0.70	44.4
L37 & L81	Min EUL	Combined		Parameter Estimate	-	-	**16.8**
				Standard Error	-	-	16.4
		Failures	Gamma	Parameter Estimate	5.50	0.32	**18.1**
				Standard Error	0.02	0.00	1.3
		Removals	Gamma	Parameter Estimate	6.95	0.39	**58.0**
				Standard Error	1.43	0.00	11.26
L37 & L81	Max EUL	Combined		Parameter Estimate	-	-	**65.0**
				Standard Error	-	-	25.5
		Failures	Exponential	Parameter Estimate	7.48	1.00	**101.9**
				Standard Error	0.07	0.00	23.0
		Removals	Log-Normal	Parameter Estimate	8.52	2.44	**418.7**
				Standard Error	0.31	0.17	**404.1**

Section 4 provides the recommended results by studied measure, and presents all of the results developed from the analysis steps discussed in this section.

4. RESULTS

This section presents the final results of the 1994 and 1995 CEEI Retention Study. As discussed in detail in Section 3, the 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.

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

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

5. ***Develop competing risks models*** that incorporate different distributions for failures and removals.

4.1 COMPILE SUMMARY STATISTICS

Exhibit 4-1 presents the percentage of measures that were found to have failed or been removed over the study period. As discussed in Section 3 an EUL was estimated was based on this percentage, assuming a constant failure rate over the life of the measure.

Exhibit 4-1
Summary Statistics on Raw Retention Data

End Use	Technology	Measure	Percent Failed, Removed, Replaced	Annualized Failure, Removal, Replacement Rate^	Mean Life*	Median Life*	Ex Ante EUL
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	5.72%	0.64%	157	109	16
	T8 Lamps and Electronic Ballasts	L23	17.69%	1.97%	51	35	16
	High Intensity Discharge (>=176)	L37	13.26%	1.47%	68	47	16
	High Intensity Discharge (251-400)	L81	13.72%	1.52%	66	45	16
HVAC	ASD	S22	7.46%	0.83%	121	84	16
	Chiller	S11	0.00%	0.00%	-	-	20
	Cooling Tower	S15	2.94%	0.33%	306	212	20
	EMS	204	38.10%	4.23%	24	16	14

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

Exhibit 4-1 clearly demonstrates that for the S11 Chiller and S15 Cooling Tower measures, it will be difficult to develop a survival function or an ex post EUL estimate, since only a few events occurred during the study period. With such limited data on failures, a reliable survival function cannot be developed nor can an ex post EUL estimate.

4.2 VISUAL INSPECTION

Using the raw retention data, we developed empirical distributions of the survival function for each of the studied measures. As discussed in Section 3, these empirical functions were used primarily as the basis for developing EULs based on linear regression. These EULs are presented in Section 4.3 below.

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 4-2 for the four Lighting measures and four HVAC measures. Also provided in Exhibit 4-2 is the estimated EUL for each measure. 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 16 years for all lighting and the S22 ASD measure, 20 years for the S11 Chiller and S15 Cooling Tower, and 14 years for the 204 EMS measure) for all except the 204 EMS measure. The linear and exponential trendlines for the 204 EMS measure estimate EULs of 10 and 12 years respectively. However, because one customer (a local school district) reported 13 of the 15 removals, these "failures" are highly correlated. The results for the remaining measures would all easily reject the ex ante estimate at the 80 percent confidence level.

Exhibit 4-2
Regression Results of Linear and Exponential Trendlines
and Resulting Ex Post EUL Estimates

Measure	Measure Description	Intercept	t-Statistic	Slope	t-Statistic	EUL
	Linear Distribution					
L19	REFLECTORS WITH DELAMPING, 4 FT LAMP REMOVED	1.00385	2259.17	-0.00049646	-64.99	85
L23	FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXTURE	1.01953	-0.0014	563.07	-45.07	31
L37 & L81	ALL HID FIXTURES: INTERIOR >= 176 WATTS LAMP AND 251-400 WATTS LAMPS	1.01272	-0.00088372	446.92	-22.68	48
S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	0.99697	190.35	-0.00013936	-1.55	297
S15	COOLING TOWER	1.00125	946.3	-0.000382	-21	109
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	0.98249	462.82	-0.00019668	-5.39	204
204	INSTALL HVAC EMS	1.07698	110.11	-0.00503	-29.9	10
	Exponential Distribution					
L19	REFLECTORS WITH DELAMPING, 4 FT LAMP REMOVED	-	-	0.00044695	83.25	129
L23	FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXTURE	-	-	0.00117	45.46	49
L37 & L81	ALL HID FIXTURES: INTERIOR >= 176 WATTS LAMP AND 251-400 WATTS LAMPS	-	-	0.00071729	30.37	81
S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	-	-	0.00019207	4.14	301
S15	COOLING TOWER	-	-	0.00036842	40.35	157
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN 50 HP MAX	-	-	0.00046576	19.42	124
204	INSTALL HVAC EMS	-	-	0.00469	36.19	12

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 4-3 provides the results of the classical survival analysis. Shown are the model results for each measure, and for each type of distribution modeled. Furthermore, the resulting EUL estimates are provided.

Exhibit 4-3
Comparison of Survival Model Results
Exponential, Logistic, Lognormal, Weibull and Gamma Models
L23 T8, L19 Delamping, L37/L81 HID, S22 ASD and 204 EMS Measures

			Variable			Resulting
Measure	**Model**		**Intercept**	**Scale**	**Shape**	**EUL**
L19	Exponential	Parameter Estimate	8.08	1.00	-	**185.6**
		Standard Error	0.03	0.00	-	44.60
	Logistic	Parameter Estimate	5.32	0.19	-	**17.0**
		Standard Error	0.03	0.01	-	4.10
	Log-Normal	Parameter Estimate	5.69	0.56	-	**24.7**
		Standard Error	0.04	0.02	-	8.83
	Weibull	Parameter Estimate	5.33	0.19	-	**16.1**
		Standard Error	0.03	0.01	-	3.49
	Gamma	Estimate	5.33	0.20	0.99566	**16.1**
		Standard Error	0.06	0.07	0.39465	28.11
L23	Exponential	Parameter Estimate	6.87	1.00	-	**55.6**
		Standard Error	0.02	0.00	-	7.01
	Logistic	Parameter Estimate	5.28	0.30	-	**16.4**
		Standard Error	0.01	0.01	-	1.77
	Log-Normal	Parameter Estimate	5.61	0.78	-	**22.9**
		Standard Error	0.02	0.01	-	3.37
	Weibull	Parameter Estimate	5.31	0.30	-	**15.1**
		Standard Error	0.01	0.01	-	1.44
	Gamma	Estimate	-	-	-	-
		Standard Error	-	-	-	-
L37 and L81	Exponential	Parameter Estimate	6.76	1.00	-	**49.7**
		Standard Error	0.05	0.00	-	7.87
	Logistic	Parameter Estimate	5.74	0.56	-	**25.9**
		Standard Error	0.07	0.03	-	5.80
	Log-Normal	Parameter Estimate	6.48	1.54	-	**54.4**
		Standard Error	0.11	0.07	-	18.21
	Weibull	Parameter Estimate	5.80	0.58	-	**22.3**
		Standard Error	0.07	0.03	-	4.42
	Gamma	Estimate	5.74	0.23	2.58281	**19.6**
		Standard Error	0.03	0.00	0.00000	1.74
S22	Exponential	Parameter Estimate	6.76	1.00	-	**49.6**
		Standard Error	0.32	0.00	-	20.51
	Logistic	Parameter Estimate	5.73	0.55	-	**25.6**
		Standard Error	0.46	0.19	-	15.32
	Log-Normal	Parameter Estimate	6.03	1.19	-	**34.6**
		Standard Error	0.57	0.39	-	25.63
	Weibull	Parameter Estimate	5.79	0.57	-	**22.2**
		Standard Error	0.47	0.20	-	11.81
	Gamma	Estimate	5.74	0.21	2.73909	**19.5**
		Standard Error	0.17	0.00	0.00000	4.45
204	Exponential	Parameter Estimate	5.64	1.00	-	**16.2**
		Standard Error	0.25	0.00	-	4.10
	Logistic	Parameter Estimate	4.99	0.55	-	**12.2**
		Standard Error	0.21	0.12	-	2.57
	Log-Normal	Parameter Estimate	5.00	0.91	-	**12.3**
		Standard Error	0.22	0.19	-	2.71
	Weibull	Parameter Estimate	5.21	0.63	-	**12.1**
		Standard Error	0.22	0.14	-	2.30
	Gamma	Estimate	-	-	-	-
		Standard Error	-	-	-	-

4.5 DEVELOP COMPETING RISKS MODELS

Competing risks models were developed to account for different events having different underlying distributions. Models were only developed for the L23 T8 measure and the L37/L81 HID measures, since all other measures observed only one event type during the study period or had too little data to be able to create distinct models for the multiple event types. Results from the best-fitting, minimum EUL and maximum EUL competing risks models are provided in Exhibit 4-4.

Exhibit 4-4
Competing Risks Model Results
L23 T8 and L37/L81 HIDCAC Measures

Measure	Method	EUL	Standard Error
L23	Best Fit	**15.5**	2.25
	Min EUL	**15.3**	2.26
	Max EUL	**57.8**	7.31
L37&L81	Best Fit	**18.2**	4.19
	Min EUL	**16.8**	16.36
	Max EUL	**65.0**	25.46

Both the L23 and L37/L81 measures have ex ante EULs of 16 years. The results presented in Exhibit 4-4 illustrate that the EULs resulting from the best fit competing risks scenario for both measures are very close to the ex ante and have standard errors that indicate that the EUL is not statistically significantly different from ex ante EUL.

4.5 FINAL RESULTS

Exhibits 4-5 and 4-6 summarize the estimated EULs for each approach and corresponding model for the studied Lighting and HVAC measures, respectively. The median EULs are provided, along with the upper and lower confidence bounds, based on the 80 percent confidence interval.

Exhibit 4-5
Comparison of Survival Model Results
Summary Statistics, Trendlines, LIFEREG, and Competing Risks Models
L23 T8, L19 Delamping, and L37/L81 HID Measures[5]

Approach	Model		Lighting Measures		
			L19	L23	L37 / L81
		Ex Ante EUL	**16**	**16**	**16**
Summary Statistics	Exponential	Median EUL	109	35	47 / 45
		Upper Bound	-	-	-
		Lower Bound	-	-	-
Trendlines	Linear	Median EUL	85	31	48
		Upper Bound	86	32	51
		Lower Bound	83	30	46
	Exponential	Median EUL	129	49	96
		Upper Bound	131	51	103
		Lower Bound	127	48	89
LIFEREG	Exponential	Median EUL	186	56	50
		Upper Bound	243	65	60
		Lower Bound	128	47	40
	Logistic	Median EUL	17	16	26
		Upper Bound	22	19	33
		Lower Bound	12	14	18
	Log-Normal	Median EUL	25	23	54
		Upper Bound	36	27	78
		Lower Bound	13	19	31
	Weibull	Median EUL	16	15	22
		Upper Bound	21	17	28
		Lower Bound	12	13	17
	Gamma	Median EUL	16	-	20
		Upper Bound	52	-	22
		Lower Bound	-20	-	17
Competing Risks	Best Fit	Median EUL	-	16	18
		Upper Bound	-	18	22
		Lower Bound	-	13	14
	Min EUL	Median EUL	-	15	17
		Upper Bound	-	18	33
		Lower Bound	-	13	0
	Max EUL	Median EUL	-	58	65
		Upper Bound	-	65	90
		Lower Bound	-	51	40

[5] Although negative EUL values are a physical impossibility, the values are presented so that the reader may understand the magnitude of the standard error.

Exhibit 4-6
Comparison of Survival Model Results
Summary Statistics, Trendlines, LIFEREG, and Competing Risks Models
S11 Chiller, S15 Cooling Tower, S22 ASD and 204 EMS Measures

Approach	Model		HVAC Measures S11	S15	S22	240
		Ex Ante EUL	**20**	**20**	**16**	**14**
Summary Statistics	Exponential	Median EUL	-	212	84	16
		Upper Bound	-	-	-	-
		Lower Bound	-	-	-	-
Trendlines	Linear	Median EUL	297	109	204	10
		Upper Bound	543	116	253	10
		Lower Bound	51	103	156	9
	Exponential	Median EUL	301	157	124	12
		Upper Bound	394	162	132	13
		Lower Bound	208	152	116	12
LIFEREG	Exponential	Median EUL	-	-	50	16
		Upper Bound	-	-	76	21
		Lower Bound	-	-	23	11
	Logistic	Median EUL	-	-	26	12
		Upper Bound	-	-	45	16
		Lower Bound	-	-	6	9
	Log-Normal	Median EUL	-	-	35	12
		Upper Bound	-	-	67	16
		Lower Bound	-	-	2	9
	Weibull	Median EUL	-	-	22	12
		Upper Bound	-	-	37	15
		Lower Bound	-	-	7	9
	Gamma	Median EUL	-	-	20	-
		Upper Bound	-	-	20	-
		Lower Bound	-	-	25	-
Competing Risks	Best Fit	Median EUL	-	-	-	-
		Upper Bound	-	-	-	-
		Lower Bound	-	-	-	-
	Min EUL	Median EUL	-	-	-	-
		Upper Bound	-	-	-	-
		Lower Bound	-	-	-	-
	Max EUL	Median EUL	-	-	-	-
		Upper Bound	-	-	-	-
		Lower Bound	-	-	-	-

Approaches 1 and 2 discussed in Section 3 (summary statistics and trendlines) were implemented for all Lighting and HVAC measures. Approach 3 (survival modeling using LIFEREG) was also implemented for all measures with the exception the S11 Chiller and S15 Cooling Tower measures since both only reported experiencing one failure over the course of the nine years and thus there was not enough "failure" data available. And finally approach 4 (competing risks modeling) was only calculated for the L23 T8 and L37/L81 HID measures since the remaining measures either did not have competing event types (failures versus removals) or had too little data to distinguish between them. 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.

The results from LIFEREG are recommended for measures L19 Delamping, S22 ASD and 240 EMS since these measures had only one event type observed during the study period or did not have enough data to create different distributions for failures vs. removals. The recommended LIFEREG distributions were chosen based upon the largest log-likelihood estimate. For L19 Delamping measure the log-logistic distribution was chosen, for the S22 ASD measure the gamma distribution was chosen and for the 204 EMS measure the lognormal distribution was selected.

The recommended results for the L23 T8 and L37/L81 HID measures are based on the competing risks models built from classical survival analysis using the LIFEREG procedure. Of the three models constructed for each measure, the best fit model is the model of choice. Because the best fit model is based upon the fit of the distribution to all of the actual data, we believe that the competing risks model produces the most reliable results. The minimum and maximum EUL methods are not recommended because they seek to minimize/maximize the EUL at the expense of goodness of fit.

Exhibit 4-7 presents the recommended ex post estimates of the EUL. Because the LIFEREG and competing risks models did not provide results that were statistically significantly different from the ex ante results, measured at the 80 percent confidence interval, all of the ex post EULs are based on the ex ante estimates. The ex post estimates are compared to the favored study results and the corresponding upper and lower 80 percent confidence interval, when available. Finally, the program realization rates are provided, which are the ratios of the ex ante and ex post estimates. For all measures, the realization rate is one.

Exhibit 4-7
Final Ex Post EUL Estimates

End Use	Technology	Measure	Ex Ante	Study Results Upper	Study Results Median	Study Results Lower	Ex Post	Realization Rate
Lighting	Optical Reflectors w/ Fluor. Delamp	L19	16	22.3	17.0	11.8	16	100%
	T8 Lamps and Electronic Ballasts	L23	16	18.4	15.5	12.6	16	100%
	High Intensity Discharge	L37&L81	16	23.5	18.2	12.8	16	100%
HVAC	Chiller	S11	20	-	-	-	20	100%
	Cooling Tower	S15	20	-	-	-	20	100%
	ASD	S22	16	25.2	19.5	13.8	16	100%
	EMS	204	14	15.8	12.3	8.9	14	100%

APPENDIX 1

PROTOCOL TABLES 6B AND 7B

FOURTH YEAR RETENTION STUDY FOR THE 1994 & 1995 COMMERCIAL EEI PROGRAM LIGHTING AND HVAC TECHNOLOGIES

PG&E STUDY ID #s LIGHTING: 310R2, 324R2
HVAC: 312R2, 326R2

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

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

Protocol Table 6.B
Results of Retention Study
PG&E 1994 & 1995 Commercial Energy Efficiency Incentives Program
LIGHTING: 310R2, 324R2
HVAC : 312R2, 326R2

Item 1			Item 2		Item 3	Item 4	Item 5	Item 6		Item 7	Item 8	Item 9
PG&E Measure Code	**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)**
L19	FIXTURE: MODIFICATION/LAMP REMOVAL, 4 FT LAMP REMOVED	Lighting	16	Advice Filing & MDSS	17	16	4.1	12	22	<0.0001	100%	L17, L18, L20, L76 - L77
L23	FIXTURE: MODIFICATION/REPLACE LAMPS & BLST, 4 FT FIXTURE	Lighting	16	Advice Filing & MDSS	16	16	2.2	13	18	<0.0001	100%	L9 - L12, L21, L22, L24, L69 - L75, L117 - L124, L160
L37	HID FIXTURE: INTERIOR, >=176 WATTS LAMP	Lighting	16	Advice Filing & MDSS	18	16	4.2	13	24	<0.0001	100%	L25, L78 - L81, L26, L27
L81	HID FIXTURE: INTERIOR, 251-400 WATTS LAMP	Lighting	16	Advice Filing & MDSS	18	16	4.2	13	24	<0.0001	100%	L25, L78 - L80, L26, L27, L37
S11	WATER CHILLER: >= 300 TONS, WATER-COOLED	HVAC	20	Advice Filing & MDSS	-	20	-	-	-	-	100%	N/A
S15	COOLING TOWER	HVAC	20	Advice Filing & MDSS	-	20	-	-	-	-	100%	S9, S10, S12, S13, S16
S22	ADJUSTABLE SPEED DRIVE: HVAC FAN, 50 HP MAX	HVAC	16	Advice Filing & MDSS	20	16	4.4	14	25	<0.0001	100%	N/A
204	INSTALL HVAC EMS	HVAC	14	Advice Filing & MDSS	12	14	2.7	9	16	<0.0001	100%	N/A

PROTOCOL TABLE 7B

1994 & 1995 COMMERCIAL EEI PROGRAM
NINTH YEAR RETENTION STUDY
PG&E STUDY ID: LIGHTING: 310R2 & 324R2
HVAC: 312R2 & 326R2

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

1. OVERVIEW INFORMATION

A. Study Title and Study ID Number

Study Title: Ninth Year Retention Study of PG&E's 1994 & 1995 Commercial EEI Program.

Study ID Numbers: LIGHTING: 310R2 & 324R2

HVAC: 312R2 & 326R2

B. Program, Program Year and Program Description

Program: PG&E Commercial EEI Program.

Program Year: Rebates Received in the 1994 & 1995 Calendar Year.

Program Description:

The Commercial Energy Efficiency Incentives Program for lighting and HVAC technologies offered by PG&E has three components: the Retrofit Express (RE) Program, the Retrofit Efficiency Options (REO) Program and the Customized Incentives (CI) Program.

The RE Program

The RE program offered fixed rebates to customers who installed specific electric energy-efficient equipment. The program covered the most common energy saving measures and spans lighting, air conditioning, refrigeration, motors, and food service. Customers were required to submit proof of purchase with these applications in order to receive rebates. The program was marketed to small- and medium-sized commercial, industrial, and agricultural customers. The maximum rebate amount, including all measure types, was $300,000 per account. No minimum amount was required to qualify for a rebate.

The REO Program

The REO program targeted commercial, industrial, agricultural, and multi-family market segments most likely to benefit from these selected measures. Customers were required to submit calculations for the projected first-year energy savings along with their application prior to installation of the high efficiency equipment. PG&E representatives worked with customers to identify cost-effective improvements, with special emphasis on operational and maintenance measures at the customers' facilities. Marketing efforts were coordinated amongst PG&E's divisions, emphasizing local planning areas with high marginal electric costs to maximum the program's benefits.

The Customized Incentives Program

The Customized Incentives program offered financial incentives to CIA customers who undertook large or complex projects that save gas or electricity. Customers may also participate under the APOS program. These customers were required to submit calculations for projected first-year energy impacts with their applications prior to installation of the project. The maximum incentive amount for the Customized Incentives program was $500,000 per account, and the minimum qualifying incentive was $2,500 per project. The total incentive payment for kW, kWh, and therm savings was limited to 50 percent of direct project cost for retrofit of existing systems. Since the program also applied to expansion projects, the new systems incentive was limited to 100 percent of the incremental cost to make new processes or added systems energy efficient. Customers were paid 4¢ per kWh and 20¢ per therm for first-year annual energy impacts. A $200 per peak kW incentive for peak demand impacts required that savings be achieved during the hours PG&E experiences high power demand.

Due to the significant documentation and analysis involved in Customized Incentives program measures, however, rebates for a number of 1992 and 1993 measures were delayed for payment until 1994 and 1995. This evaluation covers those measures where rebates were paid in 1994 and 1995.

As a result of program design, the measures installed were similar to or the same as those for the RE program, but were installed in larger and more complex projects.

C. End Uses and/or Measures Covered

End Use Covered: Indoor Lighting and HVAC Technologies.

Measures Covered: For the list of measures covered in this evaluation, see *Exhibit 2-3*.

D. Methods and Models Used

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. Upon review of the summary statistics, it became clear that such a small percentage of failures and removals had occurred, that it would be difficult to model the equipment's survival function.

2. ***Visually inspect*** the retention data, by simply calculating the cumulative percentage of equipment that had failed in a given month, and plotting the percentage over time. This step clearly illustrated that for each studied measure, there was not enough data over time to support an accurate estimate of the survival function.

3. ***Develop a trend line*** from the survival plots. Using the plots developed in (2) above, a trend line was estimated using standard linear regression techniques. We modeled the trend as a linear and an exponential function. In each case, we used the resulting trend line to estimate the EUL, which was statistically significantly larger than the ex ante estimate.

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 used the resulting survival function to estimate the EUL. In nearly every case, the resulting EUL was either statistically significantly larger than the ex ante EUL, or was not statistically significantly different than the EUL. In only 1 out of 20 cases was the resulting EUL statistically significantly less than the ex ante EUL. In this case the failure events observed during the study period clearly do not provide adequate information for a reliable estimate.

5. ***Develop competing risks models*** that incorporate different distributions for failures, removals, and replacements. Using the LIFEREG procedure in SAS from step 4 above, separate output was generated for failures, removals, and replacements. Then, the best fitting distributions for each event were combined to form one combined survival function. This additional analysis step provided valuable results that have not been previously utilized in retention studies.

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

E. Analysis Sample Size

Exhibit 3-2 provides the final sample disposition used in the study analysis.

2. DATABASE MANAGEMENT

A. Key Data Elements and Sources

The MDSS, the original retention panels and the follow-up survey data were the only data sources used for this analysis.

B. Data Attrition Process

All data points that had follow-up survey data 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 or site visits were made.

D. Unused Data Elements

Without exception, all data collected specifically for the Evaluation were utilized in the analysis.

3. SAMPLING

A. Sampling Procedures and Protocols

Section 3.1 describes the sample procedures and protocols.

B. Survey Information

The data collection instrument is presented in the *Attachment 1. Exhibit 3-2* provides the final sample disposition, which contains the number of sites and units that were in the sample frame, and the number surveyed.

C. Statistical Descriptions

Statistics variables that were used in the survival models are also presented in *Section 3.*

4. DATA SCREENING AND ANALYSIS

A. Procedures for Treating Outliers and Missing Data

All data points that had follow-up survey data 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 follow-up survey data were utilized in the analysis.

D. Regression Statistics

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

E. Model Specification

The model specifications are presented in *Section 3*.

F. Measurement Errors

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

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and mis-coded study variables. In this project, we implemented several controls to reduce systematic bias in the data. These steps include: (1) thorough auditor/coder training; (2) instrument pretest; and (3) cross-validation between on-site audit data and telephone survey responses.

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). Because the analysis was conducted on the unit of measure (e.g., a ballast) and not a site, the standard errors from SAS were grossly underestimated. SAS treats each observation in the dataset as independent. However, it is likely that there is significant correlation in the observations that are common to a single site (especially in the event that a removal occurs.) For example, when a removal occurs, it is likely that many measures are removed at once. To a lesser extent, failures are correlated since they may all come from the same manufacturing lot, they are all likely to be installed under the same circumstances, and they are also used in a similar manner.

If we believed that there was 100 percent correlation of failure/removal for all measures with a site, we could simply multiply the standard error calculated from SAS by the square root of the ratio of the number of units to sites. Therefore, if there were an average of 100 units installed per measure, we would multiply by 10.

We felt, however, that there were two components to our error: one caused by variation across sites, and another caused by variation across measures. The errors calculated by SAS correspond only to the error across measures.

To estimate the standard error associated with failures and removals, we first took the SAS output and backed out a standard deviation. This was achieved by multiplying the standard error from SAS by the square root of the sample size (in units.) We then assumed that this standard deviation was associated with the joint probability density function of failures and removals.

(1) $$StdErr_{SAS} * \sqrt{N_{Units}} = StdDev_{Failures,Removals}$$

Where,

$StdErr_{SAS}$ is the standard error around the median EUL projected with the SAS System;

$\sqrt{N_{Units}}$ is the square root of the number of sites that contributed to the regression model;

$StdDev_{Failures,Removals}$ is the standard deviation associated with the median EUL of failures and removals.

We then assumed that failures were independent of removals (Which is of course not true, since a high failure rate may cause a customer to decide to make removal. But we felt this was reasonable overall.) Therefore, the variance of removals and failures is equal to the variance of removals plus the variance of failures:

(2) $$StdDev_{Failures,Removals}{}^2 = Var_{Failures,Removals} = Var_{Failures} + Var_{Removals}$$

Where,

$StdDev_{Failures,Removals}{}^2$ is the square of the standard deviation associated with the median EUL of failures and removals;

$Var_{Failures,Removals}$ is the variance which is equivalent to the square of the standard deviation.

If we assume that failures are independent across units, and removals are independent across sites, then the standard error can be calculated as:

$$
(3)\quad \begin{aligned} StdErr_{Failures,\mathrm{Re}movals} &= \sqrt{StdErr_{Failures}{}^2 + StdErr_{\mathrm{Re}movals}{}^2} \\ &= \sqrt{\frac{Var_{Failures}}{N_{Units}} + \frac{Var_{\mathrm{Re}movals}}{N_{Sites}}} \end{aligned}
$$

Where,

$StdErr_{Failures,\mathrm{Re}movals}$ is the standard deviation associated with the median EUL of failures and removals;

N_{Units} is the number of units used for the regression models;

N_{Sites} is the total number of sites having those units.

Furthermore, if we assume that the underlying standard deviation of failures and removals are equivalent, then:

$$
(4)\quad \begin{aligned} StdDev_{Failures,\mathrm{Re}movals}{}^2 &= Var_{Failures,\mathrm{Re}movals} \\ &= Var_{Failures} + Var_{\mathrm{Re}movals} \\ &= 2Var_{Failures,or\ \mathrm{Re}movals} \end{aligned}
$$

So,

$$
(5)\quad \begin{aligned} Var_{Failures,or\ \mathrm{Re}movals} &= 0.5 * (StdDev_{Failures,\mathrm{Re}movals})^2 \\ &= 0.5 * (StdErr_{SAS})^2 * N_{Units} \end{aligned}
$$

Therefore, substituting equation (5) in equation (3), we get

$$
(6)\quad \begin{aligned} StdErr_{Failures,\mathrm{Re}movals} &= \sqrt{\frac{0.5 * (StdErr_{SAS})^2 * N_{Units}}{N_{Units}} + \frac{0.5 * (StdErr_{SAS})^2 * N_{Units}}{N_{Sites}}} \\ &= StdErr_{SAS} * \sqrt{0.5 + 0.5 * \frac{N_{Units}}{N_{Sites}}} \end{aligned}
$$

It is interesting to note that if there was only one unit per site, the standard error would equal the standard error calculated in SAS. Our resulting standard error is somewhere between the standard error found in SAS, and the standard error from SAS multiplied by the square root of the ratio of the number of units to sites (the method discussed as the beginning of this section.)

Skinner and Kish[1] both offer a more theoretical approach to solving the problem of estimating a standard error when the data are not identical and independently distributed (IID). They define this problem as a design effect, which is the case when the sample is not a simple random sample that is IID, but rather is a cluster sample such as ours. In our case, each site contains a cluster of sample points.

Skinner developed a design effect factor, Deff, that can be used to adjust the standard error obtained from SAS to estimate the true standard error:

$$(7)\quad Deff = \frac{StdErr_{TRUE}^{\ 2}}{StdErr_{SAS}^{\ 2}}$$

Where,

$StdErr_{TRUE}$ is the actual standard error associated with the median EUL;

$StdErr_{SAS}$ is the standard error associated with the median EUL obtained from SAS;

Skinner estimated the design effect factor as:

$$(8)\quad Deff = 1 + (n - 1) * \tau$$

Where,

n = the average number of sample points per cluster (or, in our case, per site)

$$= \frac{N_{Units}}{N_{Sites}}$$

τ = the intra-cluster correlation

[1] Skinner, C. J., "Analysis of Complex Surveys," John Wiley & Sons, 1989, pp. 23-46.
Kish, L., "Survey Sampling," John Wiley & Sons, 1965, pp. 162.

Skinner's design effect factor can be compare directly to the factor we developed in equation (6):

$$(9)\quad Deff\,(Eq.6) = 0.5 + 0.5 * (\frac{N_{Units}}{N_{Sites}}) = 1 + (n-1) * 0.5$$

Our method discussed above is identical to that developed by Skinner, with an intra-cluster correlation equal to 0.5. As discussed above, we believe that there are two types of events: removals and failures. Our assumption above was that removals are perfectly correlated and failures are totally uncorrelated. Therefore, an intra-cluster correlation of 0.5 is not unreasonable.

To calculate the intra-cluster correlation, it would require knowing the time of failure or removal for all units in our analysis. The intra-cluster correlation measures how correlated the failure/removal times are across all units within a site. Because our analysis is being conducted in such an early stage of the measures life, it is not possible to accurately estimate the correlation. However, given that (1) it is likely that removals are highly correlated, and failures are relatively uncorrelated; and (2) removals are expected to be as prevalent as failures over the life of the measure; then an intra-cluster correlation of 0.5 is a reasonable approximation.

Finally, relative precision estimated at the 80 percent confidence interval was calculated using the following equation:

$$RP = \frac{1.282 * StdErr}{EUL}$$

Where,

$StdErr$ = the standard error calculated using Equation 6, above.

APPENDIX 2

2003 PG&E C/I RETENTION SURVEY AND RECRUITMENT SCRIPT

LIGHTING

HELLO This is ____________, calling on behalf of Pacific Gas & Electric Company. May I speak with <CONTACT>?

If do not have <CONTACT> , or is not available, or no longer there: May I speak with the person in your organization who is responsible for energy-related decisions for your facility?

[NOTE: IF WE DON'T HAVE <CONTACT>, OR <CONTACT> NO LONGER THERE: INTERVIEWER SHOULD BE LOOKING FOR THE PERSON RESPONSIBLE FOR EQUIPMENT PURCHASES, ENERGY EFFICIENCY AND ENERGY SUPPLY AT **THIS** LOCATION. DO NOT RECORD INFORMATION FOR INDIVIDUAL AT SOME OTHER BUILDING OR LOCATION, EVEN IF BUILDING IS OWNED BY OFF-SITE MANAGER]

IF NEEDED: This is a fact-finding call; we are NOT interested in selling you anything. We are assisting PG&E in evaluating their energy efficiency programs and we would like to ask you some questions regarding the success of the retrofit that took place at <ADDRESS1> <ADDRESS2> in <YEAR>. Who would be the best person to answer questions regarding the Lighting equipment at that location?

IF NEEDED: PG&E wants to better understand how long lighting fixtures typically last. Many of the energy efficient technologies installed through the rebate program are so new that there is still some uncertainty as to how long they last. PG&E may use this information to update their programs so that they better serve the needs of the customer.

1	Respondent	INTRO1
2	Respondent not available now	CALL BACK
3	Respondent coming to phone	INTRO1
4	No such person	INTRO1A
88	Refused	INTRO1A

INTRO1A

[IF NO SUCH PERSON]: May I speak with the person in your organization who is responsible for decisions regarding construction, renovation, or operation of your physical facilities?

INTRO1B NAME OF CONTACT: ______________________________________

INTRO1C TITLE: ______________________________________

ASK TO BE TRANSFERRED, OR MAKE APPOINTMENT AS NECESSARY. PROCEED TO **INTRO1**

INTRO1 This is ____________, calling on behalf of Pacific Gas & Electric Company. We are assisting PG&E in evaluating their energy efficiency programs. We would like to ask you some questions regarding the success of the lighting retrofit that took place at <Company> in <YEAR>. The goal of the study is to determine the lifetime of the lighting equipment installed through PG&E's rebate programs. PG&E conducts this study every few years, to track specific equipment over time. Are you the best person to talk to, for this study?

IF NEEDED: PG&E wants to better understand how long lighting fixtures typically last. Many of the energy efficient technologies installed through the rebate program are so new that there is still some uncertainty as to how long they last. PG&E may use this information to update their programs so that they better serve the needs of the customer.

1	Yes	INTRO2
2	Respondent not available now	CALL BACK
3	Respondent coming to phone	INTRO2
4	No such person	INTRO1A
88	Refused	INTRO1A

INTRO2 Do you recall that there was lighting retrofit that occurred in <YEAR>, and that was subsidized by PG&E's program?

1	Yes	VER10
2	No	INTRO3
88	Refused	VER30
99	Don't Know	VER30

INTRO3
[IF NOT BEST PERSON]: May I speak with the person in your organization who may be a better respondent for this survey?

INTRO3B NAME OF CONTACT: ____
INTRO3C TITLE: ____

RETURN TO **INTRO1**

IF NO SUCH PERSON EXISTS:
- IF <PHONLY03>=0 THEN T&T
- ELSE GO TO **VER30**

VER10. Our records indicate that your facility is located at <ADDRESS1> <ADDRESS2>. Is that correct?

1	Yes	RET10
2	No	VER20
88	Refused	T&T
99	Don't Know	T&T

VER20: What is the correct address?
[DISPLAY KNOWN ADDRESS] IF CORRECT ADDRESS IS CLOSE ENOUGH, THEN PROCEED. OTHERWISE T&T.

RICHARD: DEPENDING ON THE NUMBER OF MEASURES INSTALLED AT ONE FACILITY, THE RET QUESTIONS MAY HAVE TO BE REPEATED UP TO 6 TIMES (EXACT NUMBER GIVEN IN <NRMEAS>).

DO i=1 to <NRMEAS>:

IF <CODEi>=L37 OR <CODEi>=L81 THEN ASK RET10.
ELSE IF <CODEi>=L19 THEN GO TO RET210.
ELSE IF <CODEi>=L23 THEN GO TO RET410.

HID LAMP BATTERY:

RET10. Our records indicate that in <YEAR> there were <COUNTi> high-intensity discharge (or HID) fixtures installed at <LOCi> [READ LOCi ONLY IF WE HAVE IT]. Can you verify this information?

1	Yes	RET20
2	No	SCH5 if first measure (i=1); if we have at least one measure completed, then T&T
88	Refused	SCH5 if first measure; if we have at least one measure completed, then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed, then T&T

RET20. Has any of those <COUNTi> HID fixtures failed, been removed, or replaced?

1	Yes	RET30
2	No	NEXT MEASURE OR T&T IF LAST
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RICHARD: CAN WE DISPLAY THE TOTAL COUNT, AND THE ANSWERS TO EACH OF THE FAILURE, REMOVAL AND REPLACEMENT QUESTIONS? SO THAT THE INTERVIEWER SEES WHEN THE THREE CATEGORIES ADD UP TO MORE THAN THE TOTAL?

RET30. Overall, how many of the HID fixtures installed in the <YEAR> lighting retrofit have failed, been removed, or replaced?

HGONE	Enter number, from 1 to <COUNTi>	RET40
87	Answer as a percentage of <COUNTi>	RET35
88	Refused	SCH5 if first measure; if we have at least one completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one completed then T&T

RET35. What percent of ALL the HID fixtures installed in the <YEAR> lighting retrofit have failed, been removed, or replaced?

1	Enter percentage	RET45
88	Refused	SCH5 if first measure; if we have at least one completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one completed then T&T

[READ THE FOLLOWING FOR THE FIRST MEASURE (i=1)]

Let's now try to break this number down into failed, removed and replaced.

- If the fixture doesn't switch on, then it has failed. If a fixture fails and it is replaced by something else, then it is still considered a failure.
- A fixture is considered removed if it has been taken out of its original location while it was still functional. For example: taking out a light fixture during a remodel.
- A fixture is considered replaced if another fixture has been installed in its place.

RET40. How many fixtures have failed?

IF NEEDED: If the fixture doesn't allow the lights to switch on, then it has failed. If a fixture fails and it is replaced by something else, then it is still considered a failure.

1	None	RET70
HFAILED	Enter number, from 1 to <HGONE>	RET50
87	Answer as a percentage of <COUNTi>	RET45
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET45. What percent of ALL the HID fixtures installed in <YEAR> have failed?

1	Enter percentage from 0 to 100%	RET50
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET50. Can you recall when this failure FIRST occurred? What year was it?

1	1994	RET50b
2	1995	RET50b
3	1996	RET50b
4	1997	RET50b
5	1998	RET50b
6	1999	RET50b
7	2000	RET50b
8	2001	RET50b
9	2002	RET50b
10	2003	RET50b
88	Refused	RET50d
99	Don't Know	RET50d

RET50b. And what month?

1	January	RET50d
2	February	RET50d
3	March	RET50d
4	April	RET50d
5	May	RET50d
6	June	RET50d
7	July	RET50d
8	August	RET50d
9	September	RET50d
10	October	RET50d
11	November	RET50d
12	December	RET50d
88	Refused	RET50c
99	Don't Know	RET50c

RET50c. Can you at least recall what season it was?

1	Spring	RET50d
2	Summer	RET50d
3	Fall	RET50d
4	Winter	RET50d
88	Refused	RET50d
99	Don't Know	RET50d

RET50d. And can you recall what type of failure that was? Was it… [READ LIST]?

1	Manufacturing Defect	RET55
2	Improper Installation	RET55
3	Improper Maintenance	RET55
4	Accident/Human Error	RET55
5	Other – RECORD VERBATIM	RET55
99	Don't Know/Unable to determine	RET55

RET55. Were there other failures that occurred at other times?

1	Yes	RET60
2	No	RET62
88	Refused	RET62
99	Don't Know	RET62

RET60. Can you recall when the LAST failure occurred? What year was it?

1	1994	RET60b
2	1995	RET60b
3	1996	RET60b
4	1997	RET60b
5	1998	RET60b
6	1999	RET60b
7	2000	RET60b
8	2001	RET60b
9	2002	RET60b
10	2003	RET60b
88	Refused	RET60d
99	Don't Know	RET60d

RET60b. And what month?

1	January	RET60d
2	February	RET60d
3	March	RET60d
4	April	RET60d
5	May	RET60d
6	June	RET60d
7	July	RET60d
8	August	RET60d
9	September	RET60d
10	October	RET60d
11	November	RET60d
12	December	RET60d
88	Refused	RET60c
99	Don't Know	RET60c

RET60c. Can you at least recall what season it was?

1	Spring	RET60d
2	Summer	RET60d
3	Fall	RET60d
4	Winter	RET60d
88	Refused	RET60d
99	Don’t Know	RET60d

RET60d. And can you recall what type of failure that was? Was it… [READ LIST]?

1	Manufacturing Defect	RET62
2	Improper Installation	RET62
3	Improper Maintenance	RET62
4	Accident/Human Error	RET62
5	Other – RECORD VERBATIM	RET62
99	Don’t Know/Unable to determine	RET62

RET62. Did you replace any of the failed fixtures?

1	Yes	RET64
2	No	RET70
88	Refused	RET70
99	Don’t Know	RET70

RET64. Were they replaced with… [READ LIST]?

1	Higher Efficiency HID fixtures	RET66
2	Equivalent Efficiency HID fixtures	RET66
3	Baseline Efficiency HID fixtures	RET66
4	Other – Specify	RET66
99	Don’t Know/Unable to determine	RET66

RET66. And how many of the failed fixtures were replaced under warranty?

1	None	RET70
2	Enter number, from 1 to <HFAILED>	RET70
87	Answer as a percentage of <HFAILED>	RET68
88	Refused	RET70
99	Don’t Know	RET70

RET68. What percent of the FAILED fixtures were replaced under warranty?

1	Enter percentage from 0 to 100%	RET70
88	Refused	RET70
99	Don’t Know	RET70

RET70. Let’s now talk about HID fixtures that have been removed. Can you remember how many fixtures were removed, if any?

IF NEEDED: A fixture is considered removed if it has been taken out of its original location while it was still functional (for example: taking out a light fixture during a remodel).

1	None	NEXT MEASURE OR T&T
HREMOVED	Enter number, from 1 to <HGONE>	RET80

87	Answer as a percentage of <COUNTi>	RET75
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET75. What percent of ALL the HID fixtures installed in <YEAR> have been removed?

1	Enter percentage from 0 to 100%	RET80
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET80. Can you recall when this removal FIRST occurred? What year was it?

1	1994	RET80b
2	1995	RET80b
3	1996	RET80b
4	1997	RET80b
5	1998	RET80b
6	1999	RET80b
7	2000	RET80b
8	2001	RET80b
9	2002	RET80b
10	2003	RET80b
88	Refused	RET80d
99	Don't Know	RET80d

RET80b. And what month?

1	January	RET80d
2	February	RET80d
3	March	RET80d
4	April	RET80d
5	May	RET80d
6	June	RET80d
7	July	RET80d
8	August	RET80d
9	September	RET80d
10	October	RET80d
11	November	RET80d
12	December	RET80d
88	Refused	RET80c
99	Don't Know	RET80c

RET80c. Can you at least recall what season it was?

1	Spring	RET80d
2	Summer	RET80d
3	Fall	RET80d
4	Winter	RET80d
88	Refused	RET80d
99	Don’t Know	RET80d

RET80d. And can you recall why they were removed? Was it… [READ LIST]?

1	Unsatisfactory Performance	RET85
2	Savings not worth the effort	RET85
3	Remodeling disabled the installation	RET85
4	Type of business changed	RET85
5	Moved	RET85
6	Equipment upgrade	RET85
7	Other – RECORD VERBATIM	RET85
99	Don’t Know/Unable to determine	RET85

RET85. Were there other removals that occurred at other times?

1	Yes	RET90
2	No	RET92
88	Refused	RET92
99	Don’t Know	RET92

RET90. Can you recall when the LAST removal occurred? What year was it?

1	1994	RET90b
2	1995	RET90b
3	1996	RET90b
4	1997	RET90b
5	1998	RET90b
6	1999	RET90b
7	2000	RET90b
8	2001	RET90b
9	2002	RET90b
10	2003	RET90b
88	Refused	RET90d
99	Don’t Know	RET90d

RET90b. And what month?

1	January	RET90d
2	February	RET90d
3	March	RET90d
4	April	RET90d
5	May	RET90d
6	June	RET90d
7	July	RET90d
8	August	RET90d
9	September	RET90d
10	October	RET90d
11	November	RET90d
12	December	RET90d
88	Refused	RET90c
99	Don't Know	RET90c

RET90c. Can you at least recall what season it was?

1	Spring	RET90d
2	Summer	RET90d
3	Fall	RET90d
4	Winter	RET90d
88	Refused	RET90d
99	Don't Know	RET90d

RET90d. And can you recall why they were removed? Was it… [READ LIST]?

1	Unsatisfactory Performance	RET92
2	Savings not worth the effort	RET92
3	Remodeling disabled the installation	RET92
4	Type of business changed	RET92
5	Moved	RET92
6	Equipment upgrade	RET92
7	Other – RECORD VERBATIM	RET92
99	Don't Know/Unable to determine	RET92

RET92. Did you replace any of the removed fixtures?

1	Yes	RET94
2	No	NEXT MEASURE OR T&T
88	Refused	NEXT MEASURE OR T&T
99	Don't Know	NEXT MEASURE OR T&T

RET94. Were they replaced with… [READ LIST]?

1	Higher Efficiency HID fixtures	NEXT MEASURE OR T&T
2	Equivalent Efficiency HID fixtures	NEXT MEASURE OR T&T
3	Baseline Efficiency HID fixtures	NEXT MEASURE OR T&T
4	Other - SPECIFY	NEXT MEASURE OR T&T
99	Don’t Know/Unable to determine	NEXT MEASURE OR T&T

DELAMPING BATTERY:

RET210. Our records indicate that, at <LOCi> [READ LOCATION ONLY IF WE HAVE IT], some old fluorescent fixtures were replaced with <COUNTi> new 4-foot T8 fixtures with a reduced number of lamps. Can you verify this information?

1	Yes	RET220
2	No	SCH5 if first measure; if we have at least one measure completed then T&T
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don’t Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET220. Have any of those <COUNTi> T8 fixtures failed, been removed, or replaced?

1	Yes	RET230
2	No	NEXT MEASURE OR T&T IF LAST
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don’t Know	SCH5 if first measure; if we have at least one measure completed then T&T

RICHARD: CAN WE DISPLAY THE TOTAL COUNT, AND THE ANSWERS TO EACH OF THE FAILURE, REMOVAL AND REPLACEMENT QUESTIONS? SO THAT THE INTERVIEWER SEES WHEN THETHREE CATEGORIES ADD UP TO MORE THAN THE TOTAL?

RET230. Overall, how many of the T8 fixtures have failed, been removed, or replaced?

DGONE	Enter number, from 1 to <COUNTi>	RET240
87	Answer as a percent of <COUNTi>	RET235
88	Refused	SCH5 if first measure; if we have at least one completed then T&T
99	Don’t Know	SCH5 if first measure; if we have at least one completed then T&T

RET235. What percent of ALL the T8 fixtures with fewer lamps installed in <YEAR> have failed, been removed, or replaced?

1	Enter percentage from 0 to 100%	RET245
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don’t Know	SCH5 if first measure; if we have at least one measure completed then T&T

[READ THE FOLLOWING FOR THE FIRST MEASURE]
Let’s now try to break this number down into failed, removed and replaced.

- If the fixture doesn't switch on, then it has failed. If a fixture fails and it is replaced by something else, then it is still considered a failure.
- A fixture is considered removed if it has been taken out of its original location while it was still functional, and has not been replaced with something else. For example: taking out a light fixture during a remodel, because light is no longer necessary in the area.
- A fixture is considered replaced if another fixture has been installed in its place.

RET240. How many of the <COUNTi> T8 fixtures with fewer lamps have failed?
IF NEEDED: If the fixture doesn't switch on, then it has failed. If a fixture fails and it is replaced by something else, then it is still considered a failure.

1	None	RE270
DFAILED	Enter number, from 1 to <DGONE>	RET250
87	Answer as a percentage of <COUNTi>	RET245
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET245. What percent of ALL the T8 fixtures with fewer lamps installed in <YEAR> have failed?

1	Enter percentage from 0 to 100%	RET250
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET250. Can you recall when this failure FIRST occurred? What year was it?

1	1994	RET250b
2	1995	RET250b
3	1996	RET250b
4	1997	RET250b
5	1998	RET250b
6	1999	RET250b
7	2000	RET250b
8	2001	RET250b
9	2002	RET250b
10	2003	RET250b
88	Refused	RET250d
99	Don't Know	RET250d

RET250b. And what month?

1	January	RET250d
2	February	RET250d
3	March	RET250d
4	April	RET250d
5	May	RET250d
6	June	RET250d
7	July	RET250d
8	August	RET250d
9	September	RET250d
10	October	RET250d
11	November	RET250d
12	December	RET250d
88	Refused	RET250c
99	Don’t Know	RET250c

RET250c. Can you at least recall what season it was?

1	Spring	RET250d
2	Summer	RET250d
3	Fall	RET250d
4	Winter	RET250d
88	Refused	RET250d
99	Don’t Know	RET250d

RET250d. And can you recall what type of failure that was? Was it… [READ LIST]?

1	Ballast Defect	RET255
2	Manufacturing Defect	RET255
3	Improper Installation	RET255
4	Improper Maintenance	RET255
5	Accident/Human Error	RET255
6	Other – RECORD VERBATIM	RET255
99	Don’t Know/Unable to determine	RET255

RET255. Were there other failures that occurred at other times?

1	Yes	RET260
2	No	RET262
88	Refused	RET262
99	Don’t Know	RET262

RET260. Can you recall when the LAST failure occurred? What year was it?

1	1994	RET260b
2	1995	RET260b
3	1996	RET260b
4	1997	RET260b
5	1998	RET260b
6	1999	RET260b
7	2000	RET260b
8	2001	RET260b
9	2002	RET260b
10	2003	RET260b
88	Refused	RET260d
99	Don't Know	RET260d

RET260b. And what month?

1	January	RET260d
2	February	RET260d
3	March	RET260d
4	April	RET260d
5	May	RET260d
6	June	RET260d
7	July	RET260d
8	August	RET260d
9	September	RET260d
10	October	RET260d
11	November	RET260d
12	December	RET260d
88	Refused	RET260c
99	Don't Know	RET260c

RET260c. Can you at least recall what season it was?

1	Spring	RET260d
2	Summer	RET260d
3	Fall	RET260d
4	Winter	RET260d
88	Refused	RET260d
99	Don't Know	RET260d

RET260d. And can you recall what type of failure that was? Was it… [READ LIST]?

1	Ballast Defect	RET262
2	Manufacturing Defect	RET262
3	Improper Installation	RET262
4	Improper Maintenance	RET262
5	Accident/Human Error	RET262
6	Other – RECORD VERBATIM	RET262
99	Don't Know/Unable to determine	RET262

RET262. Did you replace any of the failed T8 fixtures?

1	Yes – Replaced Only Ballast	RET270

2	Yes – Replaced Fixture	RET264
2	No	RET270
88	Refused	RET270
99	Don't Know	RET270

RET264. What were they replaced with… [READ LIST]?

1	T8 fixtures with more lamps	RET266
2	T8 fixtures with the same number of lamps	RET266
3	T8 fixtures with fewer lamps	RET266
4	Fixtures with more lamps, but not T8	RET266
5	Fixtures with the same number of lamps, but not T8	RET266
6	Fixtures with less lamps, but not T8	RET266
7	Other – SPECIFY	RET266
99	Don't Know/Unable to determine	RET266

RET266. And how many of the FAILED fixtures were replaced under warranty?

1	None	RET270
2	Enter number, from 1 to <DFAILED>	RET270
87	Answer as a percentage of <DFAILED>	RET268
88	Refused	RET270
99	Don't Know	RET270

RET268. What percentage of the FAILED T8 fixtures were replaced under warranty?

1	Enter percentage from 0 to 100%	RET270
88	Refused	RET270
99	Don't Know	RET270

RET270. Focusing on the new T8 fixtures with fewer lamps that were installed in <YEAR>, let's now talk about fixtures that have been removed. Can you remember how many of the fixtures were removed, if any?
IF NEEDED: A fixture is considered removed if it has been taken out of its original location while it was still functional (for example: taking out a light fixture during a remodel).

1	None	NEXT MEASURE OR T&T
DREMOVED	Enter number, from 1 to <DGONE>	RET280
87	Answer as a percentage of <COUNTi>	RET275
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET275. What percent of ALL of the T8 fixtures with fewer lamps installed in <YEAR> have been removed?

1	Enter percentage from 0 to 100%	RET280
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET280. Can you recall when this removal FIRST occurred? What year was it?

1	1994	RET280b
2	1995	RET280b
3	1996	RET280b
4	1997	RET280b
5	1998	RET280b
6	1999	RET280b
7	2000	RET280b
8	2001	RET280b
9	2002	RET280b
10	2003	RET280b
88	Refused	RET280d
99	Don't Know	RET280d

RET280b. And what month?

1	January	RET280d
2	February	RET280d
3	March	RET280d
4	April	RET280d
5	May	RET280d
6	June	RET280d
7	July	RET280d
8	August	RET280d
9	September	RET280d
10	October	RET280d
11	November	RET280d
12	December	RET280d
88	Refused	RET280c
99	Don't Know	RET280c

RET280c. Can you at least recall what season it was?

1	Spring	RET280d
2	Summer	RET280d
3	Fall	RET280d
4	Winter	RET280d
88	Refused	RET280d
99	Don't Know	RET280d

RET280d. And can you recall why they were removed? Was it… [READ LIST]?

1	Unsatisfactory Performance	RET285
2	Savings not worth the effort	RET285
3	Remodeling disabled the installation	RET285
4	Type of business changed	RET285
5	Moved	RET285
6	Equipment upgrade	RET285
7	Other – RECORD VERBATIM	RET285
99	Don't Know/Unable to determine	RET285

RET285. Were there other removals that occurred at other times?

1	Yes	RET290
2	No	RET292
88	Refused	RET292
99	Don't Know	RET292

RET290. Can you recall when the LAST removal occurred? What year was it?

1	1994	RET290b
2	1995	RET290b
3	1996	RET290b
4	1997	RET290b
5	1998	RET290b
6	1999	RET290b
7	2000	RET290b
8	2001	RET290b
9	2002	RET290b
10	2003	RET290b
88	Refused	RET290d
99	Don't Know	RET290d

RET290b. And what month?

1	January	RET290d
2	February	RET290d
3	March	RET290d
4	April	RET290d
5	May	RET290d
6	June	RET290d
7	July	RET290d
8	August	RET290d
9	September	RET290d
10	October	RET290d
11	November	RET290d
12	December	RET290d
88	Refused	RET290c
99	Don't Know	RET290c

RET290c. Can you at least recall what season it was?

1	Spring	RET290d
2	Summer	RET290d
3	Fall	RET290d
4	Winter	RET290d
88	Refused	RET290d
99	Don't Know	RET290d

RET290d. And can you recall why they were removed? Was it… [READ LIST]?

1	Unsatisfactory Performance	RET292
2	Savings not worth the effort	RET292
3	Remodeling disabled the installation	RET292
4	Type of business changed	RET292
5	Moved	RET292
6	Equipment upgrade	RET292
7	Other – RECORD VERBATIM	RET292
99	Don't Know/Unable to determine	RET292

RET292. Did you replace any of the removed fixtures?

1	Yes	RET294
2	No	NEXT MEASURE OR T&T
88	Refused	NEXT MEASURE OR T&T
99	Don't Know	NEXT MEASURE OR T&T

RET294. What were they replaced with… [READ LIST]?

1	T8 fixtures with more lamps	NEXT MEASURE OR T&T
2	T8 fixtures with the same number of lamps	NEXT MEASURE OR T&T
3	T8 fixtures with fewer lamps	NEXT MEASURE OR T&T
4	Fixtures with more lamps, but not T8	NEXT MEASURE OR T&T
5	Fixtures with the same number of lamps, but not T8	NEXT MEASURE OR T&T
6	Fixtures with less lamps, but not T8	NEXT MEASURE OR T&T
7	Other - SPECIFY	NEXT MEASURE OR T&T
99	Don't Know/Unable to determine	NEXT MEASURE OR T&T

T8 BATTERY:

RET410. Our records indicate that 4-foot T8 fixtures with a total number of <COUNTi> lamps were installed at <LOCi> [READ LOCATION ONLY IF WE HAVE IT]. Can you verify this information?

1	Yes	RET415
2	No	SCH5 if first measure; if we have at least one measure completed then T&T
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET415. Focusing on the new T8 fixtures, can you tell me how many lamps are controlled by one ballast? [GET AN AVERAGE FOR ALL FIXTURES]

IF NEEDED: A ballast is the electronic control device for the fixture. It powers the lights, and when a ballast fails, all lights that it runs go out. It usually costs 50 to 100 dollars to replace and requires an electrician.

IF NEEDED: For example, when you flip a switch, you may have two lamps switching on at the same time – in this case, a ballast controls two lamps.

1	1	RET420
2	1.5	RET420
3	2	RET420
3	2.5	RET420
4	3	RET420
5	3.5	RET420

6	4	RET420
7	Other - Specify	RET420
88	Refused	RET420
99	Don't Know	RET420

RET420. Have any of the ballasts failed, been removed, or replaced since they were installed in <YEAR>?

1	Yes	RET430
2	No	NEXT MEASURE OR T&T IF LAST
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RICHARD: CAN WE DISPLAY THE TOTAL COUNT, AND THE ANSWERS TO EACH OF THE FAILURE, REMOVAL AND REPLACEMENT QUESTIONS? SO THAT THE INTERVIEWER SEES WHEN THETHREE CATEGORIES ADD UP TO MORE THAN THE TOTAL?

RET430. Overall, how many of the ballasts have failed, been removed, or replaced?

TGONE	Enter number, from 1 to <COUNTi>	RET440
87	Answer as a percentage of <COUNTi>	RET435
88	Refused	SCH5 if first measure; if we have at least one completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one completed then T&T

RET435. What percent of ALL the ballasts installed in <YEAR> have failed, been removed, or replaced?

1	Enter percentage from 0 to 100%	RET445
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

[READ THE FOLLOWING FOR THE FIRST MEASURE]
Let's now try to break this number down into failed, removed and replaced.

- If the ballast doesn't allow the fixture to switch on, then it has failed. If a ballast fails and it is replaced by something else, then it is still considered a failure.
- A ballast is considered removed if it has been taken out of its original location while it was still functional, and has not been replaced with something else. For example: taking out a the entire light fixture during a remodel, because light is no longer necessary in the area.
- A ballast is considered replaced if another ballast has been installed in its place while it was still functional. For example: replacing the ballast because it made a buzzing noise.

RET440. How many ballasts have failed?

IF NEEDED: If the ballast doesn't allow the fixture to switch on, then it has failed. If a fixture fails and it is replaced by something else, then it is still considered a failure.

1	None	RE470
TFAILED	Enter number, from 1 to <TGONE>	RET450
87	Answer as a percentage of <COUNTi>	RET445
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET435. What percent of ALL of the ballasts installed in <YEAR> have failed?

1	Enter percentage from 0 to 100%	RET450
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET450. Can you recall when this failure FIRST occurred? What year was it?

1	1994	RET450b
2	1995	RET450b
3	1996	RET450b
4	1997	RET450b
5	1998	RET450b
6	1999	RET450b
7	2000	RET450b
8	2001	RET450b
9	2002	RET450b
10	2003	RET450b
88	Refused	RET450d
99	Don't Know	RET450d

RET450b. And what month?

1	January	RET450d
2	February	RET450d
3	March	RET450d
4	April	RET450d
5	May	RET450d
6	June	RET450d
7	July	RET450d
8	August	RET450d
9	September	RET450d
10	October	RET450d
11	November	RET450d
12	December	RET450d
88	Refused	RET450c
99	Don't Know	RET450c

RET450c. Can you at least recall what season it was?

1	Spring	RET450d
2	Summer	RET450d
3	Fall	RET450d
4	Winter	RET450d
88	Refused	RET450d
99	Don't Know	RET450d

RET450d. And can you recall what type of failure that was? Was it… [READ LIST]?

1	Manufacturing Defect	RET455
2	Improper Installation	RET455
3	Improper Maintenance	RET455
4	Accident/Human Error	RET455
5	Other – RECORD VERBATIM	RET455
99	Don't Know/Unable to determine	RET455

RET455. Were there other failures that occurred at other times?

1	Yes	RET460
2	No	RET462
88	Refused	RET462
99	Don't Know	RET462

RET460. Can you recall when the LAST failure occurred? What year was it?

1	1994	RET460b
2	1995	RET460b
3	1996	RET460b
4	1997	RET460b
5	1998	RET460b
6	1999	RET460b
7	2000	RET460b
8	2001	RET460b
9	2002	RET460b
10	2003	RET460b
88	Refused	RET460d
99	Don't Know	RET460d

RET460b. And what month?

1	January	RET460d
2	February	RET460d
3	March	RET460d
4	April	RET460d
5	May	RET460d
6	June	RET460d
7	July	RET460d
8	August	RET460d
9	September	RET460d
10	October	RET460d
11	November	RET460d
12	December	RET460d
88	Refused	RET460c
99	Don't Know	RET460c

RET460c. Can you at least recall what season it was?

1	Spring	RET460d
2	Summer	RET460d
3	Fall	RET460d
4	Winter	RET460d
88	Refused	RET460d
99	Don't Know	RET460d

RET460d. And can you recall what type of failure that was? Was it… [READ LIST]?

1	Manufacturing Defect	RET462
2	Improper Installation	RET462
3	Improper Maintenance	RET462
4	Accident/Human Error	RET462
5	Other – RECORD VERBATIM	RET462
99	Don't Know/Unable to determine	RET462

RET462. Did you replace any of the failed ballasts?

1	Yes	RET464
2	No	RET470
88	Refused	RET470
99	Don't Know	RET470

RET464. What were they replaced with… [READ LIST]?

1	Higher efficiency ballasts	RET466
2	Equivalent efficiency ballasts	RET466
3	Baseline efficiency ballasts	RET466
4	Other - SPECIFY	RET466
99	Don't Know/Unable to determine	RET466

RET466. And how many of the FAILED ballasts were replaced under warranty?

1	None	RET470
2	Enter number, from 1 to <DFAILED>	RET470
87	Answer as a percent of <DFAILED>	RET468
88	Refused	RET470
99	Don't Know	RET470

RET468. What percent of the FAILED the ballasts were replaced under warranty?

1	Enter percentage from 0 to 100%	RET470
88	Refused	RET470
99	Don't Know	RET470

RET470. Focusing on the new 4-foot T8 fixtures that were installed in <YEAR>, let's now talk about ballasts that have been removed. Can you remember how many of the ballasts were removed, if any?

IF NEEDED: A ballast is considered removed if it has been taken out of its original location while it was still functional (for example: taking out the entire light fixture during a remodel).

1	None	NEXT MEASURE OR T&T
TREMOVED	Enter number, from 1 to <TGONE>	RET480
87	Answer as a percentage of <COUNTi>	RET475

88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET475. What percent of the T8 ballasts have been removed?

1	Enter percentage from 0 to 100%	RET480
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET480. Can you recall when the FIRST removal occurred? What year was it?

1	1994	RET480b
2	1995	RET480b
3	1996	RET480b
4	1997	RET480b
5	1998	RET480b
6	1999	RET480b
7	2000	RET480b
8	2001	RET480b
9	2002	RET480b
10	2003	RET480b
88	Refused	RET480d
99	Don't Know	RET480d

RET480b. And what month?

1	January	RET480d
2	February	RET480d
3	March	RET480d
4	April	RET480d
5	May	RET480d
6	June	RET480d
7	July	RET480d
8	August	RET480d
9	September	RET480d
10	October	RET480d
11	November	RET480d
12	December	RET480d
88	Refused	RET480c
99	Don't Know	RET480c

RET480c. Can you at least recall what season it was?

1	Spring	RET480d
2	Summer	RET480d
3	Fall	RET480d
4	Winter	RET480d
88	Refused	RET480d
99	Don't Know	RET480d

RET480d. And can you recall why the ballasts were removed? Was it… [READ LIST]

1	Unsatisfactory Performance	RET485
2	Savings not worth the effort	RET485
3	Remodeling disabled the installation	RET485
4	Type of business changed	RET485
5	Moved	RET485
6	Equipment upgrade	RET485
7	Other – RECORD VERBATIM	RET485
99	Don't Know/Unable to determine	RET485

RET485. Were there other removals that occurred at other times?

1	Yes	RET490
2	No	RET492
88	Refused	RET492
99	Don't Know	RET492

RET490. When did the LAST removal occur? What year was it?

1	1994	RET490b
2	1995	RET490b
3	1996	RET490b
4	1997	RET490b
5	1998	RET490b
6	1999	RET490b
7	2000	RET490b
8	2001	RET490b
9	2002	RET490b
10	2003	RET490b
88	Refused	RET490d
99	Don't Know	RET490d

RET490b. And what month?

1	January	RET490d
2	February	RET490d
3	March	RET490d
4	April	RET490d
5	May	RET490d
6	June	RET490d
7	July	RET490d
8	August	RET490d
9	September	RET490d
10	October	RET490d
11	November	RET490d
12	December	RET490d
88	Refused	RET490c
99	Don't Know	RET490c

RET490c. Can you at least recall what season it was?

1	Spring	RET490d
2	Summer	RET490d
3	Fall	RET490d
4	Winter	RET490d
88	Refused	RET490d
99	Don’t Know	RET490d

RET490d. And can you recall why the ballasts were removed? Was it… [READ LIST]?

1	Unsatisfactory Performance	RET492
2	Savings not worth the effort	RET492
3	Remodeling disabled the installation	RET492
4	Type of business changed	RET492
5	Moved	RET492
6	Equipment upgrade	RET492
7	Other – RECORD VERBATIM	RET492
99	Don’t Know/Unable to determine	RET492

RET492. Did you replace any of the removed ballasts?

1	Yes	RET494
2	No	NEXT MEASURE OR T&T
88	Refused	NEXT MEASURE OR T&T
99	Don’t Know	NEXT MEASURE OR T&T

RET494. What were they replaced with… [READ LIST]?

1	Higher efficiency ballasts	NEXT MEASURE OR T&T
2	Equivalent efficiency ballasts	NEXT MEASURE OR T&T
3	Baseline efficiency ballasts	NEXT MEASURE OR T&T
4	Other - Specify	NEXT MEASURE OR T&T
99	Don’t Know/Unable to determine	NEXT MEASURE OR T&T

Verify Address

VER30. ASK ONLY IF <PHONLY03> >0, OTHERWISE T&T
Our records indicate that your facility is located at <ADDRESS1> <ADDRESS2>. Is that correct?

1	Yes	SCH5
2	No	VER40
88	Refused	T&T
99	Don’t Know	T&T

VER40: What is the correct address?
[DISPLAY KNOWN ADDRESS] IF CORRECT ADDRESS IS CLOSE ENOUGH, THEN PROCEED TO SCH5. OTHERWISE T&T.

Schedule

SCH5: ASK ONLY IF <PHONLY03> >0, OTHERWISE T&T

With your permission, we would like to have one of our energy auditors drop by and verify the success of the lighting retrofit that took place there in <YEAR>. It would require only a few minutes of your time. Would it be OK for one of our auditors to come on site?

1	Yes	SCH10
2	No	T&T
88	Refused	T&T
99	Don't Know	T&T

SCH10. The way we like to schedule the appointments is to find out what weekday (or days) and times you would be available, and then for our auditors to call you to schedule the appointment. Let's start with the weekdays. In general, on what days would you be available to spend a few minutes with our auditor? [SELECT ALL THAT APPLY]

1	Monday	SCH30
2	Tuesday	SCH30
3	Wednesday	SCH30
4	Thursday	SCH30
5	Friday	SCH30
6	Any weekday	SCH30
88	Refused	SCH30
99	Don't Know	SCH30

SCH30. Around what time would it be best that the auditor arrive at the facility?

1	Any time between 9 and 5	SCH40
2	Record verbatim	SCH40
88	Refused	T&T
99	Don't Know	T&T

SCH40. The auditor will have up to three specific locations for each lighting measure installed. The goal is to determine how many of the noted items have failed, been removed, or been replaced in each area. Any repair orders or invoices that you have may facilitate the survey.

Fill out appointment sheet with the following info:

Weekdays Available
Hours Available
Company Name
Contact Name
Contact Phone
Address
City
Cross Street
Any directions that the auditor may need to get to the place

Confirm weekdays/times by reading back to customer. Remind customer that the auditor will call within a few days to schedule the appointment.

GOODBYE

Those are all the questions I have for you today. On behalf of PG&E, thank you very much for your time and cooperation. Our auditor will schedule and perform the survey as we just discussed.

2003 PG&E C/I RETENTION SURVEY AND RECRUITMENT SCRIPT

HVAC

HELLO This is ____________, calling on behalf of Pacific Gas & Electric Company. May I speak with <CONTACT>?

If do not have <CONTACT> , or is not available, or no longer there: May I speak with the person in your organization who is most knowledgeable about the HVAC equipment at your facility?

[NOTE: IF WE DON'T HAVE <CONTACT>, OR <CONTACT> NO LONGER THERE: INTERVIEWER SHOULD BE LOOKING FOR THE PERSON RESPONSIBLE FOR EQUIPMENT PURCHASES, ENERGY EFFICIENCY AND ENERGY SUPPLY AT **THIS** LOCATION. DO NOT RECORD INFORMATION FOR INDIVIDUAL AT SOME OTHER BUILDING OR LOCATION, EVEN IF BUILDING IS OWNED BY OFF-SITE MANAGER]

IF NEEDED: This is a fact-finding call; we are NOT interested in selling you anything. We are assisting PG&E in evaluating their energy efficiency programs and we would like to ask you some questions regarding the success of the HVAC retrofit that took place at <ADDRESS1> <ADDRESS2> in <YEAR>. Who would be the best person to answer questions regarding the HVAC equipment at that location?

IF NEEDED: PG&E wants to better understand how long HVAC equipment typically lasts. Many of the energy efficient technologies installed through the rebate program are so new that there is still some uncertainty as to how long they last. PG&E may use this information to update their programs so that they better serve the needs of the customer.

1	Respondent	INTRO1
2	Respondent not available now	CALL BACK
3	Respondent coming to phone	INTRO1
4	No such person	INTRO1A
88	Refused	INTRO1A

INTRO1A

[IF NO SUCH PERSON]: May I speak with the person in your organization who is responsible for decisions regarding construction, renovation, or operation of your physical facilities?

INTRO1B NAME OF CONTACT: ____

INTRO1C TITLE: ____

ASK TO BE TRANSFERRED, OR MAKE APPOINTMENT AS NECESSARY. PROCEED TO **INTRO1**

INTRO1 This is ____________, calling on behalf of Pacific Gas & Electric Company. We are assisting PG&E in evaluating their energy efficiency programs. We would like to ask you some questions regarding the success of the HVAC retrofit that took place at <Company> in <YEAR>. The goal of the study is to determine the lifetime of the HVAC equipment installed through PG&E's rebate programs. PG&E conducts this study every few years, to track specific equipment over time. Are you the best person to talk to, for this study?

IF NEEDED: PG&E wants to better understand how long HVAC equipment typically lasts. Many of the energy efficient technologies installed through the rebate program are so new that there is still some uncertainty as to how long they last. PG&E may use this information to update their programs so that they better serve the needs of the customer.

1	Yes	INTRO2
2	Respondent not available now	CALL BACK
3	Respondent coming to phone	INTRO2

4	No such person	INTRO1A
88	Refused	INTRO1A

INTRO2 Do you recall that there was an HVAC retrofit that occurred in <YEAR>, and that was subsidized by PG&E's program?

1	Yes	VER10
2	No	INTRO3
88	Refused	VER30
99	Don't Know	VER30

INTRO3
[IF NOT BEST PERSON]: May I speak with the person in your organization who may be a better respondent for this survey?

INTRO3B NAME OF CONTACT: ____
INTRO3C TITLE: ____

RETURN TO **INTRO1**

IF NO SUCH PERSON EXISTS:
- IF <PHONLY03>=0 THEN T&T
- ELSE GO TO **VER30**

VER10. Our records indicate that your facility is located at <ADDRESS1> <ADDRESS2>. Is that correct?

1	Yes	RET10
2	No	VER20
88	Refused	T&T
99	Don't Know	T&T

VER20: What is the correct address?
[DISPLAY KNOWN ADDRESS] IF CORRECT ADDRESS IS CLOSE ENOUGH, THEN PROCEED. OTHERWISE T&T.

RICHARD: DEPENDING ON THE NUMBER OF MEASURES INSTALLED AT ONE FACILITY, THE RET QUESTIONS MAY HAVE TO BE REPEATED UP TO 5 TIMES (EXACT NUMBER GIVEN IN <NRMEAS>).

DO i=1 to <NRMEAS>
IF <COUNTi>=1 then ask RET110. ELSE ASK RET10:

MULTIPLE UNIT BATTERY

RET10. Our records indicate that in <YEAR> there were <COUNTi> <UNITi> at <LOCi> [READ LOCi ONLY IF WE HAVE IT]. Can you verify this information?

1	Yes	RET20
2	No	SCH5 if first measure (i=1); if we have at least one measure completed, then T&T
88	Refused	SCH5 if first measure; if we have at least one measure completed, then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed, then T&T

RET20. Has any of those <COUNTi> <SUNITi> failed, been removed, or replaced?

1	Yes	RET30
2	No	NEXT MEASURE OR T&T IF LAST
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RICHARD: CAN WE DISPLAY THE TOTAL COUNT, AND THE ANSWERS TO EACH OF THE FAILURE AND REMOVAL QUESTIONS? SO THAT THE INTERVIEWER SEES WHEN THE THREE CATEGORIES ADD UP TO MORE THAN THE TOTAL?

RET30. Overall, how many of the <SUNITi> installed in the <YEAR> HVAC retrofit have failed, been removed, or replaced?

RGONE	Enter number, from 1 to <COUNTi>	RET40
87	Answer as a percentage of <COUNTi>	RET35
88	Refused	SCH5 if first measure; if we have at least one completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one completed then T&T

RET35. What percent of ALL the <SUNITi> installed in the <YEAR> HVAC retrofit have failed, been removed, or replaced?

1	Enter percentage	RET45
88	Refused	SCH5 if first measure; if we have at least one completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one completed then T&T

[READ THE FOLLOWING FOR THE FIRST MEASURE (i=1)]
Let's now try to break this number down into failed, removed and replaced.

- If the installed HVAC measure breaks down and is beyond repair, then it has failed. Repair or maintenance are not considered a failure if the HVAC unit is still functional. If an HVAC measure fails and it is replaced by something else, then it is still considered a failure.
- An HVAC measure is considered removed if it has been taken out of its original location while it was still functional. For example: taking out an energy management system during a remodel.
- An HVAC measure is considered replaced if another HVAC measure has been installed in its place.

RET40. How many <SUNITi> have failed?

IF NEEDED: If the HVAC measure breaks down and is beyond repair, then it has failed. Repair or maintenance are not considered a failure if the HVAC unit is still functional. If an HVAC measure fails and it is replaced by something else, then it is still considered a failure

1	None	RET70
RFAILED	Enter number, from 1 to <RGONE>	RET50
87	Answer as a percentage of <COUNTi>	RET45
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET45. What percent of ALL the <SUNITi> installed in <YEAR> have failed?

1	Enter percentage from 0 to 100%	RET50
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET50. Can you recall when this failure FIRST occurred? What year was it?

1	1994	RET50b
2	1995	RET50b
3	1996	RET50b
4	1997	RET50b
5	1998	RET50b
6	1999	RET50b
7	2000	RET50b
8	2001	RET50b
9	2002	RET50b
10	2003	RET50b
88	Refused	RET50d
99	Don't Know	RET50d

RET50b. And what month?

1	January	RET50d
2	February	RET50d
3	March	RET50d
4	April	RET50d
5	May	RET50d
6	June	RET50d
7	July	RET50d
8	August	RET50d
9	September	RET50d
10	October	RET50d
11	November	RET50d
12	December	RET50d
88	Refused	RET50c
99	Don't Know	RET50c

RET50c. Can you at least recall what season it was?

1	Spring	RET50d
2	Summer	RET50d
3	Fall	RET50d
4	Winter	RET50d
88	Refused	RET50d
99	Don't Know	RET50d

RET50d. And can you recall what type of failure that was? Was it… [READ LIST]?

1	Manufacturing Defect	RET55
2	Improper Installation	RET55
3	Improper Maintenance	RET55
4	Accident/Human Error	RET55

5	Other – RECORD VERBATIM	RET55
99	Don't Know/Unable to determine	RET55

RET55. Were there other failures that occurred at other times?

1	Yes	RET60
2	No	RET62
88	Refused	RET62
99	Don't Know	RET62

RET60. Can you recall when the LAST failure occurred? What year was it?

1	1994	RET60b
2	1995	RET60b
3	1996	RET60b
4	1997	RET60b
5	1998	RET60b
6	1999	RET60b
7	2000	RET60b
8	2001	RET60b
9	2002	RET60b
10	2003	RET60b
88	Refused	RET60d
99	Don't Know	RET60d

RET60b. And what month?

1	January	RET60d
2	February	RET60d
3	March	RET60d
4	April	RET60d
5	May	RET60d
6	June	RET60d
7	July	RET60d
8	August	RET60d
9	September	RET60d
10	October	RET60d
11	November	RET60d
12	December	RET60d
88	Refused	RET60c
99	Don't Know	RET60c

RET60c. Can you at least recall what season it was?

1	Spring	RET60d
2	Summer	RET60d
3	Fall	RET60d
4	Winter	RET60d
88	Refused	RET60d
99	Don't Know	RET60d

RET60d. And can you recall what type of failure that was? Was it… [READ LIST]?

1	Manufacturing Defect	RET62
2	Improper Installation	RET62

3	Improper Maintenance	RET62
4	Accident/Human Error	RET62
5	Other – RECORD VERBATIM	RET62
99	Don't Know/Unable to determine	RET62

RET62. Did you replace any of the failed <SUNITi>?

1	Yes	RET64
2	No	RET70
88	Refused	RET70
99	Don't Know	RET70

RET64. Were they replaced with… [READ LIST]?

1	Higher Efficiency <SUNITi>	RET66
2	Equivalent Efficiency <SUNITi>	RET66
3	Baseline Efficiency <SUNITi>	RET66
4	Other – Specify	RET66
99	Don't Know/Unable to determine	RET66

RET66. And how many of the failed <SUNITi> were replaced under warranty?

1	None	RET70
2	Enter number, from 1 to <RFAILED>	RET70
87	Answer as a percentage of <RFAILED>	RET68
88	Refused	RET70
99	Don't Know	RET70

RET68. What percent of the FAILED <SUNITi> were replaced under warranty?

1	Enter percentage from 0 to 100%	RET70
88	Refused	RET70
99	Don't Know	RET70

RET70. Let's now talk about <SUNITi> that have been removed. Can you remember how many <SUNITi> were removed, if any?

IF NEEDED: An HVAC measure is considered removed if it has been taken out of its original location while it was still functional. For example: taking out an energy management system during a remodel.

1	None	NEXT MEASURE OR T&T
RREMOVED	Enter number, from 1 to <RGONE>	RET80
87	Answer as a percentage of <COUNTi>	RET75
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET75. What percent of ALL the <SUNITi> installed in <YEAR> have been removed?

1	Enter percentage from 0 to 100%	RET80
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET80. Can you recall when this removal FIRST occurred? What year was it?

1	1994	RET80b
2	1995	RET80b
3	1996	RET80b
4	1997	RET80b
5	1998	RET80b
6	1999	RET80b
7	2000	RET80b
8	2001	RET80b
9	2002	RET80b
10	2003	RET80b
88	Refused	RET80d
99	Don’t Know	RET80d

RET80b. And what month?

1	January	RET80d
2	February	RET80d
3	March	RET80d
4	April	RET80d
5	May	RET80d
6	June	RET80d
7	July	RET80d
8	August	RET80d
9	September	RET80d
10	October	RET80d
11	November	RET80d
12	December	RET80d
88	Refused	RET80c
99	Don’t Know	RET80c

RET80c. Can you at least recall what season it was?

1	Spring	RET80d
2	Summer	RET80d
3	Fall	RET80d
4	Winter	RET80d
88	Refused	RET80d
99	Don’t Know	RET80d

RET80d. And can you recall why they were removed? Was it… [READ LIST]?

1	Unsatisfactory Performance	RET85
2	Savings not worth the effort	RET85
3	Remodeling disabled the installation	RET85
4	Type of business changed	RET85
5	Moved	RET85
6	Equipment upgrade	RET85
7	Other – RECORD VERBATIM	RET85
99	Don’t Know/Unable to determine	RET85

RET85. Were there other removals that occurred at other times?

1	Yes	RET90
2	No	RET92
88	Refused	RET92
99	Don't Know	RET92

RET90. Can you recall when the LAST removal occurred? What year was it?

1	1994	RET90b
2	1995	RET90b
3	1996	RET90b
4	1997	RET90b
5	1998	RET90b
6	1999	RET90b
7	2000	RET90b
8	2001	RET90b
9	2002	RET90b
10	2003	RET90b
88	Refused	RET90d
99	Don't Know	RET90d

RET90b. And what month?

1	January	RET90d
2	February	RET90d
3	March	RET90d
4	April	RET90d
5	May	RET90d
6	June	RET90d
7	July	RET90d
8	August	RET90d
9	September	RET90d
10	October	RET90d
11	November	RET90d
12	December	RET90d
88	Refused	RET90c
99	Don't Know	RET90c

RET90c. Can you at least recall what season it was?

1	Spring	RET90d
2	Summer	RET90d
3	Fall	RET90d
4	Winter	RET90d
88	Refused	RET90d
99	Don't Know	RET90d

RET90d. And can you recall why they were removed? Was it… [READ LIST]?

1	Unsatisfactory Performance	RET92
2	Savings not worth the effort	RET92
3	Remodeling disabled the installation	RET92
4	Type of business changed	RET92
5	Moved	RET92
6	Equipment upgrade	RET92

7	Other – RECORD VERBATIM	RET92
99	Don't Know/Unable to determine	RET92

RET92. Did you replace any of the removed <SUNITi>?

1	Yes	RET94
2	No	NEXT MEASURE OR T&T
88	Refused	NEXT MEASURE OR T&T
99	Don't Know	NEXT MEASURE OR T&T

RET94. Were they replaced with… [READ LIST]?

1	Higher Efficiency <SUNITi>	NEXT MEASURE OR T&T
2	Equivalent Efficiency <SUNITi>	NEXT MEASURE OR T&T
3	Baseline Efficiency <SUNITi>	NEXT MEASURE OR T&T
4	Other – Specify	NEXT MEASURE OR T&T
99	Don't Know/Unable to determine	NEXT MEASURE OR T&T

ONE UNIT BATTERY

RET110. Our records indicate that in <YEAR> there was one <UNITi> at <LOCi> [READ LOCi ONLY IF WE HAVE IT]. Can you verify this information?

1	Yes	RET120
2	No	SCH5 if first measure (i=1); if we have at least one measure completed, then T&T
88	Refused	SCH5 if first measure; if we have at least one measure completed, then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed, then T&T

RET120. Has that <SUNITi> failed, or been removed, or replaced?

1	Yes	RET140
2	No	NEXT MEASURE OR T&T IF LAST
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

[READ THE FOLLOWING FOR THE FIRST MEASURE (i=1)]
Let's now try to determine if the unit failed, or was removed or replaced.

- If the installed HVAC measure breaks down and is beyond repair, then it has failed. Repair or maintenance are not considered a failure if the HVAC unit is still functional. If an HVAC measure fails and it is replaced by something else, then it is still considered a failure.
- An HVAC measure is considered removed if it has been taken out of its original location while it was still functional. For example: taking out an energy management system during a remodel.
- An HVAC measure is considered replaced if another HVAC measure has been installed in its place.

RET140. Has the <SUNITi> failed?
IF NEEDED: If a HVAC measure breaks down and is beyond repair, then it has failed. Repair or maintenance are not considered a failure if the HVAC unit is still functional. If an HVAC measure fails and it is replaced by something else, then it is still considered a failure.

1	Yes	RET150

2	No	RET170
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET150. Can you recall when this failure occurred? What year was it?

1	1994	RET150b
2	1995	RET150b
3	1996	RET150b
4	1997	RET150b
5	1998	RET150b
6	1999	RET150b
7	2000	RET150b
8	2001	RET150b
9	2002	RET150b
10	2003	RET150b
88	Refused	RET150d
99	Don't Know	RET150d

RET150b. And what month?

1	January	RET150d
2	February	RET150d
3	March	RET150d
4	April	RET150d
5	May	RET150d
6	June	RET150d
7	July	RET150d
8	August	RET150d
9	September	RET150d
10	October	RET150d
11	November	RET150d
12	December	RET150d
88	Refused	RET150c
99	Don't Know	RET150c

RET150c. Can you at least recall what season it was?

1	Spring	RET150d
2	Summer	RET150d
3	Fall	RET150d
4	Winter	RET150d
88	Refused	RET150d
99	Don't Know	RET150d

RET150d. And can you recall what type of failure that was? Was it… [READ LIST]?

1	Manufacturing Defect	RET162
2	Improper Installation	RET162
3	Improper Maintenance	RET162
4	Accident/Human Error	RET162
5	Other – RECORD VERBATIM	RET162
99	Don't Know/Unable to determine	RET162

RET162. Did you replace the failed <SUNITi>?

1	Yes	RET164
2	No	NEXT MEASURE OR T&T
88	Refused	NEXT MEASURE OR T&T
99	Don't Know	NEXT MEASURE OR T&T

RET164. Was it replaced with… [READ LIST]?

1	Higher Efficiency <SUNITi>	RET166
2	Equivalent Efficiency <SUNITi>	RET166
3	Baseline Efficiency <SUNITi>	RET166
4	Other – Specify	RET166
99	Don't Know/Unable to determine	RET166

RET166. And was the failed <SUNITi> replaced under warranty?

1	Yes	NEXT MEASURE OR T&T
2	No	NEXT MEASURE OR T&T
87	Answer as a percentage of <RFAILED>	NEXT MEASURE OR T&T
88	Refused	NEXT MEASURE OR T&T
99	Don't Know	NEXT MEASURE OR T&T

RET170. Was the <SUNITi> removed?

IF NEEDED: An HVAC measure is considered removed if it has been taken out of its original location while it was still functional. For example: taking out an energy management system during a remodel.

1	Yes	RET180
2	No	NEXT MEASURE OR T&T
88	Refused	SCH5 if first measure; if we have at least one measure completed then T&T
99	Don't Know	SCH5 if first measure; if we have at least one measure completed then T&T

RET180. Can you recall when this removal occurred? What year was it?

1	1994	RET180b
2	1995	RET180b
3	1996	RET180b
4	1997	RET180b
5	1998	RET180b
6	1999	RET180b
7	2000	RET180b
8	2001	RET180b
9	2002	RET180b
10	2003	RET180b
88	Refused	RET180d
99	Don't Know	RET180d

RET180b. And what month?

1	January	RET180d
2	February	RET180d
3	March	RET180d

4	April	RET180d
5	May	RET180d
6	June	RET180d
7	July	RET180d
8	August	RET180d
9	September	RET180d
10	October	RET180d
11	November	RET180d
12	December	RET180d
88	Refused	RET180c
99	Don't Know	RET180c

RET180c. Can you at least recall what season it was?

1	Spring	RET180d
2	Summer	RET180d
3	Fall	RET180d
4	Winter	RET180d
88	Refused	RET180d
99	Don't Know	RET180d

RET180d. And can you recall why it was removed? Was it… [READ LIST]?

1	Unsatisfactory Performance	RET192
2	Savings not worth the effort	RET192
3	Remodeling disabled the installation	RET192
4	Type of business changed	RET192
5	Moved	RET192
6	Equipment upgrade	RET192
7	Other – RECORD VERBATIM	RET192
99	Don't Know/Unable to determine	RET192

RET192. Did you replace the removed <SUNITi>?

1	Yes	RET194
2	No	NEXT MEASURE OR T&T
88	Refused	NEXT MEASURE OR T&T
99	Don't Know	NEXT MEASURE OR T&T

RET194. Was it replaced with… [READ LIST]?

1	Higher Efficiency <SUNITi>	NEXT MEASURE OR T&T
2	Equivalent Efficiency <SUNITi>	NEXT MEASURE OR T&T
3	Baseline Efficiency <SUNITi>	NEXT MEASURE OR T&T
4	Other – Specify	NEXT MEASURE OR T&T
99	Don't Know/Unable to determine	NEXT MEASURE OR T&T

Verify Address

VER30. ASK ONLY IF <PHONLY03> >0, OTHERWISE T&T
Our records indicate that your facility is located at <ADDRESS1> <ADDRESS2>. Is that correct?

1	Yes	SCH5
2	No	VER40
88	Refused	T&T

99	Don't Know	T&T

VER40: What is the correct address?
[DISPLAY KNOWN ADDRESS] IF CORRECT ADDRESS IS CLOSE ENOUGH, THEN PROCEED TO SCH5. OTHERWISE T&T.

Schedule

SCH5: ASK ONLY IF <PHONLY03> >0, OTHERWISE T&T
With your permission, we would like to have one of our energy auditors drop by and verify the success of the HVAC retrofit that took place there in <YEAR>. It would require only a few minutes of your time. Would it be OK for one of our auditors to come on site?

1	Yes	SCH10
2	No	T&T
88	Refused	T&T
99	Don't Know	T&T

SCH10. The way we like to schedule the appointments is to find out what weekday (or days) and times you would be available, and then for our auditors to call you to schedule the appointment. Let's start with the weekdays. In general, on what days would you be available to spend a few minutes with our auditor? [SELECT ALL THAT APPLY]

1	Monday	SCH30
2	Tuesday	SCH30
3	Wednesday	SCH30
4	Thursday	SCH30
5	Friday	SCH30
6	Any weekday	SCH30
88	Refused	SCH30
99	Don't Know	SCH30

SCH30. Around what time would it be best that the auditor arrive at the facility?

1	Any time between 9 and 5	SCH40
2	Record verbatim	SCH40
88	Refused	T&T
99	Don't Know	T&T

SCH40. The auditor will have up to three specific locations for each HVAC measure installed. The goal is to determine how many of the noted items have failed, been removed, or been replaced in each area. Any repair orders or invoices that you have may facilitate the survey.

Fill out appointment sheet with the following info:
Weekdays Available
Hours Available
Company Name
Contact Name
Contact Phone
Address
City
Cross Street
Any directions that the auditor may need to get to the place

Confirm weekdays/times by reading back to customer. Remind customer that the auditor will call within a few days to schedule the appointment.

GOODBYE

Those are all the questions I have for you today. On behalf of PG&E, thank you very much for your time and cooperation. Our auditor will schedule and perform the survey as we just discussed.