6TH YEAR RETENTION STUDY OF PACIFIC GAS & ELECTRIC COMPANY'S 1994 AND 1995 ENERGY EFFICIENCY INCENTIVES PROGRAMS, AGRICULTURAL SECTOR MEASURES:

PG&E Study ID number: 315R2, 321R2, 329R2, 331R2

March 1, 2001

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Disclaimer of Warranties and Limitation of Liabilities

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Sixth Year Measure Retention Study of Pacific Gas & Electric Company's Agricultural Sector
1994 and 1995 Nonresidential Energy Efficiency Incentives Programs
Study IDs: 315R2, 321R2, 329R2, & 331R2

Purpose of Study

The purpose of the attached study is to document the level of measure retention in the sixth year after installation and to estimate the ex post effective useful life (EUL) values for PG&E's 1994 and 1995 Agricultural Energy Efficiency Incentives (AEEI) Programs. As required, the 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" (Protocols), 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, and 98-03-063. The study covers measures representing the top 50% of the estimate resource value, as required by the Protocols. These measures include pump retrofit, greenhouse heat curtain, ag pumps other, and high intensity discharge lighting measures. The AEEI Program promoted the purchase of energy efficient technologies to the agricultural sector through financial incentives paid to agricultural participants.

Methodology

When PG&E conducted the 1994 and 1995 impact studies, it created retention panels documenting the equipment type and location for approximately 150 sites per program year. These sites were revisited in 2000 to assess whether the measures were still "in place and operable", as required by the Protocols. The resultant data was then analyzed using three basic approaches to estimating EULs. These were a classic survival analysis, the standard ordinary least squares, and the assumed functional form approach.

Study Results

Of the measures studied, the pump retrofit and greenhouse heat curtain measures were the only measures with enough failures (i.e., not "in place and operable") to allow analysis. The pump retrofit measure produced a measure life estimate that was statistically indistinguishable from the EUL estimate filed and accepted by the Office of Ratepayer Advocates (ORA) after the third year retention study (third year EUL estimate).[1] However, the greenhouse heat curtain measure still had 95% of the measures "in place and operable" at the six year point, making it obvious that the original 5 year ex ante EUL, which was retained after the third year retention study, is incorrect. The green house heat curtain analysis projects a sixth year ex post EUL of 15.2 years, leading to a claimed EUL of 15 years. The remainder of the measures had too few failures to allow assessment of an ex post EUL, so the third year EULs were retained.

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[1] The third year retention study results did not reject any of the ex ante estimates, thus all ex ante estimates were retained as estimated third year EULs.

PG&E's 1994 Agricultural Sector Energy Efficiency Incentive Programs
Summary of Ex Post Effective Useful Life Estimates from 6th Year Retention Study

		EUL		**Upper 80% CL**	**Lower 80% CL**	**EUL for Claim**
Measure Description	**Code**	**3rd Yr.**	**Ex Post**	**Ex Post**	**Ex Post**	**-**
Pump Retrofit	A1	9.0	9.4	10.6	8.1	9.0
Greenhouse Heat Curtain	A10	5.0	15.2	25.1	5.3	15.0
HID Fixture: Interior, 251-400 Watt Lamp	L81	16.0	NA	NA	NA	16.0
"Like" Measures for HID Fixture: Interior, 251-400 Watt Lamp						
HID Fixture: Interior, 101-175 Watt Lamp	L26	16.0	NA	NA	NA	16.0
HID Fixture: Interior, 176-250 Watt Lamp	L27	16.0	NA	NA	NA	16.0
HID Fixture: Interior, >=176 Watt Lamp	L37	16.0	NA	NA	NA	16.0

If the measure shows NA for the Ex Post EUL, it is because there were too few failures to analyze.

PG&E's 1995 Agricultural Sector Energy Efficiency Incentive Programs
Summary of Ex Post Effective Useful Life Estimates from 6th Year Retention Study

		EUL		**Upper 80% CL**	**Lower 80% CL**	**EUL for Claim**
Measure Description	**Code**	**3rd Yr.**	**Ex Post**	**Ex Post**	**Ex Post**	**-**
Pump Retrofit	A1	9.0	9.4	10.6	8.1	9.0
Ag Pumps Other	609	20.0	NA	NA	NA	20.0
HID Fixture: Interior, 251-400 Watt Lamp	L81	16.0	NA	NA	NA	16.0
"Like" Measures for HID Fixture: Interior, 251-400 Watt Lamp						
HID Fixture: Interior, 101-175 Watt Lamp	L26	16.0	NA	NA	NA	16.0
HID Fixture: Interior, 176-250 Watt Lamp	L27	16.0	NA	NA	NA	16.0
HID Fixture: Interior, >=176 Watt Lamp	L37	16.0	NA	NA	NA	16.0

If the measure shows NA for the Ex Post EUL, it is because there were too few failures to analyze.

Regulatory Waivers and Filing Variances

A waiver concerning earnings calculation methodology is included for completeness. There were no variances from the E-Tables.

Equipoise Consulting, Inc.

Energy Analysis
Project Management
Training

Final Report for

6th Year Retention Study of Pacific Gas & Electric's 1994 and 1995 Energy Efficiency Incentives Programs, Agricultural Sector Measures

Submitted by:

Equipoise Consulting Incorporated

in association with

California AgQuest Consulting Inc.

and

Ridge & Associates

February 20, 2001

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Executive Summary

This report presents the results of the 6th year retention study of Pacific Gas and Electric Company's (PG&E) Paid Year (PY) 1994 and PY 1995 Agricultural Programs. The *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs* (Protocols)[2] call for a retention study of the Effective Useful Life (EUL) for the agricultural sector three and six years after the measures are installed. A 3rd year retention study for the 1994 and 1995 Agricultural Programs was completed and filed on March 1, 1999 (Study IDs 315R1, 321R1, 329R1, & 331R1).

According to the Protocols, a measure retention study is "to collect data on the fraction of measures or practice remaining in a given year that will be used to produce a revised estimate of its effective useful life."[3] This study uses, where possible, classic survival, ordinary least squares, and assumed functional form analyses of the retention data to assess whether the sixth year ex post estimates should replace the EUL estimates filed and accepted by the Office of Ratepayer Advocates (ORA) after the third year retention study (third year EUL estimate).[1] The studies assessed EULs for measures representing 56% of the avoided cost for measures installed in the 1994 and 78% of the measures installed in 1995 in the Agricultural Sector.

Exhibit ES 1 shows the third year EULs for the measures assessed, the recommended sixth year ex post EUL, and the best estimate of ex post EUL with its 80% confidence interval, for all measures assessed. Throughout this document the term ex post refers to sixth year estimates.

ES 1
Ex Ante and Ex Post EUL Estimates for PY 1994/95 (Years)

Measure	3rd Year Value	Ex Post Recommended	Best Ex Post Model with 80% Confidence Interval
HID Lighting	16	16	Too few failures to analyze.
Other Pumping	20	20	Too few failures to analyze
Pump Repair	9	9	9.4 (8.1 - 10.6)
Greenhouse Heat Curtain	5	15	15.2 (5.3 - 25.1)

HID Lighting and Other Pumping measures, with 0.3% and 9% failure rates respectively, could not be meaningfully analyzed using existing techniques. Therefore, the third year values are retained.

While the pump repair measure had sufficient failures (23% overall), the majority of the analysis results supported retention of the third year EUL of nine years.

[1] The third year retention study results did not reject any of the ex ante estimates, thus all ex ante estimates were retained as estimated third year EULs.
[2] D.93-05-063 As adopted by California Public Utilities Commission Decision 93-05-063, revised June, 1999, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-05
[3] Protocols, Table 8A, footnote 2.

With 94% of the greenhouse heat curtains square footage still in place and operable after five years, the third year estimate of five yeas is clearly unsupportable. The log-normal model estimated EUL of 15.2 years, resulting in a recommendation of 15 years. However, model estimates have a wide confidence interval, and data and model uncertainties suggest caution in interpreting these results.

1. OVERVIEW

Energy-efficiency measures installed by Demand-Side Management (DSM) programs all have a predicted time period when the measures are expected to provide energy savings. This period of time, called the engineering useful life in the *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs* (Protocols)[4], is the engineering estimate of the number of years that a piece of equipment will operate if maintained properly. However, equipment is removed from operation for a myriad of reasons. When the engineering useful life is adjusted for early removal, the effective useful life (EUL) is determined. The Protocol definition of EUL is "an estimate of the median number of years that the measures installed under the program are still in place and operable." The EUL is, then, the median period of time it takes to go from 100% to 50% of the measures installed. According to the Protocols, a measure retention study is "to collect data on the fraction of measures or practice remaining in a given year that will be used to produce a revised estimate of its effective useful life."[5]

The Protocols call for a retention study of the EULs for the agricultural sector three and six years after the measures are installed. A 3rd year retention study for the 1994 and 1995 Agricultural Programs was completed and filed on March 1, 1999 (Study IDs 315R1, 321R1, 329R1, & 331R1). This report is of the 6th year retention of the 1994 and 1995 Agricultural Programs.

For each planned retention study, there are specific measures from each year for which EULs are, if possible, to be updated. These planned measures are shown in Exhibit 1.1.

Exhibit 1.1
Planned Measures for Retention Study

PG&E Program Year	PG&E Measure Code	Measure Description	# of Paid Units	Life Cycle Avoided Cost	Project Life	% of Total Avoided Cost
1994	A1	Pump Retrofit	850	11,205,499	9	28%
1994	A10	Greenhouse: Heat Curtain	2,275,350	3,581,667	5	9%
1994	L81	HID Fixture: Interior, 251-400 Watts Lamp	3,619	5,763,910	16	15%
Total % of Avoided Cost for 1994 Program Year						52%
1995	609	Ag Pumps Other	12	7,608,217	20	42%
1995	A1	Pump Retrofit (Repair)	295	3,224,333	9	18%
1995	L81	HID Fixture: Interior, 251-400 Watts Lamp	2,136	3,289,414	16	18%
Total % of Avoided Cost for 1995 Program Year						77%

There were three non-studied, or "like," measures associated with one of these studied measures. These measures are shown in Exhibit 1.2.

[4] D.93-05-063 as adopted by California Public Utilities Commission Decision 93-05-063, revised June, 1999, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, 98-03-063, and 99-06-05.
[5] Protocols, Table 8A, footnote 2.

Exhibit 1.2
Non-studied Measures Associated to Studied Measures

Studied Measures		Non-Studied Measures		Rationale
PG&E Measure Code	**Measure Description**	**PG&E Measure Code**	**Measure Description**	**Reason Measures are Comparable**
L81	HID Fixture: Interior, 251-400 Watts Lamp	L26	HID Fixture: Interior, 101-175 Watts Lamp	All HID interior applications are similar. The participant to participant (or application) variation is accounted for in the range of applications studied in the retention study.
		L27	HID Fixture: Interior, 176-250 Watts Lamp	
		L37	HID Fixture: Interior, >=176 Watts Lamp	

When the avoided costs for these "like measures" are added to the values in Exhibit 1.1 56% of the avoided cost for 1994 and 78% of the avoided cost for 1995 are being assessed.

The data collection process, analysis methodology, and analysis results for the 6th year retention of the 1994 and 1995 Agricultural Program measures are presented next.

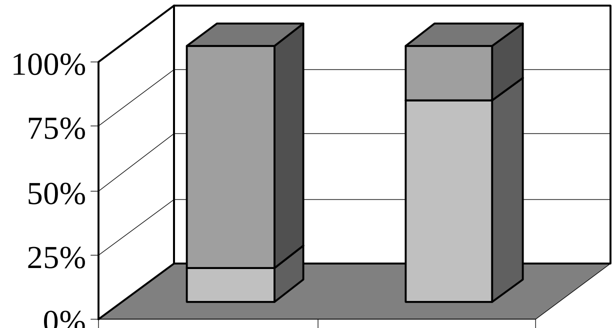
2. DATA COLLECTION

The 1994 and 1995 Agricultural Programs Impact Studies created retention databases specific to each year. These databases, assembled in the fall of 1995 and 1996, respectively, collected information on measures so that they could be located later and the extent to which they were "in place and operable" could be assessed. As required by the Protocols, the retention database measures were selected to represent "the top ten measures, excluding measures that have been identified as miscellaneous (per Table C-9), ranked by net resource value or the number of measures that constitutes the first 50% of the estimated resource value, whichever number of measures is less." The 1994 retention panel collected baseline data on three measures: pump repairs, low-pressure sprinkler nozzles, and greenhouses. The greenhouse measure included heat curtains, rigid double-walled, and double-walled polyethylene. Reassessment during the third year retention study revealed that the low-pressure sprinkler nozzle measures and the rigid double-walled and double-walled polyethylene greenhouse measures were not included in the "measures that constitutes the first 50% of the estimated resource value," and thus did not require evaluation for retention. Therefore, only data from those measures shown in Exhibit 1.1 were collected for this study. Additionally, the 1994 retention panel did not collect baseline information for the HID lighting measure, yet it is one of the top 50% by avoided cost.[6] Failure rates from the 1995 program year measures have been applied to the 1994 measures for the EUL analysis. This is the same approach used in the third year EUL assessment for the 1994-95 program years. The 1995 retention panel included pump repairs, other pumping (custom sites which included pumping), and high-intensity discharge (HID) fixtures.

As Exhibit 2.1 indicates, there were 883 total measures installed in the 1994 program for the two measures encompassed by the retention panel. Information for 138 individual measure installations (15% of the total) was gathered for the 1994 retention database.

[6] Early retention efforts under the Protocols were hampered by inconsistencies and lack of clarity in the Protocol language. Best efforts employed in attempts to satisfy the intention of the Protocols often did not meet the needs of later studies under more clearly defined, revised Protocol language.

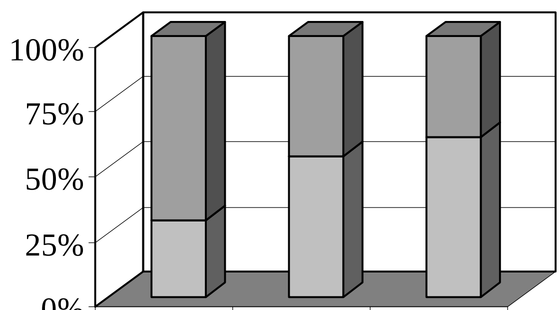
Exhibit 2.1
1994 Retention Panel and Program Population



	Pump Repair	Greenhouse Heat Curtains
1994 Measures Not in Retention Panel	738	7
1994 Retention Database	112	26

Similarly, Exhibit 2.2 shows that there were 365 total measures installed in the 1995 program for the three measure types covered by the 1995 retention panel. Information for 125 measures (34%) was gathered for the 1995 retention database.

Exhibit 2.2
1995 Retention Panel and Program Population



	Pump Repair	HID	Custom
1995 Measures Not in Retention Panel	209	24	7
1995 Retention Database	86	28	11

During the 3rd year retention study, a few points dropped out due to failures. Exhibit 2.3 shows the sample population for this 6th year retention study.

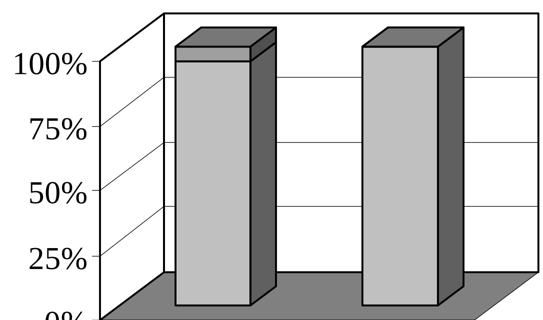
Exhibit 2.3
Sample Size

Measure	Measure Code	1994 and 1995 Program Year 1994	1994 and 1995 Program Year 1995	Total
Pump Repair	A1	106	81	187
Greenhouse HC	A10	26	0	26
HID lighting	L81	0	28	28
Custom	609	0	11	11
Total		132	120	252

The 6th year retention study audited sites that were previously considered as failures (during the 3rd year 1994-95 retention study) because they had switched to diesel fuel. The auditors checked to see if the site had reconnected to the electrical grid or continued to use diesel fuel. Additionally, the evaluation audited sites that are still on the electrical grid, but no longer have PG&E as their electric utility.

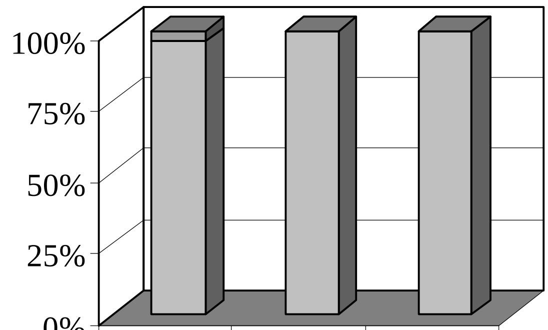
The same firm that gathered data for both the original 1994 and 1995 retention panels also collected the information for the 3rd year retention study and this 6th year retention study. Sixth year retention data was collected in the Fall of 2000 for both the 1994 and 1995 retention databases. Using the sample size from Exhibit 2.3, a census of sites was conducted. As shown in Exhibit 2.4 and Exhibit 2.5, 126 of the PY1994 132 sites (95%) were audited, and 117 of the PY1995 120 sites (98%) were audited.

Exhibit 2.4
1994 Retention Panel Evaluation Audits



	Pump Repair	Greenhouse Heat Curtains
1994 Retention Database Sites Not Audited	6	0
Year 2000 Retention Audits	100	26

Exhibit 2.5
1995 Retention Panel Evaluation Audits



	Pump Repair	HID	Custom
1995 Retention Database Sites Not Audited	3	0	0
Year 2000 Retention Audits	78	28	11

Once contacted by telephone or in person, the customer was asked a series of questions to determine if the measure was still in place and operable (see Appendix C). If the measure was no longer in place or was not operable, the customers were asked why not and when the measure had been removed from service. Also, for greenhouse and HID measures, the percentage of equipment still in place and operable was determined.

3. METHODOLOGY

Three basic approaches to estimating EULs were explored. The first approach used was a *classic survival analysis* of the data collected in this study. This approach involves the analysis of data that correspond to time from a well-defined time origin until the occurrence of some particular event or end-point (Collett, 1994). This approach is considered to be the most accurate since formal survival models can adjust for right, left, and interval censoring. The other two approaches cannot make any such adjustments. The other two approaches are used (1) when a classic survival model *cannot* be estimated, or (2) as a sanity check, if the classic survival model *can* be estimated. The second approach was the standard *ordinary least squares* (OLS) (Maddala, 1992). This involved regressing the percentage of measures still in place and operable against time (i.e., months since the installation). The third approach is the *assumed functional form* (AFF) approach (Wright, 1999). The AFF assumes a functional form and involves conducting a survey at a given point in time after the installation The collected data are then used in conjunction with the functional form to estimate the EUL.

Below is a description of the details of the most statistically rigorous approach, classic survival analysis, followed by a description of the OLS and the AFF.

3.1 Classic Survival Analysis

The first part of this section describes the appropriate unit of analysis. This is followed by a description of various issues surrounding survival analysis in the context of this study, including left versus right censoring, the hazard function, precision, covariates, hypothesis testing, and required failures.

3.1.1 Units of Analysis

The unit of analysis for the survival estimation is the survival unit being studied, such as patients or light bulbs. The unit of analysis is always a binary outcome - survival versus failure. For this study, the units of analysis are pumps, HID fixtures, custom installations, one thousand square feet units of greenhouse heat curtains, and acres of micro irrigation conversion that are no longer in place and operable.

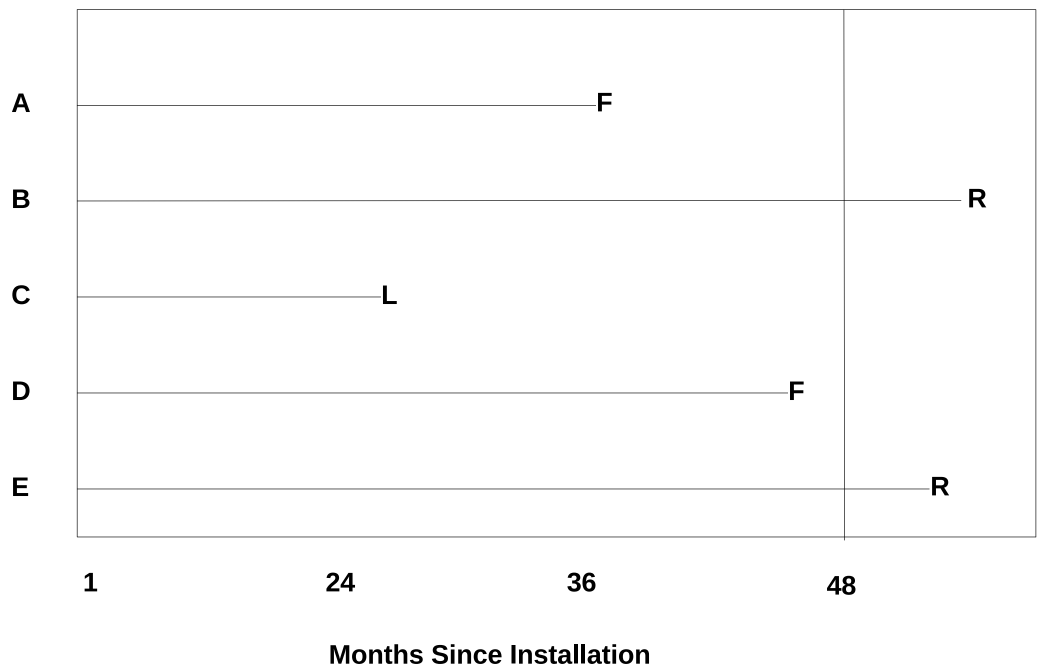
3.1.2 Left Censoring versus Right Censoring

In this survival analysis, a failure event is defined as a point in time at which a particular measure is no longer “in place and operable,” hereafter referred to as a “failure.” This implies the need to know not only that a given measure has failed but also when it failed.

Two concepts critical to this method are the right censoring and left censoring of the data. Right censoring of the data occurs when a measure is observed before the failure event occurs, i.e., the measure is still “in place and operable.” Left censoring occurs when the actual installation or failure date for a measure is unknown. Exhibit 3.1 illustrates the distinction between right and left censoring. The observation followed by an “L” is a case in which the measure did not survive until the 48th month, the month of observation, but the time of failure is still unknown. This is a case of “left” censoring. The observations by an “F” represent those cases in which the measure did not survive until the 48th month but for which the time of failure *is* known. These represent cases of “no” censoring. The observations marked by an “R” represent those cases in which the measure survived until the 48th month and will not fail until some time beyond the 48th month. These represent cases of "right" censoring. Both right censoring and left censoring can have significant impacts on the precision of any survival analysis.

Right censoring is inevitable when one conducts a three- or six-year follow-up on kWh savings associated with measures that have expected useful lives of 15 to 18 years. For example, in a six-year retention study, very few chiller or boiler measures (long life measures) in a small sample will have experienced failure. The problem with right censoring is that more measures that have experienced failure must be brought into the sample in order to produce a robust estimate of the EUL. Of course, right censoring is expected to be somewhat less of a problem in the case of measures that have a shorter EUL.

Exhibit 3.1
Right Versus Left Censoring



The problem of left censoring can be somewhat more easily mitigated by asking participants to report the time of failure. When a site was inspected, the evaluation team asked the customer when the measure failures occurred. The failures were defined as failures at that date. In using such an approach, analysis efforts must guard against the threat of measurement error since customers may not be able to remember the true failure date accurately. This can be handled through use of a hazard function.

3.1.3 Functional Forms

Initially the following general form of the constant hazard function was assumed:

$$h(t) = l \qquad (1.)$$

The corresponding survivor function is:

$$S(t) = e^{-l t} \qquad (2.)$$

This constant hazard implies an exponential distribution for the time until an event occurs.

However, because it was also realized that the probability of a measure not surviving increases with time (i.e., the hazard is not constant over time), the following four accelerated failure time (AFT) models were also explored:

1. Weibull:

$$S(t) = e^{\left[-(l t)^{K}\right]}$$

where

l = $\exp\{-[\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k]\}$

K = A constant whose value is greater than 0

Note that when K = 1 (a constant), the exponential model is specified.

2. Gamma

$$f(t) = \frac{l\,(l t)^{K-1} e^{-l t}}{\Gamma(K)}$$

where

l = $\exp\{-[\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k]\}$

Γ = The gamma function

K = $1/d^2$ (the shape parameter)

3. Log-logistic

$$S(t) = \frac{1}{1 + (l t)^{g}}$$

where

l = $\exp\{-[\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k]\}$

γ = $1/\sigma$

σ = Scale parameter

4. Log-normal

Since the log-normal cannot be expressed in closed form, it is presented as a regression model in which the dependent variable is the logarithm of the hazard:

$$\log h(t) = \log h_0(te^{-bx}) - bx$$

where

h_0 (.)= The hazard function for an individual with x = 0

Even if all the models agree on the coefficient estimates, they still have markedly different implications for the shape of the hazard function. The question is how to select the best model. To answer this question, the likelihood ratio statistic was used, which can be used to compare nested models[7]. This statistic is calculated by taking the difference in the likelihood ratios between two nested models and multiplying this difference by 2. This yields a likelihood-ratio chi-square statistic.

The first thing to note is that because the generalized gamma has one more parameter than any of the other models being considered, its hazard function can take on a wide variety of shapes. The exponential, the Weibull, and log-normal models (but not the log-logistic) are all special cases of the generalized gamma model. In addition, the generalized gamma can also take on shapes that are unlike any of these special cases. It also has hazard functions with a U or *bathtub* shape in which the hazard function declines, reaches a minimum, and then increases. Given the richness of the generalized gamma model, why not always use it instead of the other models? The main reason is that the formula for the generalized gamma model is rather complicated, involving the gamma function and the incomplete gamma function. Consequently, it is often difficult to judge the shape of the hazard function from the estimated parameters. By contrast, the hazard functions for the specific submodels can be rather easily described.

As a result, a number of models that are nested within the generalized gamma were estimated. Then any number of formal hypotheses tests were conducted by comparing the performance of each model to the generalized gamma. If the likelihood-ratio chi-square statistic suggests that the difference is not statistically significant, then the model using the more easily interpretable hazard function is adopted. Also note that the exponential is nested in the Weibull which can serve as another way of testing whether the hazard is constant or accelerated. Finally, recall that the log-logistic, because it is not nested within any other model, does not fit into the formal test of significance. It must be compared with the other models on the basis of the likelihood ratios alone and not on the basis of the likelihood-ratios chi square statistics.

3.1.4 Precision

The precision that one can achieve is in large part a function of the number of failures that one can expect to see in a study. The number of failures that one can expect to see is largely a function of the expected EULs. For example, in the hazard function (Equation 1), the median survival time is given by

[7] A model is said to be nested within another if the first model is a special case of the second

$$\hat{t}(50) = \hat{l}^{-1} \log 2 \qquad (3.)$$

with a standard error of

$$\text{s.e.}\{\hat{t}(50)\} = \frac{\hat{t}(50)}{\sqrt{r}} \qquad (4.)$$

where r is the number of failures within a sample. The more failures there are, the smaller the standard error and the greater the precision of the estimate. That is, the number of failures is directly related to the power of any survival analysis to determine whether any differences between re-estimated EULs and the third year EULs are statistically different at some predetermined level of confidence. Of course, in a third year or sixth year retention study, the number of failures for longer-EUL measures will be very small, while the numbers of failures associated with shorter-EUL measures will be more numerous. While the problem of right censoring may be somewhat serious for all measures, it may be particularly acute for the measures with longer EULs.

3.1.5 Covariates

In some retention studies, other factors that may affect the life distribution were investigated. If there are sufficient failures, one can determine whether some equipment experiences different rates of failure than others. In such a study, one can attempt to control for the heterogeneity of the determinants of measure survival. Also, note that the characteristics of each area that do not change over time can be controlled for by including an area/building-specific intercept in the model, i.e., each measure associated with a given area or building could have a common intercept. However, for this study, it was not possible to collect information on such variables.

3.1.6 Software

The Statistical Analysis System (SAS) software was used to estimate all survival functions. SAS has a wide range of procedures (e.g., LIFETEST, LIFEREG, and PHREG) that can handle right censoring and provide standard errors for each point on the survival curve, including the median.

3.1.7 Hypothesis Testing

The Protocols consider effective useful life to be that median number of years in which half of the units associated with a given measure (e.g., HID fixtures) installed in a given program year are still in place and operable. It turns out that in survival analysis, the median value is of greatest importance because the mean value is biased downward when there is right censoring, as may be the case in this study. Thus, the evaluation team's hypothesis test will focus on the third year and ex post median values.

The null hypothesis established for this phase of the analysis is that the measure-level EUL (a median value) estimated as a part of this research project is not statistically different from the third year EUL (a median value) at the 80% percent level of confidence, i.e.,

$$EUL_{ex\ post} = EUL_{third\ year}$$

For measures with relatively long expected useful lives, the hypothesis test is perhaps the most difficult task, since the model will be extrapolated to times that are beyond those that are actually observed. In such cases, the standard errors of the estimated medians will be substantial.

Along with the predicted medians, the standard errors of the medians were also produced. The 80% confidence interval was calculated by multiplying 1.28 (the t value associated with the 80% level of confidence) times the standard error. If the 80% confidence interval did not include the third year EUL, then the newly estimated ex post EUL was adopted. If the interval did include the third year EUL, then the third year will be retained.

3.1.8 Required Failures

Normally, for a classic survival analysis, one must attempt to estimate the number of failures needed to achieve the required level of precision and then determine the required sample size to produce the number of required failures. Prior to conducting any analysis of any particular measure, one should estimate the number of failures needed to achieve the required level of precision. This estimate requires that one make a number of other assumptions in addition to the confidence level. For example, how big a difference between the third year and the ex post EULs (the so-called effect size) should the statistical test be able to detect as significant? This is a particularly critical factor since the sample size is, to a large extent, a function of the effect size. As the expected size of the effect increases, the required size of the sample decreases.

Having said this, it is noted that the sizes of the samples for this retention study were not designed with the expected number of required failures in mind. Also note that because PG&E's approach relies on retention panel data collected during the first-year impact evaluation, there is no possibility of increasing the sample sizes in the event that the number of failures is insufficient. In subsequent retention studies, it is recommended that, whenever possible, a power analysis be conducted so that the required number of failures and the sample size needed to obtain these failures can be determined.

The example below illustrates how one can estimate the required number of failures. For this calculation, the exponential functional form could be assumed to produce a range of required sample sizes. The following assumptions could be made:

- a power of 0.8 or 0.7
- an alpha of 0.20 (i.e., 80% confidence level)
- a third year EUL of 9 years for pumps and the appropriate level for the other measures
- a range of possible effect sizes, Δ

The calculation of the effect size requires some further explanation. If one assumes that the survival curves have an exponential distribution, then:

$$p_{\mathrm{T}} = \mathrm{S}(t) \exp(-l_{\mathrm{T}} t) \qquad (5.)$$

where p_T is the proportion of measures surviving at some fixed time t and l_T is the constant hazard for a given measure. Equation 5 can be rewritten as

$$l_{\mathrm{T}} = \frac{-\log p_{\mathrm{T}}}{t} \qquad (6.)$$

In a similar way, one can obtain for the third year EUL at the same time t

$$l_{\mathrm{C}} = \frac{-\log p_{\mathrm{C}}}{t} \qquad (7.)$$

Thus, the effect, Δ, is defined as

$$\frac{l_T}{l_C} \qquad (8.)$$

Specifically for the median, the following equation holds

$$\Delta = \frac{l_{\mathrm{T}}}{l_C} = \frac{\mathrm{M_C}}{\mathrm{M_T}} \qquad (9.)$$

where M_C is the estimated median survival time based on the sample in this study, while M_T is the estimated median survival time for the third year EUL.

It can be shown that if an equal number of subjects are allocated to each treatment, the total number of events, E, that need to be observed in a study comparing two treatment groups is given approximately by:

$$\mathrm{E} = [(\mathrm{Z}_{1-a} + Z_{1-b})(1+\Delta)/(1-\Delta)]^2 \qquad (10.)$$

where $Z_{1-a/2}$ is the upper point of the standard normal distribution and Z_{1-b} is the power of the test.

Using Equation 10 and the assumptions listed earlier, the number of required failures could be calculated. However, an adjustment must be made to these numbers that accounts for the fact that there is only one group that has a known distribution, the sample of sites and their associated measures in this study. The third year EUL has no distribution; it is just an *a priori* engineering assumption. Such an adjustment should be done in order to account for the fact that only half of the sampling error is present. For example, an adjustment factor of 0.50 could be used to determine the number of required failures for the required precision.

3.1.9 Tied Survival Times

The survival models described above assume that the hazard function is continuous and, under this assumption, tied survival times are not possible. Some ties were present in all the data for pumps and heat curtains.

However, the number of ties in the heat curtain data set was so great that it severely affects the sensitivity of any analysis. At a given point in time, only a percentage of the installed heat curtains fail or are removed for some other reason. In what units did they fail? That is, do they fail in units of 10,000 square feet, 5,000 square feet, 1,000 square feet, etc.? After some discussion with the data collection team, it was decided to convert the square feet of installed heat curtains at each site into units of 1,000 feet. This choice of a unit was based on an assumption that when heat curtains fail or are removed, this happens in units of 1,000 square feet. This resulted in a data set with 1,815 observations, each representing 1,000 square feet of heat curtains. Of these 1,815 observations, there were 115 failures, again, each representing 1,000 square feet. This choice of units provided a sufficient number of failures with which to estimate a model. Note that one site accounted for 27 failures, while the second site accounted for 89 failures.

3.2 Ordinary Least Squares

The first alternative approach used was the familiar ordinary least squares (OLS) regression that estimates the relationship between time and the percentage of measures remaining that are still present and operable (Maddala, 1992). The following model was estimated for each measure where there were an adequate number of observations.

$$\mathrm{PR} = a + bt + e \qquad (11.)$$

where

PR = Percentage remaining

b = The change in the Percentage Remaining due to a one unit change in t (months)

a = A constant that captures the Percentage Remaining through an unspecified set of variables

e = The error term that capture changes in Percentage Remaining that are not explained by the model

Once this model was estimated, it was evaluated at values of t until the percentage remaining equaled 50%. The value of t that produced 50% was the chosen estimate of the EUL.

3.3 Assumed Functional Form

The assumed functional form (AFF) approach was explored next. The AFF first assumes a functional form, such as the logistic or exponential. Next, a survey is conducted at a given point in time after the installation. The results of the survey are entered into an equation that describes the functional form that has been manipulated algebraically to derive the EUL associated with 50% survival. This method has most recently been developed by Wright (1999). Wright begins with the exponential survival function:

$$S(t) = e^{-lt} \qquad (12.)$$

Here the mean survival time is equal to $1/l$. The EUL is defined as the value of t that satisfies the equation $S(t) = e^{-lt}$ = 0.5. Solving for t=EUL, one obtains

$$EUL = -\frac{\ln(0.5)}{l} \qquad (13.)$$

If one observes $\hat{S}$ in a sample with average measure age t, then one can solve the survival function for

$$\hat{l} = -\frac{\ln(\hat{S})}{t} \quad . \qquad (14.)$$

If one substitutes this equation in the preceding one, one obtains

$$E\hat{U}L = \frac{t \ln(0.5)}{\ln(\hat{S})} \qquad (15.)$$

Thus, for example, if one finds that, in a sample of 100, 90% survive and that the average age of the surviving units is three years, then the estimated EUL is 19.7 years.

3.4 Confidence Intervals

3.4.1 Classic Survival Analysis

Standard errors around the estimated median EUL are automatically produced by SAS for a classic survival analysis. However, these standard errors may be less precise than they appear and thus can affect the testing of the null hypotheses that the third year EUL is equal to the ex post EUL. This problem and the solution used are described below.

Using a simple random sampling (SRS), the assumption is that the observations are independent and identically distributed (IID). However, when sampling units within sampled sites, i.e., a cluster sample, this assumption may be violated. For example, when a pump or a square foot of heat curtain fails or is removed for some other reason, it is likely that other pumps or additional square feet of heat curtain also fail or are removed for some other reason. The effect of such intra-cluster correlation is to inflate the standard errors. SAS makes no such correction for intra-class correlation and thus underestimates the size of the standard error, making the estimates seem more precise than they really are. This of course affects hypotheses testing, making it easier to reject the null hypothesis, which, in this case, is that the third year EUL is equal to the ex post EUL.

Skinner (1989) provides a way to adjust the standard errors to correct for such inflation. Skinner estimated the design effect as:

$$\text{deff} = 1 + (N-1)t \qquad (16.)$$

where

N= The average number of sample points per site

t = The intra-cluster correlation

The standard error is adjusted by the design effect factor, which equals $\sqrt{deff}$. Unfortunately, with so few failures/removals, only the intra-cluster correlation can be estimated. For this analysis, it was assumed that the intra-cluster correlation is 0.50. This is based on an assumption that removals are perfectly correlated and removals for other reasons are perfectly uncorrelated.

3.4.2 Ordinary Least Squares

The pump repair measure was the only measure found to have enough failures for this type of analysis. The 80% confidence intervals shown in the tables in section 5 were calculated using the approach shown below.

The variance of the model error (the residuals) is first estimated using Equation 17 (Pindyck and Rubinfeld, 1981).

$$s^2 = \frac{1}{T-2} \Sigma(Y_t - \hat{Y}_t)^2 \qquad (17.)$$

The variance of the forecast error is then estimated using Equation 18.

$$s_f^2 = s^2\left[1 + \frac{1}{T} + \frac{(X_{T+1} - \overline{X})^2}{\sum (X_t - \overline{X})^2}\right] \qquad (18.)$$

Finally, the calculation of the confidence interval around each forecasted point is then done using Equation 19.

$$\hat{Y}_{T+1} \ +/- \ t_{.20} s_f \qquad (19.)$$

The 80% confidence interval for the percentage of pump repairs surviving is very small. There are two primary reasons for this. First, the pump forecast is unconditional, since the explanatory variable, time, is known with certainty for the entire forecast period. This absence of error around future explanatory values removes a large source of forecasting error. Second, the model has a very high R2 of 0.891, leading to a very small model error using Equation 17.

However, the percentage of pump repairs surviving is not an EUL. The EUL is derived as follows. First the estimated model is evaluated at future values of time to determine when the forecasted percentage reaches 50%. The number of months associated with this 50% value are then divided by 12 to derive the EUL. To calculate the 80% confidence interval around this EUL, the upper and lower bounds surrounding the forecasted value of 50% were first determined. Then, forecasted values that are near to the upper and lower bounds are identified. The number of months associated with the upper and lower bounds are then divided by 12 to derive the upper and lower bounds of the EUL.

3.4.3 Assumed Functional Form

Once the EUL is estimated using Equation 15, the standard error for $\hat{S}$, the estimated proportion of the measures surviving is calculated. The upper and lower bounds of the estimated proportion at the 80% confidence level are then calculated. These upper and lower bounds are then used in Equation 19 to calculate the upper and lower bounds of the EUL.

4. RESULTS

The results are presented in two ways. First, the data are tabulated to see how many measures continued to be in place and operable in 2000. Second, if there are sites with measures removed, the EUL is determined (when possible) using the three analysis methods described in Section 3.

4.1 Survival of Measures

Exhibit 4.1 shows those measures in place and operable as of 2000.

Exhibit 4.1
1994 Program Measures In Place and Operable as of 2000

Measure	Measure Code	In Place and Operable		Total*
		Yes	No	
Pump Repair	A1	73	26	99
Greenhouse HC Sites	A10	24	2	26
Total		97	28	125

*Due to uncertainty in one audit, it was not included in analysis.

As shown above, about two-thirds of the 1994 retention panel pump repair measure were in place and operable. Two greenhouse heat curtain sites have had the measure removed. These removals represented about 6% of the total square footage of greenhouse heat curtain originally installed.

Exhibit 4.2 shows the measures audited during the evaluation of the 1995 program. About three-quarters of the pump repair measures were still in place and operable. The one failure for the HID lighting represented 0.3% of the installed HID fixtures. There was one other pumping measure (custom site) that had a failure.

Exhibit 4.2
1995 Program Measures In Place and Operable as of 2000

Measure	Measure Code	In Place and Operable		Total
		Yes	No	
Pump Repair	A1	63	15	78
HID Lighting Sites	L81	27	1	28
Other Pumping	609	10	1	11
Total		100	17	117

4.2 Effective Useful Life of Measures

Where possible, an EUL was to be determined for the measures indicated in Exhibit 1.1. The pump repair measure and greenhouse heat curtain measures had sufficient failures to support an EUL analysis, while HID lighting and Other Pumping measures did not. Each measure is discussed separately below.

4.2.1 HID Lighting - Default Value Retained

Because the 1994 retention panel did not include HID fixtures, the analysis used the failure rates seen in the 1995 retention panel HID measures. Since there were only 0.3% failures observed in the 1995 data, estimating time to the 50% measure failure point (i.e., the EUL) from this point would be futile. Thus the third year HID measure EUL of 16 years (Exhibit 1.1) was retained as the best estimate of effective useful life for both 1994 and 1995.

4.2.2 "Other Pumping" Measure – Default EUL Retained

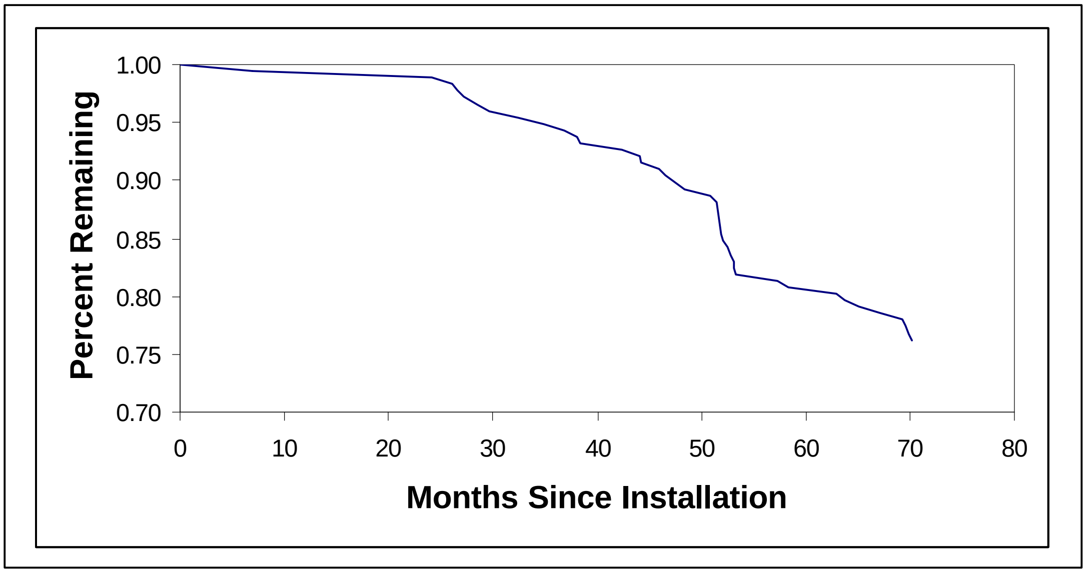
The "Other Pumping" measure only had a total of 12 sites in the 1995 program and has a third year EUL of 20 years (Exhibit 1.1). Of the 12 original sites, 11 made it into the baseline retention panel in 1995. As of the sixth year, one of these sites was no longer "in place and operable," and thus was designated a failure. Because of the small number of total sites, and the third year EUL of 20 years, using the defined techniques to evaluate an ex post EUL was not feasible. Thus the ex EUL of 20 years was retained as the best estimate of effective useful life for "Other Pumping" measures.

4.2.3 Pump Repairs

The pump repair measure had enough data for EUL analysis. The data from the two program years were combined and the three different analysis methods were applied to the data gathered on this measure.

First, the empirical survival function is presented. This is the function that the various approaches attempt to fit.

Exhibit 4.3
Empirical Survival Function for Pump Repairs



The average hazard rate is simply defined as the total number of failures (41) divided by the total number of observations (177). Thus, the average hazard rate is 0.232. The percentage of observations that are right censored is 0.768 (i.e., 1 - 0.232). Each technique will now be explored, beginning with the classic survival analysis.

Classic Survival Analysis

The exponential functional form, which assumes that hazard is constant, was tried first. Then four other functional forms that assumed that the probability of failure increased over time were tried.

These so-called accelerated failure time (AFT) models include the Weibull, the log-logistic, the log-normal, and the gamma. The results of these analyses are presented in Exhibit 4.4.

Exhibit 4.4
Estimated Pump Repair EULs and 80% Confidence Interval, by Functional Form

Functional Forms	EUL	80% Confidence	Log Likelihood
Log-logistic	10.0	8.5 - 11.4	-106.9
Weibull	9.40	8.1 - 10.6	-107.4
Log-normal	11.20	9.2 - 13.2	-106.9
Generalized Gamma	10.50	7.5 - 13.4	-106.8
Exponential	16.50	13.1 - 19.9	-117.6

Of the five models estimated, three have 80% confidence intervals that include the third year value of 9 years. The log-normal is only slightly greater than 9 years, and the exponential is more than 7 years greater.

Formal hypotheses tests were then conducted by comparing nested models. Exhibit 4.5 presents these results.

Exhibit 4.5
Pump Repair Model Comparisons

Comparisons	Likelihood-Ratio Chi-Square
Exponential vs. Weibull	20.58
Exponential vs. Generalized Gamma	21.78
Weibull vs. Generalized Gamma	1.2
Log-normal vs. Generalized Gamma	0.26

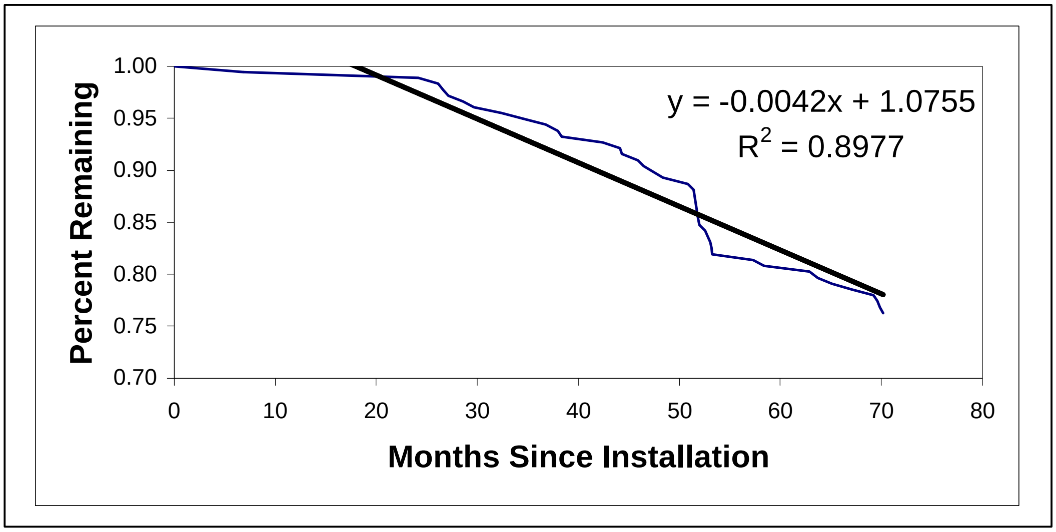
That the exponential model should be eliminated seems clear given that it produces an implausibly high EUL estimate (16.5 years) and very large chi-squares when compared to the Weibull and the generalized gamma. Thus, of the plausible models, three have 80% confidence intervals that include the third year value, and one, the log-normal, nearly includes it. As expected, the generalized gamma model has the best model fit with the largest log-likelihood. Moreover, neither the Weibull nor the log-normal are significantly different from the generalized gamma and the log-logistic model actually has a better fit than the Weibull and is nearly identical to the log-normal.

Except for the exponential model, these results strongly support the conclusion to accept the third year value of 9 years. Whether the Weibull or the log-normal is selected makes little difference since the conclusion is the same: accept the third year value of nine years. For reporting purposes, the results from the Weibull model (EUL=9.4 years) are recommended since it is both more familiar and mathematically simpler.

Ordinary Least Squares

Next, linear and exponential trend lines were fitted to the empirical survival function. The result for the linear model, which had the higher R^2, is presented in Exhibit 4.6.

Exhibit 4.6
Empirical Survival Function Versus Fitted Trend Line for Pump Repairs



The percentage remaining was forecasted until the median, 50%, was reached. The forecast error surrounding the 50% was four percentage points at the 80% level of confidence.

The 80% confidence interval for the percentage of pump repairs surviving is very small. There are two primary reasons for this. First, the pump forecast is unconditional, since the explanatory variable, *time*, is known with certainty for the entire forecast period. This absence of error around future explanatory values removes a large source of forecasting error. Second, the model has a very high R^2 of 0.898, leading to a very small model error, which has a direct effect on the forecast error.

However, the percentage of pump repairs surviving is not an EUL. The EUL is derived as follows. First, the estimated model is evaluated at future values of time to determine when the forecasted percentage reaches 50%. The number of months associated with this 50% value are then divided by 12 to derive the EUL. To calculate the 80% confidence interval around this EUL, the upper and lower bounds surrounding the forecasted value of 50% are first determined. Then, forecasted values that are near to the upper and lower bounds are identified and the number of months associated with each are divided by 12 to derive the upper and lower bounds of the EUL.

Thus, estimate of the EUL is 11.5 years, plus or minus 0.75 years, making the upper and lower bounds of the EUL 10.75 and 12.25, respectively. Because this confidence interval does not include 9, the third year EUL of 9 years is rejected using this method.

Assumed Functional Form

Next, the assumed functional form approach was used to estimate the EUL for pump repairs. The resulting EUL was 14.2 years. The 80% confidence interval was plus/minus 3.4 years. Because this interval excludes the third year value of 9 years, the third year value is rejected. However, this estimate is 58% greater than the third year, which is implausibly large. It is interesting to note that the estimate of 14.2 years is reasonably close to the 16.5 years estimated by the exponential model using classic survival analysis. However, as noted above, the formal hypotheses testing described above rejected, rather convincingly, the functional form as being exponential.

Conclusions

Based on the more robust classic survival analysis, the main conclusion is that the third year value of 9 years should be retained. The regression model estimate of 11.5 years is reasonably consistent with the estimate from the classic survival analysis. However, the estimate produced by the AFF model is implausibly large.

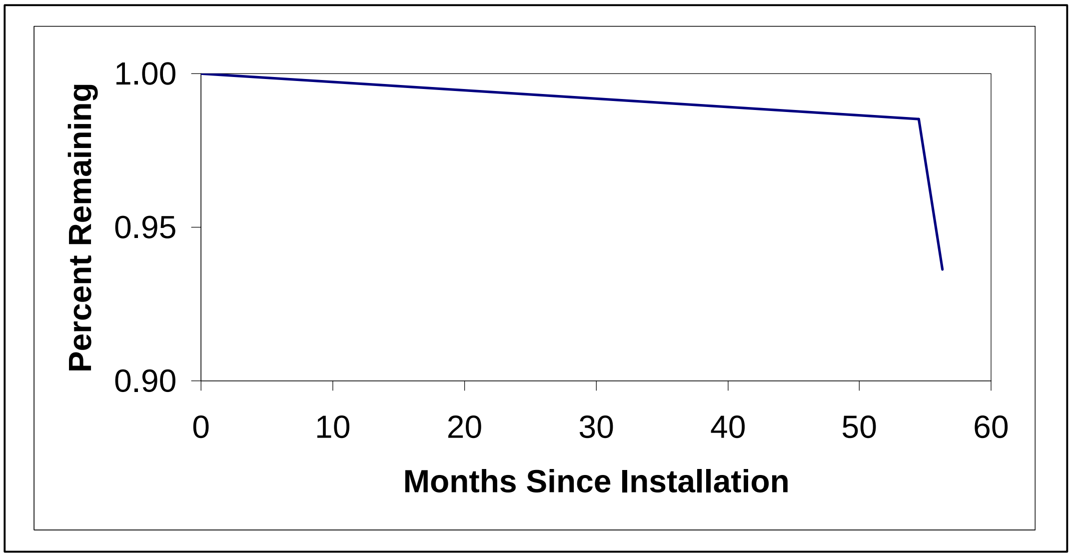
4.2.4 Heat Curtains

The greenhouse heat curtain measure from PY1994 had enough data for EUL analysis and was analyzed with the three different analysis methods.

Exhibit 4.7 shows the empirical survival function. A fit to this function was attempted using the three analysis approaches. The average hazard rate is simply defined as the total number of failures (116) divided by the total number of observations (1,815). Thus, the average hazard rate is 0.064. The percentage of observations that are right censored observations is quite high at 0.936 (i.e., 1 - 0.064).

It is important to note that only 2 of the 26 sites had heat curtains removed. These two removals represented about 6% of the total square footage originally installed. After over five years, 94% of the square footage of heat curtains is still in place and operable. Clearly, based on these preliminary results, the third year EUL of 5 years (Exhibit 1.1) is an underestimate. Each technique will now be explored, beginning with the classic survival analysis.

Exhibit 4.7
Empirical Survival Function For Heat Curtains



Classic Survival Analysis

A brief description of a problem that reduces the effectiveness of classic survival models is presented first. At a given point in time some percentage of the installed heat curtains will fail or will be removed for some reason. In what units did they fail? That is, do they fail in units of 10,000 square feet, 5,000 square feet, 1,000 square feet, etc.? After some discussion with the data collection team, it was decided to convert the square feet of installed heat curtains at each site into units of 1,000 square feet. That is, heat curtains fail or are removed in units of 1,000 square feet. This resulted in a dataset with 1,815 observations, each representing 1,000 square feet of heat curtains. Of these 1,815 observations, there were 116 failures, again, each representing 1,000 square feet. This choice of units provided a sufficient number of failures (116) with which to estimate a model. Note that one site accounted for 27 failures while the second site accounted for 89 failures. At each of these sites, all of the square footage removed was taken out at a single point in time, albeit a different point in time for each site.

Unfortunately, the manner in which the heat curtains were removed, and the manner in which this dataset was generated, created a large number of observations with the exact same dates and time duration, i.e., ties. Such a large number of ties is a problem because it reduces the sensitivity of any classic survival model. This problem may be intractable, suggesting that normal techniques of assessing survival for heat curtains may not be appropriate. Nevertheless, each technique was explored, beginning with the exponential model.

The exponential functional form, which assumes that hazard is constant, was tried first. Then the four other functional forms that assumed that the probability of failure increased over time were tried. These so-called accelerated failure time (AFT) models include the Weibull, the log-logistic, the log-normal, and the gamma. The results of these analyses are presented in Exhibit 4.8.

Exhibit 4.8
Estimated Heat Curtain EULs and 80% Confidence Interval, by Functional Form

Functional Forms	EUL	80% Confidence	Log-Likelihood
Log-logistic	13.3	5.8 -20.8	-402.8
Weibull	12.4	6.1 - 18.7	-403.9
Log-normal	15.2	5.3 - 25.1	-393.7
Generalized gamma	11.5	6.1 - 16.9	-405.1
Exponential	66.3	19.0 - 113.6	-466.6

All five models estimated exclude the third year value of 5 years. Clearly, the estimate of 66.3 years produced by the exponential model is implausibly large and is rejected. All the remaining estimates are two to three times larger than the third year value.

Formal hypotheses tests were then conducted by comparing nested models. Exhibit 4.9 presents these results.

Exhibit 4.9
Heat Curtain Model Comparisons

Comparisons	Likelihood-Ratio Chi-Square
Exponential vs Weibull	125.44
Exponential vs. Generalized Gamma	123.18
Weibull vs. Generalized Gamma	2.26
Log-normal vs. Generalized Gamma	22.68

While the Weibull with a chi-square of 2.26 is not statistically different from the generalized gamma, the generalized gamma has the worst model fit, making any formal hypotheses testing misleading. From here on, only the log-likelihood statistics must be relied on. This leads to an acceptance of the results of the log-normal model which has the largest log-likelihood and an estimated EUL of 15.2 years with an 80% confidence interval (5.3 – 25.1 years) that does not include the third year value of 5 years.

However, caution is urged in interpreting these results. First, the data were heavily censored, making any extrapolations beyond the data risky. In the process of creating the dataset, a high number of tied data (observations with exactly the same dates and time duration) were generated. This reduces the sensitivity of any model, which may explain the poor performance of the generalized gamma. Finally, it is emphasized that not enough is known about the reasons for failure or removal of heat curtains, and, therefore the nature of the intra-cluster correlation.

Ordinary Least Squares

A trend analysis was not possible due to an inadequate number of observations.

Assumed Functional Form

Next, the assumed functional form approach was used to estimate the EUL for heat curtains. The resulting EUL was 64 years, with a lower bound at the 80% confidence interval of 57.2 years and an upper bound of 72.6 years. Because this interval excludes the third year value of five years, the third year value can be rejected. However, this estimate is implausibly large and cannot be accepted. It is interesting to note that, not surprisingly, this estimate is very close to that obtained from the exponential model from the classic survival analysis of 66 years, which was also rejected. Clearly, the functional form is not exponential.

Conclusions

Since the log-normal model estimated an EUL of 15.2 years, an ex post EUL of 15 years is recommended for greenhouse heat curtains. Unfortunately, there was little insight gained from the other approaches since there were not enough observations to estimate a regression model and the AFF model produced an implausibly large number. What is clear is that more than five years after the heat curtains were installed, 94% of the square footage is still in place and operable making the third year estimate of 5 years an obvious underestimate.

5. PROTOCOL TABLES

5.1 Protocol Table 6.B – 1994 Agricultural Sector

Refer to Section 3.4 for the method used to determine the confidence intervals shown in this table.

Protocol Table 6.B
Results of 6th Year Retention Study
PG&E 1994 Agricultural Sector
Study ID 315R2 and 321R2

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	3rd Yr., Ex Ante EUL	Source of Ex Ante EUL (ref. Ftnote)	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)
A1	Pump Retrofit	Pumping and Related	9.0	2, 3	9.4	9.0	0.970	8.1	10.6	0.20	1.00	-
L81	HID Fixture: Interior, Standard, 251-400 Watts Lamp	Ag Other	16.0	1, 3	NA*	16.0	NA	NA	NA	NA	NA	L26, L27, L37
A10	Greenhouse Heat Curtain	Ag Other	5.0	2, 3	15.2	15.0	7.7	5.3	25.1	0.80	3.0	-

*Not enough failures were found during the retention study for an EUL to be calculated

Ex Ante Source References:

1 PG&E Advice Filing 1867-G-A/1481-E-A January 1995
2 PG&E Advice Filing 1997-G/1608-E October 1, 1996
3 Retention Study of Pacific Gas & Electric Company's 1994 and 1995 Energy Efficiency Incentive Programs, Agricultural Sector Measures: Study Ids: 315R1,321R1, 329R1 and 331R1, March 1, 1999.

5.2 Protocol Table 6.B – 1995 Agricultural Sector

Refer to Section 3.4 for the method used to determine the confidence intervals shown in this table for the pump retrofit measure.

Protocol Table 6.B
Results of 6th Year Retention Study
PG&E 1995 Agricultural Sector
Study ID 329R2 and 331R2

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	3rd Yr., Ex Ante EUL	Source of Ex Ante EUL (ref. Ftnote)	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)
A1	Pump Retrofit	Pumping and Related	9.0	1, 4	9.4	9.0	0.970	8.1	10.6	0.80	1.00	-
609	Ag Pumps Other	Pumping and Related	20.0	2, 4	NA*	20.0	NA	NA	NA	NA	NA	-
L81	HID Fixture: Interior, Standard, 251-400 Watts Lamp	Indoor Lighting	16.0	3, 4	NA*	16.0	NA	NA	NA	NA	NA	L26, L27, L37

*Not enough failures were found during the retention study for an EUL to be calculated

Ex Ante Source References:

1 PG&E Advice Filing 1997-G/1608-E October 1, 1996
2 Calculated from MDSS Data
3 PG&E Advice Filing 1867-G-A/1481-E-A January 1995
4 Retention Study of Pacific Gas & Electric Company's 1994 and 1995 Energy Efficiency Incentive Programs, Agricultural Sector Measures: Study Ids: 315R1,321R1, 329R1 and 331R1, March 1, 1999.

5.3 Protocol Table 7 – 1994 Retention Study (Study # 315R2 and #321R2)

1994 Agricultural EEI Program
6th Year Retention Study
PG&E Study ID #315R2 and #321R2

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

5.3.1 Overview Information

5.3.1.1 Study Title and Study ID Number

Study Title:	6th Year Evaluation of Retention in Pacific Gas &Electric Company's 1994 Agricultural Energy Efficiency Incentives (AEEI) Program
Study ID Number:	315R2 and 321R2

5.3.1.2 Program, Program Year and Program Description

Program:	PG&E Agricultural EEI Program, Agricultural Sector
Program Year:	Rebates Received in the 1994 Calendar Year.
Program Description:	The 1994 Agricultural Program rebated technologies covered by the Retrofit Express (RE) and Customized Incentives (CI) Programs.

5.3.1.3 End Uses and/or Measures Covered

End Uses Covered:	Agricultural Pumping Technologies Agricultural Other Technologies
Measures Covered:	Pump Repair Greenhouse Heat Curtain HID Interior 251-400 W Lamps

5.3.1.4 Methods and Models Used

The PG&E AEEI Program retention study evaluated three methods: 1) classic survival analysis 2) ordinary least squares (OLS), and 3) assumed functional form (AFF).

Classic Survival Analysis: Pump Repair and Heat Curtains

In addition to the exponential model, which assumes a constant hazard, also estimated were a number of accelerated time failure (AFT) models, including:

1. Weibull:

$$S(t) = e^{[-(l t)^K]}$$

where

l = $\exp\{-[\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k]\}$

K = A constant whose value is greater than 0

Note that when K = 1 (a constant), the exponential model is specified.

2. Gamma

$$f(t) = \frac{l(lt)^{K-1} e^{-lt}}{\Gamma(K)}$$

where

l = $\exp\{-[\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k]\}$

Γ = The gamma function

K = $1/d^2$ (the shape parameter)

3. Log-logistic

$$S(t) = \frac{1}{1 + (lt)^g}$$

where

l = $\exp\{-[\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k]\}$

γ = $1/\sigma$

σ = Scale parameter

4. Log-normal

Since the log-normal cannot be expressed in closed form, it is presented as a regression model in which the dependent variable is the logarithm of the hazard:

$$\log h(t) = \log h_0(te^{-bx}) - bx$$

where

h_0 (.)= The hazard function for an individual with x = 0

Ordinary Least Squares

Pump Repair. The first alternative approach used was the familiar ordinary least squares (OLS) regression that estimates the relationship between time and the percentage of measures remaining that are still present and operable (Maddala, 1992). The following model was estimated for each measure where there were an adequate number of observations.

$$PR = a + bt + e$$

where

PR = Percentage remaining

b = The change in the Percentage Remaining due to a one unit change in t (months)

a = A constant that captures the Percentage Remaining through an unspecified set of variables

e = The error term that capture changes in Percentage Remaining that are not explained by the model

Once this model was estimated, it was evaluated at values of t until the percentage remaining equaled 50%. The value of t that produced 50% was the estimate of the EUL.

Heat Curtains. A regression model could not be estimated due to an insufficient number of observations.

Assumed Functional Form: Pump Repairs and Heat Curtains

$$E\hat{U}L = \frac{t \ln(0.5)}{\ln(\hat{S})}$$

where $\hat{S}$ = equal to survey-based estimate of the proportion of measures surviving

t = average measure age in the survey

The key inputs come from the site survey which provides the percentage surviving ($\hat{S}$) and the average age of the pumps (t). These two values are inserted into the equation above to derive the estimated EUL.

5.3.1.5 Analysis Sample Size

The analysis sample size is shown below in Exhibit 5.1.

Exhibit 5.1
Sample Summary – 1994 Agricultural Sector

Measure	Measure Code	1994 and 1995 Program Year		Total
		1994	1995	
Pump Repair	A1	99	78	177
Greenhouse HC	A10	26	0	26
HID lighting	L81	0	28	28
Custom	609	0	11	11
Total		125	117	242

Note that for greenhouse heat curtains, while there were 26 sites, the unit of analysis was 1,000 square feet of heat curtain. Converting the unit of analysis from the site (N=26) to units of 1,000 square feet generated a total of 1,815 observations that were used in the classic survival analysis.

5.3.2 Database Management

5.3.2.1 Specific Data Sources

On-site survey data were collected for a census of the 1994 retention panel. All data came directly from the retention panel except for the HID measures that were not included in the original 1994 retention panel. The failure rate from the 1995 retention panel HID data was applied to the HID measures from the 1994 MDSS database.

5.3.2.2 Data Attrition

All data elements mentioned above were first validated and then merged together to form the final analysis data set. All data points collected during the on-site audits were kept.

5.3.2.3 Internal Data Quality Procedures

The data quality procedures are consistent with PG&E's internal guidelines and the guidelines established in the Protocols. The on-site audits were validated by an agricultural engineer prior to data entry.

5.3.2.4 Unused Data Elements

The low-pressure sprinkler nozzle measure was not analyzed. All other data collected specifically for the Evaluation were utilized.

5.3.3 Sampling

5.3.3.1 Sampling Procedures and Protocols

The limited participant population necessitated an attempted census of retention panel participants. The number of completed participant surveys as mentioned above in section 5.3.1.5, reflects such an attempted census.

5.3.3.2 Survey Information

On-site audit instruments are presented in Appendix C.

5.3.3.3 Statistical Descriptions: Pump Repairs and Heat Curtains

The only variables in the model were whether the measure had failed and time. No covariates were available. Descriptive statistics for variables in the models are shown in Exhibit 5.2

Exhibit 5.2
Descriptive Statistics

End Use	Average Age (Years)	Standard Deviation	Percent Surviving
Pumping	5.53	1.10	76.3
Heat Curtains	6.11	0.53	93.6

5.3.4 Data Screening and Analysis

5.3.4.1 Outliers and Missing Data

When the failure date was unavailable, the date of removal was set as May of 1999, which is 1.5 years after the 3rd year retention evaluation completed its onsite audits. There were no outliers in the analysis.

5.3.4.2 Background Variables

There were no background variables modeled.

5.3.4.3 Data Screening Process

No data were screened from the retention analysis.

5.3.4.4 Model Statistics

Classic Survival Analysis

Pump Repairs. The following tables provide the basic model results for pump repairs using classic survival analysis.

Exhibit 5.3
Estimated Pump Repair EULs and 80% Confidence Interval, by Functional Form

Functional Forms	EUL	80% Confidence	Log Likelihood
Log-logistic	10.0	8.5 -11.4	-106.9
Weibull	9.40	8.1 - 10.6	-107.4
Log-normal	11.20	9.2 - 13.2	-106.9
Generalized Gamma	10.50	7.5 - 13.4	-106.8
Exponential	16.50	13.1 - 19.9	-117.6

Of the five models estimated, three have 80% confidence intervals that include the third year value of 9 years. The log-normal is only slightly greater than 9 years, and the exponential is more than 7 years greater.

Formal hypotheses tests were then conducted by comparing nested models. The table below presents these results.

Exhibit 5.4
Model Comparisons

Comparisons	Likelihood-Ratio Chi-Square
Exponential vs. Weibull	20.58
Exponential vs. Generalized Gamma	21.78
Weibull vs. Generalized Gamma	1.2
Log-normal vs. Generalized Gamma	0.26

Based on the more robust classic survival analysis, the main conclusion is that the third year value of 9 years should be accepted.

Heat Curtains. The following tables provide the basic model results for heat curtains using classic survival analysis.

Exhibit 5.5
Estimated Heat Curtain EULs and 80% Confidence Interval, by Functional Form

Functional Forms	EUL	80% Confidence	Log Likelihood
Log-logistic	13.3	5.8 -20.8	-402.8
Weibull	12.4	6.1 - 18.7	-403.9
Log-normal	15.2	5.3 - 25.1	-393.7
Generalized gamma	11.5	6.1 - 16.9	-405.1
Exponential	66.3	19.0 - 113.6	-466.6

All five models estimated exclude the third year value of 5 years. Clearly, the estimate of 66.3 years produced by the exponential model is implausibly large and is rejected. All the remaining estimates are two to three times larger than the third year value.

Formal hypotheses tests were then conducted by comparing nested models. The table below presents these results.

Exhibit 5.6
Model Comparisons

Comparisons	Likelihood-Ratio Chi-Square
Exponential vs. Weibull	125.44
Exponential vs. Generalized Gamma	123.18
Weibull vs. Generalized Gamma	2.26
Log-normal vs. Generalized Gamma	22.68

While the Weibull with a chi-square of 2.26 is not statistically different from the generalized gamma, the generalized gamma has the worst model fit, making the formal hypotheses tests misleading. From here, only the log-likelihood statistics are to be relied on. This would lead one to accept the results of the log-normal model, which has the largest log-likelihood and an estimated EUL of 15.2 with an 80% confidence interval that does not include the third year value of 5 years. Thus, based on the more robust classic survival analysis, the main conclusion is that the ex post value of 15 years should replace the third year value of 5 years.

However, caution is urged in interpreting these results. First, the data were heavily censored, making any extrapolations beyond the data risky. In the process of creating the dataset, a high numbers of tied data (observations with exactly the same dates and time duration) were generated. This reduces the sensitivity of any model, which may explain the poor performance of the generalized gamma. Finally, it should be emphasized that not enough about the reasons for failures or other reasons for removal of heat curtains is known, and, therefore, the nature of the intra-cluster correlation is unknown.

Ordinary Least Squares (OLS)

Pump Repair. The final model used for the pump repair measure only was an OLS model with time as the independent variable and percentage surviving as the dependent variable. The final model equation was:

$Y = 1.0755 - .0042X$

where:

Y = percentage surviving
X = months

The equation had an R^2 of 0.898.

Heat Curtains. A regression model could not be estimated due to an insufficient number of observations.

Assumed Functional Form

Pump Repair. The key inputs come from the site survey which provides the percentage surviving ($\hat{S}$) and the average age of the pumps (t).

Percentage Surviving	76.3%
Average Age of Pumps	5.53 years

These two values are inserted into the equation below to derive the estimated EUL.

$$E\hat{U}L = \frac{t \ln(0.5)}{\ln(\hat{S})}$$

Heat Curtains. The key inputs come from the site survey, which provides the percentage surviving ($\hat{S}$) and the average age of the pumps (t).

Percentage Surviving	93.6%
Average Age of Pumps	6.11 years

These two values are inserted into the equation below to derive the estimated EUL.

$$E\hat{U}L = \frac{t \ln(0.5)}{\ln(\hat{S})}$$

5.3.4.5 Model Specification: Pump Repairs and Heat Curtains

Classical Survival Analysis – Specification was not an issue since there were no other variables other than whether the measure had survived up to the time of the field survey and the date of installation. There were no covariates.

Assumed Functional Form Analysis – Specification is not an issue since the functional form is assumed.

OLS Analysis – Specification is not an issue since there was only one independent variable available, time. There were no covariates. The chosen model had the highest R^2 and, therefore, the best predictive power.

5.3.4.6 Measurement Errors

The main source of measurement errors is the on-site survey. The evaluation approach was to proactively stop the problem before it happens so that statistical corrections are kept to a minimum.

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and miscoded study variables. In this project, controls were implemented to reduce the systematic bias in the data. These steps include (1) thorough auditor training, and (2) instrument pre-test.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased.

5.3.4.7 Influential Data Points

Since the analysis used only the percentage of surviving pumps and time, there were no influential data points in any of the analyses. There were no outliers in any of the analyses.

5.3.4.8 Missing Data

When the failure date was unavailable, the date of removal was set as May of 1999, which is 1.5 years after the 3rd year retention evaluation completed its on-site audits. For the 1994 HID measures that were not included in the original 1994 retention panel, the failure rate from the 1995 retention panel HID data was applied to the HID measures from the 1994 MDSS database.

5.3.4.9 Precision

The precision was determined as specified in Section 3.1.4.

5.4 Protocol Table 7 – 1995 Retention Study (Study # 329R2 and #331R2)

1995 Agricultural EEI Program
6th Year Retention Study
PG&E Study ID #329R2 and 331R2

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

5.4.1 Overview Information

5.4.1.1 Study Title and Study ID Number

Study Title:	6th Year Evaluation of Retention in Pacific Gas &Electric Company's 1995 Agricultural Energy Efficiency Incentives (AEEI) Program
Study ID Number:	329R2 and 331R2

5.4.1.2 Program, Program Year and Program Description

Program:	PG&E Agricultural EEI Program, Agricultural Sector
Program Year:	Rebates Received in the 1995 Calendar Year.
Program Description:	The 1995 Agricultural Program rebated technologies covered by the Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customized Incentives (CI) Programs.

5.4.1.3 End Uses and/or Measures Covered

End Uses Covered:	Agricultural Pumping Technologies Agricultural Indoor Lighting Technologies
Measures Covered:	Pump Repair Ag Pumps Other (Measure 609) HID Interior 251-400 W Lamps

5.4.1.4 Methods and Models Used

The PG&E AEEI Program retention study evaluated three methods: 1) classic survival analysis 2) ordinary least squares (OLS), and 3) assumed functional form (AFF).

Classic Survival Analysis: Pump Repair

In additional to the exponential model, which assumes a constant hazard, also estimated were a number of accelerated time failure (AFT) models, including:

1. Weibull:

$$S(t) = e^{[-(l t)^K]}$$

where

l = $\exp\{-[\beta_0 + \beta_1 x_1 + ... + \beta_k x_k]\}$

K = A constant whose value is greater than 0

Note that when K = 1 (a constant), the exponential model is specified.

2. Gamma

$$f(t) = \frac{l\,(l t)^{K-1} e^{-lt}}{\Gamma(K)}$$

where

l = $\exp\{-[\beta_0 + \beta_1 x_1 + ... + \beta_k x_k]\}$

Γ = The gamma function

K = $1/d^2$ (the shape parameter)

3. Log-logistic

$$S(t) = \frac{1}{1 + (l t)^g}$$

where

l = $\exp\{-[\beta_0 + \beta_1 x_1 + ... + \beta_k x_k]\}$

γ = $1/\sigma$

σ = Scale parameter

4. Log-normal

Since the log-normal cannot be expressed in closed form, it is presented as a regression model in which the dependent variable is the logarithm of the hazard:

$$\log h(t) = \log h_0(te^{-bx}) - bx$$

where

h_0 (.)= The hazard function for an individual with x = 0

Ordinary Least Squares: Pump Repair

The first alternative approach used was the familiar ordinary least squares (OLS) regression that estimates the relationship between time and the percentage of measures remaining that are still present and operable (Maddala, 1992). The following model was estimated for each measure where there were an adequate number of observations.

$$PR = a + bt + e$$

where

PR = Percentage remaining

b = The change in the Percentage Remaining due to a one unit change in t (months)

a = A constant that captures the Percentage Remaining through an unspecified set of variables

e = The error term that capture changes in Percentage Remaining that are not explained by the model

Once this model was estimated, it was evaluated at values of t until the percentage remaining equaled 50%. The value of t that produced 50% was the chosen estimate of the EUL.

Assumed Functional Form: Pump Repairs

$$E\hat{U}L = \frac{t \ln(0.5)}{\ln(\hat{S})}$$

where $\hat{S}$ = equal to survey-based estimate of the proportion of measures surviving

t = average measure age in the survey

The key inputs come from the site survey which provides the percentage surviving ($\hat{S}$) and the average age of the pumps (t). These two values are inserted into the equation above to derive the estimated EUL.

5.4.1.5 Analysis Sample Size

The analysis sample size is shown below in Exhibit 5.1.

Exhibit 5.7
Sample Summary – 1995 Agricultural Sector

Measure	Measure Code	1994 and 1995 Program Year		Total
		1994	1995	
Pump Repair	A1	99	78	177
Greenhouse HC	A10	26	0	26
HID lighting	L81	0	28	28
Custom	609	0	11	11
Total		125	117	242

5.4.2 Database Management

5.4.2.1 Specific Data Sources

On-site survey data were collected for a census of the 1995 retention panel. All data came directly from the retention panel.

5.4.2.2 Data Attrition

All data elements mentioned above were first validated and then merged together to form the final analysis data set.

5.4.2.3 Internal Data Quality Procedures

The data quality procedures are consistent with PG&E's internal guidelines and the guidelines established in the Protocols. The on-site audits were validated by an agricultural engineer prior to data entry.

5.4.2.4 Unused Data Elements

All data collected specifically for the Evaluation were utilized.

5.4.3 Sampling

5.4.3.1 Sampling Procedures and Protocols

The limited participant population necessitated an attempted census of retention panel participants. The number of completed participant surveys as mentioned above in section 5.4.1.5, reflects that a census was audited.

5.4.3.2 Survey Information

On-site audit instruments are presented in Appendix C.

5.4.3.3 Statistical Descriptions: Pump Repair

The only variables in the model were whether the measure had failed and time. No covariates were available. Descriptive statistics for variables in the model are shown in Exhibit 5.2

Exhibit 5.8
Descriptive Statistics

End Use	Average Age (Years)	Standard Deviation	Percent Surviving
Pumping	5.53	1.10	76.3

5.4.4 Data Screening and Analysis

5.4.4.1 Outliers and Missing Data

When the failure date was unavailable, the date of removal was set as May of 1999, which is 1.5 years after the 3rd year retention evaluation completed its on-site audits. There were no outliers in the analysis.

5.4.4.2 Background Variables

There were no background variables modeled.

5.4.4.3 Data Screening Process

No data were screened from the retention analysis.

5.4.4.4 Model Statistics

Classic Survival Analysis: Pump Repair

The following tables provide the basic model results for pump repairs using classic survival analysis.

Exhibit 5.9
Estimated Pump Repair EULs and 80% Confidence Interval, by Functional Form

Functional Forms	EUL	80% Confidence	Log Likelihood
Log-logistic	10.0	8.5 -11.4	-106.9
Weibull	9.40	8.1 - 10.6	-107.4
Log-normal	11.20	9.2 - 13.2	-106.9
Generalized Gamma	10.50	7.5 - 13.4	-106.8
Exponential	16.50	13.1 - 19.9	-117.6

Of the five models estimated, three have 80% confidence intervals that include the third year value of 9 years. The log-normal is only slightly greater than 9 years, and the exponential is more than 7 years greater.

Formal hypotheses tests were then conducted by comparing nested models. The table below presents these results.

Exhibit 5.10
Model Comparisons

Comparisons	Likelihood-Ratio Chi-Square
Exponential vs. Weibull	20.58
Exponential vs. Generalized Gamma	21.78
Weibull vs. Generalized Gamma	1.2
Log-normal vs. Generalized Gamma	0.26

Based on the more robust classic survival analysis, the main conclusion is that the third year value of 9 years should be accepted.

Ordinary Least Squares: Pump Repair

The final model used for the pump repair measure only was an OLS model with time as the independent variable and percentage surviving as the dependent variable. The final model equation was:

Y = 1.0755 -.0042X

where:

Y = percentage surviving
X = months

The equation had an R^2 of 0.898.

Assumed Functional Form: Pump Repair

The key inputs come from the site survey, which provides the percentage surviving ($\hat{S}$) and the average age of the pumps (t).

Percentage Surviving	76.3%
Average Age of Pumps	5.53 years

These two values are inserted into the equation below to derive the estimated EUL.

$$E\hat{U}L = \frac{t \ln(0.5)}{\ln(\hat{S})}$$

5.4.4.5 Model Specification

Classical Survival Analysis – Specification was not an issue since there were no other variables other than whether the measure had survived up to the time of the field survey and the date of installation. There were no covariates.

Assumed Functional Form Analysis – Specification is not an issue since the functional form is assumed.

OLS Analysis – Specification is not an issue since there was only one independent variable available, time. The chosen model had the highest R^2 and, therefore, the best predictive power.

5.4.4.6 Measurement Errors

The main source of measurement errors is the on-site survey. The evaluation approach was to proactively stop the problem before it happens so that statistical corrections are kept to a minimum.

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and miscoded study variables. In this project, controls have been implemented to reduce the systematic bias in the data. These steps include (1) thorough auditor training, and (2) instrument pre-test.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased.

5.4.4.7 Influential Data Points

Since the analysis consisted of a simple regression of the percentage of surviving pumps by time, there were no influential data points in the OLS analysis. There were no outliers in the analysis.

5.4.4.8 Missing Data

When data were unavailable, the date of removal was set as May of 1999, which is 1.5 years after the 3rd year retention evaluation completed its on-site audits.

5.4.4.9 Precision

The precision was determined as specified in Section 3.1.4.

APPENDIX A

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APPENDIX B

CADMAC WAIVER

PACIFIC GAS & ELECTRIC COMPANY
REQUEST FOR RETROACTIVE WAIVER FOR
COMPANY WIDE MODIFICATION TO THIRD AND FOURTH EARNINGS
CLAIM CALCULATION METHODOLOGY
Study ID: All study IDs for all PG&E programs.
Date Approved: February 17, 1999

Summary of PG&E Request

This waiver requests deviations from, or clarifications of, the Protocols[8] by PG&E for the third earnings claim methodology for PG&E's 1994 programs and for all future third and fourth earnings claims. The Protocols, as written, require that all third and fourth earnings claim impacts be calculated as the sum of the measure level AEAP values as adjusted by appropriate ex post Technical Degradation Factors (TDF) and Effective Useful Life (EUL) values. Since all PG&E second earnings claim AEAP amounts are agreed at the end use level, PG&E does not have the measure level AEAP values. PG&E seeks approval to use the first year ex post evaluation measure level findings to allocate the AEAP end use values into estimates of individual measure savings. These measure level estimates will then be combined, as specified in the Protocols, with the measure level ex post EUL and TDF values to calculate the third and fourth earnings claims.

Proposed Waiver (see Table A for Summary)

PG&E seeks CADMAC approval to:

Use the first year ex post evaluation measure level findings to allocate the AEAP end use values into estimates of individual measure savings. These measure level estimates will then be combined, as specified in the Protocols, with the measure level ex post EUL and TDF values to calculate the Resource Benefit, Net for the third and fourth earnings claims.

Parameters and Protocol Requirements

Table 10, item A.3.b.1 and 2, and A.4.a. and b., require the Resource Benefits, Net to be calculated at the measure level, then summed, using the net load impacts as "determined in the second earnings claim AEAP."

Rationale

The Protocols, as written, require that all third and fourth earnings claim impacts are calculated as the sum of the measure level second earnings claims AEAP values as adjusted by appropriate ex post TDFs and EULs. Since all PG&E second earnings claim AEAP amounts are agreed at the end use level, PG&E does not have the measure level second earnings claim AEAP values required by the methodology. PG&E cannot "back calculate" measure specific level AEAP values since there is no clear information on how to "allocate" the end use level AEAP values to the individual measures. PG&E can, however, use the measure level information from the first year evaluations to proportionally allocate or prorate the end use level AEAP values into estimates of the measure level AEAP values. These measure level estimates will then be combined, as specified in the Protocols, with the measure level ex post EUL and TDF values to calculate the Resource Benefit, Net, for the third and fourth earnings claims.

Conclusion

[8] Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs.

PG&E is seeking a retroactive waiver to clearly define, in advance, acceptable methods for calculating third and fourth earnings claims. The AEAP process results in AEAP values which cannot be used to estimate the third and fourth earnings claims as required by the Protocols. PG&E's waiver proposes a straightforward alternative that fulfills the spirit of the Protocols.

TABLE A

TABLE 10, EARNINGS DISTRIBUTION SCHEDULE			
Parameters	**Protocol Requirements**	**Waiver Alternative**	**Rationale**
Calculation Methodology for Third and Fourth Earnings Claim.	Sum the product of measure level second earnings claim AEAP, ex post TDF, and ex post EULs.	Allow the use of the first year ex post evaluation measure level findings to allocate the AEAP end use values into estimates of individual measure savings. These measure level estimates will then be multiplied by the measure level ex post EUL and TDF values to calculate the Resource Benefit, Net for the third and fourth earnings claims.	The AEAP results in end use level AEAP values. The proposed method makes maximum use of evaluation findings to allocate the end use level AEAP values to the measure level. Allocation to the measure level allows both third and fourth earnings claims to be calculated as specified in the Protocols.

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APPENDIX C

ON-SITE AUDIT INSTRUMENTS

PY1994 AGRICULTURAL PROGRAM RETENTION QUESTIONNAIRE

Customer Name		Audit Num:
Business Name		Orig CAC Surveyor
Customers Address		Division
City		Assigned To:
Phone		Old Audit ID:
New Contact Name		Date Customer Talked To:
New Phone Number	Area Code	Is a Site Visit Necessary?
PG&E Audit Acct.		Date Site Visited
New PGE Acct.		
<u>1994 Measure:</u>	<u>Measure Code</u>	<u>Measure Description</u>

Pump Audit
Greenhouse Audit
<u>Location Description – Pump Repair, Greenhouse</u>

Pump Repair Audits ONLY

Is the 1994 measure still in place and operable? (yes/no) _________________

If no, approximate date removed from service: _____________________________

If not in place and operable, explain why not.

____

Has this pump been repaired since participating in the PG&E program? (yes/no) If so, when? ______

Greenhouse Audits ONLY

There were ____ original square footage of heat curtain. How many square feet are still in place? _____

If not 100% still there, when was it removed from service? (approx.) _________________

If not 100% still there, why was it removed from service?

____

____

Auditors Comments:

____

____

____

PY1995 AGRICULTURAL PROGRAM RETENTION QUESTIONNAIRE

Customer Name		Audit Num:
Business Name		Orig CAC Surveyor
Customers Address		Division
City		Assigned To:
Phone		Old Audit ID:
New Contact Name		Date Customer Talked To:
New Phone Number	Area Code	Is a Site Visit Necessary?
PG&E Audit Acct.		Date Site Visited
New PGE Acct.		
1995 Measure:	Measure Code	Measure Description

Custom Audit
Pump Audit
Lighting Audit

Location Description – Custom, Pump Repair, Lighting

Pump Repair or Custom Audits ONLY

Is the 1995 measure still in place and operable (yes/no) ___________________

If no, approximate date removed from service ______________________________

If not in place and operable, explain why not

____

Has this pump been repaired since participating in the PG&E program? (yes/no) If so, when? ______

Lighting Audits ONLY

Num Fixtures	**Group Descriptions Watt**	**Lamp Fixture**

What % of the equipment from this measure is still in place and operable? _________________

If not 100% still in place and operable, when was it removed from service? (approx.)________________

If not 100% still in place and operable, why was it removed from service?

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Auditors Comments: