Customer Energy Efficiency Program
Measurement and Evaluation Program

# 1994-1995 Industrial Energy Efficiency Incentive Programs Third-Year Retention Study

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***PG&E Study ID numbers:***
***Process End Use: 311R1 (1994), 328R1 (1995)***
***Indoor Lighting End Use: 314R1 (1994), 325R1 (1995)***

***March 1, 1999***

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# PACIFIC GAS & ELECTRIC COMPANY'S
# 1994-1995 INDUSTRIAL
# ENERGY EFFICIENCY INCENTIVE PROGRAMS
# THIRD-YEAR RETENTION STUDY

## PROCESS END USE
***PG&E Study ID numbers: 311R1 (1994) and 328R1 (1995)***

## INDOOR LIGHTING END USE
***PG&E Study ID numbers: 314R1 (1994) and 325R1 (1995)***

## Purpose of Study

This study was conducted in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholders Earnings from Demand-Side Management Programs," as adopted by California Public Utilities Commission Decision 93-05-063, revised January, 1997, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, and 98-03-063.

This study measures the Effective Useful Life of indoor lighting and process measures for which rebates were paid through PG&E's 1994 and 1995 Industrial Energy Efficiency Incentive Programs. The Effective Useful Life is the estimated time at which half the units installed through these programs will no longer be in place and operable.

## Methodology

The general method of study for each measure is to collect measure retention data from a sample of participants, and fit a parametric survival function to those data. The survival function gives the probability of surviving to any positive time $t$. These parameters of the function are estimated from the retention data. Once the survival function parameters are estimated, median lifetime or EUL is determined as the time $t^*$ such that the survival probability is equal to 50 percent.

All study data were collected via on-site surveys. The 1994 program-year data were collected in 1997, and the 1995 program-year data were collected in 1998. A total of 187 indoor lighting measure sites were surveyed, and a total of 58 process measure sites were surveyed.

## Study Results

The results of this study are summarized in the table below. For three of the process measures (Measures 560, 590, and 599), there were no observed failures. As a result, no model could be estimated and no *ex post* EUL is available. For the 251-400W HID lighting measure (Measure L81), the *ex post* estimate is formally significantly different from the *ex ante* EUL. However, these estimates are not considered reliable, and revision of the *ex ante* EUL based on these results is not recommended. For the remaining process measures (Measures 550 and 569) and lighting measures (Measures L19, L23, and L37), the *ex post* EUL estimates are not significantly different from the *ex ante* values. The *ex ante* EULs for these measures are therefore not to be revised. In summary, none of the *ex ante* EULs should be revised based on the study findings.

***Industrial Energy Efficiency Incentive Programs, 1994 and 1995***
***Summary of Ex Post Effective Useful Life Estimates***

| | | | | | | 80% Confidence Interval | | |
|---|---|---|---|---|---|---|---|---|
| **End Use** | **Measure Group** | **Measure Codes** | ***ex ante EUL*** | **Distribution for *ex post* EUL** | ***ex post* EUL** | **Lower** | **Upper** | **EUL for claim** |
| **Indoor Lighting** | Delamping/Reflector | L19 | 16.0 | Weibull | 12.1 | 0.0 | 31.3 | 16.0 |
| | Lamps and ballasts-4' Fixture | L23 | 16.0 | Weibull | 27.1 | 0.0 | 94.4 | 16.0 |
| | Interior HID, 175+W | L37 | 20.0 | Exponential | 116.3 | 0.0 | 376.4 | 20.0 |
| | Interior HID, 251-400W | L81 | 16.0 | Weibull | 7.3 | 4.1 | 10.5 | 16.0 |
| **Process** | Process Controls | 550 | 12.1 | Weibull | 6.8 | 0.0 | 18.4 | 12.1 |
| | Process Heat Recovery | 560 | 28.9 | n/a | n/a | n/a | n/a | 28.9 |
| | Process Change/Add Equipment | 569 | 18.9 | Exponential | 13.7 | 1.9 | 25.4 | 18.9 |
| | Process Insulate | 590 | 10.1 | n/a | n/a | n/a | n/a | 10.1 |
| | Process Other | 599 | 17.0 | n/a | n/a | n/a | n/a | 17.0 |

## Regulatory Waivers and Filing Variances

This study is conducted according to the terms of Pacific Gas & Electric Company's requested retroactive waiver for a modification to third and fourth earnings claim calculation methodology, approved February 17, 1999.

# 1994-1995 INDUSTRIAL ENERGY EFFICIENCY INCENTIVE PROGRAMS THIRD-YEAR RETENTION STUDY

**PROCESS END USE**
**PG&E Study IDs 311R1 (1994) and 328R1 (1995)**

**INDOOR LIGHTING END USE**
**PG&E Study IDs 314R1 (1994) and 325R1 (1995)**

**Prepared for**

**Pacific Gas and Electric Company**
**San Francisco, California**

**Prepared by**


**XENERGY Inc.**
**Oakland, California**



**March 1, 1999**

## LIST OF TABLES

# E EXECUTIVE SUMMARY

## E.1 BACKGROUND

This report provides the results of the third-year retention study of Pacific Gas and Electric Company's (PG&E's) 1994 and 1995 Industrial Energy Efficiency Incentives (IEEI) Programs, as required by the Measurement and Evaluation (M&E) Protocols of the California DSM Measurement Advisory Committee (CADMAC). The results of the analysis will be used in the third earnings claims filed for each program year.

As given in the Protocols, the goal of the measure retention study is to determine "the length of time the measure(s) installed during the program year are maintained in operating condition." As agreed within the CADMAC Subcommittee on measure retention, this question is addressed by estimating each measure's Effective Useful Life (EUL). The EUL is defined as the median survival time, that is, as the time until half the units are no longer in place and operable.

Each measure has an *ex ante* estimate of the EUL, which has been used in the first and second earnings claims. If the *ex post* EUL determined by the retention study for a particular measure is statistically significantly different from the *ex ante* EUL at the 20 percent significance (80 percent confidence) level, the *ex post* EUL will be used for future earnings claims. If there is not such a statistically significant difference, the *ex ante* EUL will be retained. Whether or not the EUL is revised as a result of this study, the EUL may be revised in the future based on subsequent retention studies required by the Protocols.

In this study, indoor lighting and process measures are addressed in separate chapters. For each specific measure studied, the resulting EUL estimate will be applied both to it and to a group of like measures. The specific measures studied for each end use and the associated like measures are indicated in each chapter.

## E.2 STUDY METHODS

### *E.2.1 Survival Analysis*

#### *The General Survival Function*

The general method of study for each measure is to collect measure retention data from a sample of participants, and fit a parametric survival function to those data. The survival function is a function that gives the probability a unit will survive to any positive time $t$. The parameters of the survival function are estimated from the retention data. Once the survival function parameters are estimated, the median lifetime or EUL is determined as the time $t^*$ when the survival probability is 50 percent. This is the estimated time when half the units will be gone.

### *Interpretation of Survival Model Results*

Estimating a survival function and the corresponding median lifetime from retention data requires an assumed functional form. At this point in the life of the measures addressed in this study, the failure rates are generally low. As a result, there is little solid empirical basis for choosing among possible forms. In some cases, it may be possible to match the empirical data reasonably well over the limited domain of the analysis (three to four years since program participation). However, in most cases the resulting estimated median lifetime will be substantially greater than this elapsed lifetime. That is, the EUL estimate entails extrapolating the data far beyond their original range. Such extrapolation is precarious in any modeling exercise. The exception would be if there were a very strong basis for knowing that the model form had been appropriately specified and that its parameters are consistent across the range from the data to the point of extrapolation.

In the present study, there is no such *a priori* basis for specifying the form. Consequently, in cases where the estimated EULs are substantially greater than the four years of observed lifetimes, these estimates should be regarded as indicative, but not definitive. This issue is discussed further in the context of each measure group's analysis.

### *Data Required for the Survival Analysis*

The retention data required for the survival analysis are data that indicate for each rebated unit at each sampled premise whether the unit was still in place and operable at the time of the survey. A unit not in place and operable is classified as a "failure" for purposes of this analysis. The unit may not have failed physically, but in terms of the program savings objectives, it has failed. Wherever possible, the retention data for failed units also include the date when the failure occurred.

## E.3 SUMMARY OF RESULTS

The results of this study are summarized in Table E-1. The table shows the estimates for the most appropriate distribution for which results were obtained. Conceptually the Weibull or gamma distributions are most appropriate. The gamma distribution is the most general and is able to follow the empirical data most closely. The Weibull distribution assumes failure rates increase as the equipment ages, which is the most reasonable assumption for the equipment explored in this study. However, the gamma distribution failed to converge for three of the four measures and the Weibull distribution failed to converge for interior 175+W high-intensity discharge (HID) lamps. That is, the available data were insufficient to allow an estimate to be developed with these forms for these measures. Therefore, for 175+W interior HIDs the results for the exponential distribution are shown.

For three of the process measures, there were no observed failures. As a result, no model could be estimated and no *ex post* EUL is available. These measures are:

- Process Heat Recovery (Measure 560)
- Process Insulate (Measure 590)

- Process Other (Measure 599)

For the other two process measures, Process Controls (Measure 550) and Process Change/Add Equipment (Measure 569), the *ex ante* EUL was not significantly different from the *ex post* EUL at the 80 percent significance level for any of the hazard distributions. Therefore the *ex ante* EUL is retained for these measures. To be conservative, Table E-1 shows the smallest EUL of the estimates.

For the 4-foot fixture lamps and ballast replacement measure (Measure L23), the 175+W HID lamp measure (Measure L37), and the delamping/reflectors measure (Measure L19), the *ex ante* EULs fall within the 80 percent confidence interval of the *ex post* EUL. For the other indoor lighting measure, 251-400W HID lamps (Measure L81), short *ex post* EULs are obtained from the analysis. However, this measure had removal rates of only 2 percent, with the majority of removals coming from one site. It is unlikely that half of the units will be removed after less than eight years given that only 2 percent were removed after three years. In addition, removal of one site from the analysis significantly increases the EUL of this measure to the extent it is not significantly different from the *ex ante* estimate. Given the sensitivity of the Measure L81 results to exclusion of one site, it does not appear the models are robust enough to be reliable. The models simply do not have enough data for the reasonable estimation of EULs. Thus, retaining the *ex ante* EUL' is recommended for all four indoor lighting measures.

For all the process and indoor lighting measures studied, retaining the *ex ante* EUL is recommended. No *ex post* EULs have been estimated with sufficient reliability to warrant revising the *ex ante* values.

**Table E-1**
**Summary of EUL Findings (Years)**

| End Use | Measure Group | Measure Codes | *ex ante* EUL | Distribution for *ex post* EUL | *ex post* EUL | 80% Confidence Interval Lower | 80% Confidence Interval Upper | EUL for claim |
|---|---|---|---|---|---|---|---|---|
| Indoor Lighting | Delamping/Reflector | L19 | 16.0 | Weibull | 12.1 | 0.0 | 31.3 | 16.0 |
| | Lamps and ballasts-4' Fixture | L23 | 16.0 | Weibull | 27.1 | 0.0 | 94.4 | 16.0 |
| | Interior HID, 175+W | L37 | 20.0 | Exponential | 116.3 | 0.0 | 376.4 | 20.0 |
| | Interior HID, 251-400W | L81 | 16.0 | Weibull | 7.3 | 4.1 | 10.5 | 16.0 |
| Process | Process Controls | 550 | 12.1 | Weibull | 6.8 | 0.0 | 18.4 | 12.1 |
| | Process Heat Recovery | 560 | 28.9 | n/a | n/a | n/a | n/a | 28.9 |
| | Process Change/Add Equipment | 569 | 18.9 | Exponential | 13.7 | 1.9 | 25.4 | 18.9 |
| | Process Insulate | 590 | 10.1 | n/a | n/a | n/a | n/a | 10.1 |
| | Process Other | 599 | 17.0 | n/a | n/a | n/a | n/a | 17.0 |

# 1 INTRODUCTION

## 1.1 BACKGROUND

This report provides the results of the third-year retention study of Pacific Gas and Electric Company's (PG&E's) 1994 and 1995 Industrial Energy Efficiency Incentives (IEEI) Programs, as required by the Measurement and Evaluation Protocols of the California DSM Measurement Advisory Committee (CADMAC).[1]

### *1.1.1 Protocol Requirements*

The Protocols require that retention studies be performed in the third and sixth years for rebates received under the IEEI Programs. The CADMAC Persistence Subcommittee has directed that the 1994 and 1995 program-year retention studies be combined into a single analysis. The results of the combined analysis will be used in the third earnings claims filed for each program year.

#### *Estimating Effective Useful Life (EUL)*

The goals of the measure retention study are to determine

> (a) the length of time the measure(s) installed during the program year are maintained in operating condition; and (b) the extent to which there has been a significant reduction in the effectiveness of the measures (Protocols page A-9).

The CADMAC Persistence Subcommittee has agreed that the Protocols require that the first question (a) should be addressed by estimating each measure's Effective Useful Life (EUL). The EUL is defined by CADMAC as the median survival time, that is, as the time until half the units are no longer in place and operable. Estimating the EUL is the primary focus of this report. The question of reduced measure effectiveness has been addressed in a separate set of studies.

For each measure, there is an *ex ante* EUL estimate which has been used in the first and second earnings claims. If the *ex post* EUL determined by the retention study for a particular measure is statistically significantly different from the *ex ante* EUL at the 20 percent significance (80 percent confidence) level, the *ex post* EUL will be used for future earnings claims. If there is not such a statistically significant difference, the *ex ante* EUL will be retained. Whether or not the EUL is revised as a result of this study, the EUL may be revised in the future based on subsequent retention studies required by the Protocols.

In this study, indoor lighting and process measures rebated to industrial facilities are addressed in separate chapters. For each specific measure studied, the resulting EUL estimate will be applied.

[1] California Public Utilities Commission, *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs*, Decision 93-05-063 Revised March, 1999.

No "like" measures were identified for the IEEI Programs, so the results of this study apply only to the measures directly analyzed in this study. The specific measures studied for each end use are indicated in each chapter.

## 1.2 STUDY METHODS

### *1.2.1 Survival Analysis*

#### *The General Survival Function*

The general method of study for each measure is to collect measure retention data from a sample of participants, and fit a parametric survival function to those data. The survival function is a function $S(t;\theta)$ that gives the probability S of surviving to any positive time $t$, given the parameters θ. These parameters are estimated from the retention data. Once the survival function parameters are estimated, median lifetime or EUL is determined as the time $t^*$ such that the survival probability $S(t;\theta) = 0.5$.

The estimation and application of the survival function requires the specification of the function's parametric form. This form is typically specified in terms of the *hazard function* $h(t;\theta)$. Roughly, the hazard function can be thought of as the instantaneous probability of failing at time $t$, given that a unit has survived up to that time.

The survival probability $S(t;\theta)$ is one minus the probability $F(t;\theta)$ that a unit will die by time $t$. Formally, the hazard function is the ratio of the probability density function of the distribution $F(t,\theta)$ to the survival probability $S(t;\theta)$:

$$h(t;\theta) = (dF/dt)/S(t;\theta).$$

#### *Choices of Parametric Forms for the Survival Function*

Several parametric forms are in common use as hazard functions. Those explored in this study include the following:

- Gamma
- Weibull
- Exponential
- Log-normal
- Log-logistic.

The Gamma function is the most general of these, and includes the Weibull, Exponential, and Log-normal as special cases. In essence, the Gamma function allows certain parameters to be determined by the data that are constrained by each of the other specifications. As a result, the Gamma function will be able to follow the empirical data most closely. If one of the other forms is a good description of the data, its results will be similar to those of the less constrained

Gamma fit. If the other form is not a good match to the data, its results will be at odds with those of the Gamma fit. This "goodness-of-fit" can be formally tested by the log-likelihood test.

Similarly, the Weibull also includes the Exponential as a special case. The goodness of fit for the exponential form can be tested against the Weibull results, again using the log likelihood test.

The log-normal and log-logistic forms have decreasing hazard functions after an initial peak. That is, failure rates decline over time. This form may be a reasonable fit over a portion of time for certain types of equipment or processes. However, declining failure rates are unlikely to be an accurate representation of the failure pattern several years out.

The exponential form represents a constant hazard function. That is, the chance that a unit will fail in the next time increment, given that it has already survived to the current time, is the same no matter what the current time. This form is often used in survival analysis.

The Weibull form has an increasing hazard function. That is, the failure rate increases as equipment ages. In many respects, this basic assumption is the most reasonable of all the distributions explored.

As noted, the Gamma form is the most general. Depending on the empirical data and the resulting parameters estimated, this form may produce an increasing, decreasing, or essentially constant hazard function.

### *Interpretation of Survival Model Results*

At this point in the life of the measures addressed in this study, the failure rates are generally low. As a result, there is little solid empirical basis for choosing among possible forms of the hazard function. In some cases, it may be possible to match the empirical data reasonably well over the limited domain of the analysis (three to four years since program participation). However, in most cases the resulting estimated median lifetime will be substantially greater than this elapsed lifetime. That is, the EUL estimate entails extrapolating the data far beyond their original range. Such extrapolation is precarious in any modeling exercise. The exception would be if there were a very strong basis for knowing that the model form had been appropriately specified and that its parameters are consistent across the range from the data to the point of extrapolation.

In the present study, there is no such *a priori* basis for specifying the form, and no basis for assuming that the patterns evident so far are retained over extended periods. Consequently, in cases where the estimated EULs are substantially greater than the four years of observed lifetimes, these estimates should be regarded as indicative, but not definitive. This issue is discussed further in the context of each measure group's analysis.

### *Data Required for the Survival Analysis*

The retention data required for the survival analysis are data that indicate for each rebated unit at each sampled participant whether the unit was still in place and operable at the time of the survey. A unit not in place and operable is classified as a "failure," for purposes of this analysis.

The unit may not have failed physically, but, in terms of the program savings objectives, it has failed. Wherever possible, the retention data for failed units also include the date when the failure occurred.

In many cases, the failure is reported but the date when the failure occurred is not known. In this case, the observation is said to be left-censored. That is, the unit is known to have failed by a particular date, but the date of its failure is not known. In other cases, indeed the majority in this study, the unit had still not failed at the time the retention data were collected. In this case, the observation is said to be right-censored. The unit will fail at some future, as yet unknown time. The model forms used in this analysis accept both left- and right-censored data.

## 1.3 REPORT ORGANIZATION

Details on the retention studies for indoor lighting and process measures are presented in Chapters 2 and 3. A description of the 1994 program year sample design and data collection in contained in Appendix A. Tables meeting the requirements of Table 6B of the Protocols are given in Appendix B. The documentation required by Table 7 of the Protocols is given in Appendix C. A copy of PG&E's approved waiver on study methods is in Appendix D.

# 2 INDOOR LIGHTING RETENTION

## 2.1 INTRODUCTION

This section presents the retention analysis of the industrial indoor lighting rebated under the 1994 and 1995 IEEI Programs. The study methods are described in Section 2.2, and the results in Section 2.3. The measures included in the study and the program years for which they apply are indicated in Table 2-1.

**Table 2-1**
**Indoor Lighting Measures Included in This Study**

| Measure Group | Measure Code | Program Year |
|---|---|---|
| Fluorescent Delamping, Install Optical Reflectors | L19 | 1994, 1995 |
| Replace Lamps and Ballasts, 4 ft Fixture | L23 | 1994 |
| Interior HID, 175+W | L37 | 1994 |
| Interior HID, 251-400W | L81 | 1994, 1995 |

## 2.2 METHODS

### *2.2.1 Overview*

As described in Section 1, the effective useful life of indoor lighting measures was estimated by fitting a set of survival functions to retention data for a sample of customers. The retention data for this program were collected via onsite inspections. The data sources and data collection are described below. The estimation procedures specific to this program are then described.

### *2.2.2 Data Sources*

Data sources used in this study include:

- Onsite data collected for this study, and
- Program tracking data.

The onsite inspection data constitute the primary data collected for the study. For each sampled site, the inspector determined the number of units currently in place and operable for each of the technology types rebated at that site. Wherever possible, the reason for any shortfall from the rebated number was obtained from a customer respondent. Also obtained if possible was the approximate date any missing equipment was removed or failed. Data collection occurred in conjunction with two separate impact studies: the 1996 Industrial Impact Evaluation[1] and the 1997 Industrial Impact Evaluation.[2]

Program tracking data were used in several ways. These data were used to draw the samples and provide contact information used to recruit sites for the study. For those sites that were visited, the numbers of rebated units of each technology type were provided to the inspectors.

### *Data Collection*

All data was collected via on-site surveys associated with the impact evaluations discussed above. Data collection approaches and survey instruments are available in the cited reports.

### *Sample Design*

Sample design and data collection for the 1994 Program was developed by SBW Consulting, Inc. (SBW). A copy of the retention study document is provided in Appendix A.

The sample was drawn from retention databases prepared in the 1994 rebate program evaluation. The 1994 retention panel consisted of 286 sites, which contained 305 projects and 592 rebated items. This sample was developed before PG&E was able to finalize the list of measure that was to be included in the 1994 Retention Study. To develop the retention sample, SBW selected projects with the largest ex ante gross savings in each of the three end uses (HVAC, indoor lighting, and process) to evaluate, so that a total of 130 projects accounting for at least 70percent of the ex ante savings in the panel for each end use was reviewed.

This sample consisted of 60 indoor lighting projects, 45 HVAC projects and 25 process projects that combined, account for 305 items. Although these items only made up 52percent of the total number of items in the 1994 retention panel, they account for 82 percent, 85 percent, and 96 percent of the ex ante kWh, kW, and therm savings, respectively. (Note: while the HVAC end use was included in the group of end uses that comprised 85percent of avoided cost savings in 1994, none of the HVAC measures were in the group of measures account for the first 50 percent of estimated resource value. Therefore, HVAC measures are not included in the Retention study.)

[1] Impact Evaluation of Pacific Gas and Electric Companies 1996 Industrial Sector Energy Efficiency Incentives Programs: Lighting, HVAC, and Process – PG&E Study ID Numbers: 350, Lighting; 352, HVAC; 353, Process, SBW Consulting, Inc., March 1, 1998.

[2] 1997 Industrial Energy Efficiency Incentive Program Impact Evaluation – Final Report – Process, PG&E Study ID #334a; Indoor Lighting, PG&E Study ID #334b, XENERGY, Inc, March 1, 1999.

Indoor lighting items contained in the 1994 retention database are shown in Table 2-2.

**Table 2-2**
**1994 Industrial Indoor Lighting Retention Items**

| Measure Description | Measure Code | #Items in Database |
|---|---|---|
| Fluorescent Delamp, Install Optical Reflector | L19 | 24 |
| Replace Lamps and Ballast, 4 Foot Fixture | L23 | 30 |
| Interior HID, 175+W | L37 | 15 |
| Interior HID, 251-400W | L81 | 14 |
| Total | | 83 |

XENERGY completed the sample design for the 1995 Program. The sample was drawn from retention databases prepared in the 1995 rebate program evaluation.

A review of the 1995 retention panel (developed as part of the 1995 program evaluation) revealed that 157 sites contained projects with targeted indoor lighting measures. The breakdown in sites is presented in Table 2-3. A census of the 128 sites was attempted and 104 sites were surveyed. Of the 24 sites that were not included in the study, 9 sites could not be accommodated in the survey scheduling time frame, one site could not be contacted, and 14 sites refused surveys.

**Table 2-3**
**Sites with 1995 Industrial Indoor Lighting Retention Measures**

| Measure Description | Measure Code | # Sites | # Completed |
|---|---|---|---|
| Fluorescent Delamp, Install Optical Reflector | L19 | 1 | 1 |
| Replace Lamps and Ballast, 4 Foot Fixture | L23 | 22 | 14 |
| Interior HID, 251-400W | L81 | 50 | 45 |
| Delamp / Lamps and Ballast | L19 / L23 | 49 | 39 |
| Lamps and Ballast / HIDs | L23 / L81 | 3 | 2 |
| Delamp / Lamps and Ballast / HIDs | L19 / L23 / L81 | 3 | 3 |
| Total | | 128 | 104 |

### *2.2.3 Estimation*

The primary objective of the analysis is the estimation of the EUL or median survival time, by fitting a survival function to the collected retention data. The general methodology is described in Section 1. Details specific to industrial indoor lighting are provided below.

#### *Survival Modeling*

Many removed units were left-censored. That is, it was possible to determine whether the unit was still in place and operable at the time of the visit, but the failure time of units that had failed was not available from facility personnel.

As discussed in Section 1, a standard survival analysis was conducted on the censored data. This analysis estimated the time when 50 percent of all equipment will fail, with failure defined as final breakdown or disposal, or removal from the PG&E service territory.

### 2.2.4 Weighting

A function of weighting is to correct the apparent sample size for the true number of independent observations. In the survival analysis, each individual unit at each visited site is effectively treated as a separate observation. As a result, without weighting, the apparent sample size for the survival analysis is up to several thousand. This inflated apparent sample size distorts the calculated standard errors, making the estimates appear to be much more accurate than they are. In reality, the analysis has only one observation on each technology for each site. To have this actual sample size reflected in the analysis, the weights are applied so that the sum of the weights over all observations in the sample is equal to the number of sampled sites. That is, the final weight for each premise *i* is calculated as

$$w_i = \mathrm{n}/\Sigma_i N_i$$

where

$w_i$ = final weight for premise *i*
$n$ = total number of premises in the sample
$N_i$ = number of rebated units at premise *i*.

## 2.3 RESULTS

### 2.3.1 Data Attrition

All collected data of the types listed in Table 2-1 were used in the analysis. Rebates were provided for various technology types including several not included in the retention study. The initial data collected in 1995 included some rebated equipment not included in Table 2-1. These units were not used in the analysis.

Table 2-4 shows the numbers included in the analysis by technology group.

**Table 2-4**
**Data Included in Analysis by Technology Group**

| Measure Group | Measure Code | Sites | | Lamps | |
|---|---|---|---|---|---|
| | | Number | Percent | Number | Percent |
| Delamping/Reflector | L19 | 66 | 28.9% | 25,730 | 25.3% |
| Replace Lamps and Ballast- 4' Fixture | L23 | 86 | 37.7% | 73,028 | 71.9% |
| Interior HID, 175+W | L37 | 15 | 6.6% | 502 | 0.5% |
| Interior HID, 251-400W | L81 | 61 | 26.8% | 2,302 | 2.3% |
| Total | | 228 | 100.0% | 101,562 | 100.0% |

### 2.3.2 Units Still in Place

Table 2-5 shows the status at the time of inspection of the rebated lamps used in the analysis.

**Table 2-5**
**Status of Rebated Lamps**

| Measure Group | Measure Code | Lamps in Place | Lamps Removed | Total Lamps | Percent Removed |
|---|---|---|---|---|---|
| Delamping/Reflector | L19 | 25,331 | 399 | 25,730 | 1.6% |
| Replace Lamps and Ballast- 4' Fixture | L23 | 71,913 | 1,115 | 73,028 | 1.5% |
| Interior HID, 175+W | L37 | 491 | 11 | 502 | 2.2% |
| Interior HID, 251-400W | L81 | 2,255 | 47 | 2,302 | 2.0% |
| Total | | 99,990 | 1,572 | 101,562 | 1.5% |

### 2.3.3 Survival Analysis Results

Table 2-6 presents the estimated median lifetime (or EUL) in years, and the corresponding standard error for various distributional assumptions. Missing values indicate that the model did not converge. The final two columns of Table 2-6 show results for Measure L81 after excluding from the analysis one site that removed 34 lamps. A comparison of the L81 results with and without this site shows how sensitive the models are to small changes, given the limited number of measure removals see to date.

**Table 2-6**
**Estimated EULs and Standard Errors for Various Hazard Functions**

| | L19 (Delamp/Reflector) | | L23 (Lamps and ballasts-4' Fixture) | | L37 (Interior HID, 175+W) | | L81 (Interior HID, 251-400W) | | L81 (Interior HID, 251-400W) - Outlier | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Ex Ante EUL** | **16** | | **16** | | **20** | | **16** | | **16** | |
| Distribution | EUL (Years) | Standard Error | EUL (Years) | Standard Error | EUL (Years) | Standard Error | EUL (Years) | Standard Error | EUL (Years) | Standard Error |
| Weibull | 12.1 | 14.9 | 27.1 | 52.5 | | | 7.3 | 2.5 | 13.5 | 36.3 |
| Gamma | | | 22.7 | 416.7 | | | | | 10.9 | 233.9 |
| Exponential | 168.3 | 166.4 | 166.1 | 145.0 | 116.3 | 202.9 | 119.5 | 107.7 | 425.2 | 725.0 |
| Log Normal | 18.8 | 31.8 | 195.9 | 668.3 | | | 7.5 | 3.2 | 19.5 | 71.3 |
| Log Logistc | 13.3 | 17.8 | 32.5 | 68.6 | | | 7.4 | 2.8 | 14.6 | 42.1 |

Table 2-7 shows the corresponding 80 percent confidence intervals. Also indicated in the table are the estimates that are statistically significantly different from the *ex ante* EUL at this confidence level. Formally, the Protocols indicate that the *ex ante* EULs should be replaced by the *ex post* results in these cases. However, the range of results across the different hazard function forms, and the conceptual appropriateness of these forms, suggest that such replacement would be premature. This issue is discussed further below.

**Table 2-7**
**Estimated EULs and Confidence Intervals for Various Hazard Functions**

| | L19 (Delamping/Reflector) | | L23 (Lamps and ballasts-4' Fixture) | | L37 (Interior HID, 175+W) | | L81 (Interior HID, 251-400W) | | L81 (Interior HID, 251-400W)-Extreme Outlier Removed | |
|---|---|---|---|---|---|---|---|---|---|---|
| | EUL | 80% Confidence Interval | EUL | 80% Confidence Interval | EUL | 80% Confidence Interval | EUL | 80% Confidence Interval | EUL | 80% Confidence Interval |
| Weibull | 12.1 | ( 0.0 , 31.3 ) | 27.1 | ( 0.0 , 94.4 ) | | | 7.3 | ( 4.1 , 10.5 ) * | 13.5 | ( 0.0 , 60.0 ) |
| Gamma | | | 22.7 | ( 0.0 , 556.8 ) | | | | | 10.9 | ( 0.0 , 310.8 ) |
| Exponential | 168.3 | ( 0.0 , 381.6 ) | 166.1 | ( 0.0 , 352.1 ) | 116.3 | ( 0.0 , 376.4 ) | 119.5 | ( 0.0 , 257.6 ) | 425.2 | ( 0.0 , 1354.7 ) |
| Log-normal | 18.8 | ( 0.0 , 59.5 ) | 195.9 | ( 0.0 , 1052.7 ) | | | 7.5 | ( 3.4 , 11.5 ) * | 19.5 | ( 0.0 , 110.9 ) |
| Log-logistic | 13.3 | ( 0.0 , 36.1 ) | 32.5 | ( 0.0 , 120.4 ) | | | 7.4 | ( 3.8 , 11.0 ) * | 14.6 | ( 0.0 , 68.6 ) |

* The *ex ante* useful life of 16 years (20 years for L37) does not fall within the 80 percent confidence interval

### Interpretation of the Results

With the Gamma hazard function, the survival model did not converge for three of the four technology types. Failure to converge means that there is not enough information in the available data to determine the parameters of this most general form. As noted in Section 1, the Weibull form is conceptually the most appropriate, as it allows an increasing hazard function—that is, a failure rate increasing with age. This form did not converge for Measure L37.

The log-normal and log-logistic forms converged for all but 175+W HID. The two forms gave roughly similar results for the L19 and L81 measure codes. As noted in Section 1, these forms both have decreasing hazard functions after an early peak. While that pattern may fit the data observed in these early years since participation, it is not reasonable to assume that the same pattern would extend over the later life of the measures. Thus, these results must be considered questionable.

Likewise, the exponential form, with its assumption of a constant hazard function, is also questionable. In most cases, the constant hazard function would be expected to give longer EULs than a form that allows for an increasing hazard.

The log likelihoods can be compared for nested distributions to determine if one distribution provides a "better" estimate than the other. The exponential distribution is nested within the Weibull distribution. The Weibull, log-normal, and exponential distributions are all nested within the gamma distribution. Using this method of comparing models, we can reject the exponential model for all measures.

Based on the results shown in Table 2-7, the ex ante EUL falls within the 80 percent confidence interval for all measures except Measure L81. However, when only one site is removed from the study (the one site that removed 34 lamps, as discussed above), the ex ante EUL falls within the 80 percent confidence interval for Measure L81 also. (See the last four columns of Tables 2-6 and 2-7 for a comparison of Measure L81 results with and without the one outlier site.) Given the sensitivity of the Measure L81 results to exclusion of one site, it does not appear the models are robust enough to be reliable. The models simply do not have enough data for the reasonable estimation of EULs. It is not reasonable to rely on a model that predicts that 50 percent of the Measure L81 lamps will be removed in 7.3 years when only 2 percent of these lamps have been removed after 3 years. Thus, at this time in the life of the measures, revision of the *ex ante* EULs based on the retention study results is not recommended.

# 3 PROCESS RETENTION

## 3.1 INTRODUCTION

This section presents the retention analysis of the industrial process equipment rebated under the 1994 and 1995 IEEI program. The study methods are described in Section 3.2, and the results in Section 3.3. The measures included in the study and the program years for which they apply are indicated in Table 3-1.

**Table 3-1**
**Process Measures Included in This Study**

| Measure Group | Measure Code | Program Year |
|---|---|---|
| Process Controls | 550 | 1995 |
| Process Heat Recovery | 560 | 1995 |
| Process Change/Add Equipment | 569 | 1994, 1995 |
| Process Insulate | 590 | 1994 |
| Process Other | 599 | 1994,1995 |

## 3.2 METHODS

### *3.2.1 Overview*

As described in Section 1, the effective useful life of process measures was estimated by fitting a set of survival functions to retention data for a sample of customers. The retention data for this program were collected via onsite inspections. The data sources and data collection are described below. The estimation procedures specific to this program are then described.

### *3.2.2 Data Sources*

Data sources used in this study include:

- Onsite data collected for this study, and
- Program tracking data.

The onsite inspection data constitute the primary data collected for the study. For each sampled site, the inspector determined the number of units currently in place and operable for each of the technology types rebated at that site. Wherever possible, the reason for any shortfall from the rebated number was obtained from a customer respondent. Also obtained if possible was the approximate date any missing equipment was removed or failed. Data collection occurred in conjunction with two separate impact studies: the 1996 Industrial Impact Evaluation[1] and the 1997 Industrial Impact Evaluation.[2]

Program tracking data were used in several ways. These data were used to draw the samples and provide contact information used to recruit sites for the study. For those sites that were visited, the numbers of rebated units of each technology type were provided to the inspectors.

### *Data Collection*

All data was collected via on-site surveys associated with the impact evaluations discussed above. Data collection approaches and survey instruments are available in the cited reports.

### *Sample Design*

Sample design and data collection for the 1994 Program was developed by SBW Consulting, Inc. (SBW). A copy of the retention study document is provided in Appendix A.

The sample was drawn from retention databases prepared in the 1994 rebate program evaluation. The 1994 retention panel consisted of 286 sites, which contained 305 projects and 592 rebated items. This sample was developed before PG&E was able to finalize the list of measure that was to be included in the 1994 Retention Study. To develop the retention sample, SBW selected projects with the largest ex ante gross savings in each of the three end uses (HVAC, indoor lighting, and process) to evaluate, so that a total of 130 projects accounting for at least 70 percent of the ex ante savings in the panel for each end use was reviewed.

This sample consisted of 60 indoor lighting projects, 45 HVAC projects and 25 process projects that combined, account for 305 items. Although these items only made up 52 percent of the total number of items in the 1994 retention panel, they account for 82 percent, 85 percent, and 96 percent of the ex ante kWh, kW, and therm savings, respectively. (Note: While the HVAC end use was included in the group of end uses that comprised 85 percent of avoided cost savings in 1994, none of the HVAC measures were in the group of measures account for the first 50 percent of estimated resource value. Therefore, HVAC measures are not included in the Retention study.)

Process items contained in the 1994 retention database are shown in Table 3-2 on the following page.

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[1] Impact Evaluation of Pacific Gas and Electric Companies 1996 Industrial Sector Energy Efficiency Incentives Programs: Lighting, HVAC, and Process – PG&E Study ID Numbers: 350, Lighting; 352, HVAC; 353, Process, SBW Consulting, Inc., March 1, 1998.

[2] 1997 Industrial Energy Efficiency Incentive Program Impact Evaluation – Final Report – Process, PG&E Study ID #334a; Indoor Lighting, PG&E Study ID #334b, XENERGY, Inc., March 1, 1999.

**Table 3-2**
**1994 Industrial Process Retention Items**

| Measure Group | Measure Code | #Items in Database |
|---|---|---|
| Process Controls | 550 | 3 |
| Process Heat Recovery | 560 | 1 |
| Process Change/Add Equipment | 569 | 6 |
| Process Insulate | 590 | 1 |
| Process Other | 599 | 5 |

XENERGY completed the sample design for the 1995 Program. The sample was drawn from retention databases prepared in the 1995 rebate program evaluation.

A review of the 1995 retention panel (developed as part of the 1995 program evaluation) revealed that 53 sites contained projects with targeted process measures. The breakdown in sites is presented in Table 3-3. A census of the 53 sites was attempted and 42 sites were surveyed. Of the 11 sites that were not included in the study, 2 sites could not be accommodated in the survey scheduling time frame and 9 sites refused surveys.

**Table 3-3**
**Sites with 1995 Process Retention Measures**

| Measure Group | Measure Code | # Sites | # Completed |
|---|---|---|---|
| Process Controls | 550 | 13 | 8 |
| Process Heat Recovery | 560 | 4 | 4 |
| Process Change/Add Equipment | 569 | 12 | 10 |
| Process Insulate | 590 | 2 | 2 |
| Process Other | 599 | 22 | 18 |
| Total | | 53 | 42 |

### *3.2.3 Estimation*

The primary objective of the analysis is the estimation of the EUL or median survival time, by fitting a survival function to the collected retention data. The general methodology is described in Section 1. Details specific to industrial process measures are provided below.

#### *Survival Modeling*

Many removed units were left-censored. That is, it was possible to determine whether the unit was still in place and operable at the time of the visit, but the failure time of units that had failed was not available from facility personnel.

As discussed in Section 1, a standard survival analysis was conducted on the censored data. This analysis estimated the time when 50 percent of all equipment will fail, with failure defined as final breakdown or disposal, or removal from the PG&E service territory.

### 3.2.4 Weighting

A function of weighting is to establish the relative importance of a site. In this case, the initial weighting was by avoided cost. This weight was then adjusted to correct the apparent sample size for the true number of independent observations. In the survival analysis, each individual unit at each visited site is effectively treated as a separate observation. This inflated apparent sample size distorts the calculated standard errors, making the estimates appear to be much more accurate than they are. In reality, the analysis has only one observation on each technology for each site. To have this actual sample size reflected in the analysis, the weights are applied so that the sum of the weights over all observations in the sample is equal to the number of sampled sites.

## 3.3 RESULTS

### 3.3.1 Data Attrition

All data of the types listed in Table 3-1 were used in the analysis. Rebates were provided for various technology types including several not included in the retention study. The initial data collected in 1995 included some rebated equipment not included in Table 3-1. These units were not used in the analysis. Table 3-4 shows the numbers included in the analysis by technology group.

**Table 3-4**
**Data Included in Analysis by Technology Group**

| Measure Group | Measure Code | # Sites | # Units |
|---|---|---|---|
| Process Controls | 550 | 12 | 761 |
| Process Heat Recovery | 560 | 5 | 5 |
| Process Change/Add Equipment | 569 | 16 | 241 |
| Process Insulate | 590 | 3 | 568 |
| Process Other | 599 | 24 | 167 |

### 3.3.2 Units Still in Place

Table 3-5 shows the status at the time of inspection of the rebated equipment used in the analysis.

**Table 3-5**
**Status of Rebated Equipment**

| Measure Description | Measure Code | Observed Units | Removed Units | Total Units | Percent Removed |
|---|---|---|---|---|---|
| Process Controls | 550 | 533 | 228 | 761 | 30.0% |
| Process Heat Recovery | 560 | 5 | 0 | 5 | 0.0% |
| Process Change/Add Equipment | 569 | 224 | 17 | 241 | 7.1% |
| Process Insulate | 590 | 568 | 0 | 568 | 0.0% |
| Process Other | 599 | 167 | 0 | 167 | 0.0% |
| Total | | 1,497 | 245 | 1,742 | |

### *3.3.3 Survival Analysis Results*

Table 3-6 presents the estimated median lifetime or EUL in years, and the corresponding standard error for various distributional assumptions for process controls and process change/add equipment. The other measures did not have any nonretention. Survival analysis could not be performed at this time on the other three measures. Missing values in Table 3-6 indicate that the model did not converge.

**Table 3-6**
**Estimated EULs and Standard Errors for Various Hazard Functions**

| | 550-Process Controls | | 569-Process Change/Add Equipment | |
|---|---|---|---|---|
| **Distribution** | **EUL** | **Std Error** | **EUL** | **Std Error** |
| Weibull | 6.8 | 8.4 | 67.2 | 497.8 |
| Gamma | | | | |
| Exponent | 37.0 | 43.5 | 13.7 | 8.6 |
| Log Normal | 9.0 | 13.9 | 124.6 | 1115.8 |
| Log Logistic | 7.4 | 10.1 | 91.9 | 752.0 |

Table 3-7 shows the corresponding 80 percent confidence intervals. Also indicated in the table are the estimates that are statistically significantly different from the *ex ante* EUL at this confidence level. Since all *ex ante* EULs fall within the 80 percent confidence interval, all *ex ante* EULs should be retained.

**Table 3-7**
**Estimated EULs and Confidence Intervals for Various Hazard Functions**

| | 550-Process Controls | | 569-Process Change/Add Equipment | |
|---|---|---|---|---|
| ***Ex Ante* EUL** | **12.1** | | **18.9** | |
| **Distribution** | **EUL** | **80% Confidence Interval** | **EUL** | **80% Confidence Interval** |
| Weibull | 6.8 | ( 0.0 , 18.4 ) | 67.2 | ( 0.0 , 750.1 ) |
| Gamma | | | | |
| Exponent | 37.0 | ( 0.0 , 96.3 ) | 13.7 | ( 1.9 , 25.4 ) |
| Log Normal | 9.0 | ( 0.0 , 28.1 ) | 124.6 | ( 0.0 , 1655.4 ) |
| Log Logistic | 7.4 | ( 0.0 , 21.3 ) | 91.9 | ( 0.0 , 1123.6 ) |

* The ex ante EUL does not fall within the 80 percent confidence interval

# A

# 1994 Sample Design and Data

**DRAFT REPORT**

# 1996 Retention Study

**of**

# 1994 Industrial IEEI Programs Retention Panel

---

**PG&E Study ID Numbers:**

**350 (Lighting)**
**352 (HVAC)**
**353 (Process)**

*Submitted to*

PACIFIC GAS & ELECTRIC CO.
123 Mission Street
San Francisco, CA 94105

*Submitted by*

SBW CONSULTING, INC.
2820 Northup Way, Suite 230
Bellevue, WA 98004

March 16, 1998

# <u>Supporting Data and Documentation</u>

## 1996 Retention Study

**of**

## PG&E's 1994 IEEI Programs Retention Panel

### Summary

This report documents the final data products from the 1996 study of the retention panel for PG&E's 1994 Industrial Energy Efficiency Incentives (IEEI) Programs. It also contains tables summarizing the sample disposition and raw measure survival rates in the panel. The final data products consist of the final retention panel data base, as well as corresponding paper files. With the exception of the paper files, all of these data products are loaded on one 3-1/2" floppy disk, included at the back of this report.

### Sample Design and Disposition

The sample for the 1996 study was drawn from retention databases prepared in the 1994 rebate program evaluation. The 1994 retention panel consisted of 286 sites, which contained 305 projects and 592 rebated items. To develop the 1996 retention sample, we selected projects with the largest ex ante gross savings in each of the three end uses (HVAC, indoor lighting, and process) to evaluate, so that we reviewed a total of 130 projects accounting for at least 70% of the ex ante savings in the panel for each end use. This sample consists of 60 lighting projects, 45 HVAC projects and 25 process projects that combined, account for 305 items. Although these items only made up 52% of the total number of items in the 1994 retention panel, they account for 82%, 85%, and 96% of the ex ante kWh, kW, and therm savings, respectively. A more detailed breakdown of item counts by end use, as well as the percentage of ex ante savings the items represent, can be found in Table 1.

### Preliminary Results

For sampled projects and items, we located and inspected the rebated units. During the inspection, we determined the fraction of the equipment described in the program application that was still installed, and what portion of this installed equipment was operational. Tables 2, 3, and 4 present raw results of this research for HVAC, lighting, and process measures, respectively. The table lists sampled measures ranked according to the percentage of total Btu savings they account for (Btu, or British Thermal Units, combine electric (kWh) and gas (therm) energy). Also included in the table are the number of sampled items and the total number of rebated measure units for each measure. The rightmost portion of the table shows the decrease in the total number of these units, first from installation to the 1994 evaluation, and then from the 1994 to the 1996 evaluation. These decreases are expressed as positive percentages, so for instance, the decrease for a measure where the number of units dropped from 20 to 15 would be 25%. A missing decrease indicates no change in the number of units.

Table 5 provides a glimpse at the reasons for decreases in the number of units. It lists the number of times a particular reason was cited (note a given location for an item could have more than one reason for missing units).

## Data Product Description

The data base consists of four data sets, shown in Table 6 below. These data sets are zipped into a self-extracting zip file on the data diskette, called I94RT2.EXE.

We have supplied these data sets in two formats: (1) SAS Version 6 transport file (file name extension XPT), and (2) Microsoft Excel 5.0 workbook (file name extension XLS). The SAS Version 6 transport file can be read by any version of SAS on any currently supported platform, including SAS PC for Windows, and SAS under TSO. The transport file is self-documenting, as it contains labels for each variable, along with information on each variable's data type and format. This information can be accessed via the SAS PROC CONTENTS procedure.

The key variables for each of the data sets are also shown in Table 7. Each data set can be linked to the others with these keys. In all data sets except I94RT2_S, items evaluated during the 1996 study will have the value "RELEASE" in the STATUS variable. We have flagged missing item count data with the value "-99". Table 4 contains a complete listing of all variables in the data sets, along with corresponding variable types and labels.

## Supporting Documentation

Some information collected while recruiting the customer and performing the onsite survey are only available on hard copy. Copies of such documents, such as recruitment forms, data collection forms, contact logs, and supplemental reports from the 1994 evaluations, were shipped to PG&E separately. This supporting documentation has been purged of any information that might reveal the identity, phone number, or location of a customer.

## Table 1: Breakdown of 1996 Retention Sample Frame

| End Use | Items: Evaluated for 1996 | Items: 1994 Panel Total | Items: % Evaluated | % of Total 1994 Retention Panel Ex Ante Savings Represented: kWh | % of Total 1994 Retention Panel Ex Ante Savings Represented: kW | % of Total 1994 Retention Panel Ex Ante Savings Represented: therms |
|---|---|---|---|---|---|---|
| HVAC | 69 | 188 | 36.7 | 91.8 | 97.2 | 100.0 |
| Lighting | 207 | 335 | 61.8 | 85.0 | 85.6 | -- |
| Process | 29 | 69 | 42.0 | 79.2 | 76.1 | 95.8 |
| **Total** | **305** | **592** | **51.5** | **82.4** | **84.5** | **95.8** |

## Table 2: Raw 1996 Study Results (HVAC)

| Measure: Code | Measure: Description | Measure: Units | Eval. Item Statistics: # Items | Eval. Item Statistics: % Total BTU savings | Eval. Item Statistics: # Units rebated | % Decrease: Installation-1994 Eval. | % Decrease: 1994 Eval.-1996 Eval. |
|---|---|---|---|---|---|---|---|
| S0 | Space Conditioning (Customized) | Tons | 4 | 35.1 | 482 | | |
| S11 | Water Chiller: > = 300 Tons, Water-Cooled | Tons | 6 | 13.8 | 4,694 | | |
| S15 | Cooling Tower | Tons | 9 | 10.8 | 8,647 | | |
| 201 | Hvac Controls | Features | 2 | 8.3 | 7 | | |
| 230 | Convert To Vav | Hp | 2 | 8.0 | 100 | | |
| 204 | Install Hvac Ems | Features | 2 | 4.7 | 4 | | |
| 248 | Hvac Adjustable Speed Drive | Hp | 4 | 4.2 | 180 | | 33.3 |
| S21 | Evaporative Cooler | Coolers | 1 | 3.2 | 11 | | |
| S16 | Water Chiller: Early Replacement, > 150 Tons | Tons | 1 | 2.1 | - | | |
| S18 | Thermostat: Setback Programmable | Thermostats | 10 | 2.0 | 58 | 24.1 | 11.4 |
| S22 | Adjustable Speed Drive: Hvac Fan, 50 Hp Max | Horsepower | 4 | 2.0 | 315 | 34.9 | |
| 228 | Add Economizer - Air | Ahu | 1 | 1.8 | 1 | | |
| S10 | Water Chiller: > = 150 & < 300 Tons, Water-Cooled | Tons | 1 | 1.6 | 598 | | |
| S20 | Reflective Window Film | Square Feet | 9 | 1.2 | 9,629 | | |
| S9 | Water Chiller: < 150 Tons, Water-Cooled | Tons | 2 | 0.4 | 255 | | |
| S2 | A/C: Central, < 65 Kbtu/Hr, Air-Cooled, Single Package (Yr< 96) | Tons | 7 | 0.3 | 88 | | |
| S4 | A/C: Central, > = 135 & < 760 Kbtu/Hr, Air-Cooled, Single Pkg (Yr< 96) | Tons | 2 | 0.2 | 50 | | |
| 299 | Hvac - Other | Fan | 1 | 0.2 | 1 | | |
| S3 | A/C: Central, > = 65 & < 135 Kbtu/Hr, Air-Cooled, Split-Sys/Sngl Pkg (Yr< 96) | Tons | 1 | 0.02 | 5 | | |

# Table 3: Raw 1996 Study Results (Lighting)

| Measure | | | Eval. Item Statistics | | | % Decrease | |
|---|---|---|---|---|---|---|---|
| Code | Description | Units | # Items | % Total BTU savings | # Units rebated | Installation-1994 Eval. | 1994 Eval.-1996 Eval. |
| L37 | Hid Fixture: Interior, > = 176 Watts Lamp | Fixtures | 15 | 23.8 | 509 | 1.4 | 2.2 |
| L19 | Reflectors With Delamping, 4 Ft Lamp Removed | Lamps | 24 | 21.9 | 7,135 | 9.1 | 0.2 |
| L81 | Hid Fixture: Interior, Standard, 251-400 Watt Lamp | Fixtures | 14 | 15.0 | 362 | 0.3 | 9.4 |
| L23 | Fixture: T-8 Lamp & Elec Blst, (Fem Or New Fixture), 4 Ft Fixt | Lamps | 30 | 13.0 | 16,238 | 0.8 | 2.9 |
| L27 | Hid Fixture: Interior, Standard, 176-250 Watt Lamp | Fixtures | 8 | 4.9 | 138 | | |
| L20 | Reflectors With Delamping, 8 Ft Lamp Removed | Lamps | 11 | 4.9 | 1,254 | 8.5 | |
| L14 | Ballast: Electronic, 2-Lamp Ballast | Fixtures | 7 | 2.6 | 2,039 | 0.2 | 9.7 |
| L26 | Hid Fixture: Interior, Standard, 101-175 Watt Lamp | Fixtures | 8 | 2.4 | 149 | 2.0 | 2.1 |
| L77 | High Output: 2 36 W, T-8 Or 2 40 W, T-10 W/Elec Blst | Fixtures | 3 | 2.4 | 790 | 41.6 | |
| L13 | Lamp: T-8 | Lamps | 4 | 1.8 | 2,641 | 0.7 | |
| L24 | Fixture: T-8 Lamp & Elec Blst, (Fem Or New Fixture), 8 Ft Fixt | Lamps | 6 | 1.6 | 1,037 | 2.9 | 10.3 |
| L30 | Hid Fixture: Exterior, > = 176 Watt Lamp | Fixtures | 6 | 1.4 | 34 | | |
| L15 | Ballast: Electronic, 3-Lamp Ballast | Fixtures | 1 | 0.9 | 457 | | |
| L29 | Hid Fixture: Exterior, 101-175 Watt Lamp | Fixtures | 4 | 0.5 | 33 | 45.5 | |
| L73 | Fixture: 4 Ft T-8 W/Elec Blst, 2 32-Watt T-8 Lamps | Fixtures | 7 | 0.5 | 321 | 6.5 | |
| L21 | Fixture: T-8 Lamp & Elec Blst, (Fem Or New Fixture), 2 Ft Fixt | Lamps | 8 | 0.4 | 386 | 10.4 | |
| L74 | Fixture: 4 Ft T-8 W/Elec Blst, 3 32-Watt T-8 Lamps | Fixtures | 4 | 0.4 | 145 | | |
| L5 | Exit Sign: Retrofit Kit | Fixtures | 7 | 0.3 | 61 | 8.2 | |
| L3 | Compact Fluorescent: Screw-In, Replace Lmp,Reuse Blst | Lamps | 6 | 0.2 | 75 | 16.0 | |
| L82 | Occupancy Sensor: Wall Mounted | Sensors | 4 | 0.2 | 45 | | 2.2 |
| L75 | Fixture: 8-Ft T-8 W/El Blst, 2 8-Ft T-8 Or 4 32-W, 4-Ft T-8 | Fixtures | 3 | 0.2 | 67 | 4.5 | 1.6 |
| L33 | Occupancy Sensor: 351-1000 Watts Controlled | Sensors | 2 | 0.2 | 14 | 42.9 | 12.5 |
| L28 | Hid Fixture: Exterior, 0-100 Watt Lamp | Fixtures | 3 | 0.2 | 22 | | |
| L11 | Fixture: T-8, 3-Lamp, 4 Ft Fixture (Yr< 96) | Fixtures | 1 | 0.1 | 39 | | |
| L16 | Ballast: Electronic, 4-Lamp Ballast | Fixtures | 1 | 0.1 | 30 | | |
| L64 | Compact Fluorescent: Screw-In, Modular Blst, 5-13 W | Lamps | 2 | 0.1 | 18 | 5.6 | 41.2 |
| L72 | Fixture: 4 Ft T-8 W/Elec Blst, 1 32-Watt T-8 Lamp | Fixtures | 2 | 0.04 | 28 | 50.0 | |
| L4 | Compact Fluorescent: Hardwire | Fixtures | 1 | 0.04 | 7 | 14.3 | |
| L69 | Fixture: 2 Ft T-8 W/El Blst, 1 31-W T-8 U Or 2 17-W T-8 | Fixtures | 1 | 0.03 | 23 | 4.3 | |
| L10 | Fixture: T-8, 2-Lamp, 4 Ft Fixture (Yr< 96) | Fixtures | 2 | 0.02 | 15 | 53.3 | |
| L31 | Time Clock: Lighting | Time Clocks | 1 | 0.01 | 2 | 50.0 | |
| L66 | Compact Fluorescent: Hardwired Fixture, 5-13 Watts | Fixtures | 1 | 0.01 | 3 | | |
| L36 | Photocell: Lighting | Photocells | 3 | 0.01 | 5 | 40.0 | |
| L17 | Reflectors With Delamping, 2 Ft Lamp Removed | Lamps | 1 | 0.004 | 2 | | |
| L68 | Compact Fluorescent: Hardwired Fixture, 27-50 Watts (Yr< 96) | Fixtures | 1 | 0.003 | 1 | | |
| L12 | Fixture: T-8, 4-Lamp, 8 Ft Fixture | Fixtures | 1 | 0.003 | 1 | | |
| L9 | Fixture: T-8, 1-Lamp, 4 Ft Fixture (Yr< 96) | Fixtures | 1 | 0.001 | 1 | | |
| L70 | Fixture: 2 Ft T-8 W/El Blst, 2 31-W T-8 U Or 4 17-W T-8 | Fixtures | 1 | | 2 | | |

## Table 4: Raw 1996 Study Results (Process)

| Measure | | | Eval. Item Statistics | | | % Decrease | |
|---|---|---|---|---|---|---|---|
| Code | Description | Units | # Items | % Total BTU savings | # Units rebated | Installation-1994 Eval. | 1994 Eval.-1996 Eval. |
| 590 | Process Insulate | Furnace | 1 | 42.4 | 1 | | |
| 569 | Process Change/Add Equipment | Tons | 6 | 37.5 | 1,006 | | |
| 389 | Process Boiler Other | Pumps | 2 | 3.8 | 5 | | |
| 580 | Process Change Physical | Pumps | 3 | 3.8 | 160 | | |
| 372 | Process Boiler Economizer | Economizer | 3 | 3.5 | 3 | | |
| 599 | Process Other | Tons | 5 | 3.0 | 635 | | |
| 379 | Process Boiler Change/Add | Boiler | 1 | 2.6 | 1 | | |
| 550 | Process Controls | Timeclocks | 3 | 2.3 | 331 | | 42.6 |
| P0 | Process (Customized) | Pocs | 2 | 0.4 | 43 | | 7.0 |
| 589 | Air Compresser System Change/Modify | Compressor | 1 | 0.4 | 1 | | |
| 560 | Process Heat Recovery | System | 1 | 0.2 | 1 | | |
| 578 | Process Adjustable Speed Drive | Hp | 1 | 0.1 | 3,600 | | |

## Table 5: Reasons for Missing Units

| Reason for Missing Units | # of Times Reason Was Cited | | | | % of # Total Times | | | |
|---|---|---|---|---|---|---|---|---|
| | HVAC | Lighting | Process | **Total** | HVAC | Lighting | Process | **Total** |
| Replaced with better technology | 2 | 1 | 1 | **4** | 22 | 1 | 13 | **4** |
| Could not find during onsite visit | 1 | 57 | 3 | **61** | 11 | 71 | 38 | **63** |
| Incompatible with existing equipment | | | 2 | **2** | | | 25 | **2** |
| Never installed | | 7 | | **7** | | 9 | | **7** |
| Remodel or demolition | 1 | 4 | 1 | **6** | 11 | 5 | 13 | **6** |
| Unit failure(s) | | 1 | | **1** | | 1 | | **1** |
| Other | 5 | 10 | 1 | **16** | 56 | 13 | 13 | **16** |

**Table 6: Retention Panel Data Sets**

| **Data Set** | | **Key Variables** | | | |
|---|---|---|---|---|---|
| **Name** | **Description** | **Site** (SITEID) | **Project** ( PROJID) | **Item** (ITEMNUM) | **Location** (LOCNUM) |
| I94RT2_S | Site contact information (contains confidential customer info) | X | | | |
| I94RT2_P | Project-level information (contains confidential customer info) | X | X | | |
| I94RT2_I | Item-level information | | X | X | |
| I94RT2_L | Location-level information | | X | X | X |

**Table 7: Variable Lists for Retention Panel Data Sets**

| DATA SET | VARIABLE | TYPE | LABEL |
|---|---|---|---|
| **I94RT2_S** | CONTADDR* | Char | Contact address (from 1996 SBW eval) |
| | CONTCITY* | Char | Contact city (from 1996 SBW eval) |
| | CONTNAME* | Char | Contact name (from 1996 SBW eval) |
| | CONTPHON* | Char | Contact phone number (1996 SBW eval) |
| | CONTSTAT | Char | Contact state (from 1996 SBW eval) |
| | CONTZIP* | Num | Contact zip code (from 1996 SBW eval) |
| | **SITEID** | Num | KEY: Site ID number (SBW-assigned) |
| **I94RT2_P** | APPCD | Char | PG&E application number |
| | CNAME* | Char | Contact name (original) |
| | COMPANY* | Char | Company name |
| | CONTROL | Num | PG&E control number |
| | CORPID | Num | Corporate ID number (SBW-assigned) |
| | CPHONE* | Char | Contact phone number (original) |
| | DIV | Char | PG&E division |
| | EU | Char | End use |
| | **PROJID** | Num | KEY: Project ID number (SBW-assigned) |
| | SCITY* | Char | Service city |
| | **SITEID** | Num | Site ID number (SBW-assigned) |
| | SSTREET* | Char | Service street |
| | STATUS | Char | Evaluation status |
| | SZIP* | Num | Service zip code |
| **I94RT2_I** | COMMENTS | Char 2 | Auditor notes on measure (96 SBW eval) |
| | EU | Char | End use |
| | **ITEMNUM** | Num | KEY: Item number (SBW-assigned) |
| | MEASCODE | Char | PG&E measure/action code |
| | MEASLBL | Char | PG&E measure/action description |
| | MEASUNIT | Char | Measure units (based on SBW review) |
| | N_94EVAL | Num | # of rebated units (1994 eval) |
| | N_96EVAL | Num | # of rebated units (1996 SBW eval) |
| | N_REB_OR | Num | # of rebated units (in PG&E data base) |
| | N_REB_RV | Num | # of rebated units (PG&E w/SBW review) |
| | PKW | Num | PG&E data base gross kW savings |
| | PKWH | Num | PG&E data base gross kWh savings |
| | **PROJID** | Num | KEY: Project ID number (SBW-assigned) |
| | PTHM | Num | PG&E data base gross therm savings |
| | QBBRAND | Char | Ballast brand (from 94 eval) |
| | QBBRAND2 | Char | Ballast brand, secondary (from 94 eval) |
| | QBCOUNT | Char | Number of ballasts per fixture (94 eval) |
| | QBDUAL | Char | Dual switching? (from 94 eval) |
| | QBINFO | Char | # of lamps ballast can serve (94 eval) |
| | QBMODEL | Char | Ballast model (from 94 eval) |
| | QBMODEL2 | Char | Ballast model, secondary (from 94 eval) |
| | QBNOTES | Char | Ballast type (from 94 eval) |
| | QLBRAND | Char | Lamp brand (from 94 eval) |
| | QLFIXTUR | Char | # of lamps per fixture (from 94 eval) |

* Variables marked with asterisks contain confidential customer information

| DATA SET | VARIABLE | TYPE | LABEL |
|---|---|---|---|
| | QLMODEL | Char | Lamp model number (from 94 eval) |
| | QLNOTES | Char | Additional lamp information (94 eval) |
| | QLTYPE | Char | Lamp type (from 94 eval) |
| | QLWATTS | Char | Rated watts per lamp (from 94 eval) |
| | QMNOTES | Char | Auditor notes on measure (94 eval) |
| | STATUS | Char | Evaluation status |
| | XPROJDSC | Char | HVAC/process proj. description (94 eval) |
| **I94RT2_L** | **ITEMNUM** | Num | KEY: Item number (SBW-assigned) |
| | LOCDESC1 | Char | Location description (94 eval) |
| | LOCDESC2 | Char | Location description (96 eval) |
| | LOCITEM1 | Char | Item description for location (94 eval) |
| | LOCITEM2 | Char | Item description for location (96 eval) |
| | **LOCNUM** | Num | KEY: Location number (SBW-assigned) |
| | LOCSPUS1 | Char | Space use (94 eval) |
| | LOCSPUS2 | Char | Space use (96 eval) |
| | MANUF1 | Char | Manufacturer (94 eval) |
| | MANUF2 | Char | Manufacturer (96 eval) |
| | MODEL1 | Char | Model (94 eval) |
| | MODEL2 | Char | Model (96 eval) |
| | N_INST94 | Num | # rebated units installed at loc. (1994) |
| | N_INST96 | Num | # rebated units installed at loc. (1996) |
| | N_OPER94 | Num | # reb. units operational at loc. (1994) |
| | N_OPER96 | Num | # reb. units operational at loc. (1996) |
| | **PROJID** | Num | KEY: Project ID number (SBW-assigned) |
| | QUANT1 | Num | Reason 1: # of units missing |
| | QUANT2 | Num | Reason 2: # of units missing |
| | QUANT3 | Num | Reason 3: # of units missing |
| | REASON1** | Char | Reason 1 for missing units** |
| | REASON2** | Char | Reason 2 for missing units** |
| | REASON3** | Char | Reason 3 for missing units** |
| | STATUS | Char | Evaluation status |

* Variables marked with asterisks contain confidential customer information.
** Key to reason codes:
BT - Replaced with better technology
CF - Couldn't find location
IC - Incompatible with existing equipment
NI - Never installed
OT - Other reason
PC - Process change
RM - Remodel or demolition
UF - Unit failure(s)
UP - Under-performance

# B

# PROTOCOLS TABLE 6B

## *Protocol Table 6.B*
## *Results of Retention Study*
## *PG&E 1994-1995 Industrial Sector*
## *Energy Efficiency Incentive Programs Third Year Retention Study*
## *Study ID Process: 311R1 (1994) 328R1 (1995); Indoor Lighting: 314R1 (1994) 325R1 (1995)*

| Item 1 | | Item 2 | | Item 3 | Item 4 | Item 5 | Item 6 | | Item 7 | Item 8 | Item 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Studied Measure Description | End Use | Ex Ante EUL | Source of Ex Ante EUL (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 |
| Delamping/Reflector (L19) | Lighting | 16.0 | 1 | 12.1 | 16.0 | 12.2 | 0.0 | 31.3 | 0.7 | 1.0 | n/a |
| Lamps and ballasts-4' Fixture (L23) | Lighting | 16.0 | 1 | 27.1 | 16.0 | 36.8 | 0.0 | 94.4 | 0.8 | 1.0 | n/a |
| Interior HID, 175+W (L37) | Lighting | 20.0 | 1 | 116.3 | 20.0 | 146.8 | 0.0 | 376.4 | 0.5 | 1.0 | n/a |
| Interior HID, 251-400W (L81) | Lighting | 16.0 | 1 | 7.3 | 16.0 | 2.5 | 4.1 | 10.5 | 0.0 | 1.0 | n/a |
| Process Controls (550) | Process | 12.1 | 1 | 6.8 | 12.1 | 7.2 | 0.0 | 18.4 | 0.5 | 1.0 | n/a |
| Process Heat Recovery (560) | Process | 28.9 | 1 | n/a | 28.9 | n/a | n/a | n/a | n/a | 1.0 | n/a |
| Process Change/Add Equipment (569) | Process | 18.9 | 1 | 13.7 | 18.9 | 9.2 | 1.9 | 25.4 | 0.6 | 1.0 | n/a |
| Process Insulate (590) | Process | 10.1 | 1 | n/a | 10.1 | n/a | n/a | n/a | n/a | 1.0 | n/a |
| Process Other (599) | Process | 17.0 | 1 | n/a | 17.0 | n/a | n/a | n/a | n/a | 1.0 | n/a |

Ex Ante Source References: 1 - PG&E Advice Letter 1800-G/1446-E. 1994 DSM Program Activity and Expected Earnings. As approved by the California Public Utilities Commission April 19, 1994; and PG&E Advice Letter 1867-G/1481-E. 1995 DSM Program Activity and Expected Earnings. As approved by the California Public Utilities Commission May 8, 1995.

1994 Program Year Measures: L19, L81, 550, 560, 569, 599

1995 Program Year Measures: L19, L23, L37, L81, 550, 569, 590, 599

Note: no "like" measures were identified for this study.

C

# M&E PROTOCOLS, TABLE 7

The indoor lighting end use is discussed first, followed by a discussion of the process end use.

## C.1 INDOOR LIGHTING

### C.1.1 Overview Information

#### a. Study Title and Study ID Number

Study Title: 1994-1995 Industrial Energy Efficiency Third Year Retention Study, Indoor Lighting End Use

Study ID Numbers: 314R1 and 325R1

#### b. Program Years and Program Description

Program years: 1994, 1995

The Programs provide incentives to industrial customers to install energy-efficiency measures. The programs include the Retrofit Express Program (RE), the Retrofit Efficiency Options Program (REO), the Advanced Performance Options Program (APO), and the Customer Efficiency Options Program (CEO).

#### c. End Uses and Measures Covered

The measures included in the study and the program years for which they apply are indicated in the following table.

| Measure Group | Measure Code | Program Year |
|---|---|---|
| Fluorescent Delamping, Install Optical Reflectors | L19 | 1994, 1995 |
| Replace Lamps and Ballasts, 4 ft Fixture | L23 | 1994 |
| Interior HID, 175+W | L37 | 1994 |
| Interior HID, 251-400W | L81 | 1994, 1995 |

#### d. Methods and Models Used

Survival analysis was performed using data collected during on-site surveys. The survival analysis utilized the SAS procedure LIFEREG, and considered the following hazard distributions:

- log-normal,

- exponential,
- log-logistic,
- Weibull, and
- Gamma.

#### *e. Analysis Sample Size*

Number of customers: 228 sites.
Number of measures: 101,562 units.

## C.2 DATABASE MANAGEMENT

### *C.2.1 Database Management*

#### *a. Specific Data Sources*

Tracking Data:

| | |
|---|---|
| 1994 Data | indapp94.sd2<br>inditm94.sd2 |
| 1995 Data | rp_trak.sd2 |

On-site survey data:

| | |
|---|---|
| 1994 Data | i94rt2_s.sd2<br>i94rt2_p.sd2<br>i94rt2_l.sd2 |
| 1995 Data | rp_sum.sd2 |

#### *b. Data Attrition*

All collected data on the covered measures were used in the analysis.

#### *c. Data Quality*

The PG&E control number, application code, and measure code were used to link tracking data and survey data.

#### *d. Data Collected Specifically for the Analysis but not Used*

All collected data were used in the analysis.

### C.2.2 Sampling

#### a. Sampling Procedures and Protocols

See section 2.2.2 and Appendix B of this report for more detailed sampling procedures.

For 1994, 207 of a total of 335 projects were surveyed. Eighty three of the 207 projects contained measures that were included in this study.

For 1995, a census of the 128 projects with study measures was attempted. One hundred three surveys were completed. Of the 24 sites that were not included in the study, 9 sites could not be accommodated in the survey scheduling time frame, one site could not be contacted, and 14 sites refused surveys.

#### b. Survey Information

Data collection occurred in conjunction with two separate impact studies: the 1996 Industrial Impact Evaluation[1] and the 1997 Industrial Impact Evaluation.[2] All data was collected via on-site surveys associated with the impact evaluations discussed above. Data collection approaches and survey instruments are available in the cited reports.

#### c. Statistical Descriptions

See the following table.

**Status of Rebated Lamps**

| Measure Group | Measure Code | Lamps in Place | Lamps Removed | Total Lamps | Percent Removed |
|---|---|---|---|---|---|
| Delamping/Reflector | L19 | 25,331 | 399 | 25,730 | 1.6% |
| Replace Lamps and Ballast- 4' Fixture | L23 | 71,913 | 1,115 | 73,028 | 1.5% |
| Interior HID, 175+W | L37 | 491 | 11 | 502 | 2.2% |
| Interior HID, 251-400W | L81 | 2,255 | 47 | 2,302 | 2.0% |
| Total | | 99,990 | 1,572 | 101,562 | 1.5% |

[1] Impact Evaluation of Pacific Gas and Electric Companies 1996 Industrial Sector Energy Efficiency Incentives Programs: Lighting, HVAC, and Process – PG&E Study ID Numbers: 350, Lighting; 352, HVAC; 353, Process, SBW Consulting, Inc., March 1, 1998.

[2] 1997 Industrial Energy Efficiency Incentive Program Impact Evaluation – Final Report – Process, PG&E Study ID #334a; Indoor Lighting, PG&E Study ID #334b, XENERGY, Inc., March 1, 1999.

## *C.2.3 Data Screening and Analysis*

### *a. Outliers and Missing Data*

The data were screened for outlying removal dates. Extremely influential premises were also examined for some process measures. Missing removal dates were considered censored values with the site visit date as the left censoring endpoint.

### *b. Control of Background Variables*

N/A

### *c. Data Screening*

All collected data on the analyzed measures were used in the analysis.

### *d. Model Statistics*

See following table.

| End Use | Measure Group | Measure Codes | Distribution for *ex post* EUL | *ex post* EUL | SE | 80% Confidence Interval Lower | 80% Confidence Interval Upper | Intercept | SE | Scale | SE | Number of Units in Analysis | Sum of Weights=Number of Independant Observations (Premises) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Lighting** | Delamping/Reflector | L19 | Weibull | 12.1 | 14.9 | 0.0 | 31.3 | 8.51 | 1.3 | 0.3 | 0.3 | 25730 | 66 |
| | Lamps and ballasts-4' Fixture | L23 | Weibull | 27.1 | 52.5 | 0.0 | 94.4 | 9.39 | 2.1 | 0.5 | 0.5 | 73028 | 86 |
| | Interior HID, 175W | L37 | Exponential | 116.3 | 202.9 | 0.0 | 376.4 | 11.02 | 1.7 | 1.0 | n/a | 502 | 15 |
| | Interior HID, 251-400W | L81 | Weibull | 7.3 | 2.5 | 4.1 | 10.5 | 7.96 | 0.4 | 0.2 | 0.1 | 2302 | 61 |

### *e. Specification*

The following report sections discuss model specification:

- Section 1.2 - general modeling approach.
- Section 3.2 - modeling issues specific to the process end use

### *f. Error in Measuring Variables*

Uncertainty in removal dates was addressed using the onsite visit date as the left censoring endpoint.

### *g. Influential Data Points*

See 4a

### *h. Missing Data*

See 4a

### *i. Precision*

Standard errors produced by SAS procedure. Weights adjusted to the number of independent observations (number of premises), to avoid overstating the accuracy of the standard errors that comes from counting each unit as a separate observation.

## C.3 PROCESS END USE

### C.3.1 Overview Information

#### a. Study Title and Study ID Number

Study Title: 1994-1995 Industrial Energy Efficiency Third Year Retention Study, Process End Use

Study ID Numbers: 311R1 and 328R1

#### b. Program Years and Program Description

Program years: 1994, 1995

The Programs provide incentives to industrial customers to install energy-efficiency measures. The programs include the Retrofit Express Program (RE), the Retrofit Efficiency Options Program (REO), the Advanced Performance Options Program (APO), and the Customer Efficiency Options Program (CEO).

#### c. End Uses and Measures Covered

The measures included in the study and the program years for which they apply are indicated in the following table.

| Measure Group | Measure Code | Program Year |
|---|---|---|
| Process Controls | 550 | 1995 |
| Process Heat Recovery | 560 | 1995 |
| Process Change/Add Equipment | 569 | 1994, 1995 |
| Process Insulate | 590 | 1994 |
| Process Other | 599 | 1994,1995 |

#### d. Methods and Models Used

Survival analysis was performed using data collected during on-site surveys. The survival analysis utilized the SAS procedure LIFEREG, and considered the following hazard distributions:

- log-normal,
- exponential,
- log-logistic,
- Weibull, and
- Gamma.

#### e. Analysis Sample Size

Number of customers: 48 sites.
Number of measures: 1,742 units.

### C.3.2 Database Management

#### a. Specific Data Sources

Tracking Data:

| | |
|---|---|
| 1994 Data | indapp94.sd2<br>inditm94.sd2 |
| 1995 Data | rp_trak.sd2 |

On-site survey data:

| | |
|---|---|
| 1994 Data | i94rt2_s.sd2<br>i94rt2_p.sd2<br>i94rt2_l.sd2 |
| 1995 Data | rp_sum.sd2 |

#### b. Data Attrition

All collected data on the covered measures were used in the analysis.

#### c. Data Quality

The PG&E control number, application code, and measure code were used to link tracking data and survey data.

#### d. Data Collected Specifically for the Analysis but not Used

All collected data were used in the analysis.

### C.3.3 Sampling

#### a. Sampling Procedures and Protocols

See section 3.2.2 and Appendix B of this report for more detailed sampling procedures.

For 1994, 29 of a total of 69 projects were surveyed. Sixteen of the 29 projects contained measures that were included in this study.

For 1995, a census of the 53 projects with study measures was attempted. Forty-three surveys were completed. Of the 11 sites that were not included in the study, 2 sites could not be accommodated in the survey scheduling time frame and 9 sites refused surveys.

### *b. Survey Information*

Data collection occurred in conjunction with two separate impact studies: the 1996 Industrial Impact Evaluation[3] and the 1997 Industrial Impact Evaluation.[4] All data was collected via on-site surveys associated with the impact evaluations discussed above. Data collection approaches and survey instruments are available in the cited reports.

### *c. Statistical Descriptions*

See the following table.

**Status of Rebated Equipment**

| Measure Description | Measure Code | Observed Units | Removed Units | Total Units | Percent Removed |
|---|---|---|---|---|---|
| Process Controls | 550 | 533 | 228 | 761 | 30.0% |
| Process Heat Recovery | 560 | 5 | 0 | 5 | 0.0% |
| Process Change/Add Equipment | 569 | 224 | 17 | 241 | 7.1% |
| Process Insulate | 590 | 568 | 0 | 568 | 0.0% |
| Process Other | 599 | 167 | 0 | 167 | 0.0% |
| Total | | 1,497 | 245 | 1,742 | |

## *C.3.4 Data Screening and Analysis*

### *a. Outliers and Missing Data*

The data were screened for outlying removal dates. Extremely influential premises were also examined for some process measures. Missing removal dates were considered censored values with the site visit date as the left censoring endpoint.

### *b. Control of Background Variables*

N/A

### *c. Data Screening*

All collected data on the analyzed measures were used in the analysis.

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[3] Impact Evaluation of Pacific Gas and Electric Companies 1996 Industrial Sector Energy Efficiency Incentives Programs: Lighting, HVAC, and Process – PG&E Study ID Numbers: 350, Lighting; 352, HVAC; 353, Process, SBW Consulting, Inc., March 1, 1998.

[4] 1997 Industrial Energy Efficiency Incentive Program Impact Evaluation – Final Report – Process, PG&E Study ID #334a; Indoor Lighting, PG&E Study ID #334b, XENERGY, Inc., March 1, 1999.

### d. Model Statistics

See following table.

| | | | | | | 80% Confidence Interval | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| End Use | Measure Group | Measure Codes | Distribution for *ex post* EUL | *ex post* EUL | SE | Lower | Upper | Intercept | SE | Scale | SE | Number of Units in Analysis | Sum of Weights=Number of Independant Observations (Premises) |
| Process | Process Controls | 550 | Weibull | 6.8 | 8.4 | 0.0 | 18.4 | 7.9 | 1.4 | 0.3 | 0.5 | 761 | 12 |
| | Process Heat Recovery | 560 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 5 | 5 |
| | Process Change/Add Equipment | 569 | Exponential | 13.7 | 8.6 | 1.9 | 25.4 | 8.9 | 0.6 | 1.0 | n/a | 241 | 16 |
| | Process Insulate | 590 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 568 | 3 |
| | Process Other | 599 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | 167 | 24 |

### e. Specification

The following report sections discuss model specification:

- Section 1.2 - general modeling approach.
- Section 3.2 - modeling issues specific to the process end use

### f. Error in Measuring Variables

Uncertainty in removal dates was addressed using the onsite visit date as the left censoring endpoint.

### g. Influential Data Points

See 4a

### h. Missing Data

See 4a

### i. Pecision

Standard errors produced by SAS procedure. Weights adjusted to the number of independent observations (number of premises), to avoid overstating the accuracy of the standard errors that comes from counting each unit as a separate observation.

D

# APPROVED STUDY METHOD 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[1] 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

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

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

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. |

m&e\retention\calc approach waiver second approach v.1.doc - 05/12/1999