SOUTHERN CALIFORNIA EDISON COMMERCIAL/INDUSTRIAL/AGRICULTURAL ENERGY EFFICIENCY INCENTIVES PROGRAM RETENTION STUDY

CEC Study ID # 547 B,C and 558 B, C

Sixth Year Report
for Program Years 1993 - 1997
Industrial and Agricultural Measures

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EXECUTIVE SUMMARY

This report is the sixth year report on the retention of industrial and agricultural measures that were installed under Southern California Edison's (SCE) Commercial/Industrial/Agricultural (C/I/A) Energy Efficiency Incentives Program.,

Since 1995, SCE has been conducting a multi-year study to track the retention of the energy efficiency measures installed by commercial, industrial and agricultural customers who received financial incentives for energy efficiency measures that they installed under the program. Data for the study have been collected through a longitudinal survey effort that has involved visiting and/or telephoning each site to track the retention of the rebated measures at each facility.

The initial focus of the measure retention study was on measures installed by customers participating in the (C/I/A) Energy Efficiency Incentives Program during 1993 and 1994 in order to satisfy regulatory requirements for a third-year retention study for industrial and agricultural measures and a fourth-year retention study for commercial measures.[1] Similar third- and fourth-year studies would have been required by the protocols for the 1996 and 1997 program years. However, SCE requested and received a waiver to continue the data collection through 2000 for sites included in the base study. The data collection and analysis effort was also expanded to include additional selected measures installed by customers who participated in SCE's program in 1996 or 1997. The types of measures covered in the study from different sectors and program years are shown in Table ES-1.

Previous analyses of data collected during the period 1995 through 2000 were presented and discussed in earlier reports. For this sixth-year report on industrial and agricultural measures, data that were collected through on-site visits to industrial and agricultural sites in 2002 have been added to the data collected from 1995 through 2000 and used to determine the retention rates for each measure through 2002. Based on the data collected, the retention rates for the various measures installed at industrial and agricultural sites are as shown in Table ES-2 for the 1993/1994 program years and in Table ES-3 for the 1996/1997 program years.

[1] *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs*, as adopted by California Public Utilities Commission Decision 93-05-063, with subsequent revisions.

Table ES-1. Measures Included in Retention Study by Sector and Program Year

Program Year	*Sector*	
	Industrial	*Agricultural*
1993 and 1994	T8 fixtures T8 lamps Ballasts Adjustable Speed Drives For 1994 only: Lighting EMS Injection molding Process cooling Process equipment insulation Air compressors High efficiency chillers for process	Pumps Pump system (hardware) improvements
1996	Injection molding machines Plastic extrusion Process cooling Process equipment insulation High efficiency chillers Air compressors	No measures added
1997	Lighting EMS Injection molding machines Plastic extrusion Process cooling High efficiency chillers Air compressors	Pump system control Water service EMS Hardware to lower temperature

Table ES-2. Retention Rates through 2002 for I/A EE Incentives Program Measures: Installed in 1993 and 1994 Program Years

Type of Measure	*Percentage of Measures Removed, Failed or Replaced by 2002*	*Percentage of Measures Retained after 2002*
Industrial Measures		
T8 lighting fixtures	25.0%	75.0%
T8 lamps	84.8%	15.2%
Electronic ballasts	31.5%	68.5%
Adjustable speed drives*	33.8%	66.2%
Lighting EMS	9.1%	90.9%
Injection molding machines	3.7%	96.3%
Plastic extrusion equipment	0.0%	100.0%
Process cooling	0.0%	100.0%
Process equipment insulation	0.0%	100.0%
High efficiency chillers	0.0%	100.0%
Air compressors	5.6%	94.4%
Agricultural Measures		
Pumps/pump system improvements	32.6%	67.4%
Adjustable speed drives*	16.7%	83.3%

*In previous reports, retention rates were calculated for agricultural ASDs and industrial ASDs combined. This report calculates separate retention rates for the two sectors.

Table ES-3. Retention Rates through 2002 for I/A EE Incentives Program Measures: Installed in 1996 and 1997 Program Years

	Percentage of Measures Removed, Failed or Replaced by 2002	*Percentage of Measures Retained after 2002*
Industrial Measures		
Adjustable speed drives*	13.3%	86.7%
Lighting EMS	50.0%	50.0%
Injection molding machines	0.0%	100.0%
Plastic extrusion equipment	0.0%	100.0%
Process cooling	20.0%	80.0%
Process equipment insulation	50.0%	50.0%
High efficiency chillers	0.0%	100.0%
Air compressors	14.3%	85.7%
Agricultural Measures		
Adjustable speed drives*	0.0%	100.0%
Hardware to lower temperature	0.0%	100.0%
Pump system controls	0.0%	100.0%
Water service EMS	0.0%	100.0%

*In previous reports, retention rates were calculated for agricultural ASDs and industrial ASDs combined. This report calculates separate retention rates for the two sectors.

Another objective of the study has been to estimate effective useful life (EUL) for each measure and to determine if the estimated EUL was different from the expected EUL. Because the early retention rates for the different measures were relatively high, direct estimation of survival functions from the collected data was not informative. However, hazard functions could be estimated for many of the measures, and corresponding survival functions could be developed using the estimated hazard functions. For measures where there was a relatively small number of failures, the hazard analysis could not be performed.

The estimates of effective useful lives determined through this study are reported in Table ES-4, which also reports SCE's *ex ante* estimates of effective useful lives. The hypothesis of no difference between *ex ante* and *ex post* estimates of useful life could not be rejected for any of the measures.

Table ES-4. Estimated Median Lives Compared to SCE's Ex Ante Estimates for Effective Useful Lives (Lives in years)

Type of Measure	*SCE Ex Ante Estimate of EUL*	*Estimated Median Life*	*Ex Ante Different from Ex Post?*
Industrial Measures			
T8 lighting fixtures	11.0	14.1	No
T8 lamps**	5.0	7.5	No
Electronic ballasts	10.0	13.9	No
Adjustable speed drives	10.0	11.6	No
Lighting EMS	15.0	*	*
Injection molding machines	15.0	*	*
Plastic extrusion equipment	15.0	*	*
Process cooling	15.0	*	*
Process equipment insulation	15.0	*	*
High efficiency chillers	20.0	*	*
Air compressors	15.0	*	*
Agricultural Measures			
Pumps/pump system improvements	15.0	32.1	No
Adjustable speed drives	10.0	11.6	No

*Data on numbers of removals/failures were not sufficient to estimate median useful life.

**The estimated median life is derived from the hazard rate analysis. In fact, nearly 85 percent of the T8 lamps are no longer in place. The number of years when 50 percent of T8 lamps were not in place was 5.7 years.

1. INTRODUCTION AND BACKGROUND

This report is the sixth-year report on industrial and agricultural measures installed by customers of Southern California Edison (SCE) under the Energy Management Hardware Rebate Program (EMHRP), which was the name of SCE's nonresidential energy efficiency incentives (EEI) program. The analysis reported in this report is part of the overall measure retention study that SCE has been conducting since 1995. Data collected at industrial and agricultural sites during 2002 have been added to the data previously collected for the retention study[1]

1.1 OVERALL PROJECT OBJECTIVES

The overall objectives of the nonresidential measure retention study are as follows:

- Locate energy conservation measures installed by participants in SCE's Energy Management Hardware Rebate Program;
- Determine the number of measures that were installed and operational to establish a baseline condition;
- Determine the rates of early removal and disconnects, including survival functions;
- Determine reasons for early removal and disconnects;
- Determine what has replaced removed measures;
- Identify changes in usage patterns over time;
- Identify changes in circumstances of use (e.g., location of measure, end-use service provided, use of space in the area surrounding the measure, etc.) over time; and
- Establish measures' effective useful lives.

1 Earlier analyses of the data collected during the measure retention study were reported in three reports:
Commercial/Industrial/Agricultural Energy Efficiency Incentives Program Fourth Year Retention Study, Final Report. Prepared for Southern California Edison by ADM Associates, Inc., March 1999.
Commercial/Industrial/Agricultural Energy Efficiency Incentives Program Fourth Year Retention Study, Annual Report for 1999 Data Collection. Prepared for Southern California Edison by ADM Associates, Inc., July 2000.
Commercial/Industrial/Agricultural Energy Efficiency Incentives Program Retention Study, Annual Report for 2000 Data Collection. Prepared for Southern California Edison by ADM Associates, Inc., February 2001

Under the DSM Protocols[2] adopted by the California Public Utilities Commission (CPUC), measures are to be studied in retention studies that either make up 50% of the savings for their respective sectors or that account for the top 10 measures in a sector.

The initial focus of the study was on measures installed by customers participating in SCE's nonresidential energy efficiency incentives programs during 1993 and 1994 in order to satisfy the Measurement Protocols requirements for a third-year retention study for industrial and agricultural measures and a fourth-year retention study for commercial measures.

Under the protocols, similar third- and fourth-year studies would have been required by the protocols for the 1996 and 1997 program years. (There was effectively no program operating during 1995.) However, SCE requested and received a waiver to continue the data collection through 2000 for sites included in the base study. The rationale for continuing the data collection for these sites was that the longitudinal survey methodology being used will provide a very rich data set for the development of survival curves for the major end uses in the program. Continuing to survey these customers in lieu of performing a "point estimate" study for the 1996 and 1997 program years would provide two additional years of data for the survival curve modeling used to estimate effective useful lives. "Point estimate" studies for the 1996 and 1997 studies would have repeated work already done and would probably not be fully informative since retention rates for the measures installed under the 1996 and 1997 programs were expected to be relatively high.

However, the data collection and analysis effort was expanded to include additional selected measures installed by customers who participated in SCE's program in 1996 or 1997 to ensure that empirical data that provided evidence on retention rates were available. Tables showing the *ex ante* savings for measures installed by customers participating in the EMHR Program in program years 1996 and 1997 were developed and used to identify the measures that should be added to the study to provide the coverage required by the protocols. The types of measures covered in the study from different sectors and program years are shown in Table 1-1.

2 See *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs*, as adopted by California Public Utilities Commission Decision 93-05-063, with subsequent revisions.

Table 1-1. Industrial and Agricultural Measures Included in Retention Study by Sector and Program Year

<table>
<tr><th rowspan="2">Program Year</th><th colspan="2">Sector</th></tr>
<tr><th>Industrial</th><th>Agricultural</th></tr>
<tr><td>1993 and 1994</td><td>T8 fixtures
T8 lamps
Ballasts
Adjustable speed drives

For 1994 only:
Lighting EMS
Injection molding
Process cooling
Process equipment insulation
Air compressors
High efficiency chillers for process</td><td>Pumps
Pump system (hardware) improvements</td></tr>
<tr><td>1996</td><td>Injection molding machines
Plastic extrusion
Process cooling
Process equipment insulation
High efficiency chillers
Air compressors</td><td>No measures added</td></tr>
<tr><td>1997</td><td>Lighting EMS
Injection molding machines
Plastic extrusion
Process cooling
High efficiency chillers
Air compressors</td><td>Pump system control
Water service EMS
Hardware to lower temperature</td></tr>
</table>

The data for accomplishing the study objectives were collected for a sample of facilities chosen from among customers who participated in SCE's EMHRP in 1993, 1994, 1996, and 1997. The 1995 program has not been included in the measure retention study because it involved only eight customers, and SCE's request to waiver the requirement to measure the impacts of that year was approved by the CPUC. The waiver is provided in Appendix C.

This report has been prepared as part of the overall measure retention study. It is a sixth-year report on the retention of industrial and agricultural measures installed by customers under SCE's program.

1.2 ORGANIZATION OF REPORT

This report is organized as follows.

- Chapter 2 discusses the methods used for the study.
- Chapter 3 presents and discusses the results of the analysis of industrial measures.
- Chapter 4 presents and discusses the results of the analysis of agricultural measures.
- Appendix A provides the data used to estimate hazard functions for industrial/agricultural measures and plots of the estimated hazard and survival functions.
- Appendix B contains Tables 6 and 7 as required by the Protocols. These tables contain detailed information regarding study sample sizes, data attrition, analysis methods, and results.
- Appendix C provides the retroactive waiver that excluded the 1995 C/I/A EEI program from the nonresidential measure retention study.

2. DATA COLLECTION AND ANALYSIS METHODS AND PROCEDURES

This chapter discusses the methods and procedures used to collect data for the nonresidential measure retention study. Section 2.1 discusses the survey design underlying the data collection effort. Section 2.2 discusses the data collection instruments. Section 2.3 discusses the data collection procedures. Section 2.4 discusses the methods used to analyze the data to estimate effective useful lives for the measures.

2.1 SURVEY DESIGN

The data on measure retention were collected for a sample of facilities chosen from among SCE customers who participated in SCE's Energy Management Hardware Rebate Program (EMHRP). A detailed discussion of the survey design used to select the initial cadre of study sites from participants in the 1993 and 1994 EMHR programs was provided in an earlier report.[1] That discussion is summarized in Section 2.1.1. Data collection for these sites was extended to include 1999 and 2000 in order to provide longer time spans for identifying removals/failures and hence to better estimate effective useful lives.

In addition, sites and measures were added to the study from the 1996 and 1997 programs to ensure that empirical data that provided evidence on retention rates for measures installed in those years are available. A discussion of the procedures used to identify the measures from the 1996 and 1997 programs requiring coverage is provided in Section 2.1.2.

The survey design that had been implemented for previous data collection was continued during 2002 to collect data that could be used to prepare this sixth year report on the retention of industrial and agricultural measures. Data were collected during 2002 at the industrial and agricultural sites that participated in the program.

2.1.1 Sampling Plan for Selecting Sites from 1993/1994 Program Years

The initial sample of facilities for the measure retention study was chosen through measure-based sampling. The goal in preparing the sample design was to permit the useful life of a measure to be estimated with a relative precision of ±20 percentage points at the 80 percent confidence level. A sample that combined

1 See Chapter 2 in *Commercial/Industrial/Agricultural Energy Efficiency Incentives Program Fourth Year Retention Study*, *Final Report*. Prepared for Southern California Edison by ADM Associates, Inc., March 1999.

sample points from the EMHRP for 1993 and 1994 was used to satisfy these precision/confidence requirements. At the same time, the sample design incorporated features to lower the data collection costs.

The analytical framework for the development of the sample design for the study was provided by survival analysis techniques. Survival analysis pertains to the analysis of data that correspond to the time from a well-defined time origin until the occurrence of some particular event or end-point. For this study, the time origin was defined by the installation of a measure under the EMHR program, while the end-point was defined by the removal or failure of the measure or the discontinuance of its use.

The measure survival data were expected to have several features that warranted special treatment in preparing the sample design.

- The measure survival data would probably not be symmetrically distributed and could not be reasonably represented by a normal distribution.
- The survival data would be right-censored in that the removal, failure, or discontinuance end-points would not be observable for some of the installed measures.
- The survival data for some types of measures (e.g., lighting measures) would likely be affected by clustering. That is, a single customer might have multiple occurrences of a particular type of measure (e.g., T8 lamps). For a single customer, there could be expected to be some homogeneity in the lifetimes for the particular type of measure, since they were all installed at the same time and were subject to similar operational conditions. Because of this homogeneity, a sample of clustered measure occurrences would provide less information than a similar sample that did not show such homogeneity.

The sample design for addressing these and other features of the data was developed through the following steps.

- First, the number of removals/failures required to meet the precision/confidence specifications for each type of measure was determined.
- Second, the probability of removal/failure for each type of measure over the period of the study was determined and applied to the required number of removals/failures to determine the number of points required in the sample.
- Third, the required sample size was adjusted to account for the effects of clustering.
- Fourth, sample points for a measure were allocated among facilities.

To arrive at quantitative estimates of the required sample sizes for the various types of measures, it was necessary to use a parametric representation for the measure survival data. For the purposes of sample design, it was assumed that the survivor function for a measure's life data could be represented with an exponential distribution. With an exponential survivor function, the standard error for the estimated mean from a sample depends on the number of removals/failures that are observed. In particular, 41 removals/failures would be required to estimate mean measure life for a particular measure at a relative precision of ±20 percent at the 80 percent confidence level.

Not all of the occurrences of a measure would be observed until their life end-point, giving rise to right-censoring in the sample. Accordingly, the number of measure occurrences brought into the sample had to be greater to accommodate this right censoring phenomenon. The sample size needed to provide the required number of removals was determined as follows:

$$\text{Sample Size} = \frac{\text{Number of required removals or failures}}{\text{Probability of removal or failure}}$$

The probability of removal or failure with an assumed survivor function could be calculated as a function of (1) specified values for the survivor function, (2) the study accrual time (i.e., the period when measure occurrences take place) and (3) the study follow-up time (i.e., the period when occurrences are tracked to see whether they are removed or fail). For the overall measure retention study, the accrual period was 24 months (the years 1993 and 1994 for the EMHR Program), and the follow-up period was 48 months (the four years 1995-1998 when on-site and telephone data collection occur). Mean values of measure life for calculating the parameters of the assumed exponential survivor functions for the various types of measures were taken from a report prepared for the California DSM Measurement Advisory Committee (CADMAC).[2]

Given that the length of the study was fixed, the probability of removal/failure was determined primarily by the expected mean life of a measure. The shorter the mean life of a measure, the higher the probability of removal or failure. For example, the probability of removal/failure is 0.593 for a measure with a mean life of 5 years and 0.368 for a measure with a mean life of 10 years. With the required number of removals/failures for either type of measure being 41, the respective sample sizes are 69 and 112.

2 *DSM Measure Life Project: Master Tables of Measure Life Estimates and Final Report.* Prepared by Energy Management Services for the California DSM Measurement Advisory Committee (CADMAC), August 1993.

For measures where there were expected to be multiple occurrences at a site (e.g., for lighting measures), an additional step in the sample design was to adjust for the intra-site correlation among useful lives for the different occurrences at a site. A sample drawn from clusters with some degree of homogeneity carries less information than a random sample of the same size which is heterogeneous. On the other hand, using a cluster sampling approach would lower the number of sites that needed to be visited, thereby reducing costs.

A two-stage sampling procedure was used, with sites designated as primary sampling units and measure occurrences as secondary sampling units. A sample of sites was chosen first, and then a sample of measure occurrences was chosen within each selected site. Whether information was collected for all or for a sample of measure occurrences at a site depended on the type of measure.

- For lighting measures, a sampling of occurrences was used. For each type of lighting measure, 10 occurrences of the measure were inspected at a sample site. Fixture groups were defined that had equivalent physical design and approximately similar operating hours (based on lighting system operating controls). Detailed information was recorded on ballast, reflector, lens, bulb, controls, task use, and other features as installed under the program and as noted on program records.
- For HVAC measures and process measures, a census approach was used, since there were generally only one or two occurrences of a measure at a site.
- For each type of measure, EMHRP participants in each year were stratified according to program year, business sector and size.
- The number of sample points required for any particular measure was divided equally between 1993 and 1994 participants.
- With the business sector stratification, participants were separated into a commercial customer class and an industrial/agricultural customer class.
- Within each measure/sector grouping, customers were further stratified according to size using a program category variable developed by SCE program staff. Commercial and industrial customers were assigned to categories according to their kW demand.
- Data for sites with chillers that had been visited as part of an impact evaluation of the EMHR Program were included in the sample for the retention study.

For the 1994 program year, inspection of the coverage of savings in each sector provided by the initial set of measures indicated that additional measures should be added to the study in the industrial sector. These measures included:

- EMS on lighting
- Injection molding machines
- Plastic extrusion equipment
- Process cooling
- Insulation on process equipment
- Air compressors

With these measures added, the menu of 1994 measures included in the retention study provided the coverage required by the Protocols. This coverage is shown in Table 2-1.

Table 2-1. Coverage of Sector kWh Savings Provided by 1994 Measures Included in Retention Study

Type of Measure	*Industrial Sector*	*Agricultural Sector*
Indoor lighting	15.61%	2.80%
HVAC-EMS	2.54%	0.00%
Chillers	1.23%	0.00%
ASDs	11.59%	33.10%
Pump replacement	0.16%	28.78%
Pump improvement	3.04%	14.59%
Injection molding machine	5.26%	
EMS on lighting	4.59%	
Process cooling	2.59%	
Insulation on process equipment	1.27%	
Air compressors	1.14%	
Percent of Sector Savings	49.02%	79.27%
Tracking system kWh savings	289,287,201	32,706,638

The initial cadre of industrial and agricultural sites for the study that resulted after the recruitment effort is shown in Table 2-2. There was a total of 328 industrial and agricultural sites included in the initial cadre for the overall measure retention study, distributed across sectors and program years as shown in Table 2-2. Also shown in Table 2-2 are the numbers of sites having the measures of interest for the study. Note, moreover, that the number of occurrences for some of the measures was higher than the number of sites because of multiple occurrences of a measure at a site. For example, there generally were multiple occurrences of lighting measures at a site.

Table 2-2. Initial Cadre of Industrial and Agricultural Sites Selected for Retention Study by Program Year

	1993 Industrial/ Agricultural	*1994 Industrial/ Agricultural*	*All I/A Sites*
Total Number of I/A Sites	179	149	328
Numbers of I/A Sites with Specified Measures			
ASDs	49	42	91
T8 Lamps	59	41	100
Electronic Ballasts	52	41	93
Pump Improvements	26	31	57
Pump Replacements	48	50	98
Lighting EMS	-	11	11
Injection molding machines	-	24	24
Plastic extrusion equipment	-	6	6
Process cooling	-	7	7
Process equipment insulation	-	9	9
High efficiency chillers	-	7	7
Air compressors	-	18	18

2.1.2 Procedures for Selecting Sites from 1996 and 1997 Program Years

Many of the measures installed under the program in 1996 and 1997 were the same type of measures as were installed under the program in 1993 and 1994. SCE successfully sought a waiver from the Protocol requirement by arguing that better information could be obtained by tracking the 1993 and 1994 measures for a longer time. In addition, sites were added to the study to gather retention data on measures that were installed under the program in 1996 and 1997 but not in 1993 and 1994.

In order to identify the measures from the 1996 and 1997 programs that should be added to the study to provide the aforementioned proportional coverage of total program savings required by the Protocols, tables showing the *ex ante* savings for measures installed by customers participating in the EMHR Program in program years 1996 and 1997 were developed.

The sites added were those with measures that provided the Protocol-required coverage of *ex ante* program savings. Except for sites with lighting EMS, the number of sites with particular measures were relatively few. Accordingly, these sites were not sampled but taken into the study by censusing. The numbers of sites from the 1996 and 1997 programs that were surveyed are shown by type of measure in Table 2-3.

Table 2-3. Numbers of Industrial and Agricultural Sites Surveyed from 1996 and 1997 Program Years by Type of Measure

	1996 Industrial/ Agricultural	*1997 Industrial/ Agricultural*	*All Sites*
Total Number of Sites	31	51	82
Numbers of Sites with Specified Measures			
Adjustable speed drives	1	4	5
HVAC EMS	-	3	3
Lighting EMS	1	4	5
Injection molding machines	3	5	8
Plastic extrusion equipment	4	3	7
Process cooling	3	2	5
Process equipment insulation	3	-	3
High efficiency chillers	2	2	4
Air compressors	15	6	21
Pump system control	-	2	2
Water service EMS	-	13	13
Hardware to lower temperature	-	2	2

2.2 DATA COLLECTION INSTRUMENT

Data on which to base the sixth year study for industrial and agricultural measures were collected through on-site visits. Data were collected that could be used to estimate effective measure lives and to analyze the effects on service lives of different factors, such as operational hours and maintenance practices.

Examples of the type of information that were collected with the on-site data collection form included the following:

- Was the program-installed measure still in place and properly installed as specified by program requirements?
- If the measure was not in place and/or properly installed:
  - Was it removed, disconnected, broken, or damaged?
  - Why?
  - When was it removed/disconnected?
  - Was its removal part of a larger change? What?
  - What, if anything, replaced the measure?
- Was the measure in a good state of repair?
- Was there a specific maintenance schedule for each measure?

- Has the use of space surrounding the measure changed since installation? How?
- Was the equipment used differently than it was originally? Less? More? Had it been modified?
- Had there been business turnover and/or occupant changes?
- What were the customer and building characteristics?

2.3 DATA COLLECTION PROCEDURES

Data for the measure retention study were collected from 1995 through 1998 according to the program year and sector. The schedule for the data collection for those years is shown in Table 2-4.

Table 2-4. Data Collection Schedule from 1995 through 1998

Study Cohort	*1995 (Baseline)*	*1996*	*1997*	*1998*
1993 Commercial	On-site	Telephone	On-site	Telephone
1993 Industrial/Agricultural	On-site	On-site	Telephone	Telephone
1994 Commercial	On-site	Telephone	Telephone	On-site
1994 Industrial/Agricultural	On-site	Telephone	On-site	Telephone

For 1999 and 2000, the type of data collection depended on whether a site had installed lighting or non-lighting measures. For sites with lighting measures, data were collected through on-site visits. For sites with non-lighting measures, telephone calls were used to determine whether the measures were still in place. The procedures used for the data collection are described in the following discussion.

For 2002, data on industrial and agricultural measures were collected through on-site visits to industrial or agricultural sites.

2.3.1 Customer Recruitment and Tracking

Because the industrial and agricultural sites that were to be visited during 2002 had already been visited several times before during the measure retention study, a list with contact names and telephone numbers was available. The scheduler used this list to contact the sites for the 2002 data collection effort.

When a customer agreed to participate in the data collection effort, the scheduler arranged a mutually acceptable date and time for data collection, based on the convenience of the customer and on the travel schedule of the field staff. After each data collection visit was scheduled, the date, time, and any other particulars pertaining to the visit were entered onto the customer's record in a Customer

Status File on the computerized tracking and reporting system that was used to administer and manage the data collection effort.

The Customer Status File contained a record of specified characteristics for each customer in the sample, along with information pertaining to all attempts to contact a customer and to the final disposition of the attempts to schedule a data collection visit. Accordingly, if all attempts to recruit a candidate were unsuccessful, a report was generated from the Customer Status File that documents the attempts that had been made. This report is used to determine whether to release an alternate sample point to replace a customer that could not be recruited. The procedures used in recruiting primary candidates were also used in recruiting any alternate candidates.

2.3.2 Data Collection and Quality Control

The discussion in this section addresses the various aspects of the work effort involved in conducting the on-site data collection for the customers selected for the sample. These aspects included selecting and supervising the field staff; contacting customers and scheduling data collection visits; and collecting data.

Trained engineers who had collected the data in the previous years of the measure retention study were used as the field staff for the on-site data collection during 2002. A training session was held before the beginning of the data collection effort to instruct the field staff on changes in the requirements of the data collection effort. The training session included a discussion of project objectives and provided for review of the data collection form and of the procedures to be used to collect data effectively with minimum disruption to the customer.

Once the arrangement for a data collection visit had been made, a member of the field staff visited the customer's facility on the scheduled date to collect the data. Before the field staff went to a facility, they reviewed information on the measures installed at that facility. This review ensured that the field engineer was familiar with the facility and measures for which data were to be collected when he went on-site and that he appropriately allocated his time to collect data on those measures that were the primary subjects for the analysis.

Program data that SCE had collected were used to facilitate the on-site data collection. These program data were used to establish the baseline information on equipment and measures that were installed in the buildings under the EMHR Program. Changes from these data were indicative of building changes and component changeouts. These and other items of information were extracted from the program records and provided to the field staff to facilitate the site visits. This was needed so that the field staff could know what “was” to compare with what “is” at the site and thereby note or ask about any apparent changes.

During the on-site data collection visit, the field personnel used the data collection form described in Section 2.2.1 to collect the required data. They paid particular attention to getting sufficient information with which to analyze the life of the measures. They located the measures and verified the ratings and operational characteristics of the affected equipment. They also collected information on other building operations that affect the operation of the installed measures.

Some of the required data were collected through interviews with the staff of the facility. For most sizable facilities, there was generally a building or plant engineer who was familiar with the operation of the facility and its equipment. This interview provided the facility staff with a brief introduction to the purpose and conduct of the study. Facility staff were asked a limited set of questions that were directed at investigating inconsistencies in previous data as well as toward forming a basis for visual inspection of measures. Following the interview, the field engineer visually inspected and verified measure installation. Data were recorded on whether the measure was installed and operating; equipment maintenance was assessed qualitatively; and (where relevant) make and model number of equipment was verified.

Quality control procedures were used throughout the data collection effort to ensure that the data collected were of high quality. Discrepancies between baseline, interview, and visual inspection results were resolved prior to leaving a facility. The field staff prepared facility layouts that showed the locations of the measures inspected. They also placed stickers on the measure devices to identify them as being included in this study; the stickers included a telephone number to be called if the devices were removed.

The data collected on-site for each customer were entered into a computerized file using a *Paradox for Windows* full-screen data entry/modification form. The data entered into the Paradox data base were later converted into a PC-SAS database for validation and analysis.

2.4 ANALYSIS METHODS

The data collected during 1995 through 2000 were used in earlier analyses to accomplish the following:

- Establish baseline conditions by determining the fraction of measures that had been installed and were operational;
- Determine the rates of early removal and disconnects and the reasons for early removal and disconnects; and
- Establish measures’ effective useful lives.

The data collected for industrial and agricultural sites during 2002 were combined with the data collected earlier to further analyze rates of early removal and disconnect and to re-estimate the effective useful lives of installed measures.

Determining the rates of early removal or disconnection could be accomplished through tabulation of the data collected through the on-site surveying. However, additional analysis was required to establish the effective useful lives of the measures.

2.4.1 Procedure to Estimate EUL

Under the DSM Measurement Protocols, a utility can recover earnings based on the following equation:

Net resource benefits = first year impacts x EUL x TDF

where EUL is the effective useful life of a measure and TDF is a technical degradation factor used to account for time-and-use related change in the energy savings of a high efficiency measure or practice relative to a standard efficiency measure or practice. The first-year impacts are developed in the first-year impact evaluation studies, while the technical degradation factors have been developed from a statewide study sponsored by CADMAC. Estimates of EUL are to be developed through retention studies, such as this one.

Under the Protocols, the effective useful life of a measure is defined as the median number of years that the measure installed under the program is still in place and operable. In effect, the median age is the number of years that pass until 50% of the installed measures are no longer in place and operable. Determining the effective useful life according to this definition requires deriving a survival function for a measure, where a survival function shows the fraction of installed measures still in place and operable as time passes.

The analytical difficulty that arises in trying to derive a survival function for a program measure is that the amount of data available is relatively limited. There are 100% of the measures in place and operable under the baseline conditions that are established. Moreover, estimates of the percentage of measures still in place after a given number of years (e.g., six or seven years for measures installed in 1993 or 1994) are shown by the retention rates determined from the data collected in a retention study. However, no actual data on which to base the survival function are available for the particular measures beyond the data collection period.

As the data presented below will show, retention rates have been high for some of the measures considered in this study. Because of this, non-parametric methods of estimating survival functions are not appropriate for such measures. Non-parametric methods can give an accurate estimate of median survival time only if more than 50% of the measures are no longer in place and operable. Only for T8 lamps are more than 50% of the installed measures no longer in place and operable.

Parametric methods were therefore used for estimating a median survival time for each measure. A possible difficulty with the parametric approach is that if a measure has a high early retention rate, then there is little information with which to distinguish between different functional forms for the survival function if estimated directly. Because of the limited time span that the collected data cover, a variety of functions that imply significantly different survival patterns and median lives can be fitted through the data.[3]

However, an alternative to trying to estimate the survival function directly is to estimate a hazard function using the available data, and then using the estimated hazard function to develop an associated survival function. The steps in the parametric procedure for estimating the effective useful lives were as follows:

- Prepare data for calculation of hazard rate function;
- Calculate hazard rate function;
- Use hazard rate function to determine survival function; and
- Estimate effective useful life of measures from survival function.

An essential component in this analytical procedure is the estimation of the hazard rate function. A hazard function defines the probability that an item will fail in the next unit of time, given that it has survived to the present. The hazard rate at time t is the ratio of the number of units failing in that interval to the number surviving to that time:

$$h(t) = \frac{f(t)}{1-F(t)}$$

where h(t) is the hazard rate at time t; f(t) is the probability of failure during an increment of time at time t; and F(t) is the cumulative probability of failure up to time t. For the analysis in this study, the hazard rate for any given time period (e.g., a year) represents the proportion of items that were removed or failed during the time period, given that they had survived to the beginning of the time period.

3 For discussion of this problem, see Hahn, G.J. and Meeker, W.Q, Jr., "Pitfalls and Practical Considerations in Product Life Analysis—Part I: Basic Concepts and Dangers of Extrapolation", *Journal of Quality Technology*, Vol. 14, July 1982, pp. 144-152.

Once a hazard function is estimated, a corresponding survival function S(t) can be determined, where S(t) represents the percent surviving at time t.[4]

Two of the distributions commonly used for survival analysis are the exponential distribution and the Weibull distribution[5]. The probability density functions and associated hazard functions and survival functions for these distributions are shown in Table 2-5.

Table 2-5. Hazard and Survival Functions for Exponential and Weibull Distributions

Exponential Distribution	
Probability Density Function	$f(t) = \gamma\exp(-\gamma t)$
Hazard Function	$h(t) = \gamma$
Survival Function	$S(t) = \exp(-\gamma t)$
Weibull Distribution	
Probability Density Function	$f(t) = \alpha\beta t^{\beta-1}\exp(-\alpha t^{\beta})$
Hazard Function	$h(t) = \alpha\beta t^{\beta-1}$
Survival Function	$S(t) = \exp(-\alpha t^{\beta})$

As Table 2-5 shows, the exponential distribution can be used to represent a hazard rate that is constant. The associated survival function is also exponential. However, the exponential distribution does not represent hazards that increase or decrease over time. If the hazard rate does increase or decrease with age, the Weibull distribution can be used to represent the hazard function and the survival function. (Note that with the Weibull distribution, α is termed as the scale parameter, while β is termed as the shape parameter.)

As provided for in the Protocols, a statistical test of whether the *ex post* estimate of useful life is significantly different from the *ex ante* estimate can be made by constructing an 80% confidence interval around the *ex post* estimate and determining whether the *ex ante* estimate falls within this confidence interval. That is, if the *ex ante* estimate falls inside the constructed confidence interval, then the hypothesis of no difference between the *ex ante* and *ex post* estimates cannot be rejected. If the *ex ante* estimate falls outside the constructed confidence interval, then the hypothesis of no difference between the *ex ante* and *ex post* estimates can be rejected.[6]

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4 Collett, D. *Modelling Survival Data in Medical Research*, Chapman & Hall, 1994, pp. 10-13.

5 Collett, *ibid.* Also see Kiefer, Nicholas "Economic Duration Data and Hazard Functions", *Journal of Economic Literature*, Vol. XXVI, pp. 646-679, June 1988.

6 See, for example, Snedecor, G.W. and Cochran, W.G., *Statistical Methods, 7th Edition*, Iowa State University Press, 1980, p. 66.

For the analytical approach used in this study to estimate useful lives of the measures, an 80% confidence interval for the estimated median life of a measure was calculated as follows. The regression fit of the power curve coefficients was used to report the values of the estimated coefficients associated with the 80% confidence levels. Thus, the power curve regression analysis for each measure provided three sets of parameters for the Weibull hazard rate function: the "best" fit parameters and parameters for the upper and lower bounds of the 80% confidence interval for the estimated coefficients. In effect, the analysis provided an estimate of the "best" hazard function and survival function for a measure, plus estimates of the functions for the upper and lower bounds of the 80% confidence interval.

3. RESULTS FOR INDUSTRIAL MEASURES

This section presents and discusses the results from analyzing retention rates and estimating effective useful lives for industrial measures. Summary statistics on the industrial sites for which data were collected are reported in Section 3.1. Retention rates are presented in Section 3.2, while estimates of effective useful lives are presented in Section 3.3.

3.1 DATA COLLECTED FOR INDUSTRIAL SITES

During 2002, data were collected on-site for the industrial sites that are included in the study sample. The distribution of the on-site data collection effort for these sites is shown in Table 3-1.

Table 3-1. Industrial Sites for Which Data Were Collected during 2002

Program Year	*Number of Sites Surveyed*
1993	103
1994	75
1996/1997	81

3.2 RETENTION RATES FOR INDUSTRIAL MEASURES

Retention rates for the various types of industrial measures for each program year were calculated using the information collected through the on-site surveying. Table 3-2 shows the percentage of measures installed in each year that were no longer in place by 2002. The implied retention rates are also shown.

3.3 ESTIMATES OF EFFECTIVE USEFUL LIVES FOR INDUSTRIAL MEASURES

The analytical procedure described in Section 2.4.1 was used to develop estimates of effective useful lives for four of the industrial measures for which there were sufficient data. As Table 3-2 showed, there were seven industrial measures for which the number of installations and number of removals/failures were relatively small and not sufficient to support analysis of median useful life.

Table 3-2. Retention Rates for Industrial Measures by Program Year

Type of Measure	*Number of Measures Installed*	*Number of Measures Removed, Failed or Replaced by 2002*	*Percentage of All Measures Removed, Failed or Replaced by 2002*	*Percentage of Measures Retained after 2002*
		1993 Program Year		
T8 lighting fixtures	660	190	28.8%	71.2%
T8 lamps	1,841	1,567	85.1%	14.9%
Electronic ballasts	715	256	35.8%	64.2%
Adjustable speed drives*	73	28	38.4%	61.6%
		1994 Program Year		
T8 lighting fixtures	355	64	18.0%	82.0%
T8 lamps	915	771	84.3%	15.7%
Electronic ballasts	377	88	23.3%	76.7%
Adjustable speed drives*	66	19	28.8%	71.2%
Lighting EMS	11	1	9.1%	90.9%
Injection molding machines	27	1	3.7%	96.3%
Plastic extrusion equipment	8	0	0.0%	100.0%
Process cooling	6	0	0.0%	100.0%
Process equipment insulation	5	0	0.0%	100.0%
High efficiency chillers	5	0	0.0%	100.0%
Air compressors	18	1	5.6%	94.4%
		1996 Program Year		
Adjustable speed drives*	4	0	0.0%	100.0%
Injection molding machines	5	0	0.0%	100.0%
Plastic extrusion equipment	3	0	0.0%	100.0%
Process cooling	2	1	50.0%	50.0%
Process equipment insulation	2	1	50.0%	50.0%
High efficiency chillers	2	0	0.0%	100.0%
Air compressors	14	3	21.4%	78.6%
		1997 Program Year		
Adjustable speed drives*	11	2	18.2%	81.8%
Lighting EMS	4	2	50.0%	50.0%
Injection molding machines	4	0	0.0%	100.0%
Plastic extrusion equipment	6	0	0.0%	100.0%
Process cooling	3	0	0.0%	100.0%
Process equipment insulation	-	-	-	-
High efficiency chillers	5	0	0.0%	100.0%
Air compressors	7	0	0.0%	100.0%

*In previous reports, retention rates were calculated for agricultural ASDs and industrial ASDs combined. This report calculates separate retention rates for the two sectors.

The results from the analysis to determine EULs for industrial measures are summarized in Table 3-3 and Table 3-4. Plots of the hazard functions and survival functions for the industrial measures analyzed are provided in Appendix A. A Weibull distribution was used to represent the hazard function for each measure. The parameters estimated through power curve fits and the estimated scale and shape parameters of the Weibull function are reported in Table 3-3. The resulting estimates of median survival lives are reported in Table 3-4 and compared to SCE's *ex ante* estimates of effective useful lives.

Inspection of the estimates reported in Table 3-4shows that there is relatively good agreement between SCE's *ex ante* estimates of effective useful lives for industrial measures and the median survival lives estimated through this study. For measures for which median useful lives could be estimated, the hypothesis of no difference between *ex ante* and *ex post* estimates cannot be rejected.

Table 3-3. Summary of Hazard Rate Estimation for Industrial Measures

Type of Measure	*Power Curve Fit*			*Weibull Distribution Parameters*	
	A	*b*	*R-squared*	*α (Scale)*	*β (Shape)*
T8 lighting fixtures	-3.00974	-0.32536	0.062	0.04930	1
T8 lamps	-5.54211	2.14247	0.614	0.00125	3.14247
Electronic ballasts	-4.78442	0.92495	0.573	0.00434	1.92495
Adjustable speed drives	-3.07827	0.16875	0.302	0.03939	1.16875

Table 3-4. Estimated Median Lives Compared to Ex Ante Estimates for Industrial Measures (Lives in years)

Measure	*SCE Ex Ante Useful Life Estimate*		*Estimated Median Life*		
	Value	*Source*	*80% Lower bound*	*Estimate*	*80% Upper Bound*
T8 lighting fixtures	11	1997 AEAP, Table C	4.04	14.06	48.90
T8 lamps**	5	Protocol, App. F, Table 1	3.56	7.47	27.54
Electronic ballasts	10	Protocol, App. F, Table 1	7.07	13.95	39.16
Adjustable speed drives	10	Protocol, App. F, Table 1	7.96	11.63	18.69
Lighting EMS	15	Tracking System	*	*	*
Injection molding machines	15	Tracking System	*	*	*
Plastic extrusion equipment	15	Tracking System	*	*	*
Process cooling	15	Tracking System	*	*	*
Process equipment insulation	15	Tracking System	*	*	*
High efficiency chillers	20	Protocol, App. F, Table 1	*	*	*
Air compressors	15	Tracking System	*	*	*

*Data were not sufficient to estimate median life and realization rates.

**The estimated median life is derived from the hazard rate analysis. In fact, nearly 85 percent of the T8 lamps are no longer in place. The number of years when 50 percent were not in place was 5.7 years.

The EULs estimated for this report are compared in Table 3-5 to the EULs estimated in prior reports. Except for electronic ballasts, the EULs estimated in this report are somewhat higher than those estimated in the previous reports.

Table 3-5. Comparison of EUL Estimates for Industrial Measures across Measure Retention Study Reports

Type of Measure	*EUL Estimate from First Report*	*EUL Estimate from Second Report*	*EUL Estimate from Third Report*	*EUL Estimate from This Report*
T8 lighting fixtures	9.18	12.04	16.80	14.06
T8 lamps	4.32	5.78	6.19	7.47
Electronic ballasts	7.94	15.24	12.51	13.95
Adjustable speed drives	12.31	10.62	10.99	11.63

4. RESULTS FOR AGRICULTURAL MEASURES

This section presents and discusses the results from analyzing retention rates and estimating effective useful lives for agricultural measures. Summary statistics on the agricultural sites for which data were collected are reported in Section 4.1. Retention rates are presented in Section 4.2, while estimates of effective useful lives are presented in Section 4.3.

4.1 DATA COLLECTED FOR AGRICULTURAL SITES

During 2002, data were collected on-site for 144 sites with agricultural measures. The distribution of these sites by program year is shown in Table 4-1.

Table 4-1. Sites with Agricultural Measures for Which Data Were Collected during 2002

Program Year	*Number of Sites Surveyed*
1993	73
1994	71

4.2 RETENTION RATES FOR AGRICULTURAL MEASURES

Retention rates for the agricultural measures for each program year were calculated using the information collected through the on-site surveying. Table 4-2 shows the percentage of measures installed in each year that were no longer in place by 2002. The implied retention rates are also shown.

4.3 ESTIMATES OF EFFECTIVE USEFUL LIVES FOR AGRICULTURAL MEASURES

Analyses similar to those for industrial measures were used to develop estimates of effective useful lives for pumps and pump improvements. Adjustable speed drives were also an agricultural measure, but agricultural ASDs were combined with industrial ASDs for analysis purposes to provide a sample of sufficient size to estimate effective useful life. The estimates reported for industrial ASDs also apply to agricultural ASDs and are repeated here.

Table 4-2. Retention Rates for Agricultural Measures by Program Year

Type of Measure	*Number of Measures Installed*	*Number of Measures Removed, Failed or Replaced by 2002*	*Percentage of All Measures Removed, Failed or Replaced by 2002*	*Percentage of Measures Retained after 2002*
1993 Program Year				
Pumps/pump system improvements	93	30	32.3%	67.7%
Adjustable speed drives*	5	1	20.0%	80.0%
1994 Program Year				
Pumps/pump system improvements	82	27	45.1%	54.9%
Adjustable speed drives*	1	0	0.0%	100.0%
1996 Program Year				
Adjustable speed drives*	4	0	0.0%	100.0%
1997 Program Year				
Adjustable speed drives*	11	0	0.0%	100.0%
Hardware to lower temperature	2	0	0.0%	100.0%
Pump system controls	2	0	0.0%	100.0%
Water service EMS	13	0	0.0%	100.0%

*In previous reports, retention rates were calculated for agricultural ASDs and industrial ASDs combined. This report calculates separate retention rates for the two sectors.

The results from the analysis are summarized in Table 4-3 and Table 4-4. Plots of the hazard functions and survival functions for these agricultural measures are provided in Appendix A. A Weibull distribution was used to represent the hazard function for each. The parameters estimated through power curve fits and the estimated scale and shape parameters of the Weibull function are reported in Table 4-3. The resulting estimates of median survival lives are reported in Table 4-4 and compared to SCE's *ex ante* estimates of effective useful lives.

Inspection of the estimates reported in Table 4-4 shows that the estimated median effective useful life for pumps/pump system improvements estimated through this study is 10.58 years, which is close to SCE's *ex ante* estimate of 11 years.

Table 4-3. Summary of Hazard Rate Estimation for Agricultural Measures

Type of Measure	*Power Curve Fit*			*Weibull Distribution Parameters*	
	a	*b*	*R-squared*	*α (Scale)*	*β (Shape)*
Pumps/pump system improvements	-3.83591	0.38958	0.096	0.02158	1
Adjustable speed drives	-3.07827	0.16875	0.302	0.03939	1.16875

Table 4-4. Estimated Median Lives Compared to Ex Ante Estimates for Agricultural Measures (Lives in years)

Measure	*SCE Ex Ante Useful Life Estimate*		*Estimated Median Life*		
	Value	*Source*	*80% Lower bound*	*Estimate*	*80% Upper Bound*
Pumps/pump system improvements	11	1997 AEAP, Table C	9.96	32.12	> 100
Adjustable speed drives	10	Protocol, App. F, Table 1	7.96	11.63	18.69

APPENDIX A
HAZARD FUNCTIONS AND SURVIVAL FUNCTIONS FOR INDUSTRIAL/AGRICULTURAL MEASURES

This appendix provides the data used for the hazard function analyses of the industrial/agricultural measures and plots of the estimated hazard functions and survival functions. Plots are provided for the following measures:

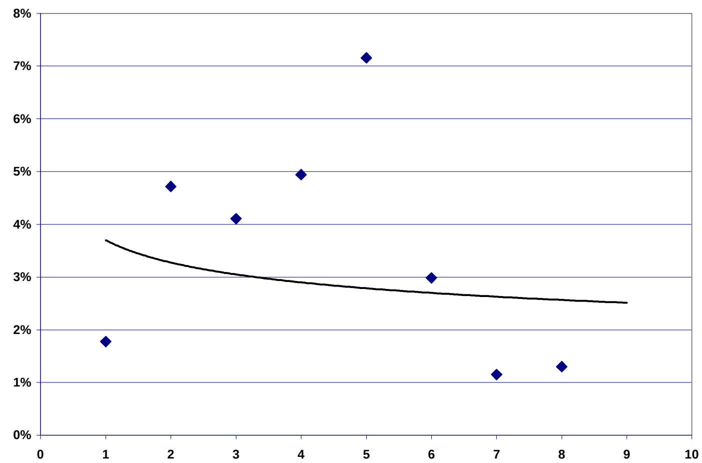
- T8 lighting fixtures
- T8 lamps
- Electronic ballasts
- Pumps/pump system improvements
- Adjustable speed drives

For the following measures, the numbers of removals/failures were not sufficient to support hazard function analysis.

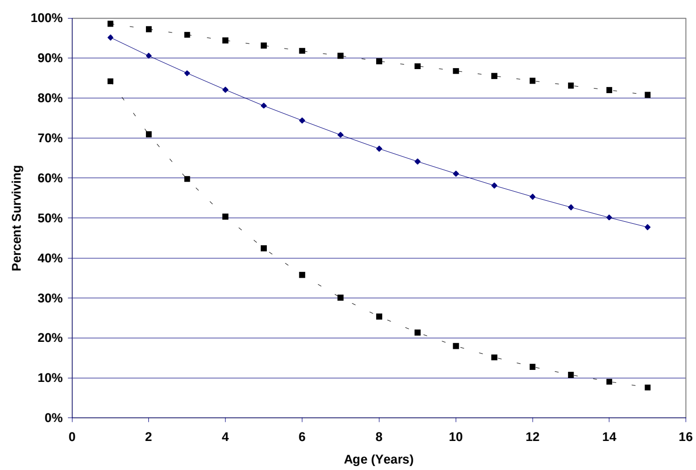
- Lighting EMS
- Injection molding machines
- Plastic extrusion equipment
- Process cooling
- Process equipment insulation
- High efficiency chillers
- Air compressors
- Pump system controls
- Water service EMS
- Hardware to lower temperatures

Data for Calculating Hazard Rates for Industrial T8 Fixtures

Year	Fixtures at Start of Year	Fixtures Removed/Failed during Year	Hazard Rate (Rate of Removal/Failure)
1	1,015	0	0.0%
2	1,015	18	1.8%
3	997	47	4.7%
4	950	39	4.1%
5	911	45	4.9%
6	866	62	7.2%
7	804	24	3.0%
8	780	9	1.2%
9	771	10	1.3%



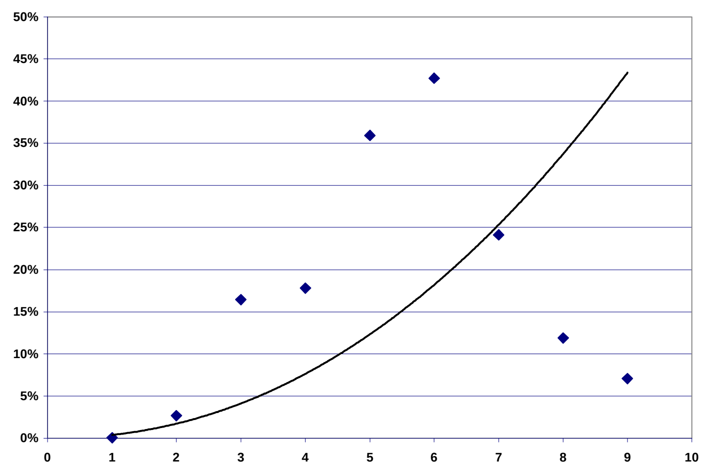
Plot of Hazard Rates for T8 Fixtures in Industrial Sector



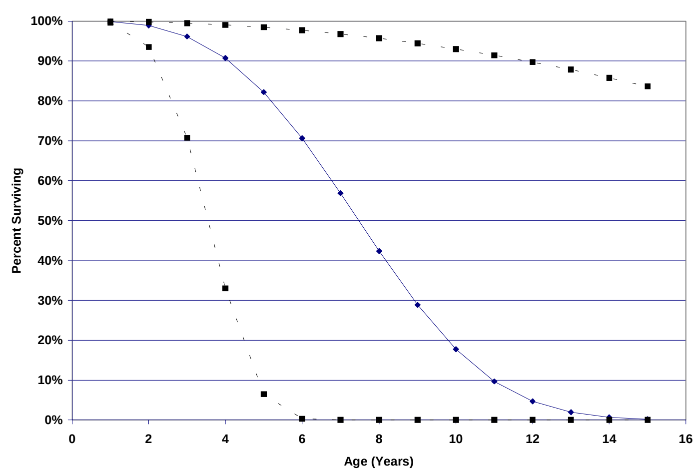
Survival Function Plot for T8 Fixtures in Industrial Sector

Data for Calculating Hazard Rates for Industrial/Agricultural T8 Lamps

Year	*Lamps at Start of Year*	*Lamps Removed/Failed during Year*	*Hazard Rate (Rate of Removal/Failure)*
1	2,758	2	0.1%
2	2,756	74	2.7%
3	2,682	441	16.4%
4	2,241	399	17.8%
5	1,842	657	35.7%
6	1,180	504	42.7%
7	676	163	24.1%
8	513	61	11.9%
9	452	32	7.1%



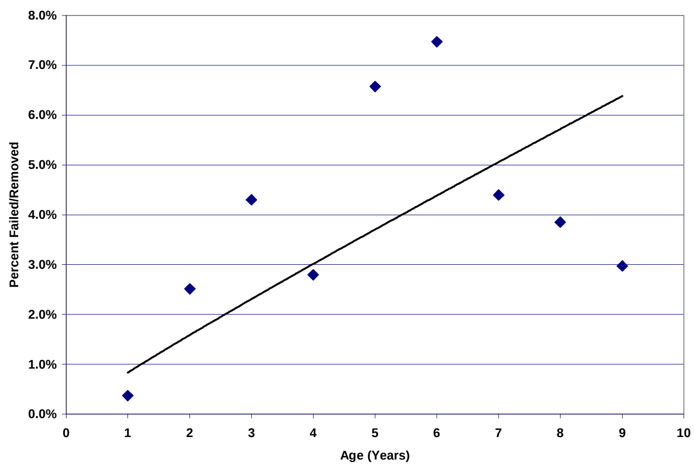
Plot of Hazard Rates for T8 Lamps in Industrial/Agricultural Sector



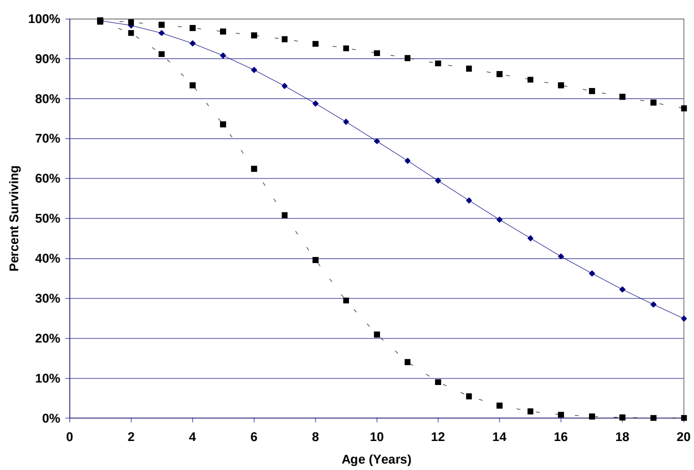
Survival Function Plot for T8 Lamps in Industrial/Agricultural Sector

Data for Calculating Hazard Rates for Industrial/Agricultural Electronic Ballasts

Year	*Ballasts at Start of Year*	*Ballasts Removed/Failed during Year*	*Hazard Rate (Rate of Removal/Failure)*
1	1,078	4	0.4%
2	1,074	27	2.5%
3	1,047	45	4.3%
4	1,002	28	2.8%
5	974	64	6.6%
6	910	68	7.5%
7	842	37	4.4%
8	805	31	3.9%
9	774	23	3.0%



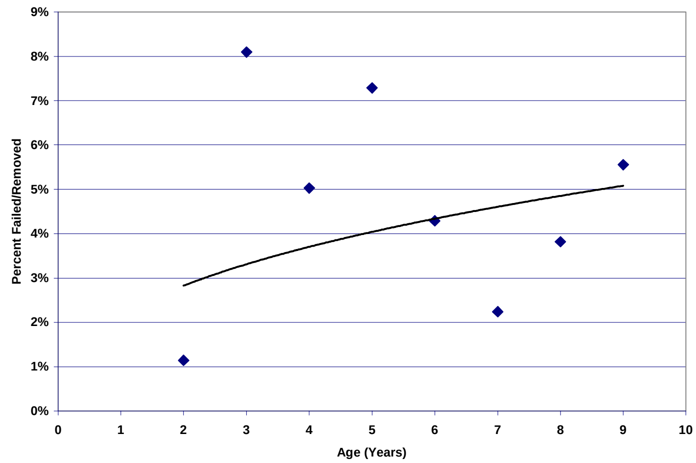
Plot of Hazard Rates for Electronic Ballasts in Industrial/Agricultural Sector



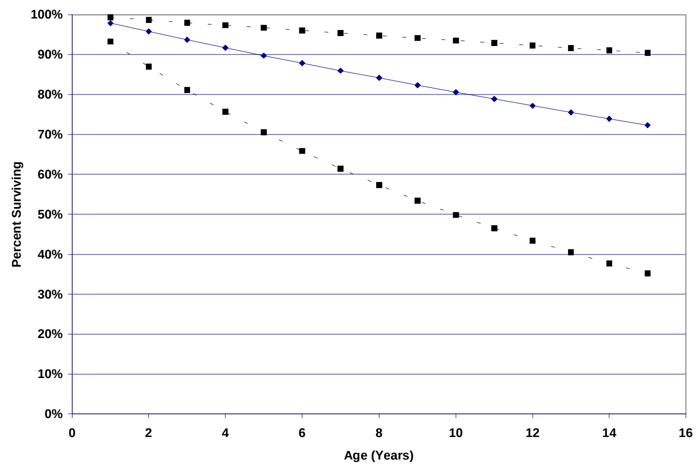
Survival Function Plot for Electronic Ballasts in Industrial/Agricultural Sector

Data for Calculating Hazard Rates for Industrial/Agricultural Pumps and Pump System Improvements

Year	Pumps at Start of Year	Pumps Removed/Failed during Year	Hazard Rate (Rate of Removal/Failure)
1	176	1	0.6%
2	175	2	1.1%
3	173	14	8.1%
4	159	8	5.0%
5	151	11	7.3%
6	140	6	4.3%
7	134	3	2.2%
8	131	5	3.8%
9	126	7	5.6%



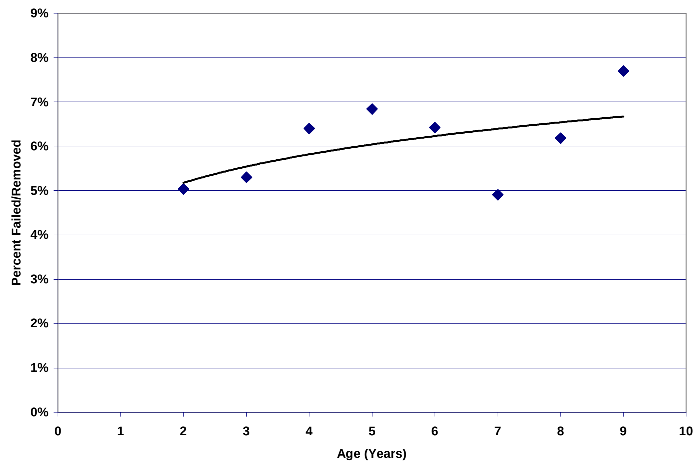
Plot of Hazard Rates for Pumps in Industrial/Agricultural Sector



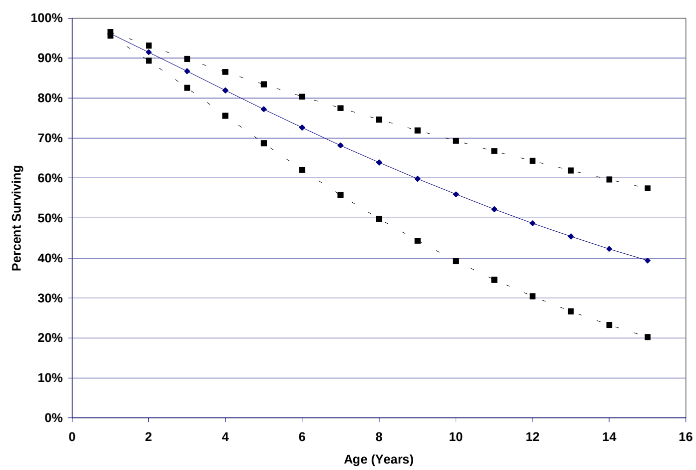
Survival Function Plot for Pumps in Industrial/Agricultural Sector

Data for Calculating Hazard Rates for Industrial/Agricultural ASDs

Year	ASDs at Start of Year	ASDs Removed/Failed during Year	Hazard Rate (Rate of Removal/Failure)
1	139	0	0.0%
2	139	7	5.0%
3	132	7	5.3%
4	125	8	6.4%
5	117	8	6.8%
6	109	7	6.4%
7	102	5	4.9%
8	97	6	6.2%
9	91	7	7.7%



Plot of Hazard Rates for ASDs in Industrial/Agricultural Sector



Survival Function Plot for ASDs in Industrial/Agricultural Sector

APPENDIX B
PROTOCOL TABLES 6 AND 7

This appendix provides the information requested in Tables 6 and 7 of the M&E Protocols.

B.1 INFORMATION REQUIRED PER TABLE 6 OF M&E PROTOCOLS

The information required per Table 6 of the M&E Protocols is reported in Table B-1.

1. *Identify the studied measure and the end use it belongs to.*

   This information is provided in Columns (1) and (2) of Table B-1.

2. *Identify the ex ante expected useful life and the source of the ex ante expected useful life.*

   This information is provided in Columns (3) and (4) of Table B-1.

3. *Identify the ex post expected useful life estimated in the study.*

   This information is provided in Column (6) of Table B-1.

4. *Identify the ex post expected useful life to be used by the utility in the third and fourth earnings claim.*

   This information is provided in Column (8) of Table B-1.

5. *Identify the standard error associated with the ex post expected useful life.*

   Because the survival functions for the measures are not symmetric, the standard error does not provide meaningful information on the spread around the estimated median life. The information on the spread around the estimated value is provided by the lower and upper bounds of the confidence interval, reported in Columns (5) and (7) of Table B-1.

6. *Provide the 80% confidence interval associated with the ex post expected useful life.*

   This information is provided in Columns (5) and (7) of Table B-1.

7. *Provide the p-value associated with the ex post expected useful life.*

   The p-value is 20%.

8. *Provide the realization rate for the adopted ex post expected useful life. This is defined as the ratio of the adopted ex post expected useful life to the ex ante expected useful life.*

   This information is provided in Column (9) of Table B-1.

9. *Identify all the “like” measures associated with the studied measure.*

This information is provided in Column (10) of Table B-1.

Table B-1. Required Information per Protocols Table 6

Measure	*End Use*	*SCE Ex Ante Useful Life*		*Estimated Median Life*			*Ex Post EUL for Earnings Claim*	*Realization Rate*	*"Like" Measures*
		Value	*Source*	*80% Lower bound*	*Estimated Median*	*80% Upper bound*			
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
			Industrial Sector						
T8 lighting fixtures	Lighting	11	1997 AEAP, Table C	4.04	14.06	48.90	11	1	None
T8 lamps	Lighting	5	Protocol, App. F, Table 1	3.56	7.47	27.54	5	1	None
Electronic ballasts	Lighting	10	Protocol, App. F, Table 1	7.07	13.95	39.16	10	1	None
Adjustable speed drives	Motors	10	Protocol, App. F, Table 1	7.96	11.63	18.69	10	1	None
Lighting EMS	Lighting	15	Tracking System	*	> 5	*	15	1	None
Injection molding machines	Process	15	Tracking System	*	> 5	*	15	1	None
Plastic extrusion equipment	Process	15	Tracking System	*	> 5	*	15	1	None
Process cooling	Process	15	Tracking System	*	> 5	*	15	1	None
Process equipment insulation	Process	15	Tracking System	*	> 5	*	15	1	None
High efficiency chillers	Process	20	Protocol, App. F, Table 1	*	> 5	*	20	1	None
Air compressors	Process	15	Tracking System	*	> 5	*	15	1	None
			Agricultural Sector						
Pumps/pump system improvements	Pumping	15	1997 AEAP, Table C	9.96	32.12	> 100	15	1	None
Adjustable speed drives	Motors	10	Protocol, App. F, Table 1	7.96	11.63	18.69	10	1	None

B.2 INFORMATION REQUIRED PER TABLE 7 OF M&E PROTOCOLS

This section provides the information required per Table 7 of the M&E Protocols.

1. a. Study Title and Study ID No.

Study title is:
1996/97 Commercial/Industrial/Agricultural
Energy Efficiency Incentives Program
Sixth-Year Retention Study for Industrial and Agricultural Measures

Study ID No. is:
CEC Study Id #558A

b. Program, Program years, and program description

Program is:

Commercial/Industrial/Agricultural
Energy Efficiency Incentives Program
(Energy Management Hardware Rebate Program, EMHRP)

Program Years are 1993, 1994, 1996 and 1997. Program Year 1995 is excluded per retroactive waivers (cf. Appendix C).

Program Description:

After receiving a detailed facilities survey, nonresidential customers are offered and paid financial incentives for installing the recommended energy efficiency measures.

c. End Uses and Measures Covered:

The sectors, end uses and measures covered were as listed in Table B-2.

d. Methods and Models Used: Describe the final model specification used for the study. Where applicable, indicate the study location of the competing class or types of models that were estimated but were not selected. State why the final specification was chosen.

Data for the study have been collected through a longitudinal survey effort since 1995. Data on whether installed measures were still in place and operable were collected through on-site visits and telephone surveys. (The data collection included the first-year impact study of the program.)

The data collected were directly tabulated to determine the percent retention for each measure. Another objective of the study was to estimate effective useful life (EUL) for each measure and to determine if the *ex post* EULs were different from *ex ante* EULs. Because the early retention rates for the different measures were relatively high, direct estimation of survival functions from the collected data was not informative. However, hazard functions could be estimated for some of the measures, and corresponding survival functions could be developed using the estimated hazard functions. For measures where there was a relatively small number of failures, even the hazard analysis could not be performed. However, because more than 50 percent of the measures for which there was a relatively small number of removals or failures were still in place after five years, the *ex post* EUL will be greater than five years.

Table B-2. Measures and End Uses Covered by Sector

Industrial Sector	
T8 lighting fixtures	Lighting
T8 lamps	Lighting
Electronic ballasts	Lighting
Adjustable speed drives	Motors
Lighting EMS	Lighting
Injection molding machines	Process
Plastic extrusion equipment	Process
Process cooling	Process
Process equipment insulation	Process
High efficiency chillers	Process
Air compressors	Process
Agricultural Sector	
Pumps/pump system improvements	Pumping
Adjustable speed drives	Motors
Water service EMS	Pumping
Hardware to lower temperature	Process

e. Analysis Sample Size: Provide the number of customers, number of installations, number of measures (if different) and the number of observations in the analysis and time periods of data collection. If different for different units of analysis, a summary table should be provided.

Tables B-3 and B-4 show the number of customers included in the study from each sector and program year.

Table B-3. Numbers of Industrial and Agricultural Sites from 1993 and 1994 Program Years Surveyed in 2002 by Type of Measure

	1993 Industrial/ Agricultural	*1994 Industrial/ Agricultural*	*All Sites*
Total Number of Sites	179	149	328
Numbers of Sites with Specified Measures			
ASDs	29	23	52
T8 Lamps	67	36	103
Electronic Ballasts	68	36	104
Pump Improvements	30	38	68
Pump Replacements	53	42	95
Lighting EMS		6	6
Injection molding machines		12	12
Plastic extrusion equipment	1	7	8
Process cooling		7	7
Air compressors		12	12

Table B-4. Numbers of Sites from 1996 and 1997 Program Years Surveyed in 2002 by Type of Measure

	1996 Industrial/ Agricultural	*1997 Industrial/ Agricultural*	*All Sites*
Total Number of Sites	31	51	82
Numbers of Sites with Specified Measures			
Adjustable speed drives	1	4	5
HVAC EMS	-	3	3
Lighting EMS	1	4	5
Injection molding machines	3	5	8
Plastic extrusion equipment	4	3	7
Process cooling	3	2	5
Process equipment insulation	3	-	3
High efficiency chillers	2	2	4
Air compressors	15	6	21
Pump system control	-	2	2
Water service EMS	-	13	13
Hardware to lower temperature	-	2	2

The number of measures for the analysis was greater because of multiple occurrences of a measure at sites. The numbers of measure occurrences in the analysis sets are shown in Table B-5 for the industrial/agricultural sectors.

Table B-5. Numbers of Measure Occurrences in Analysis Set for Industrial/Agricultural Sectors

Type of Measure	*1993*	*1994*	*1996*	*1997*
T8 lighting fixtures	660	355	0	0
T8 lamps	1,841	917	0	0
Electronic ballasts	715	377	0	0
Adjustable speed drives	73	66	4	11
Lighting EMS	0	11	0	4
Injection molding machines	0	27	5	4
Plastic extrusion equipment	0	8	3	6
Process cooling	0	6	2	3
Process equipment insulation	0	5	2	0
High efficiency chillers	0	5	2	5
Air compressors	0	18	14	7
Pumps/pump system improvements	93	83	0	0
Hardware to lower temperature	0	0	0	2
Pump system controls	0	0	0	2
Water service EMS	0	0	0	13

2 a. *Identify the specific data sources used for each data element.*

The source for the initial data was the program tracking system. Thereafter data for the study have been collected through a longitudinal survey effort since 1995. The data that have been collected through on-site visits and telephone surveys since 1995 were used to determine the removals/failures and percent retention for each measure.

b. *Diagram and describe the data attrition process commencing with the program database for participants. Specific numbers and decision points for inclusion and exclusion should be provided. Where different data sources are used (e.g., surveys and program records), appropriate attrition categories should be used (e.g., response rates for surveys).*

The steps involved in preparing the various data sets used for the measure retention analysis are depicted in Figures B-1, B-2, and B-3.

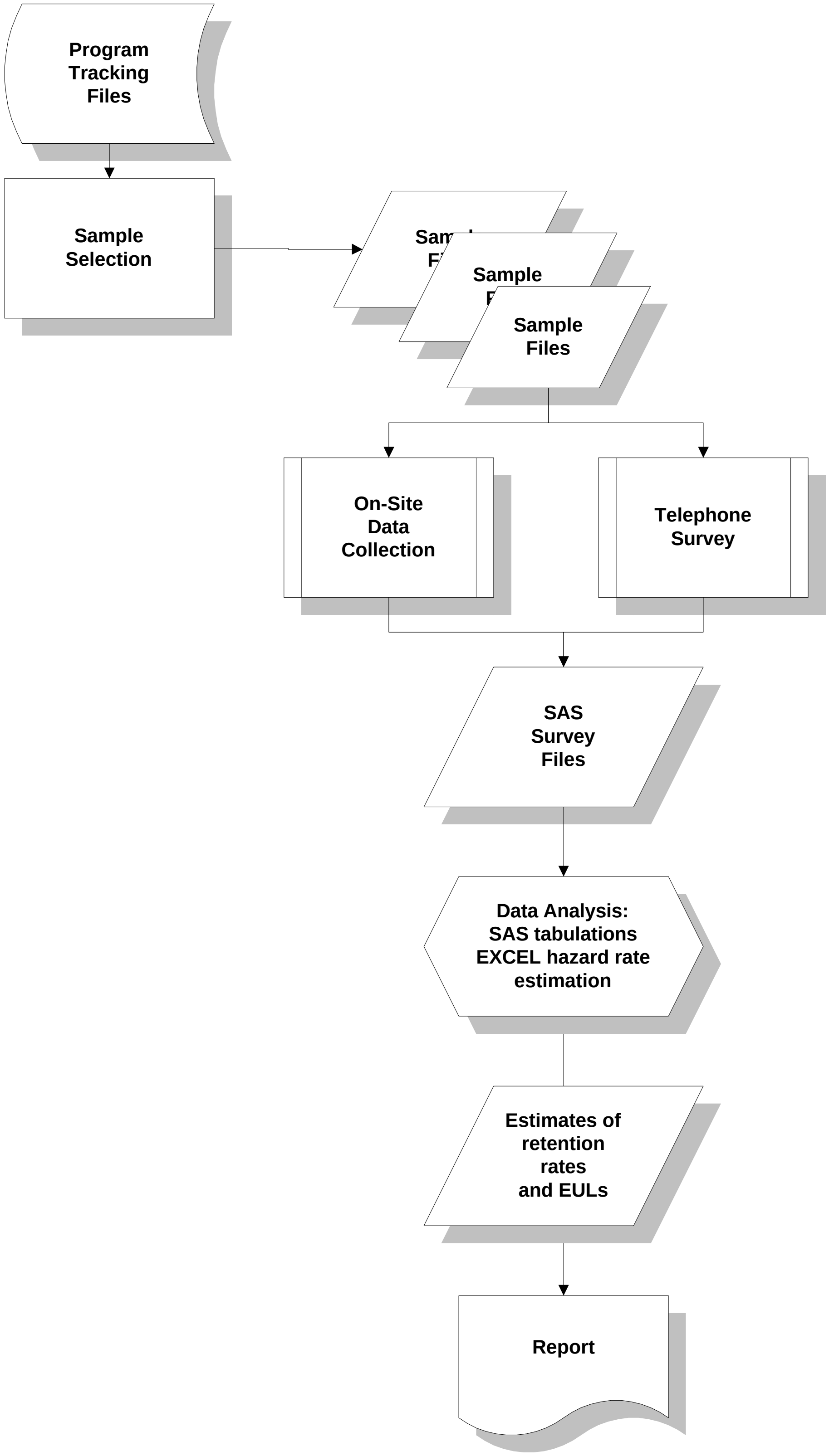


Figure B-1. Overall Data Preparation Process

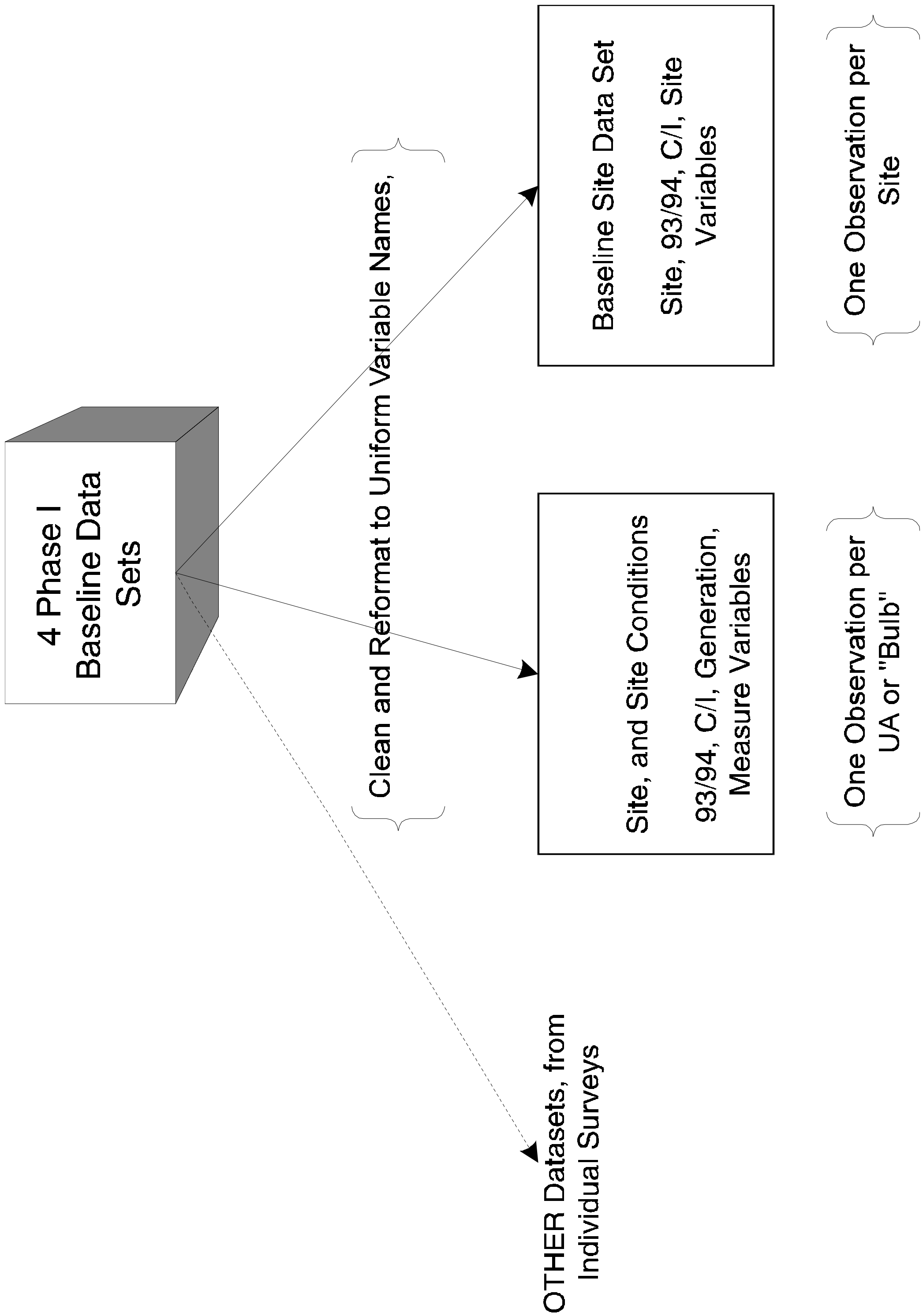


Figure B-2. Baseline Data Sets

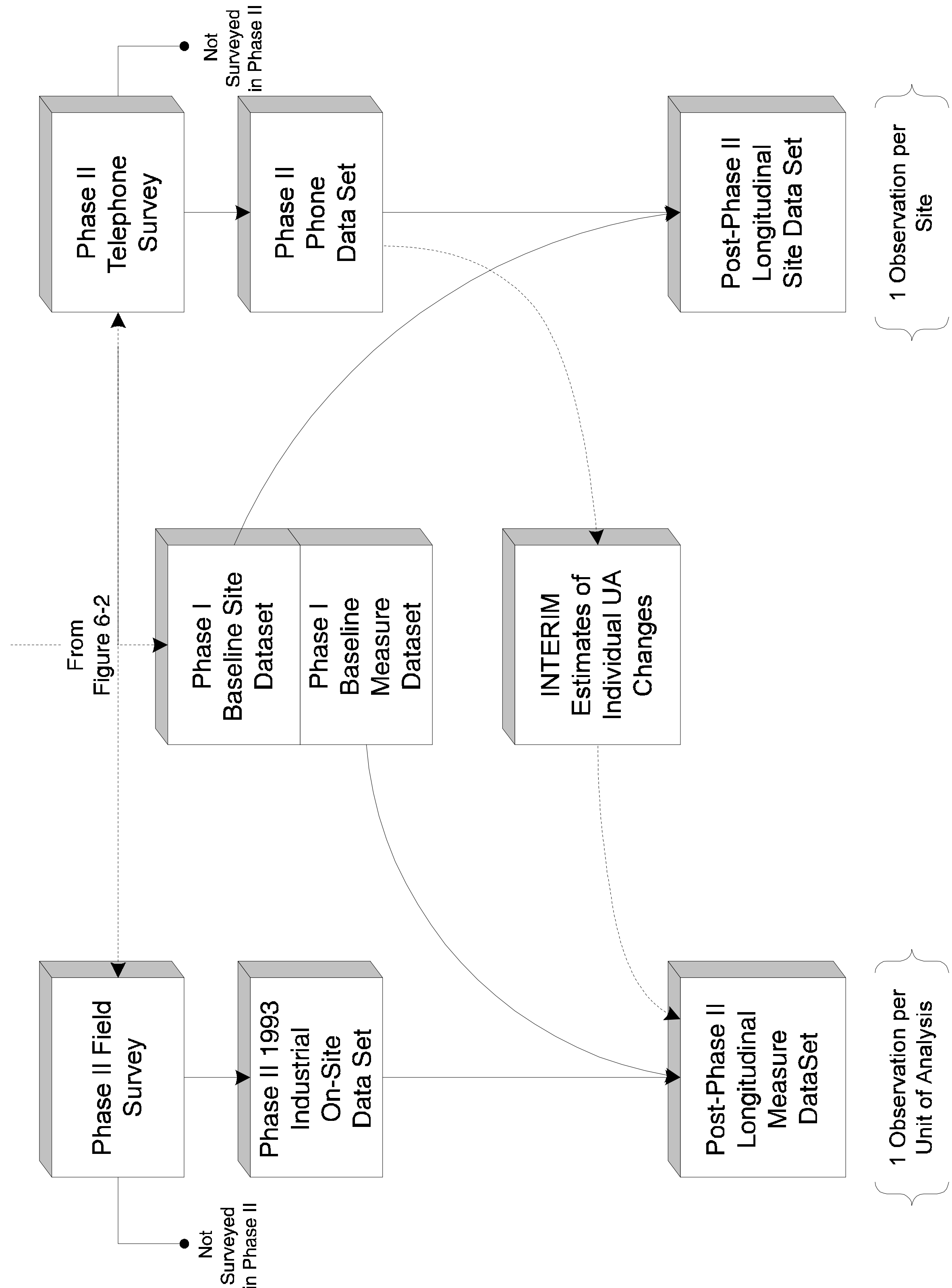


Figure B-3. Creation of Longitudinal Site and Measure Data Sets

c. *Describe the internal/organizational data quality checks and data quality procedures used to match customers and surveys, participation records, and any other data used in the analysis.*

As discussed below with respect to sampling, several files were provided by SCE that contained information on the customers who participated in the Energy Management Hardware Rebate Programs in 1993, 1994, 1996, and 1997. Each participant was identified by the PREMNO9 identifier that SCE uses for geographical locations; each PREMNO9 identifies a unique customer location. This PREMNO9 was used as the key by which to match customer information across program files and SCE's customer information files. Matches were inspected manually for verification purposes.

d. *Provide a summary of the data collected specifically for the analysis but not used, the reasons for them not being used, and a documentation of where those data reside.*

The instruments that were used for the on-site and telephone data collection were provided as appendices to the final report for the fourth year study.[1] These instruments show all of the data that were collected for the analysis. The major items that were used for the analysis were the removal/failure data. Other data were not used in the quantitative analysis, but were used to verify that the removal/failure data was accurate.

3 a. *Sampling procedures and protocols: Describe the sampling procedures and protocols used. Information provided should include the sampling frame (e.g., eligible population), sampling strategy (e.g., random, stratified, etc.), sampling basis (e.g., customers, installation, rebate issued), and stratification criteria (e.g., geographic, etc.). Specific data and formulas should be used to present sampling goals and achieved results.*

The analytical framework for the development of the sample design for the study was provided by survival analysis techniques. Survival analysis pertains to the analysis of data that correspond to the time from a well-defined time origin until the occurrence of some particular event or end-point. For this study, the time origin is defined by the installation of a measure under the EMHR program, while the end-point is defined by the removal or failure of the measure or the discontinuance of its use.

The measure survival data were expected to have several features that warranted special treatment in preparing the sample design.

1 *Commercial/Industrial/Agricultural Energy Efficiency Incentives Program Fourth Year Retention Study, Final Report*. Prepared for Southern California Edison by ADM Associates, Inc., March 1999.

- The measure survival data would probably not be symmetrically distributed and cannot be reasonably represented by a normal distribution.
- The survival data would be *right-censored* in that the removal/failure/discontinuance end-points will not be observable for some of the installed measures.
- The survival data for some types of measures (e.g., lighting measures) would likely be affected by clustering. That is, a single customer may have multiple occurrences of a particular type of measure (e.g., T8 lamps). For a single customer, there can be expected to be some homogeneity in the lifetimes for the particular type of measure, since they were all installed at the same time and were subject to similar operational conditions. Because of this homogeneity, a sample of clustered measure occurrences provides less information than a similar sample that does not show such homogeneity.

A sample design for addressing these and other features of the data was developed through the following steps.

- First, the number of removals/failures required to meet the precision/confidence specifications for each type of measure was determined.
- Second, the probability of removal/failure for each type of measure over the period of the study was determined and applied to the required number of removals/failures to determine the number of points required in the sample.
- Third, the required sample size was adjusted to account for the effects of clustering.
- Fourth, sample points for a measure were allocated among facilities.

Sampling frames for selecting the sample sites for the different types of measures were created by extracting various items of data from three sets of files.

- The first set of files included the "Coupon Files" for 1993 and 1994 EMHRP participants that had been created by the Pine Company. The file for 1993 contained information for (approximately) the 1,000 largest coupons for program participants in that year. The 1994 Coupon file contained information for about 1,250 coupons. In creating these files, the Pine Company disaggregated some of the measures on the original coupons, thus providing a higher degree of measure resolution. For example, Lighting System Replacement was broken down into its component parts (i.e., fixture, lamp, ballast, reflector, etc.) to facilitate the identification of measures for this study.

- The second set of files included measure-based files (FRAME3B for 1993 and Frame3AB for 1994) that contained information on *all* measures installed by EMHRP participants in the two program years.
- The third set of files included a customer-based file (CUSTINC) that contained information on the *customers* who were EMHRP participants.

The number of sample points required for any particular measure was divided equally between 1993 and 1994 participants. For each type of measure, EMHRP participants in each year were stratified according to business sector and size.

- With the business sector stratification, participants were separated into a commercial customer class and an industrial/agricultural customer class.
- Within each measure/sector grouping, customers were further stratified according to size using a program category variable developed by SCE program staff. Agricultural customers were assigned to an "A" category. Commercial and industrial customers were assigned to categories according to their kW demand.[2]
  - Small (S) included C&I customers with demand between 0 and 49 kW.
  - Medium (M) included C&I customers with demand between 50 and 499 kW.
  - Large (L) included C&I customers with demand of 500 kW or more.
- If the program category assignment for a customer was not available on the SCE files, the customer was assigned to an Unknown (U) category.

Data were available on the SCE files regarding the kWh savings associated with a measure. For most measures, sample points for a measure were allocated to program categories in proportion to the distribution of savings. However, for some types of measures, the required sample size exceeded the number of customer facilities available on the sampling frame. For example, the sample size calculations design called for 199 sample points allocated to commercial locations that installed high efficiency chillers, of which 100 would be allocated to 1993 participants and 99 to 1994 participants. However, in actuality there were only 30 sites where high efficiency chillers were installed under the 1993 program. Accordingly, this left 70 sample points to be reallocated among measures for the commercial sector. Since the original sample sizes satisfied the confidence/precision requirements that SCE desired, the increases in sample sizes for the various measures in effect improved the precision with which the measure lives are estimated.

2 The program category assignments were generally available on the CUSTINC file.

During 1999, the data collection and analysis effort included selected measures installed by customers who participated in SCE's program in 1996 or 1997. Sites and measures from the 1993 and 1994 program years were also used to ensure that there was sufficient empirical data to provide evidence on retention rates for measures installed in the various years.

In order to identify the measures from the 1996 and 1997 programs to include in the study to provide the coverage required by the protocols, tables showing the *ex ante* savings for measures installed by customers participating in the EMHR Program in program years 1996 and 1997 were developed.

The sites from 1996 and 1997 for the study were those with measures that provided coverage of *ex ante* program savings. Except for sites with lighting EMS, the number of sites with particular measures were relatively few. Accordingly, these sites were not sampled but taken into the study by censusing. For sites with lighting EMS, a 50% sample was taken.

b. *Survey information: Survey instruments should be provided. Response rates should be presented. Reasons for refusals should be presented in tabular form. Efforts to account for or test for non-response bias should be presented, as well as corrections to account for the bias.*

The instruments that were used for the on-site data collection were provided as appendices to the final report for the fourth-year study.

For a longitudinal data set as was developed for this study, the important consideration is the degree of attrition among customers in the sample as time passes. Table B-6 reports the overall attrition from the sample at the end of 2002.

c. *Statistical descriptions. For the key variables that were used in the final models, provide descriptive statistics for the participant group, and, when present, for the comparison group.*

The key variable for the analysis of retention is the number of removal/failures that occur for a measure over a specified time period. The removal/failure rates by the end of 2002 are summarized for the various measures in Table B-7.

Table B-6. Overall Attrition from Sample of Industrial/Agricultural Sites as of End of 2002

Disposition of Contact	*1993 Sites*	*1994 Sites*	*1996/1997 Sites*
1 – No Answer			
4 – Not in service			
20 – Complete	158	126	73
22 – Permanent Refusal	9	8	4
23 – Site Closed	3	0	1
24 – Business Closed	9	14	6
25 – Building Torn Down		1	1
99 – Not Complete			
Totals	179	149	85

Table B-7. Removal/Failure Rates by End of 2002 for I/A EE Incentives Program Measures

1993 and 1994 Program Years		*1996 and 1997 Program Years*	
Type of Measure	*Percentage Removed or Failed by End of 2002*	*Type of Measure*	*Percentage Removed or Failed by End of 2002*
Industrial Measures		Industrial Measures	
T8 lighting fixtures	25.0%	Adjustable speed drives	13.3%
T8 lamps	84.8%	Lighting EMS	50.0%
Electronic ballasts	31.5%	Injection molding machines	0.0%
Adjustable speed drives*	33.8%	Plastic extrusion equipment	0.0%
Lighting EMS	9.1%	Process cooling	20.0%
Injection molding machines	3.7%	Process equipment insulation	50.0%
Plastic extrusion equipment	0.0%	High efficiency chillers	0.0%
Process cooling	0.0%	Air compressors	14.3%
Process equipment insulation	0.0%	Agricultural Measures	
High efficiency chillers	0.0%	Adjustable speed drives	0.0%
Air compressors	5.6%	Hardware to lower temperature	0.0%
Agricultural Measures		Pump system controls	0.0%
Pumps/pump system improvements	32.6%	Water service EMS	0.0%
Adjustable speed drives*	16.7%		

*Numbers are for all ASDs in both industrial and agricultural sectors.

4 a. *Describe procedures used for the treatment of outliers, and missing data points.*

The basic information required for the analysis was whether a measure had failed or been removed within the time span of the study period. For an individual measure, a removal or failure is essentially a binary 0-1 decision for purposes of analysis. The problem of outliers would arise primarily at the aggregate level if there appeared to be a disproportionate percentage of removals or failures. The possibility of outlier percentages was examined on a measure-by-measure basis. No excessively high rates of removal/failure were detected.

b. *Describe what was done to control for the effects of background variables, such as economic, political activity, etc.*

For each of the sites in the sample, information was collected regarding major changes in the facility's structure, equipment, or operating hours. The responses given to these questions on tenancy changes, building and HVAC renovations, and lighting system changes provided data that was used in analyzing whether there were aggregate economic or political events affecting the sample sites. It was assumed that such events would manifest at the site level. As Table B-6 showed, the overall attrition of sites from the sample was low, indicating that there were no major economic or political events that would introduce bias into the data used for analysis of measure life.

c. *Describe procedures used to screen data for inclusion into the final analysis dataset. Show how many customers, installations or observations were eliminated with each screen.*

No screens were used to eliminate customers, installations, or observations from the longitudinal data set that was used for the analysis. The numbers of sites and measures used for the analysis were as reported in Tables B-3, B-4, B-5 and B-6.

d. *Model Statistics. For all final models, provide standard model statistics in a tabular form.*

The final models used for estimating median useful lives for various measures were established by estimating hazard functions for each such measure, using power curve fits for a hazard function defined by a Weibull distribution. The summary statistics for the various models fitted are shown in Table B-8.

Table B-8. Summary of Hazard Function Estimation

Type of Measure	*Power Curve Fit*			*Weibull Distribution Parameters*	
	a	*b*	*R-squared*	*α (Scale)*	*β (Shape)*
Industrial Measures					
T8 lighting fixtures	-3.00974	-0.32536	0.062	0.04930	1
T8 lamps	-5.54211	2.14247	0.614	0.00125	3.14247
Electronic ballasts	-4.78442	0.92495	0.573	0.00434	1.92495
Adjustable speed drives	-3.07827	0.16875	0.302	0.03939	1.16875
Agricultural Measures					
Pumps/pump system improvements	-3.83591	0.38958	0.096	0.02158	1
Adjustable speed drives	-3.07827	0.16875	0.302	0.03939	1.16875

e. *Specification: Refer to the section(s) of the Study that present the initial and final model specifications that were used, the rationale for each, and the* *documentation for the major alternative models used. In addition, the presentation of the specification should address, at a minimum, the following:*

1)Describe how the model specification and estimation procedures recognize and address heterogeneity of customers (i.e., cross-sectional variation)

2) Discuss the factors, and their associated measures, that are omitted from the analysis, and any tests, reasoning, or special circumstances that justify their omission.

The model specifications used for the study are presented and discussed in Section 2.4 (theoretical considerations) and Sections 3.3 and 4.3.

For some measures, the numbers of removals or failures observed over the period from 1995 through 2002 were too small to support estimation of hazard functions. The measures for which this occurred include HVAC EMS and high efficiency chillers in the commercial sector and lighting EMS, injection molding, process cooling, insulation on process equipment, air compressors, and high efficiency chillers for process in the industrial sector.

f. Error in measuring variables: Describe whether and how this issue was addressed, and what was done to minimize the problem (e.g., response bias, measurement errors, etc.)

Because the removal/failure variable is binary, the issue of measurement error was not considered to affect the results of the analysis.

g. Influential data points. Describe the influential data diagnostics that were used, and how the identified outliers were treated.

For some measures, the hazard plots showed a sawtooth pattern over period of study (i.e., low, high, low, high). With this pattern, a low or a high point could move the fitted regression line. Further data collected over time will allow for better determination of the appropriate hazard function.

h. Missing data: Describe the methods used for handling missing data during the analysis phase of the study.

Missing data was not a problem for this analysis, except in the sense that some measures showed few removals/failures.

i. Precision: Present the methods for the calculation of standard errors.

Because the survival functions for the measures studied are not symmetric, the standard error does not provide meaningful information on the spread around the estimated median life. The information on the spread around the estimated value is provided by the lower and upper bounds of the confidence interval.

An 80% confidence interval for the estimated median life of a measure was calculated as follows. The regression fit of the power curve coefficients was used to report the values of the estimated coefficients associated with the 80% confidence levels. Thus, the power curve regression analysis for each measure provided three sets of parameters for the Weibull hazard rate function: the "best" fit parameters and parameters for the upper and lower bounds of the 80% confidence interval for the estimated coefficients. In effect, the analysis provided an estimate of the "best" hazard function and survival function for a measure, plus estimates of the functions for the upper and lower bounds of the 80% confidence interval.

APPENDIX C
RETROACTIVE WAIVERS

This appendix provides two retroactive waivers: one excluding the 1995 C/I/A EEI Program from the study requirement and one permitting the retention studies for the 1996-97 C/I/A EEI programs to be done as a continuation and supplementation of the retention studies for the 1993-94 programs.

SOUTHERN CALIFORNIA EDISON COMPANY
REQUEST FOR RETROACTIVE WAIVER
1995 COMMERCIAL, INDUSTRIAL AND AGRICULTURAL
ENERGY EFFICIENCY INCENTIVE PROGRAMS

Approved November 13, 1996

PARAMETER

Lines 3 and 4 of Table 8A,"Impact and Persistence Studies Required for an Earnings Claim for PG&E, SDG&E, and SCE*, specifying the filing of first-year impact analyses of the energy-efficiency incentive (EEI) programs in the commercial, industrial, and agricultural (CIA) sectors.

PROTOCOL REQUIREMENT

Table 8A of the Protocols requires first-year impact studies for the 1995 CIA EEI programs.

WAIVER ALTERNATIVE

Waive the requirement for impact studies of these programs for 1995.

RATIONALE

With only 8 Customers participating in the 1995 program, no shareholder payments in question, and a study of the 1996 program scheduled, there is really no ratepayer value provided by requiring a 1995 load impact study. It is reasonable to treat 1995 as a skip year for evaluation of this very small program.

There are no earnings (and no penalties) associated with these programs. The Nonresidential EEI portfolio achieved 49% of the forecast Performance Earnings Basis ("PEB"). Since the portfolio did not achieve the minimum 75% performance standard, this program was not entitled to earnings, and none were claimed. Since the actual PEB was well above zero, there are no penalties. Edison's ability to spend DSM funds and to accrue resource benefits in 1995 was slowed by the substantial challenges Edison faced from the Internal Revenue Service's proposed change in the treatment of DSM expenses for tax purposes.

PROGRAM SUMMARY

	CEEI[1]
Number of Participants	8[2]
Administrative Costs	$322,000
Incentive Costs	$62,000
Total Program Costs	$384,000
Net Resource Benefits	$1,315,000

[1] There were no EEI program results from the industrial and Agricultural sectors in 1995.

[2] All but one of the measures installed were lighting end uses: the other was refrigeration.

SOUTHERN CALIFORNIA EDISON COMPANY

RETROACTIVE WAIVER REQUEST FOR THE MEASURE RETENTION STUDY OF THE 1996-97 COMMERCIAL, INDUSTRIAL AND AGRICULTURAL EEI PROGRAMS

(Study ID #553)

Background/ Introduction

The Measurement Protocols require that a fourth year commercial retention study and a third year industrial & agricultural retention study be performed for the energy efficiency incentive (EEI) programs of the 1996-97 program years. The results of these studies are due on March 1, 2001. Southern California Edison has been conducting a retention study which includes all three sectors for the 1993 and 1994 program years (SCE had virtually no program in 1995) since the spring of 1995. The sample consists of 988 participant sites. The study involves visiting, and in alternate years telephoning, each site over a four year period to track the retention of rebated measures at each facility. The methodology for this study depends on observing a certain number of measure failures/removals/replacements over the period of the study in order to estimate the EUL and a survival curve for each measure. Obviously, the longer this study continues the better the information being collected will be and the more confidence we will have in the results.

Summary of Request

This waiver requests deviations from the Protocols for the 1996-97 Commercial, Industrial, and Agricultural EEI Program retention studies. SCE seeks approval to modify the requirement to conduct a completely new and separate study for the 1996-97 program years and instead allow these to be replaced by a continuation and supplementation of the study currently underway for the 1993-94 programs years for all three sectors.

PROGRAM SUMMARY

Cost Category and Sector	Commercial $000	Industrial $000	Agricultural $000	Total $000
1996				
Administrative	733	1,150	73	1,956
Incentive	1,678	2,051	120	3,849
Net Resource Benefit	11,943	15,937	628	28,508
Recorded Earnings	2,185	3,347	51	5,583
1997				
Administrative	736	4,535	155	5,426
Incentive	5,005	883	16	5,904
Net Resource Benefit	35,756	42,867	733	79,647
Recorded Earnings	7,151	10,357	139	17,647

Parameter

Table 9, Sections A.2 and A.3 as they apply to the program years to be included and the retention period to be covered for retention studies.

Protocol Requirement

The protocol requires a third year retention study for industrial and agricultural measures and a fourth year retention study for commercial measures. This dictates that a third year retention study for the 1996/1997 industrial and agricultural program years be carried out in 1999 and a fourth year retention study for the 1996/1997 commercial program years be carried out in 2000.

Waiver Alternative

1. Substitute a two-year supplement to the current 1993-94 study for the Protocol requirement of mounting a new and separate set of studies of the 1996-97 program year measures.

2. Add 1996-97 sites to the 1993-94 study only as required: (1) in order to cover measures not included in the 1993-94 study; and (2) if justified by changes in the technology of some measures between 1993 and 1997 that could lead to changes in the measure life. A review of the state of technology changes in the covered measures was included in the 1993-94 retention study report filed March 30, 1999. (See attached extract.)

Rationale

Since SCE had only eight participants in its combined commercial, industrial and agricultural energy efficiency incentive programs in 1995, the company received permission from CADMAC to substitute the 1993/1994 program years for 1994/1995 as they pertain to the execution of retention studies. SCE began this study in 1995 (three years ahead of the required time for initiating a retention study of the 1994/1995 program years) and has surveyed each of the 988 study participants each year since either via telephone survey or on-site inspection. This longitudinal survey methodology will provide a very rich data set for the development of survival curves for the major end uses in the program. Continuing to survey these customers for two additional years in lieu of performing a "point estimate" study for the 1996/1997 program years will provide an two additional years of data for the survival curve model while the "point estimate" study will merely repeat work already done. The initial wave of retention studies completed by all four utilities this year demonstrate that the three-to-four year time period is too short to develop estimates of the effective useful lives of many long-lived measures. Adding two years may permit development of meaningful ex post estimates for more measures.

An examination of the measures installed reveals that the same measures which made up 50% or more of the kWh savings for 1993/1994 are the same measures that comprised the majority of the kWh savings in 1996/1997.

1994 Measures	Commercial	Industrial*	Agricultural
Indoor Lighting	40.36	15.61	2.80
HVAC - EMS	9.64	2.54	0.00
Chillers*	2.62	1.23	0.00
ASD's	9.90	11.59	33.10
Pump Replacement	0.00	0.16	28.78
Pump Improvement	0.00	3.04	14.59
Lighting - EMS*		4.59	
Injection Molding Machine*		5.26	
Process Cooling*		2.59	
Process Equipment Insulation *		1.27	
Air Compressor*		1.14	
% of Total Savings	62.52	49.02	79.27
Tracking System Savings (kWh)	313,290,256	289,287,201	32,706,638

**These industrial measures were not monitored throughout the period, but checked once for retention at the end of the period.*

1996 Measures	Commercial	Industrial	Agricultural
Indoor Lighting	26.53	15.17	7.88
HVAC - EMS	17.47	0.00	0.00
Chillers	0.74	0.60	0.00
ASD's	21.93	16.11	68.5
Pump Replacement	0.00	0.00	0.00
Pump Improvement	0.00	12.21	22.13
Lighting EMS*	10.27	0.93	0.00
Water Service EMS*	0.00	0.00	0.00
Air Compressor Systems*	1.32	10.08	0.00
Injection Molding Machine*	0.00	1.57	0.00
% of Total Savings	78.26	56.58	98.51
Tracking System Savings (kWh)	51,350,928	89,144,593	4,048,905

1997 Measures	Commercial	Industrial	Agricultural
Indoor Lighting	21.7	16.00	0.00
HVAC - EMS	14.8	1.90	0.00
Chillers	5.2	0.90	0.00
ASD's	14.6	16.90	25.90
Pump Replacement	0.00	0.90	0.00
Pump Improvement	0.00	0.00	12.70
Lighting EMS*	7.9	11.10	0.00
Water Service EMS*	0.00	0.00	12.10
Air Compressor Systems*	3.1	4.40	0.00
Injection Molding Machine*	0.00	3.10	0.00
% of Total Savings	67.3	55.20	50.70
Tracking System Savings (kWh)	117,157,386	166,429,784	3,127,425

**EMS on lighting systems, EMS on water service, air compressor systems and injection molding machine are needed by industrial or agricultural sectors to reach the 50% threshold for either 1996 or 1997 and have therefore been included for both years.*

Lighting EMS, air compressors and injection molding machines were surveyed for 1994. These sites can be resurveyed to provide additional points on the hazard curve and can be supplemented with sites from the 1996/97 programs. Water service EMS is a new measure for 1997 and is added to the mix to meet the 50% of savings coverage criteria. Only site-specific information is expected, however, as only one site is involved.

Table A

Summary of Retroactive Waiver for Study #553

Retention Measurement Requirements - Table 9A

Parameter	Protocol Requirements	Waiver Alternative	Rationale
Table 9A.2	Perform separate studies every two years beginning in 1999. Survival data from participants in at least the two covered program years will be pooled.	Continue current longitudinal study of 1993/94 program years for a fifth and sixth year rather than beginning a new and separate study of the 1996/97 program years using 1996/97 program participants.	1. Measures required to achieve top 10 or 50% coverage for every year will be included. 2. This approach will provide additional points for improved survival curve estimation (fifth and sixth years) versus repeating estimates for the third and fourth years. Current 1993/94 studies show four years is not long enough to provide good estimates for most long-lived measures.

TECHNOLOGY CHANGES AND EFFECTS ON USEFUL LIVES

As part of the retention study, an examination was made of whether there had been changes in technology for the types of measures installed in 1993 and 1994 that would have affected the expected lives of these measures. Data for this examination were gathered from three main sources:

- From interviews with manufacturers
- From interviews with research organizations (e.g., EPRI, Lighting Research Center, etc.)
- From review of equipment catalogs (e.g., Graingers, manufacturers)

The results of examining changes in technology for the 1993 and 1994 measures are summarized in Table 4-1. There were no changes in basic technology for any of the measures. Short synopses are provided here of the information gathered during the examination.

For adjustable speed drives (ASDs), information on changes technology was obtained from one manufacturer, from the EPRI Adjustable Speed Drive Demonstration Office, from the Advanced Energy Industrial Energy Lab, and from a consulting engineer specializing in ASDs.

- One respondent pointed out that vendors are reporting much higher levels of reliability for ASDs and that a MTF (mean time to failure) of 80,000 hours is now common. There has been a substantial change in the technology and reliability with the increase of digitization of the designs. The advertised MTF has drifted up since 1989–1990. In the 1993-1995 period, he estimated the MTF quoted by manufacturers would be in the 35-40,000 hour range.
- Others interviewed reported that the drives themselves have not significantly changed. They did not feel that the drives had substantially longer full lives. All respondents stressed that actual MTF was highly dependent on actual operating conditions (e.g., temperature, load).

Table 4-1. Summary of Changes in Technology for 1993/1994 Measures

Technology	*Change in basic technology?*	*New Features?*	*Decrease in premature failure?*	*Change in rated life expectancy?*	*New longer life models available?*
ASDs	No	Minor	No	Yes—manufacturers report longer MTF, but no consensus that this is true from respondents	No
Electronic Ballasts	No	No	Yes—problems with premature failures solved	No	No
Chillers	No	Yes—electronic controls and safeties	No	No	No
Compact Fluorescents	No	Yes—changes in shape and configuration	No	No	No
Energy Management Systems	No	Yes--More user friendly	No	No	No
Pumps	No	No	No	No	No
Reflectors	No	No	No	No	Yes—models with harder finishes
T-8 lamps	No	No	No	No	Yes—higher priced for special applications

For electronic ballasts, information was obtained from four major manufacturers, from Lawrence Berkeley Laboratories, Energy Efficiency and Renewable Energy Clearinghouse and from the Lighting Research Center at Renesselaer Polytechnic Institute. In addition sales literature from 1994 and 1999 was examined.

- Lighting ballasts are described with a rated life. This is defined as the median life for the equipment or the age by which 50% of the equipment is estimated to fail.
- During the 1993-1994 period there were relatively high percentages of premature failures of electronic ballasts manufactured by some manufacturers. However, the consensus of those interviewed was that changes in the design, components and manufacturing have led to much lower "out-of-box" and premature failures of electronic ballasts. This has led too much higher overall reliability.
- The maximum life determined by end-of-life failure has not increased much or at all. Manufacturers report rated lives in the 60,000 to 80,000 hour range. Catalogs confirm that manufacturers have not increased the rated life of electronic ballasts. Rated life is estimated to decrease 50% with a 10-degree Celsius increase in operating temperature (which allows accelerated testing of the equipment). This needs to be kept in mind when comparing rated life among manufacturers, since they may report the rated life under different operating temperatures. The initial failure rate for the major manufacturers is now estimated in the range of 0.1% to 1%.

For compact fluorescent lamps and ballasts, information was obtained from two major manufacturers, from Lawrence Berkeley Laboratories' Energy Efficiency and Renewable Energy Clearinghouse, and from the Lighting Research Center. In addition sales literature from 1994 and 1999 was examined.

- One manufacturer's representative reported changes in size configuration and design. NEMA now requires CFL's to have end of life circuitry to prevent overheating and meltdown. Other changes in design have increased compatibility between manufacturers and created de facto standards. This may decrease some premature failures. The miss-match of bulbs and ballasts can shorten the life of the equipment.
- Other respondents reported that there have been no changes in the technology. All of the respondents reported that the rated life of the equipment has not changed.

For T-8 lamps, information was obtained from two major manufacturers, from Lawrence Berkeley Laboratories's Energy Efficiency and Renewable Energy

Clearinghouse and from the Lighting Research Center. In addition sales literature from 1994 and 1999 was examined.

- Both manufacturers reported new models of T-8 lamps with rated lives of 24,000 hours. (Corresponding models are also available from other manufacturers.) These long life models have a rated life 20% longer than the longest rated life T-8 models available in 1994. The long life models sell for approximately double the price of older models, about $10 compared to $5 per bulb. In terms of lumen output, color, and other characteristics they are comparable to the older models. Because of the higher cost, these lamps appear to be of use in areas where the labor cost or other costs of replacement are quite high.

For chillers, information was obtained from two manufacturers and from the Energy Efficiency and Renewable Energy Clearinghouse. The consensus was that there have been no fundamental changes in technologies that would increase the life of the equipment. There has been an increase in the use of helical screw compressors, which have fewer moving parts than reciprocating compressors and are more reliable and more efficient. However, helical screw compressors were available in 1993-1994. Electronic controls and safeties have been added to some chillers. This may improve maintenance and may prevent some premature failure of equipment but does not change the 20- to 30-year design life of the equipment.

For pumps, information was obtained from three pump manufacturers. The consensus was there have been very minor changes to some pump designs since 1993 –1994. This has allowed minor increases in efficiency.

- One respondent felt this increase in efficiency would increase pump life on the order of 5 to 10%.
- The other respondents reported that the small changes to pump design would not increase in reliability noticeably, if at all. There is an increased use of energy efficient motors due to their greater availability and lower prices.

For reflectors, information was obtained from two vendors and from the Energy Efficiency and Renewable Energy Clearinghouse. One respondent reported that there are luminaires available with harder finishes. These finishes result in the reflectors staying cleaner longer and being somewhat more resistant to corrosion.

For energy management systems, information was obtained from three manufacturers of energy management systems and from Lawrence Berkeley Laboratories. The life span of the equipment is determined by the ability to repair the equipment, with the availability of components from the manufacturer being the limiting factor. Two of the manufacturers reported having equipment in place and operating since the beginning of their businesses 10 to 12 years ago. The electronics of the systems have not changed, and there have been relatively minor changes in the hardware. Changes in the technology have been in the areas of "user friendliness" and increased functionality.