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

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Annual Report
for Year 1999
Data Collection
and Analysis

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EXECUTIVE SUMMARY

Under Southern California Edison's (SCE) Commercial/Industrial/Agricultural (C/I/A) Energy Efficiency Incentives Program, commercial, industrial, and agricultural customers received financial incentives for energy efficiency measures that they installed. 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 under the program. Data for the study are being 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 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.

The data that were collected through on-site visits and telephone surveys in 1999 have been added to the data collected over the four-year period from 1995 through 1998 and used to determine the retention rates for each measure. Based on the data collected, the retention rates for the various measures are as shown in Table ES-2 for the 1993/1994 program years and in Table ES-3 for the 1996/1997 program years.

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

[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.

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. For most measures, the hypothesis of no difference between *ex ante* and *ex post* estimates of useful life could not be rejected. The hypothesis of no difference could be rejected only for CF lamps in the commercial sector.

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

Program Year	*Sector*		
	Commercial	*Industrial*	*Agricultural*
1993 and 1994	T8 fixtures T8 lamps Electronic ballasts CF (modular) fixtures CF lamps Delamping/Reflectors HVAC EMS systems High-Efficiency Chiller Systems Adjustable Speed Drives	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	Lighting EMS Adjustable speed drives Electronic ballasts	Injection molding machines Plastic extrusion Process cooling Process equipment insulation High efficiency chillers Air compressors	No measures added
1997	Lighting EMS Adjustable speed drives Electronic ballasts CF lamps	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 1999 for C/I/A EE Incentives Program Measures: Installed in 1993 and 1994 Program Years

Type of Measure	*Percentage of Measures Removed, Failed or Replaced by 1999*	*Percentage of Measures Retained after 1999*
Commercial Measures		
T8 lighting fixtures	16.3%	83.7%
T8 lamps	62.2%	37.8%
Electronic ballasts	14.2%	85.8%
CF fixtures (modular)	12.2%	87.8%
CF lamps	51.5%	48.5%
Delamping/reflectors	9.9%	90.1%
HVAC EMS	1.1%	98.9%
Chillers	0.0%	100.0%
Adjustable speed drives	10.2%	89.8%
Industrial Measures		
T8 lighting fixtures	16.1%	83.9%
T8 lamps	59.9%	40.1%
Electronic ballasts	11.7%	88.3%
Adjustable speed drives*	21.6%	78.4%
Lighting EMS	9.1%	90.9%
Injection molding machines	18.5%	81.5%
Plastic extrusion equipment	37.5%	62.5%
Process cooling	0.0%	100.0%
Process equipment insulation	20.0%	80.0%
High efficiency chillers	0.0%	100.0%
Air compressors	16.7%	83.3%
Agricultural Measures		
Pumps/pump system improvements	18.9%	81.1%
Adjustable speed drives*	21.6%	78.4%

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

Table ES-3. Retention Rates through 1999 for C/I/A EE Incentives Program Measures: Installed in 1996 and 1997 Program Years

Type of Measure	*Percentage of Measures Removed, Failed or Replaced by 1999*	*Percentage of Measures Retained after 1999*
Commercial Measures		
Adjustable speed drives	0.0%	100.0%
HVAC EMS	0.7%	99.3%
Lighting EMS	0.0%	100.0%
Electronic ballasts	0.0%	100.0%
CF lamps	4.2%	95.8%
Industrial Measures		
Adjustable speed drives	0.0%	100.0%
Lighting EMS	0.0%	100.0%
Injection molding machines	0.0%	100.0%
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	0.0%	100.0%
Agricultural Measures		
Adjustable speed drives	0.0%	100.0%
Hardware to lower temperature	0.0%	100.0%
Pump system controls	50.0%	50.0%
Water service EMS	0.0%	100.0%

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

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?*
Commercial Measures			
T8 lighting fixtures	11.0	9.59	No
T8 lamps	5.0	5.82	No
Electronic ballasts	10.0	10.93	No
CF fixtures (modular)	12.2	11.50	No
CF lamps	2.2	6.34	Yes
Delamping/reflectors	10.0	55.82	No
Adjustable speed drives	10.0	7.98	No
HVAC EMS	15.0	*	*
Chillers	20.0	*	*
Industrial Measures			
T8 lighting fixtures	11.0	12.04	No
T8 lamps	5.0	5.78	No
Electronic ballasts	10.0	15.24	No
Adjustable speed drives	10.0	10.62	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	9.21	No
Adjustable speed drives	10.0	10.62	No

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

1. INTRODUCTION AND BACKGROUND

This report provides the results of an analysis of the data collected during 1999 as part of a multi-year study of the retention of 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 during the years covered by this analysis. A previous analysis of data collected during the period 1995 through 1998 was presented and discussed in an earlier report prepared in March 1999.[1]

1.1 PROJECT OBJECTIVES

The objectives of this 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.

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.

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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.

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.

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 is 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 will 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 long-lived.

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. These tables are provided in Appendix A. The types of measures covered in the study from different sectors and program years are shown in Table 1-1.

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 is not included in this 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 E.

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

Program Year	*Sector*		
	Commercial	*Industrial*	*Agricultural*
1993 and 1994	T8 fixtures T8 lamps Electronic ballasts CF (modular) fixtures CF lamps Delamping/Reflectors HVAC EMS systems High-Efficiency Chillers Adjustable Speed Drives	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	Lighting EMS Adjustable speed drives Electronic ballasts	Injection molding machines Plastic extrusion Process cooling Process equipment insulation High efficiency chillers Air compressors	No measures added
1997	Lighting EMS Adjustable speed drives Electronic ballasts CF lamps	Lighting EMS Injection molding machines Plastic extrusion Process cooling High efficiency chillers Air compressors	Pump system control Water service EMS Hardware to lower temperature

1.2 ORGANIZATION OF REPORT

This report on the nonresidential measure retention study is organized as follows.

- Chapter 2 discusses the methods used for the study.
- Chapter 3 presents and discusses the results of the analysis of commercial measures.
- Chapter 4 presents and discusses the results of the analysis of industrial measures.
- Chapter 5 presents and discusses the results of the analysis of agricultural measures.
- Appendix A provides tables showing the *ex ante* savings for measures installed by customers participating in the EMHR Program in program years

1996 and 1997. These tables were used to identify the measures that should be added to the study to provide the coverage required by the Protocols.

- Appendix B provides the data used to estimate hazard functions for commercial measures and plots of the estimated hazard and survival functions.
- Appendix C provides the data used to estimate hazard functions for industrial/agricultural measures and plots of the estimated hazard and survival functions.
- Appendix D 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 E 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 has been 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 have been 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.

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

The initial sample of facilities 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 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.

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.

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 this 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.

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

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.

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.

In practice, customers who had been surveyed within the past year for another SCE study were not included in the sample. Where possible, the data collected on such customers for the other studies were used. For example, 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 1994, 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 this 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	*Commercial Sector*	*Industrial Sector*	*Agricultural Sector*
Indoor lighting	40.36%	15.61%	2.80%
HVAC-EMS	9.64%	2.54%	0.00%
Chillers	2.62%	1.23%	0.00%
ASDs	9.90%	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	62.52%	49.02%	79.27%
Tracking system kWh savings	313,290,256	289,287,201	32,706,638

The initial cadre of sites for the study that resulted after the recruitment effort is shown in Table 2-2. There was a total of 937 sites included in the initial cadre, 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 Sites Selected for Retention Study by Program Year and Sector

	1993 Commercial	*1993 Industrial/ Agricultural*	*1994 Commercial*	*1994 Industrial/ Agricultural*	*All Sites*
Total Number of Sites	356	179	253	149	937
		Numbers of Sites with Specified Measures			
ASDs	78	49	64	42	233
T8 Lamps	145	59	114	41	359
Electronic Ballasts	98	52	114	41	305
Compact Fluorescent Bulbs	79	-	50	-	129
Delamping/Reflectors	72	-	28	-	100
Chillers	17	-	21	-	38
HVAC Energy Management Systems	94	-	84	-	178
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 as measures 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 in PY96 and PY97 but not in PY93 and PY94.

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. These tables are provided in Appendix A.

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. For sites with lighting EMS, a 50% sample was taken. 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 Sites from 1996 and 1997 Program Years Surveyed in 1999 by Type of Measure

	1996 Commercial	*1996 Industrial/ Agricultural*	*1997 Commercial*	*1997 Industrial/ Agricultural*	*All Sites*
Total Number of Sites	73	31	178	51	333
Numbers of Sites with Specified Measures					
Electronic ballasts	25	-	70	-	95
CF lamps	-	-	77	-	77
Adjustable speed drives	1	3	18	6	28
HVAC EMS	46	-	93	4	143
Lighting EMS	48	-	93	4	146
Injection molding machines	-	5	-	4	9
Plastic extrusion equipment	-	3	-	6	9
Process cooling	-	2	-	3	5
Process equipment insulation	-	2	-	-	2
High efficiency chillers	-	2	-	5	7
Air compressors	-	14	-	7	21
Pump system control	-	-	-	2	2
Water service EMS	-	-	-	13	13
Hardware to lower temperature	-	-	-	2	2

2.2 DATA COLLECTION INSTRUMENTS

The types of instruments required for the nonresidential measure retention study were as follows:

- Baseline and follow-up on-site data collection forms; and
- Follow-up telephone survey form.

Preparation of these instruments is discussed in this section. Copies of the data collection forms and data collection manual were included as appendices to the earlier report on the retention study.[3]

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

2.2.1 Baseline and Follow-Up On-Site Data Collection Forms

Baseline and follow-up data on the measures studied were collected through on-site visits. Data items included those that could be used to estimate effective measure lives and to analyze the effects on service lives of such factors as operational hours, maintenance practices, etc.

Examples of the type of information that needed to be collected with the on-site data collection forms 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?

2.2.2 Follow-up Telephone Survey Instrument

To keep track of events that were relevant to measure retention but which occurred between on-site surveys, telephone follow-up interviews were conducted. Substantively, the survey instrument for the telephone interviews was designed to allow collection of information to determine the following:

- Whether the facility identified in the baseline survey was still occupied;
- Whether the owner/tenant had changed;
- Whether the business conducted on the site had changed;
- Whether remodels or renovations had occurred or were planned; and
- Whether the building occupant was satisfied with the measure.

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. For 1999, 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.

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

2.3.1 Customer Recruitment and Tracking

Contacts with customers to schedule the on-site data collection visits were coordinated with SCE staff and/or customer service representatives. The list of customers in the sample was provided to SCE staff to identify any (1) customers who had been already surveyed in other data collection projects that SCE had recently performed; (2) customers who should not be contacted at all; and (3) customers who should be contacted by SCE before they were called for scheduling an on-site data collection visit.

During the scheduling effort, a callback procedure was used to ensure that data collection visits were scheduled and completed with a large percentage of the "primary" customers in the sample. Three attempts were made by phone to contact a customer and schedule a data collection visit. To help increase the probability for scheduling a data collection visit, telephone contacts were attempted on different days at different times. Attempts to recruit a customer were stopped after three calls. Unlike households, it is generally possible to reach businesses during the day, and their agreement or refusal to participate can be attained over the telephone.

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

Data for the measure retention study were collected through on-site visits to customers' facilities. 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 were used as the field staff for the on-site data collection. A training session was held before the beginning of the data collection effort to instruct the field staff on the specific 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.

For the follow-up on-site data collection, the baseline data collection form was carried back to the site, and changes in any of the original conditions at the site were noted on the form.

The baseline and follow-up 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.

2.3.3 Follow-Up Telephone Procedures

Telephone interviews of program participants in the study sample were used to obtain information with which to track retention-related events occurring between on-site visits that might influence the longevity of energy efficiency measures installed by customers in the two cohorts. The major objectives of the telephone surveying were as follows:

- To determine reasons for early removal and disconnects of installed measures;
- To determine what has replaced any removed measures; and
- To identify any changes in circumstances of use over time.

A survey instrument structured to obtain information regarding these objectives was used for conducting the telephone interviews. The interview was structured into two major parts.

- The first part of the interview addressed what changes might have occurred in building usage, renovations, operating hours, or other conditions that could affect measure life.
- The second part of the interview attempted to tie down (in the absence of an on-site visit) any factors that might have affected the temporal life of specific measures, as opposed to its changes in the more general environment of a site.

2.4 ANALYSIS METHODS

The data collected during 1995 through 1998 were used in an earlier analysis 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 during 1999 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 and telephone 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, in the third and fourth earnings claims a utility can recover 25% of the 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 three or four years 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 fifth or sixth year.

As the data presented below will show, the retention rates for the first five years after installation are high for the measures considered in this study. Because of this, non-parametric methods of estimating survival functions are not appropriate. 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.

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.[4]

4 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.

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. 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.[5]

Two of the distributions commonly used for survival analysis are the exponential distribution and the Weibull distribution[6]. The probability density functions and associated hazard functions and survival functions for these distributions are shown in Table 2-5.

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

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

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 monotonically 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.[7]

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

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

estimates of the functions for the upper and lower bounds of the 80% confidence interval.

An example to illustrate this procedure for estimating effective useful lives is provided in the next subsection. The results from applying this parametric analytical approach to analyze the effective useful lives for the different types of measures are presented and discussed in the following chapters.

2.4.2 Example to Illustrate EUL Estimation Procedure

An analysis of the effective useful lives for T8 lamps installed in commercial facilities can be used to illustrate the estimation procedure.

The first step in the analysis to determine the effective useful life for a measure is to estimate a hazard function. The data for this for commercial T8 lamps were taken from the on-site data collection, since the on-site inspections allowed for identifying removals of individual lamps. Data for both 1993 and 1994 program years were combined for the analysis. These data and the calculated hazard rates are reported in Table 2-6, and the calculated hazard rates for T8 lamps are plotted in Figure 2-1.

Table 2-6. Data for Calculating Hazard Rates for Commercial T8 Lamps

Year	*Lamps at Start of Year*	*Lamps Removed/Failed during Year*	*Hazard Rate (Percent Removed or Failed)*
1	6,704	36	0.5%
2	6,668	175	2.6%
3	6,493	778	12.0%
4	5,715	1,877	32.8%
5	3,838	1,000	26.1%

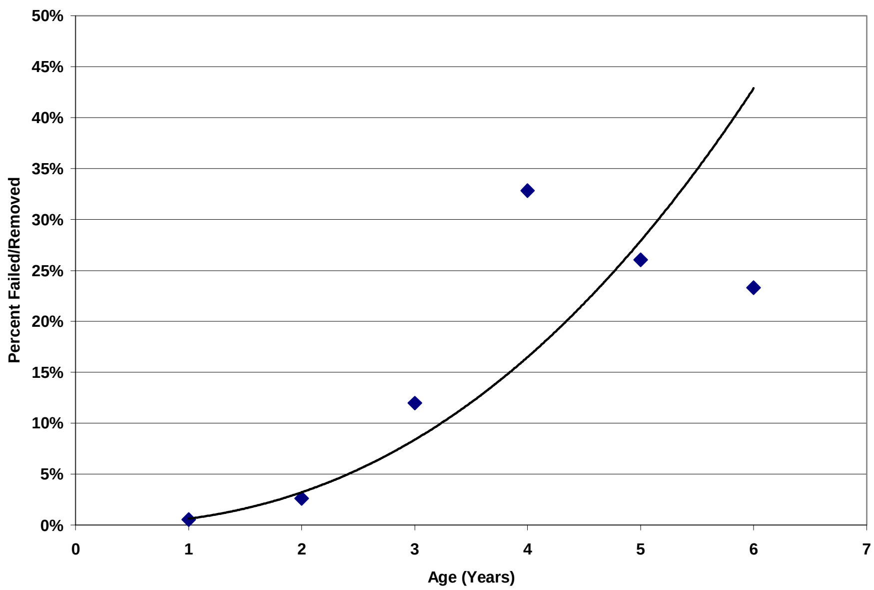


Figure 2-1. Plot of Hazard Rates for T8 Lamps in Commercial Sector

Inspection of the calculated hazard (removal/failure) rates for each year since installation showed that the hazard rate was not constant over time. This indicated that it was not warranted to assume that the survival function for T8 lamps could be represented using the exponential distribution, since the hazard rate for an exponential survival function is constant. However, the Weibull distribution does allow for hazard rates that change over time, and the Weibull-based hazard function was therefore used as the functional form for estimating the hazard function for T8 lamps.

A power curve fit to the hazard rate data in Table 2-6 provided the estimates of the parameters for the Weibull distribution representation of the hazard rate function. The fitted power curve was:

$$\text{Hazard rate at time t} = h(t) = 0.00631\text{Age}^{2.3549}$$

The R^2 for this fit was 0.921.

The parameters from the power curve fit to the hazard rate data imply the following parametrization of the Weibull function for the hazard function:

$$\text{Weibull hazard rate function} = 0.00188 \times 3.3549 \times \text{Age}^{2.3549}$$

where 0.00188 represents the α (scale) parameter for the Weibull distribution and 3.3549 represents the β (shape) parameter.

Given that the Weibull distribution provides a representation of the hazard function for T8 lamps, the associated survival function is given as:

$$\text{Percent surviving at age t} = S(t) = \exp(-0.00188 \times \text{Age}^{3.3549})$$

The implied survival function for T8 lamps is shown in Figure 2-2. With the survival function estimated, the effective useful life of T8 lamps can be estimated as the median survival time, defined as that age where 50% of the lamps have been removed or failed. For the survival function calculated for commercial T8 lamps, the median survival time is 5.82 years. This can be compared to SCE's *ex ante* estimate that the effective useful life of a T8 lamp is 5 years.

Figure 2-3 shows the "best" fit survival function (as in Figure 2-2) and the upper and lower bound survival functions associated with the 80% confidence level. The upper and lower bounds on the "best" fit survival function provide the confidence interval bounds for the estimated median useful life. For T8 lamps, the estimated median useful life is 5.82 years. The 80% confidence interval for this estimate (*cf*. Figure 2-3) is 4.01 years to 9.64 years. Because SCE's *ex ante* estimate of 5 years for the useful life of T8 lamps falls within this confidence interval, the hypothesis of no difference between the *ex ante* and *ex post* estimates cannot be rejected.

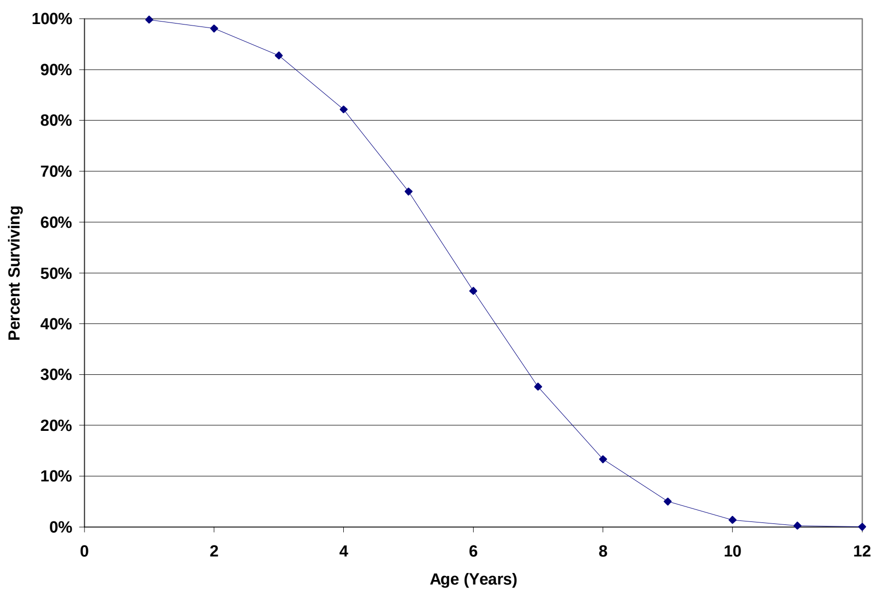


Figure 2-2. Survival Function Plot for T8 Lamps in Commercial Sector

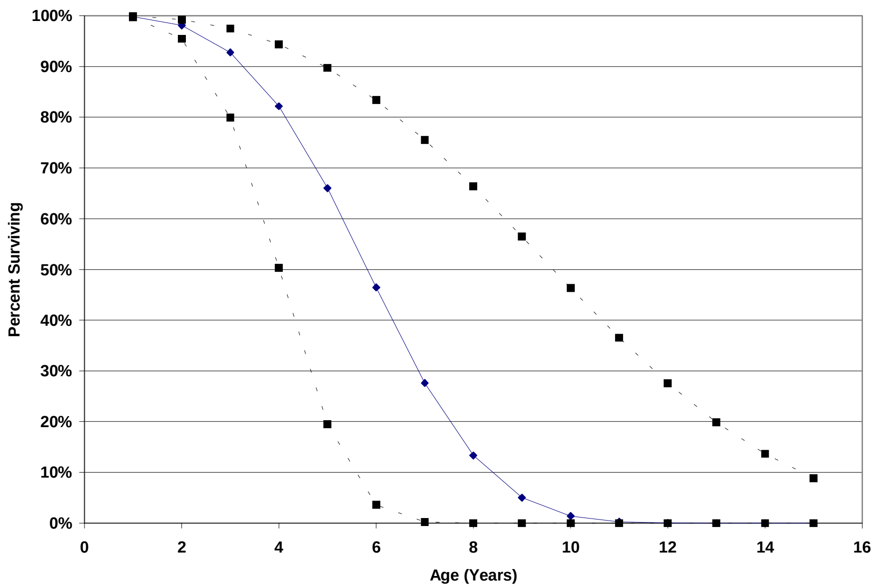


Figure 2-3. Survival Function Plot for T8 Lamps in Commercial Sector with Upper and Lower Bounds

3. RESULTS FOR COMMERCIAL MEASURES

This section presents and discusses the results from analyzing retention rates and estimating effective useful lives for commercial measures. Summary statistics on the commercial 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 COMMERCIAL SITES

During 1999, data were collected from 442 commercial sites out of the 574 commercial sites included in the study sample. The distribution of the on-site and telephone data collection effort for these sites is shown in Table 3-1.

Table 3-1. Commercial Sites for Which Data Were Collected during 1999

Program Year	*Number of Sites in Study Sample*	*Sites Surveyed in 1999*		
		On-Site	*Telephone*	*Total*
1993	323	166	84	250
1994	251	142	50	192
Combined	574	308	134	442

3.2 RETENTION RATES FOR COMMERCIAL MEASURES

Retention rates for the various types of commercial measures for each program year were calculated using the information collected through the on-site and telephone surveying. Table 3-2 shows the percentage of measures installed in each year that were no longer in place by 1999. The implied retention rates are also shown. The rates of retention for some of the measures are relatively high (e.g., energy management systems, chillers).

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

Type of Measure	*Number of Measures Installed*	*Number of Measures Removed, Failed or Replaced by 1999*	*Percentage of All Measures Removed, Failed or Replaced by 1999*	*Percentage of Measures Retained after 1999*
		1993 Program Year		
T8 lighting fixtures	1,248	263	21.1%	78.9%
T8 lamps	3,155	2,157	68.4%	31.6%
Electronic ballasts	1,362	216	15.9%	84.1%
CF fixtures (modular)	832	110	13.2%	86.8%
CF lamps	1,025	553	54.0%	46.0%
Delamping/reflectors	766	84	11.0%	89.0%
HVAC EMS	96	1	1.0%	99.0%
Chillers	25	0	0.0%	100.0%
Adjustable speed drives	129	15	11.6%	88.4%
		1994 Program Year		
T8 lighting fixtures	1,384	166	12.0%	88.0%
T8 lamps	3,549	2,012	56.7%	43.3%
Electronic ballasts	1,436	182	12.7%	87.3%
CF fixtures (modular)	489	51	10.4%	89.6%
CF lamps	612	290	47.4%	52.6%
Delamping/reflectors	489	40	8.2%	91.8%
HVAC EMS	82	1	1.2%	98.8%
Chillers	13	0	0.0%	100.0%
Adjustable speed drives	96	8	8.3%	91.7%
		1996 Program Year		
Adjustable speed drives	2	0	0.0%	100.0%
HVAC EMS	46	0	0.0%	100.0%
Lighting EMS	48	0	0.0%	100.0%
Electronic ballasts	249	0	0.0%	100.0%
		1997 Program Year		
Adjustable speed drives	34	0	0.0%	100.0%
HVAC EMS	93	1	1.1%	98.9%
Lighting EMS	93	0	0.0%	100.0%
Electronic ballasts	704	0	0.0%	100.0%
CF lamps	742	31	4.2%	95.8%

3.3 ESTIMATES OF EFFECTIVE USEFUL LIVES FOR COMMERCIAL MEASURES

Estimates of effective useful lives for the various commercial measures were developed by applying the procedure described in Chapter 2 to the data for measures from program years 1993 and 1994. Those estimates are presented and discussed in this section. We provide a summary of the results for all of the measures and compare these results to those produced for the prior report.

Detailed charts and information for the estimated hazard functions and survival functions are provided for all of the commercial measures in Appendix A.

Results are not reported for measures for which there were not sufficient numbers of removals/failures to support the hazard function estimation.

- For HVAC EMS, the system had been removed or had failed at 2 out of 178 sites. Both removals/failures occurred during the fourth year after installation.
- For high efficiency chillers, none of the chillers had been replaced or had failed at the 38 sites in the sample.
- For measures installed during the 1996 and 1997 program years, the number of removals/failures was not sufficient to support the estimation of hazard functions.

All of the measures for which the data allowed analysis of effective useful lives showed hazard rates that increased with time, so that 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 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.

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

Type of Measure	*Power Curve Fit*			*Weibull Distribution Parameters*	
	a	*b*	*R-squared*	*α (Scale)*	*β (Shape)*
T8 lighting fixtures	0.00152	2.2279	0.803	0.00047	3.2279
T8 lamps	0.00631	2.3549	0.921	0.00188	3.3549
Electronic ballasts	0.00198	1.8946	0.642	0.00068	2.8946
CF fixtures (modular)	0.00251	1.7103	0.841	0.00092	2.7103
CF lamps	0.00469	2.3614	0.934	0.00139	3.3614
Delamping/reflectors	0.01370	-0.0326	0.001	0.01416	0.9674
Adjustable speed drives	0.00008	4.1573	0.927	0.00002	5.1573

Table 3-4. Estimated Median Lives Compared to Ex Ante Estimates for Commercial 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	4.90	9.59	29.35
T8 lamps	5	Protocol, App. F, Table 1	4.01	5.82	9.64
Electronic ballasts	10	Protocol, App. F, Table 1	4.38	10.93	74.93
CF fixtures (modular)	12	Protocol, App. F, Table 1	6.42	11.50	27.51
CF lamps	2	Protocol, App. F, Table 1	4.45	6.34	10.08
Delamping/reflectors	10	Protocol, App. F, Table 1	5.78	55.82	> 100
Adjustable speed drives	10	Protocol, App. F, Table 1	2.05	7.98	> 100
HVAC EMS	15	Protocol, App. F, Table 1	*	*	*
Chillers	20	Protocol, App. F, Table 1	*	*	*

*Data were not sufficient to estimate median life.

Inspection of the estimates reported in Table 3-4 shows that there is relatively good agreement between SCE's *ex ante* estimates of effective useful lives and the median survival lives estimated through this study. Except for one measure, the hypothesis of no difference between *ex ante* and *ex post* estimates cannot be rejected. The hypothesis can be rejected for compact fluorescent lamps, where the median useful life estimated through this study is higher than SCE's *ex ante* estimate.

The EULs estimated for this report are compared in Table 3-5 to the EULs estimated in the prior report. Except for adjustable speed drives, the EULs estimated in this report are somewhat higher than those estimated in the previous report, although the differences are generally not substantial. For delamping/reflectors, the considerably higher EUL estimated in this report must be interpreted with caution because the statistical precision with which the hazard function was estimated for delamping/reflectors was very low (i.e., as shown in Table 3-3 the R-squared was only 0.001).

Table 3-5. Comparison of EUL Estimates for Commercial Measures between 1999 Report and 2000 Report

Type of Measure	*EUL Estimate from 1999 Report*	*EUL Estimate from 2000 Report*
T8 lighting fixtures	9.11	9.59
T8 lamps	5.37	5.82
Electronic ballasts	7.80	10.93
CF fixtures (modular)	10.51	11.50
CF lamps	5.73	6.34
Delamping/reflectors	18.85	55.82
Adjustable speed drives	11.13	7.98

3.4 REASONS FOR REMOVAL OR FAILURE OF COMMERCIAL MEASURES

For purposes of estimating the effective useful lives of installed measures, no distinction needed to be made between measures that failed and those that were removed or replace for reasons other than failure. However, information was gathered regarding whether a measure had failed or had been removed or replaced before failing. That information is summarized in this section for commercial measures.

For lighting measures, the major reasons for removals or failures differ between fixtures and lamps. Table 3-6 reports on the number of fixtures, lamps or ballasts installed, the number removed or failed, the percentage of fixtures, lamps or ballasts installed that had been removed or failed by the end of 1999, and the percentage of the removed or failed fixtures, lamps or ballasts that had burned out.

- Lighting fixtures are generally removed and replaced because of changes being made to the spaces in which they are located. Reflectors installed during delamping are also removed or replaced because of such changes.
- For T8 lamps, compact fluorescent lamps, and electronic ballasts, burn-out was the primary reason for these measures not being in service. For T8 and compact fluorescent lamps, Table 3-6 shows that over 70 percent of the removals or failures were attributable to the lamps having burned out. For electronic ballasts, just over half of the removals or failures were attributable to ballasts burning out.

Table 3-6. Rates of Removals or Failures for Lighting Fixtures, Lamps and Electronic Ballasts

Type of Measure	*Number Installed*	*Number Removed or Failed*	*% Removed or Failed*	*% of Removed or Failed that had Burned Out*
T8 fixtures	2,632	429	16.3%	0.0%
CF fixtures	1,321	161	12.2%	0.0%
Delamping/reflectors	1,255	124	9.9%	2.4%
T8 lamps	6,704	4,169	62.2%	71.1%
CF lamps	1,637	843	51.5%	77.3%
Electronic ballasts	2,798	398	14.2%	54.3%

Further information on removals of lighting fixtures and reflectors is provided by looking at removal rates for different types of businesses. These data are reported in Table 3-7, which shows the number of installed measures (fixtures or reflectors) in the study sample for two-digit SIC groupings and the percent of the installed measures that had been removed for each grouping.

- Five SICs (i.e.,53, 65, 80, 82, and 91) account for about two-thirds of the installed T8 fixtures for the sample. As Table 3-7 shows, there are significant differences in removal rates among these SICs. While just over half of the fixtures installed in SIC 53 facilities have been removed, only about 3 percent of the fixtures for SIC 91 have been removed. Removal rates for SICs 80 and 82 are about 10 percent, somewhat higher than the rate for SIC 91 but lower than the rate for SIC 53.
- Four SICs (i.e., 65, 70, 80, and 82) account for about two-thirds of the installed CF fixtures for the sample. Removal rates for CF fixtures for SICs 80 and 82 are significantly lower than the rates for SICs 65 and 70.
- Four SICs (i.e., 53, 65, 80, and 82) account for about two-thirds of the installed reflectors for the sample. Removal rates for reflectors for SICs 80 and 82 are significantly lower than rates for SICs 53 and 65.

Thus, for lighting fixtures and reflectors, the removal rates for public facilities (e.g., schools, hospitals) are generally lower than for private facilities.

Table 3-7. Removal Rates by Two-Digit SIC for Commercial Lighting Fixtures and Reflectors

SIC	Description	T8 Fixtures		CF Fixtures		Delamping/Reflectors	
		Sample of Installed Fixtures	Percent Removed	Sample of Installed Fixtures	Percent Removed	Sample of Installed Fixtures	Percent Removed
15	Building construction					10	0.0%
25	Furniture & fixtures	10	50.0%				
28	Chemicals	10	0.0%			10	0.0%
37	Transportation equip.	16	6.3%				
41	Local transportation	1	0.0%			1	0.0%
42	Motor freight	27	14.8%	10	0.0%	20	0.0%
43	U.S. Postal Service	10	0.0%	10	0.0%	20	55.0%
45	Air transportation	8	12.5%	10	10.0%	8	0.0%
49	Electric/gas services	9	11.1%	10	0.0%	9	0.0%
50	Wholesale durable goods	56	26.8%	10	0.0%	37	0.0%
51	Wholesale nondurable goods	27	44.4%			17	0.0%
52	Building materials	10	10.0%			10	0.0%
53	General Mdse stores	215	53.0%	30	0.0%	163	18.4%
54	Food stores	90	7.8%	10	10.0%	20	15.0%
55	Auto dealers/gas stations	69	10.1%			59	0.0%
56	Apparel stores	30	0.0%			10	0.0%
57	Home furnishing stores	20	0.0%				
58	Eating/drinking places	74	13.5%	36	0.0%	5	0.0%
59	Miscellaneous retail	10	0.0%	4	0.0%	10	0.0%
60	Depository institutions	32	9.4%	30	13.3%	24	0.0%
61	Credit institutions	10	0.0%			10	0.0%
63	Insurance carriers	30	66.7%	10	10.0%	10	100.0%
64	Insurance agents & brokers	6	0.0%	10	0.0%		
65	Real estate	390	17.9%	219	16.0%	273	11.0%
70	Lodging places	59	8.5%	170	19.4%		
72	Personal services	10	0.0%			10	0.0%
73	Business services	30	3.3%	10	0.0%	20	0.0%
75	Auto repair	10	10.0%	10	50.0%		
78	Motion pictures	10	0.0%			10	0.0%
79	Amusement services	19	57.9%	50	72.0%	9	0.0%
80	Health services	213	10.8%	148	6.1%	114	3.5%
82	Educational services	791	10.9%	359	5.6%	281	7.1%
83	Social services	43	16.3%	20	5.0%	13	0.0%
86	Membership organizations	65	4.6%	38	2.6%		
91	General government	102	2.9%	60	6.7%	35	17.1%
92	Justice, public order	54	22.2%	20	50.0%	14	71.4%
94	Human resource programs	9	0.0%	17	0.0%		
96	Economic programs	10	0.0%			10	0.0%
99	Nonclassifiable	10	0.0%			2	0.0%
--	SIC not known	37	16.2%	20	0.0%	11	0.0%
All		2,632	16.3%	1,321	12.2%	1,255	9.9%

As shown in Table 3-8, only two of the HVAC energy management systems and none of the chillers were removed or had failed, as would be expected for measures with relatively longer lives. However, there were 23 of the adjustable speed drives in commercial facilities that were removed or that had failed. There were several different reasons for these ASDs not being in service.

- For 5 ASDs that were not in service, the ASD had broken down or failed in some way (e.g., needed a new fan, kept tripping circuit breaker).
- For 6 ASDs, the ASD had been replaced by a different ASD (e.g., of greater capacity, of different capability).
- For 4 ASDs, the ASDs were not in service because the facility was closed.
- For 8 ASDs, the ASD had been removed or replaced for an unspecified reason.

Table 3-8. Rates of Removals or Failures for HVAC EMS, Chillers,and Adjustable Speed Drives

Type of Measure	*Number Installed*	*Number Removed or Failed*	*% Removed or Failed*
HVAC EMS	178	2	1.1%
Chillers	38	0	0.0%
Adjustable speed drives	225	23	10.2%

4. 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 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 INDUSTRIAL SITES

During 1999, data were collected for 274 industrial sites out of the 328 industrial sites that are included in the study sample. The distribution of the on-site and telephone data collection effort for these sites is shown in Table 4-1.

Table 4-1. Industrial Sites for Which Data Were Collected during 1999

Program Year	*Number of Sites in Study Sample*	*Sites Surveyed in 1999*		
		On-Site	*Telephone*	*Total*
1993	179	65	90	155
1994	149	34	85	119
Combined	328	99	175	274

4.2 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 and telephone surveying. Table 4-2 shows the percentage of measures installed in each year that were no longer in place by 1999. The implied retention rates are also shown.

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

Type of Measure	Number of Measures Installed	Number of Measures Removed, Failed or Replaced by 1999	Percentage of All Measures Removed, Failed or Replaced by 1999	Percentage of Measures Retained after 1999
		1993 Program Year		
T8 lighting fixtures	660	132	20.0%	80.0%
T8 lamps	1,841	1,133	61.5%	38.5%
Electronic ballasts	715	105	14.7%	85.3%
Adjustable speed drives	73	13	17.8%	82.2%
		1994 Program Year		
T8 lighting fixtures	355	31	8.7%	91.3%
T8 lamps	917	520	56.7%	43.3%
Electronic ballasts	377	23	6.1%	93.9%
Adjustable speed drives	66	17	25.8%	74.2%
Lighting EMS	11	1	9.1%	91.9%
Injection molding machines	27	5	18.5%	81.5%
Plastic extrusion equipment	8	3	37.5%	63.5%
Process cooling	6	0	0.0%	100.0%
Process equipment insulation	5	1	20.0%	80.0%
High efficiency chillers	5	0	0.0%	100.0%
Air compressors	18	3	16.7%	83.3%
		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	0	0.0%	100.0%
Process equipment insulation	2	0	0.0%	100.0%
High efficiency chillers	2	0	0.0%	100.0%
Air compressors	14	0	0.0%	100.0%
		1997 Program Year		
Adjustable speed drives	11	0	0.0%	100.0%
Lighting EMS	4	0	0.0%	100.0%
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	-	0	0.0%	100.0%
High efficiency chillers	5	0	0.0%	100.0%
Air compressors	7	0	0.0%	100.0%

4.3 ESTIMATES OF EFFECTIVE USEFUL LIVES FOR INDUSTRIAL MEASURES

Analyses similar to those for commercial measures were used to develop estimates of effective useful lives for four of the industrial measures for which there were sufficient data. As Table 4-2 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.

The results from the analysis to determine EULs for industrial measures are summarized in Table 4-3 and Table 4-4. Plots of the hazard functions and survival functions for the industrial measures analyzed are provided in Appendix B. All of the industrial measures analyzed showed hazard rates that increased with time, so that 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 4-4shows 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 4-3. 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	0.00935	1.0118	0.633	0.00465	2.0118
T8 lamps	0.00152	3.3212	0.907	0.00035	4.3212
Electronic ballasts	0.00624	0.9798	0.656	0.00315	1.9798
Adjustable speed drives	0.03825	0.3546	0.916	0.02823	1.3546

Table 4-4. 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	4.83	12.04	75.99
T8 lamps	5	Protocol, App. F, Table 1	3.71	5.78	10.98
Electronic ballasts	10	Protocol, App. F, Table 1	7.12	15.24	54.99
Adjustable speed drives	10	Protocol, App. F, Table 1	8.04	10.62	14.85
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 EULs estimated for this report are compared in Table 4-5 to the EULs estimated in the prior report. Except for adjustable speed drives, the EULs estimated in this report are somewhat higher than those estimated in the previous report.

Table 4-5. Comparison of EUL Estimates for Industrial Measures between 1999 Report and 2000 Report

Type of Measure	*EUL Estimate from 1999 Report*	*EUL Estimate from 2000 Report*
T8 lighting fixtures	9.18	12.04
T8 lamps	4.32	5.78
Electronic ballasts	7.94	15.24
Adjustable speed drives	12.31	10.62

4.4 REASONS FOR REMOVAL OR FAILURE OF INDUSTRIAL MEASURES

For purposes of estimating the effective useful lives of installed industrial measures, no distinction needed to be made between measures that failed and those that were removed or replace for reasons other than failure. However, information was gathered regarding whether a measure had failed or had been removed or replaced before failing. That information is summarized in this section.

For lighting measures, the major reasons for removals or failures differ between fixtures and lamps. Table 4-6 reports on the number of fixtures, lamps or ballasts installed, the number removed or failed, the percentage of fixtures, lamps or ballasts installed that had been removed or failed by the end of 1999, and the percentage of the removed or failed fixtures, lamps or ballasts that had burned out.

- As for commercial facilities, lighting fixtures for industrial facilities are generally removed and replaced because of changes being made to the spaces in which they are located. Reflectors installed during delamping are also removed or replaced because of such changes.
- For T8 lamps, burn-out was the primary reason for these measures not being in service. Table 4-6 shows that just over 70 percent of the removals or failures of T8 lamps in industrial facilities were attributable to the lamps having burned out.
- For electronic ballasts, somewhat under a half (44 percent) of the removals or failures were attributable to ballasts burning out. Electronic ballasts were

more likely to be removed or replaced because of changes being made to the spaces in which they were located.

Table 4-6. Rates of Removals or Failures for Industrial T8 Lighting Fixtures, Lamps and Electronic Ballasts

Type of Measure	*Number Installed*	*Number Removed or Failed*	*% Removed or Failed*	*% of Removed or Failed that had Burned Out*
T8 fixtures	1,015	163	16.1%	
T8 lamps	2,758	1,653	59.9%	72.4%
Electronic ballasts	1,092	128	11.7%	44.5%

Further information on removals of T8 lighting fixtures and reflectors is provided by looking at removal rates for different types of businesses. These data are reported in Table 4-7, which shows the number of installed fixtures in the study sample for two-digit SIC groupings and the percent of the installed fixtures that had been removed for each grouping. The installed fixtures are spread across a wide variety of industrial SICs, so that the samples are not large for any one SIC. The data on removal rates show variation across the SICs.

Of the 154 adjustable speed drives installed in industrial facilities during 1993, 1994, 1996, and 1997, there were 30 of the ASDs that were removed or that had failed. There were several different reasons for these ASDs not being in service.

- None of the 30 ASDs that were no longer in service were reported to have failed.
- For 16 ASDs, the ASD had been replaced by a different ASD (e.g., of greater capacity, of different or upgraded capability).
- For 14 ASDs, the ASD had been removed or replaced for an unspecified reason.

Table 4-7. Removal Rates by Two-Digit SIC for Industrial T8 Lighting Fixtures

SIC	Description	T8 Fixtures	
		Sample of Installed Fixtures	Percent Removed
14	Mining nonmetallic materials	10	0.0%
17	Special trades construction	20	5.0%
20	Food & kindred products	69	20.3%
23	Apparel manufacturing	10	100.0%
24	Lumber & wood products	10	0.0%
26	Paper & allied products	30	13.3%
27	Printing, publishing & allied products	41	0.0%
28	Chemicals & allied products	56	1.8%
30	Rubber & miscellaneous plastics	89	11.2%
32	Stone, clay, glass, & concrete	40	30.0%
33	Primary metal industries	10	0.0%
34	Fabricated metal products	49	4.1%
35	Industrial/commercial machinery	69	33.3%
36	Electronic equipment	138	10.9%
37	Transportation equipment	100	16.0%
38	Measuring instruments	126	16.7%
39	Miscellaneous manufacturing	30	46.7%
49	Electric/gas services	2	0.0%
51	Wholesale nondurable goods	10	0.0%
65	Real estate	10	30.0%
Unknown	SIC not known	96	17.7%
All		1,015	16.1%

5. 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 5.1. Retention rates are presented in Section 5.2, while estimates of effective useful lives are presented in Section 5.3.

5.1 DATA COLLECTED FOR AGRICULTURAL SITES

During 1999, data were collected for 68 sites with agricultural measures out of the industrial/agricultural sites that are included in the study sample. The distribution of the on-site and telephone data collection effort for these sites is shown in Table 5-1.

Table 5-1. Sites with Agricultural Measures for Which Data Were Collected during 1999

Program Year	*Number of Sites in Study Sample*	*Sites Surveyed in 1999*		
		On-Site	*Telephone*	*Total*
1993	74	0	29	29
1994	81	0	39	39
Combined	155	0	68	68

5.2 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 and telephone surveying. Table 3-9 shows the percentage of measures installed in each year that were no longer in place after five years. The implied retention rates are also shown.

Table 5-2. Retention Rates for Agricultural Measures by Program Year

Type of Measure	*Number of Measures Installed*	*Number of Measures Removed, Failed or Replaced by 1999*	*Percentage of All Measures Removed, Failed or Replaced by 1999*	*Percentage of Measures Retained after 1999s*
		1993 Program Year		
Pumps/pump system improvements	93	13	14.0%	86.0%
Adjustable speed drives	73	13	17.8%	82.2%
		1994 Program Year		
Pumps/pump system improvements	82	20	24.4%	75.6%
Adjustable speed drives	66	17	25.8%	74.2%
		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	1	50.0%	50.0%
Water service EMS	13	0	0.0%	100.0%

5.3 ESTIMATES OF EFFECTIVE USEFUL LIVES FOR AGRICULTURAL MEASURES

Analyses similar to those for commercial and 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. The estimates reported for industrial ASDs also apply to agricultural ASDs and are repeated here.

The results from the analysis are summarized in Table 5-3 and Table 5-4. Plots of the hazard functions and survival functions for these agricultural measures are provided in Appendix B. The agricultural measures showed hazard rates that increased with time, so that 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 5-3. The resulting estimates of median survival lives are reported in Table 5-4 and compared to SCE's *ex ante* estimates of effective useful lives.

Inspection of the estimates reported in Table 5-4 shows that the estimated median effective useful life for pumps/pump system improvements estimated through this study is 9.21 years, which is close to SCE's *ex ante* estimate of 11 years.

Table 5-3. 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	0.00630	1.5362	0.504	0.00248	2.5362
Adjustable speed drives	0.03825	0.3546	0.916	0.02823	1.3546

Table 5-4. 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	2.24	9.21	> 100
Adjustable speed drives	10	Protocol, App. F, Table 1	8.04	10.62	14.85

APPENDIX A
EX ANTE SAVINGS FOR MEASURES INSTALLED DURING PROGRAM YEARS 1996 AND 1997

This appendix contains tables showing the *ex ante* savings for measures installed by customers participating in SCE's EMHR Program in 1996 and 1997. These tables were used to identify the measures that needed to be added to the study to provide the coverage required by the DSM Measurement Protocols.

Table A-1. Ex Ante Savings by Measure: 1996 Program Year, Agricultural Sector

Measure	*End Use*	*Ex Ante kWh Savings*	*Percent of Sector*
Adj Spd Drive, (Water Serv)	Water Services	2,773,580	68.50%
Irrig Eff Improvements	Water Services	881,796	21.78%
Component	Lighting	318,974	7.88%
Misc (Process)	Process	27,118	0.67%
Motors-Three Phase (Tefc)	Water Services	20,120	0.50%
Pump System Eff Improv	Water Services	14,367	0.35%
Motors (Proc)-Three Phase	Process	12,950	0.32%
		4,048,905	

Table A-2. Ex Ante Savings by Measure: 1996 Program Year, Commercial Sector

Measure	*End Use*	*Ex Ante kWh Savings*	*Percent of Sector*
Component	Lighting	15,314,338	29.82%
Adj Spd Drive, (Hvac)	Space Conditioning	10,715,013	20.87%
EMS (Space Conditioning)	Space Conditioning	8,971,830	17.47%
Engy Mgnmt Sys (Lighting)	Lighting	5,274,428	10.27%
Misc (Space Cond)	Space Conditioning	2,203,297	4.29%
EMS (Refrigeration)	Refrigeration	1,484,034	2.89%
Economy Cycle	Space Conditioning	902,716	1.76%
Indoor Lgting Sys Replace	Lighting	902,094	1.76%
Anti-Sweat Heater Control	Refrigeration	887,643	1.73%
Air Distribution System	Space Conditioning	769,891	1.50%
Adj Spd Drive, (Refrig)	Refrigeration	543,880	1.06%
Air Compressor System	Process	534,481	1.04%
Indoor Lgting Sys Modif	Lighting	406,207	0.79%
Component	Space Conditioning	391,946	0.76%
Outdoor Lgting Sys Replac	Lighting	364,083	0.71%
Misc (Refrigeration)	Refrigeration	330,174	0.64%
Chilled Water Controls	Space Conditioning	293,108	0.57%
Chiller 200 - <600 Tons	Space Conditioning	267,003	0.52%
Misc (Process)	Process	265,086	0.52%
Air Compressor	Process	146,000	0.28%
Daylighting Systems	Lighting	118,936	0.23%
Chiller 75 - <200 Tons	Space Conditioning	114,198	0.22%
Cooling Tower	Process	96,768	0.19%
Motors (Hvac)-Three Phase	Space Conditioning	41,306	0.08%
Occupancy Sensor	Lighting	12,468	0.02%
		51,350,928	

Table A-3. Ex Ante Savings by Measure: 1996 Program Year, Industrial Sector

Measure	*End Use*	*Ex Ante kWh Savings*	*Percent of Sector*
Misc (Process)	Process	27,681,047	31.05%
Adj Spd Drive, (Hvac)	Space Conditioning	10,570,088	11.86%
Air Compressor	Process	7,494,285	8.41%
Pump Sys Cntrls (Process)	Process	7,183,585	8.06%
Component	Lighting	5,095,923	5.72%
Indoor Lgting Sys Modif	Lighting	4,768,624	5.35%
Adj Spd Drive, (Process)	Process	3,791,593	4.25%
Pump System, (Process)	Process	3,703,179	4.15%
Indoor Lgting Sys Replace	Lighting	3,667,589	4.11%
Plastic Extrusion Equip	Process	2,803,102	3.14%
EMS (Space Conditioning)	EMS (Space Conditioning)	2,561,183	2.87%
Air Compressor System	Process	1,484,495	1.67%
Injection Molding Machine	Process	1,398,560	1.57%
Process Cooling	Process	1,230,528	1.38%
Insul - Plastic Extrusion	Process	1,025,432	1.15%
Insul - Process Equipment	Process	859,114	0.96%
EMS (Lighting)	EMS (Lighting)	834,744	0.94%
Motors (Proc)-Three Phase	Process	672,059	0.75%
EMS (Space Conditioning)	Space Conditioning	590,074	0.66%
Chilled Water Controls	Space Conditioning	487,442	0.55%
Chiller 200 - <600 Tons	Space Conditioning	371,700	0.42%
Misc (Space Cond)	Space Conditioning	208,497	0.23%
Daylighting Systems	Lighting	176,254	0.20%
Chllr 600 - <2000 Tons	Space Conditioning	159,263	0.18%
Economy Cycle	Space Conditioning	151,596	0.17%
Cooling Tower	Process	127,008	0.14%
Component	Space Conditioning	47,629	0.05%
		89,144,593	

Table A-4. Ex Ante Savings by Measure: 1997 Program Year, Agricultural Sector

Measure	*End Use*	*Ex Ante kWh Savings*	*Percent of Sector*
Adj Spd Drve, (Water Serv)	Water Services	641,851	20.52%
Misc (Refrigeration)	Refrigeration	430,425	13.76%
Pump Sys Cntrls (Wtr Ser)	Water Services	397,900	12.72%
Misc (Process)	Process	384,451	12.29%
EMS (Water Services)	Water Services	377,843	12.08%
Hdwr To Lower Cond Temp	Refrigeration	277,655	8.88%
Adj Spd Drive, (Process)	Process	167,544	5.36%
Motors-Three Phase (Tefc)	Water Services	143,750	4.60%
Process Cooling	Process	141,602	4.53%
Motors-Three Phase (Odp)	Water Services	138,376	4.42%
Motors (Proc)-Three Phase	Process	26,028	0.83%

Table A-5 Ex Ante Savings by Measure: 1997 Program Year, Commercial Sector

Measure	*End Use*	*Ex Ante kWh Savings*	*Percent of Sector*
Indoor Lgting Sys Modif	Lighting	20,130,868	17.18%
EMS (Space Conditioning)	Space Conditioning	17,305,847	14.77%
Adj Spd Drive, (Hvac)	Space Conditioning	17,066,470	14.57%
Adj Spd Drive, (Process)	Process	11,370,220	9.71%
EMS (Lighting)	Lighting	9,153,977	7.81%
EMS (Refrigeration)	Refrigeration	5,595,864	4.78%
Indoor Lgting Sys Replace	Lighting	5,322,327	4.54%
Air Compressor System	Process	3,364,998	2.87%
Chllr 600 - <2000 Tons	Space Conditioning	3,162,554	2.70%
Economy Cycle	Space Conditioning	2,932,217	2.50%
Misc Process--Destage 2 Units	Process	2,765,094	2.36%
Component	Lighting	2,587,892	2.21%
Chiller 200 - <600 Tons	Space Conditioning	2,350,338	2.01%
Motors (Proc)-Three Phase	Process	2,259,779	1.93%
Misc (Space Cond)	Space Conditioning	1,928,913	1.65%
Occupancy Sensor	Lighting	1,614,792	1.38%
Pump Sys Cntrls (Process)	Process	1,443,871	1.23%
Outdoor Lgting Sys Repl	Lighting	1,340,884	1.14%
Misc (Refrigeration)	Refrigeration	673,080	0.57%
Component-Led Exit Signs	Lighting	659,007	0.56%
Chilled Water Controls	Space Conditioning	621,283	0.53%
Chiller 75 - <200 Tons	Space Conditioning	563,087	0.48%
Misc (Process)	Process	516,065	0.44%
Motors (Hvac)-Three Phase	Space Conditioning	409,574	0.35%
Outdoor Lgting Sys Mod	Lighting	266,430	0.23%
Anti-Sweat Heater Control	Refrigeration	258,405	0.22%
Cooling Tower	Space Conditioning	247,003	0.21%
Air Compressor	Process	196,527	0.17%
Adj Spd Drive, (Refrig)	Refrigeration	182,964	0.16%
Air Distribution System	Space Conditioning	182,752	0.16%
Component-Delamping	Lighting	174,685	0.15%
Timeclock/Occupancy Sensors	Lighting	142,043	0.12%
EMS (Process)	Process	112,953	0.10%
Component	Space Conditioning	81,131	0.07%
Component- Led Exit Signs	Lighting	72,594	0.06%
Component, Led Exit Signs	Lighting	56,943	0.05%
Chiller <75 Tons	Space Conditioning	10,998	0.01%
Component-Outdoor Cfbs	Lighting	8,204	0.01%
Outdoor Lgting Sys Modif	Lighting	8,103	0.01%
Daylighting Systems	Lighting	6,259	0.01%
Component, Exit Led Signs	Lighting	5,994	0.01%
Component, Exit Signs	Lighting	2,664	0.00%
Component	Process	1,019	0.00%
Indoor Lgting Sys Replacement	Lighting	421	0.00%
Outdoor Lgting Sys Replac	Lighting	293	0.00%

Table A-6. Ex Ante Savings by Measure: 1997 Program Year, Industrial Sector

Measure	End Use	Ex Ante kWh Savings	Percent of Sector
Misc (Process)	Process	42,936,171	25.80%
EMS (Lighting)	EMS (Lighting)	18,018,824	10.83%
Indoor Lgting Sys Replace	Lighting	15,832,403	9.51%
Adj Spd Drive, (Hvac)	Space Conditioning	15,541,091	9.34%
Plastic Extrusion Equip	Process	12,784,207	7.68%
Adj Spd Drive, (Process)	Process	11,047,986	6.64%
Indoor Lgting Sys Modif	Lighting	10,784,528	6.48%
Furnace/Energy Efficient	Process	5,389,709	3.24%
Injection Molding Machine	Process	5,175,662	3.11%
Air Compressor System	Process	4,085,592	2.45%
Motors (Proc)-Sgle Phase	Process	2,967,300	1.78%
EMS (Space Conditioning)	EMS (Space Conditioning)	2,797,971	1.68%
Air Compressor System - Qty 2	Process	2,577,462	1.55%
Pump Sys Cntrls (Process)	Process	2,577,060	1.55%
Motors (Proc)-Three Phase	Process	2,369,485	1.42%
Adj Spd Drive, (Refrig)	Refrigeration	1,724,025	1.04%
Cooling Tower	Space Conditioning	1,335,610	0.80%
Pump System (Process)	Process	1,265,920	0.76%
Chllr 600 - <2000 Tons	Space Conditioning	1,059,275	0.64%
Economy Cycle	Space Conditioning	1,000,346	0.60%
Hdwr To Lower Cond Temp	Refrigeration	777,743	0.47%
Process Cooling	Process	775,679	0.47%
Air Compressor	Process	726,418	0.44%
Ems (Space Conditioning)	Space Conditioning	497,654	0.30%
Engy Mgnmt Sys (Lighting)	Ems (Lighting)	426,535	0.26%
Chiller 75 - <200 Tons	Space Conditioning	382,477	0.23%
Vacuum System	Process	316,642	0.19%
Power Factor Capacitors	Process	252,030	0.15%
Daylighting Systems	Lighting	243,141	0.15%
Chiller 200 - <600 Tons	Space Conditioning	127,325	0.08%
Solid State Controls	Process	121,500	0.07%
Air Distribution System	Space Conditioning	117,940	0.07%
Cooling Tower	Process	94,476	0.06%
Component	Lighting	86,558	0.05%
Misc (Process)-Ir Lamps	Process	71,142	0.04%
Component-Led Exit Signs	Lighting	70,929	0.04%
Motors (Hvac)-Three Phase	Space Conditioning	22,482	0.01%
Outdoor Lgting Sys Replac	Lighting	15,294	0.01%
Component	Space Conditioning	14,051	0.01%
Outdoor Lgting Sys Repl	Lighting	10,841	0.01%
Air Cooled, Single Pkg	Process	6,968	0.00%
Component, Led Exit Signs	Lighting	1,332	0.00%

APPENDIX B
HAZARD FUNCTIONS AND SURVIVAL FUNCTIONS FOR COMMERCIAL MEASURES

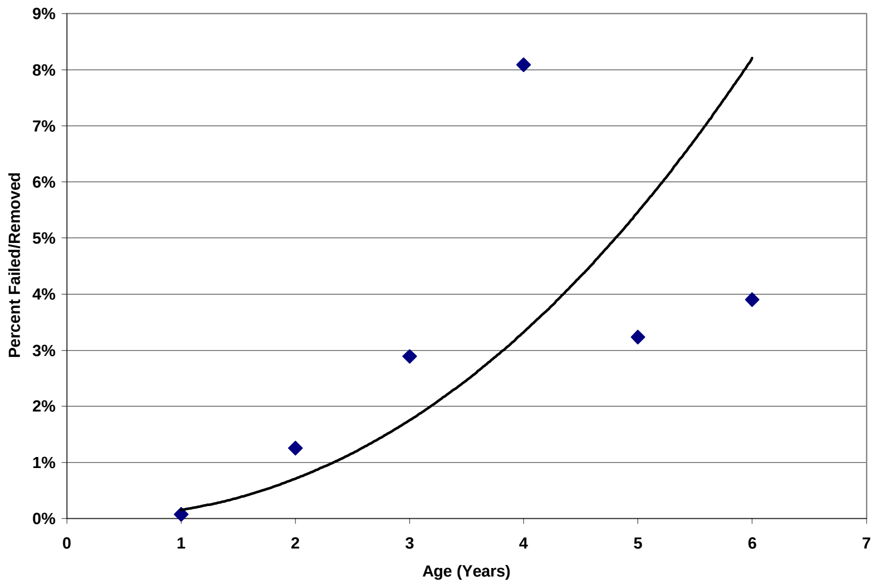
This appendix provides the data used for the hazard function analyses of the commercial measures and plots of the estimated hazard functions and survival functions. Plots are provided for the following measures:

- T8 lighting fixtures
- T8 lamps
- Electronic ballasts
- Compact fluorescent fixtures
- Compact fluorescent lamps
- Delamping/reflectors
- Adjustable speed drives

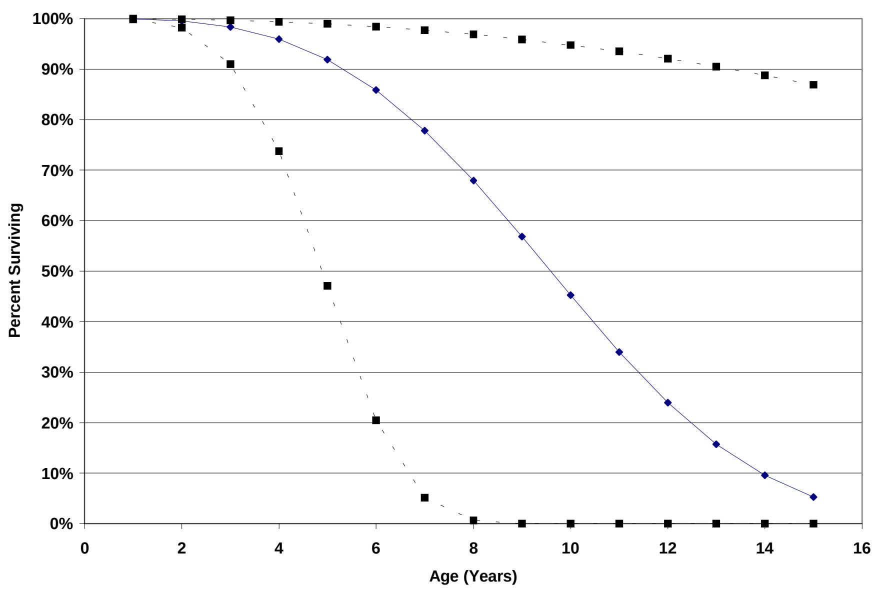
The numbers of removals/failures for HVAC EMS and for high efficiency chillers installed in program years 1993 and 1994 were not sufficient to support hazard function analysis.

Data for Calculating Hazard Rates for Commercial T8 Fixtures

Year	*Fixtures at Start of Year*	*Fixtures Removed/Failed during Year*	*Hazard Rate (Rate of Removal/Failure)*
1	2,632	2	0.1%
2	2,630	33	1.3%
3	2,597	75	2.9%
4	2,522	204	8.1%
5	2,318	75	3.2%



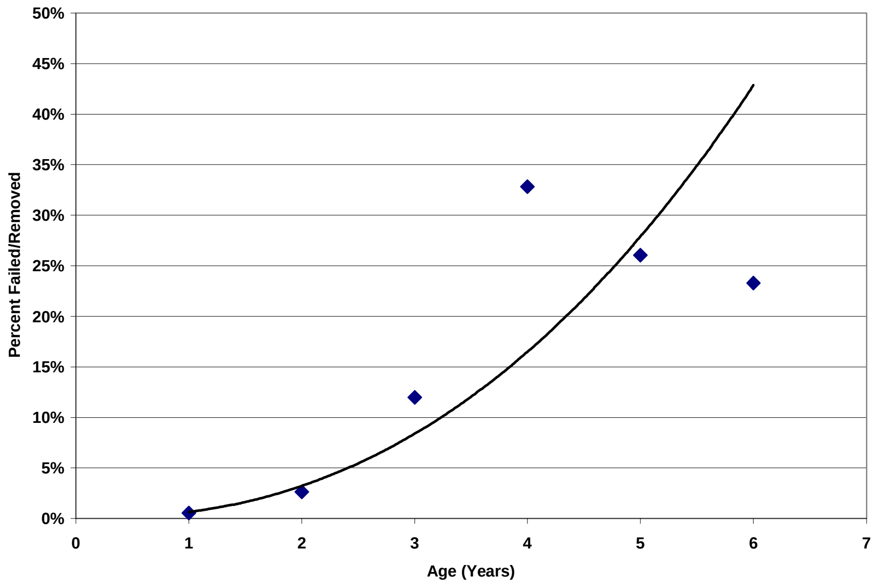
Plot of Hazard Rates for T8 Fixtures in Commercial Sector



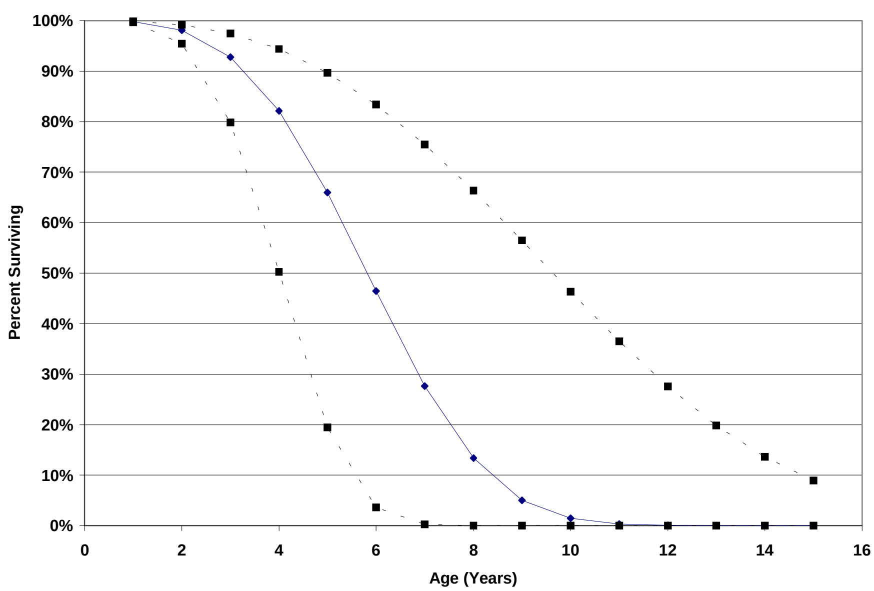
Survival Function Plot for T8 Fixtures in Commercial Sector

Data for Calculating Hazard Rates for Commercial T8 Lamps

Year	*Lamps at Start of Year*	*Lamps Removed/Failed during Year*	*Hazard Rate (Rate of Removal/Failure)*
1	6,704	36	0.5%
2	6,668	175	2.6%
3	6,493	778	12.0%
4	5,715	1,877	32.8%
5	3,838	1,000	26.1%



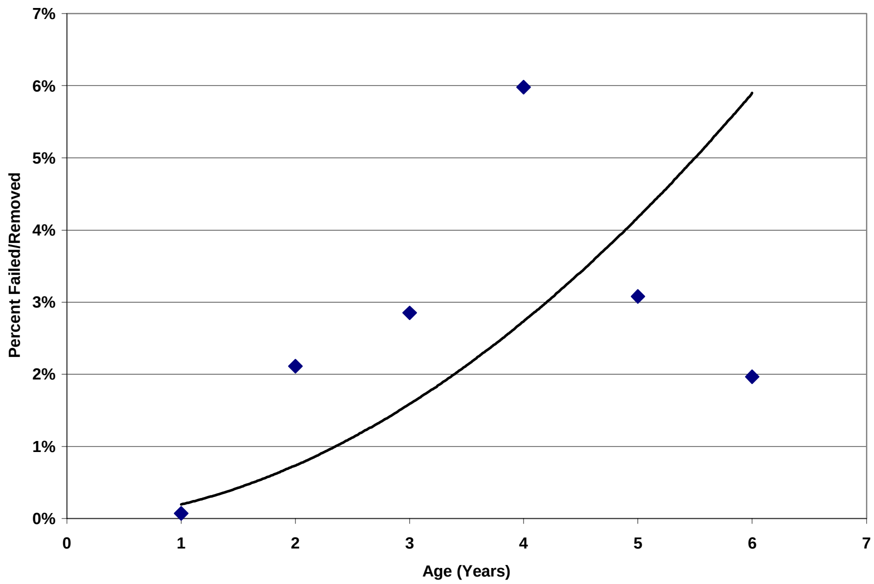
Plot of Hazard Rates for T8 Lamps in Commercial Sector



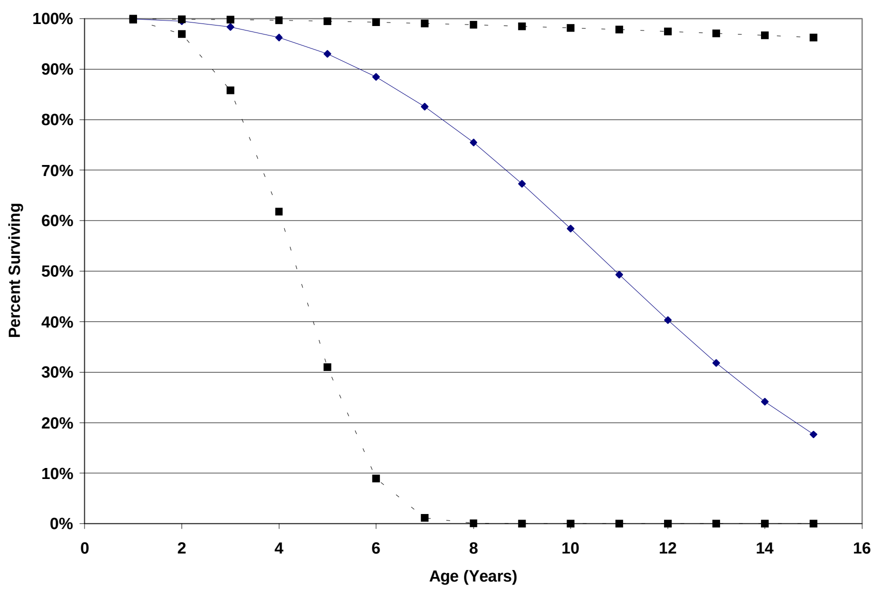
Survival Function Plot for T8 Lamps in Commercial Sector

Data for Calculating Hazard Rates for Commercial Electronic Ballasts

Year	*Ballasts at Start of Year*	*Ballasts Removed/Failed during Year*	*Hazard Rate (Rate of Removal/Failure)*
1	2,798	2	0.1%
2	2,796	59	2.1%
3	2,737	78	2.8%
4	2,659	159	6.0%
5	2,500	77	3.1%



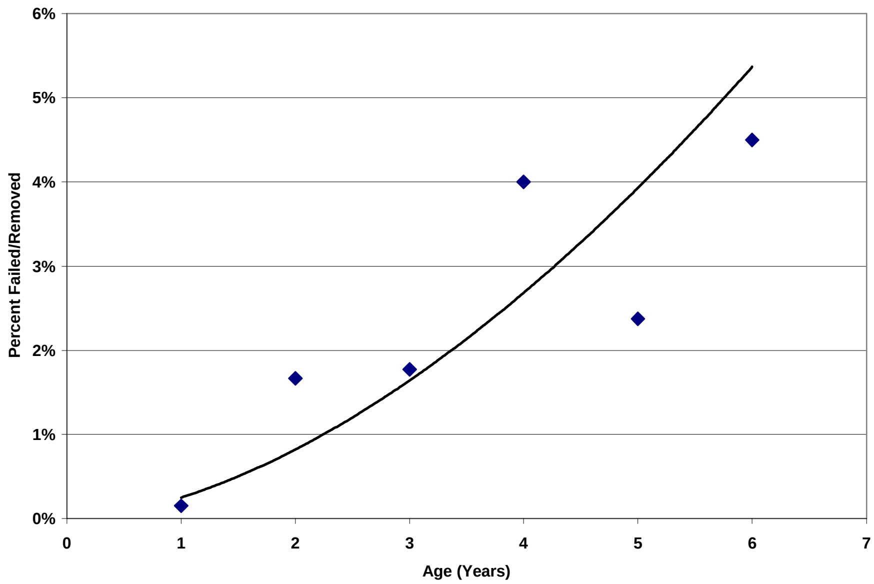
Plot of Hazard Rates for Electronic Ballasts in Commercial Sector



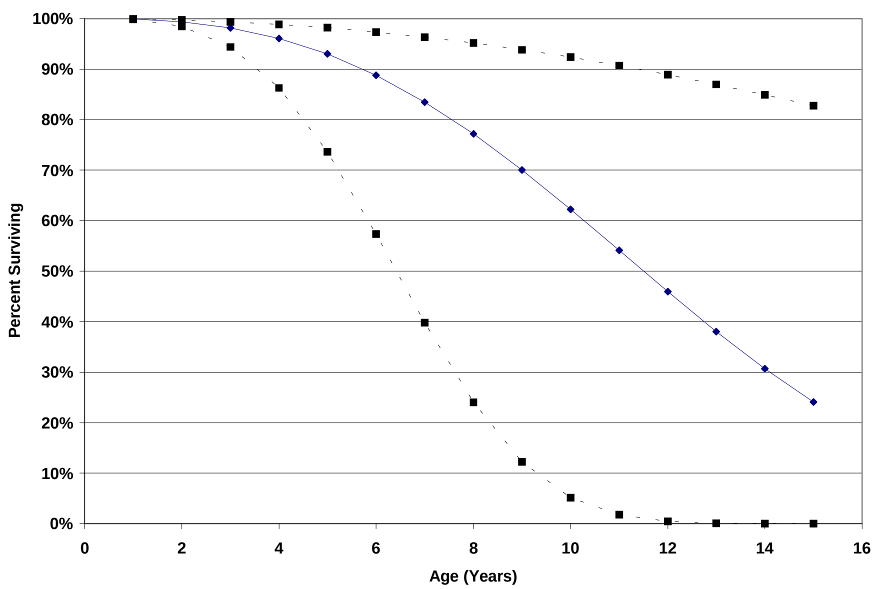
Survival Function Plot for Electronic Ballasts in Commercial Sector

Data for Calculating Hazard Rates for Commercial CF Fixtures

Year	*Fixtures at Start of Year*	*Fixtures Removed/Failed during Year*	*Hazard Rate (Rate of Removal/Failure)*
1	1,321	2	0.2%
2	1,319	22	1.7%
3	1,297	23	1.8%
4	1,274	51	4.0%
5	1,223	29	2.4%



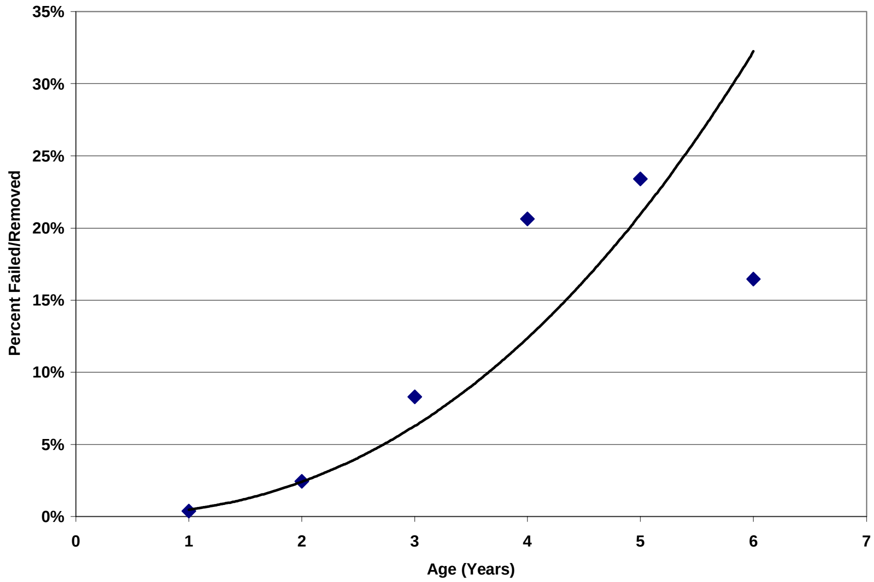
Plot of Hazard Rates for CF Fixtures in Commercial Sector



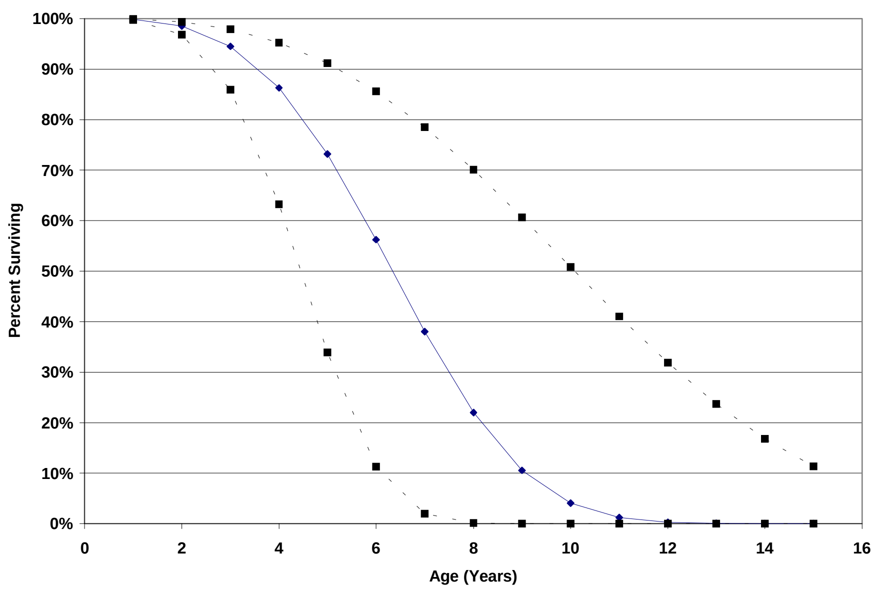
Survival Function Plot for CF Fixtures in Commercial Sector

Data for Calculating Hazard Rates for Commercial CF Lamps

Year	Lamps at Start of Year	Lamps Removed/Failed during Year	Hazard Rate (Rate of Removal/Failure)
1	1,637	6	0.4%
2	1,631	40	2.5%
3	1,591	132	8.3%
4	1,459	301	20.6%
5	1,158	271	23.4%



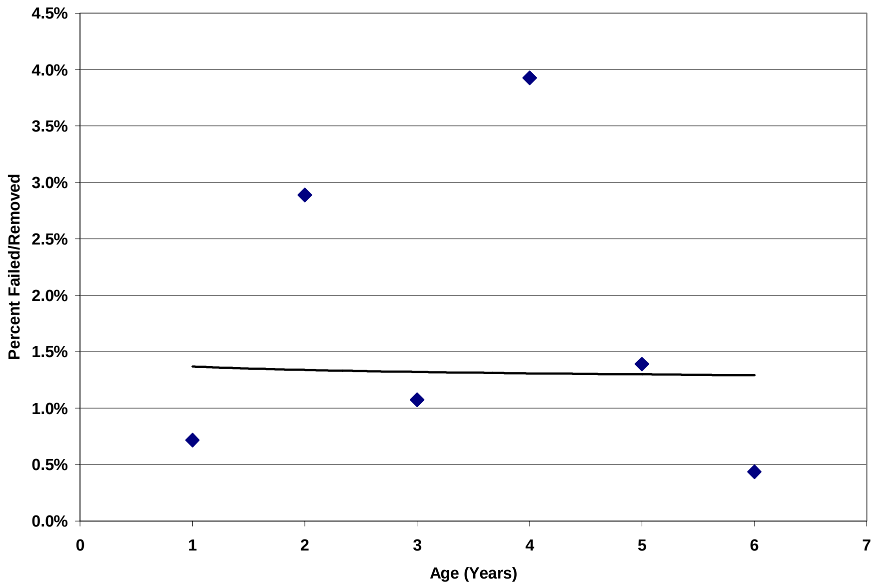
Plot of Hazard Rates for CF Lamps in Commercial Sector



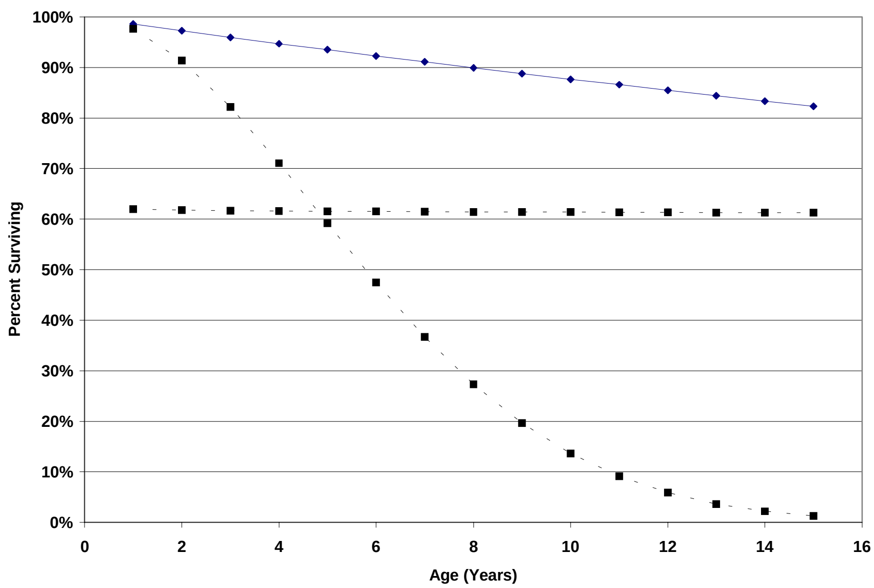
Survival Function Plot for CF Lamps in Commercial Sector

Data for Calculating Hazard Rates for Commercial Delamping/Reflectors

Year	*Lamps at Start of Year*	*Lamps Removed/Failed during Year*	*Hazard Rate (Rate of Removal/Failure)*
1	1,255	9	0.7%
2	1,246	36	2.9%
3	1,210	13	1.1%
4	1,197	47	3.9%
5	1,150	16	1.4%



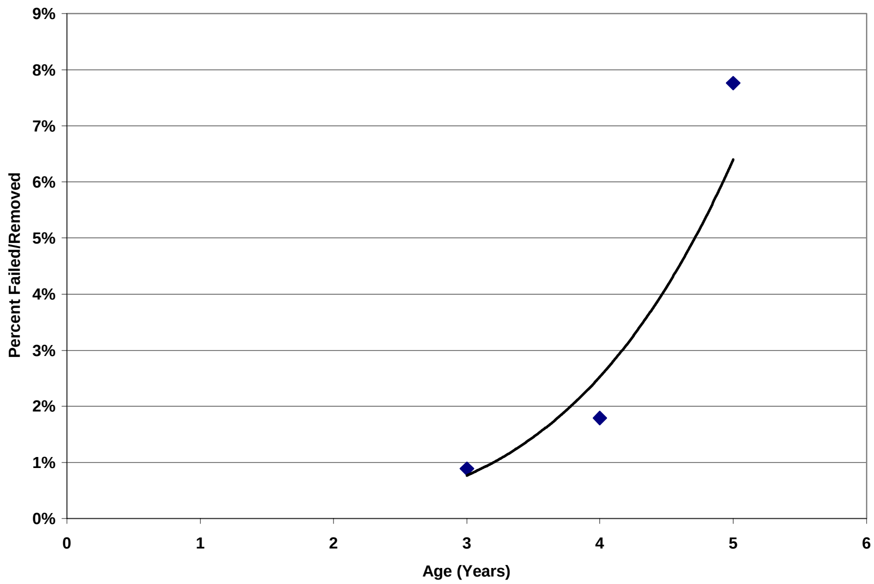
Plot of Hazard Rates for Delamping/Reflectors in Commercial Sector



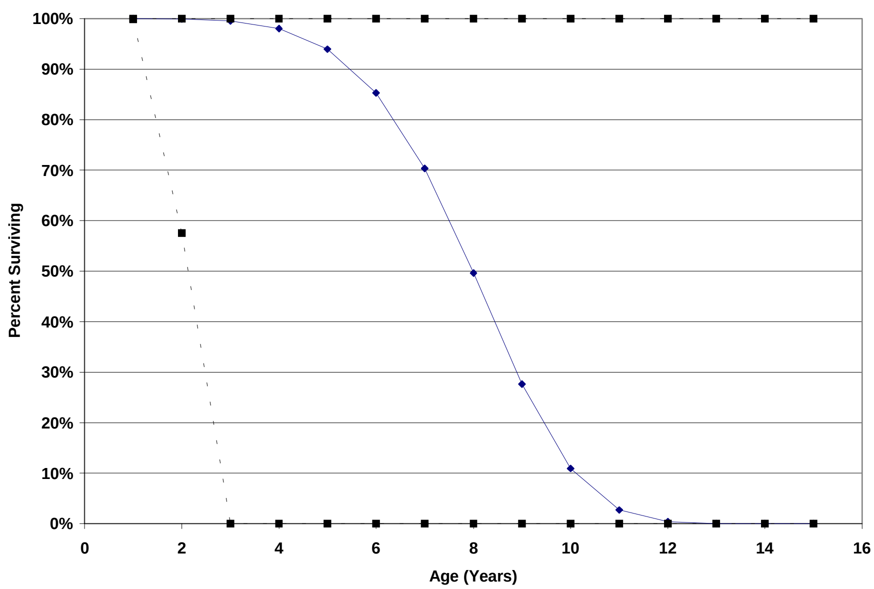
Survival Function Plot for Delamping/Reflectors in Commercial Sector

Data for Calculating Hazard Rates for Commercial ASDs

Year	*ASDs at Start of Year*	*ASDs Removed/Failed during Year*	*Hazard Rate (Rate of Removal/Failure)*
1	225	-	0.0%
2	225	-	0.0%
3	225	2	0.9%
4	223	4	1.8%
5	219	17	7.8%



Plot of Hazard Rates for ASDs in Commercial Sector



Survival Function Plot for ASDs in Commercial Sector

APPENDIX C
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:

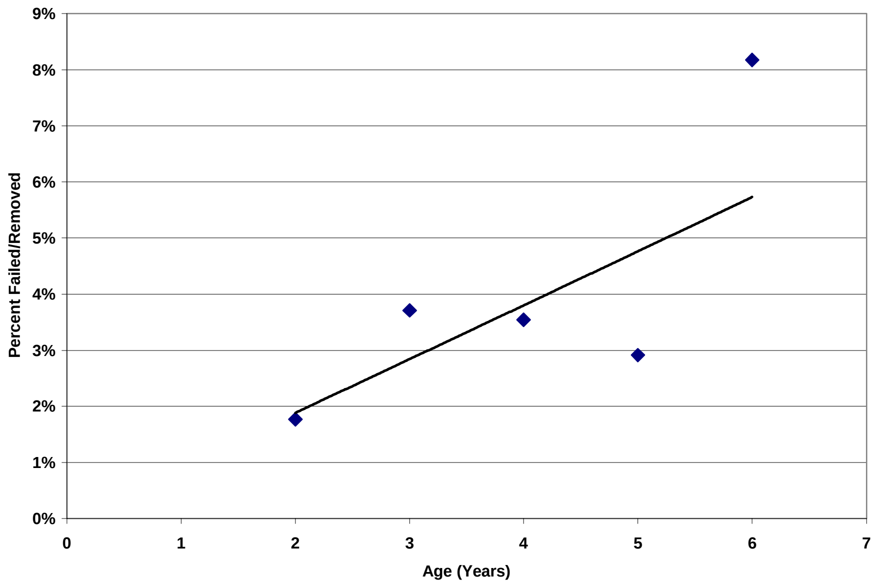
- T8 lighting fixtures
- T8 lamps
- Electronic ballasts
- Pumps/pump system improvements
- Adjustable speed drives

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

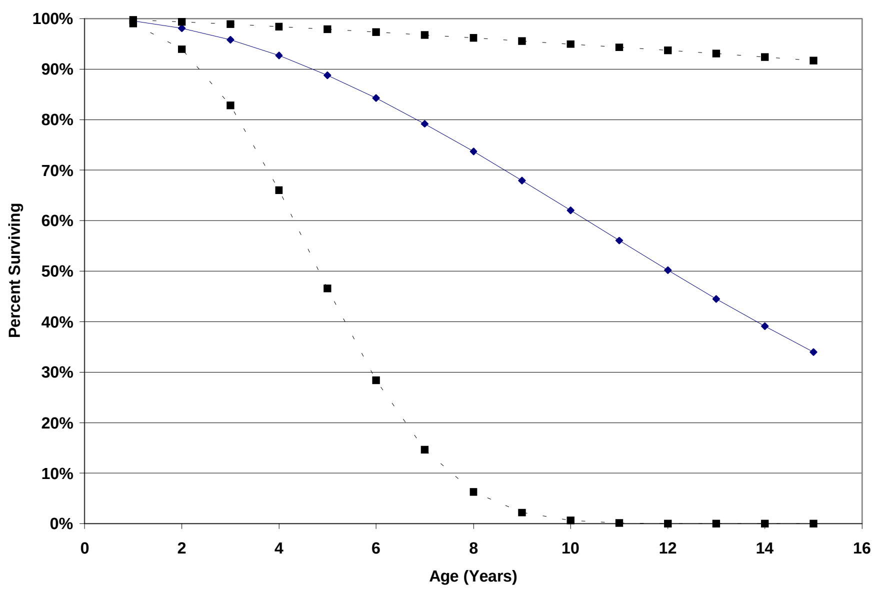
- Lighting EMS
- Injection molding machines
- Plastic extrusion equipment
- Process cooling
- Process equipment insulation
- High efficiency chillers
- Air compressors
- Pump system controls
- Water service EMS
- Hardware to lower temperatures

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%
2	1,015	18	1.8%
3	997	37	3.7%
4	960	34	3.5%
5	926	27	2.9%



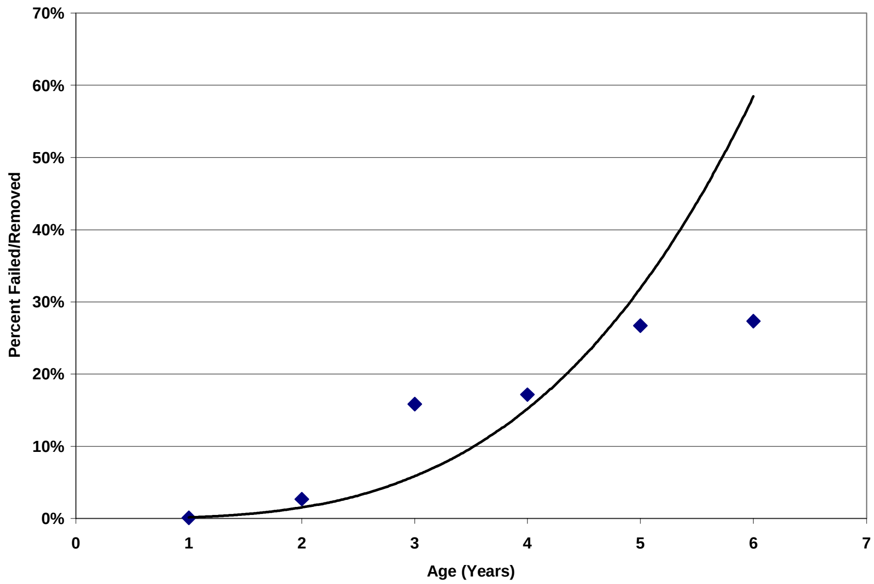
Plot of Hazard Rates for T8 Fixtures in Industrial Sector



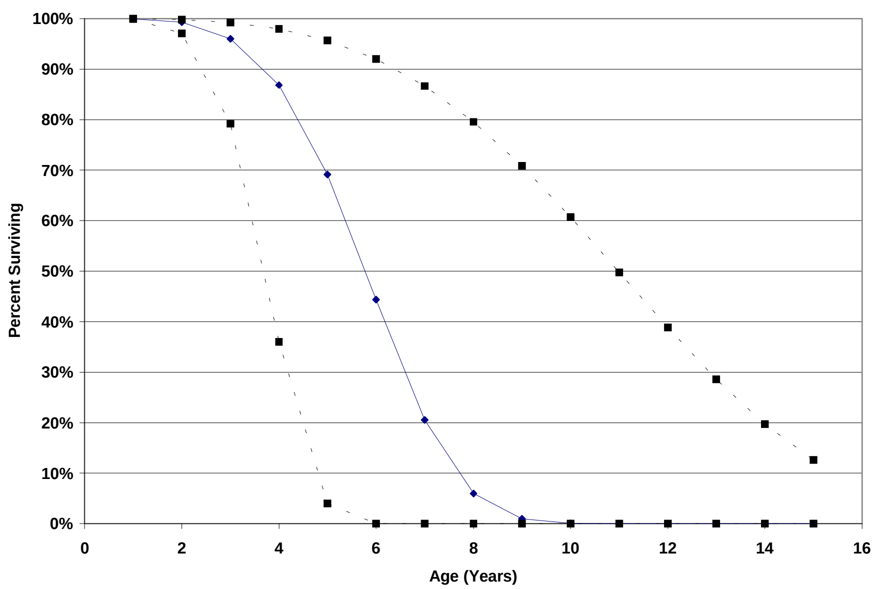
Survival Function Plot for T8 Fixtures in Industrial Sector

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	425	15.8%
4	2,257	387	17.1%
5	1,870	499	26.7%



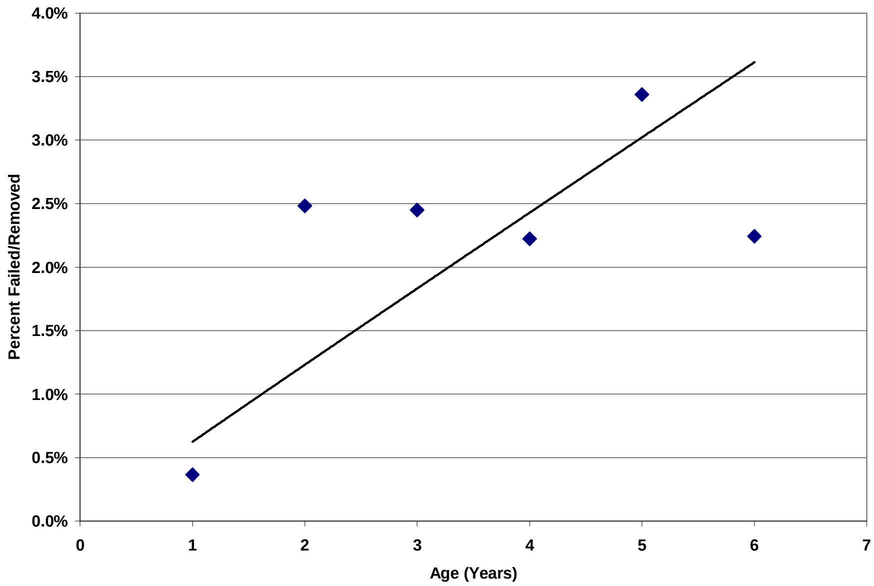
Plot of Hazard Rates for T8 Lamps in Industrial/Agricultural Sector



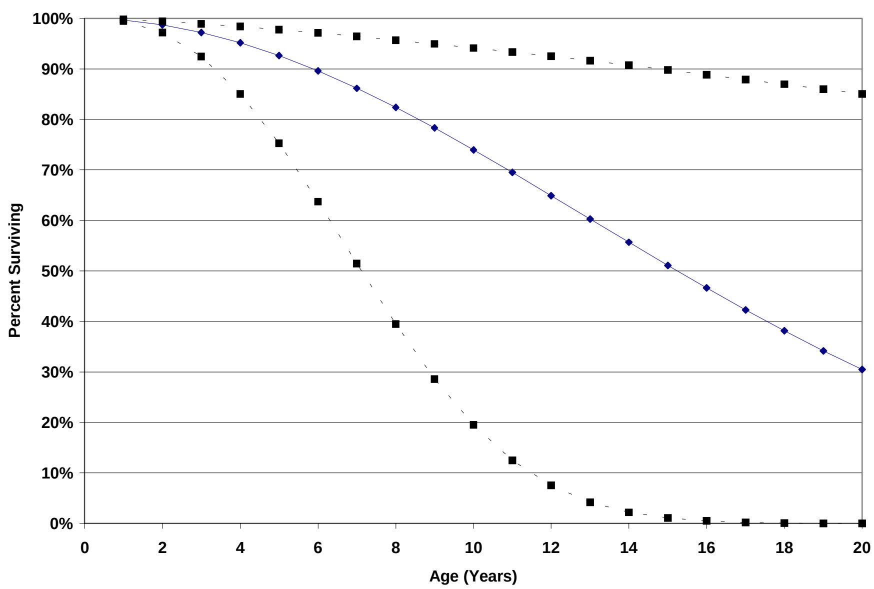
Survival Function Plot for T8 Lamps in Industrial/Agricultural Sector

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	1,092	4	0.4%
2	1,088	27	2.5%
3	1,061	26	2.5%
4	1,035	23	2.2%
5	1,012	34	3.4%



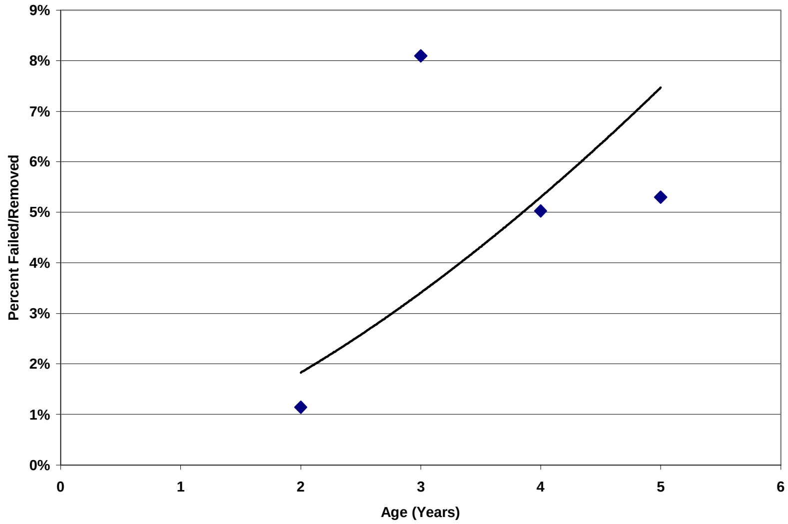
Plot of Hazard Rates for Electronic Ballasts in Industrial/Agricultural Sector



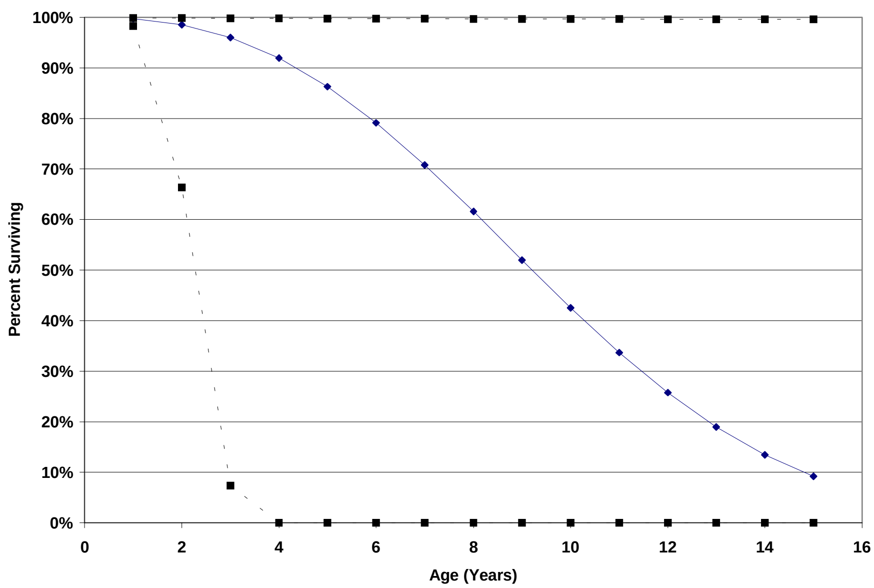
Survival Function Plot for Electronic Ballasts in Industrial/Agricultural Sector

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	8	5.3%



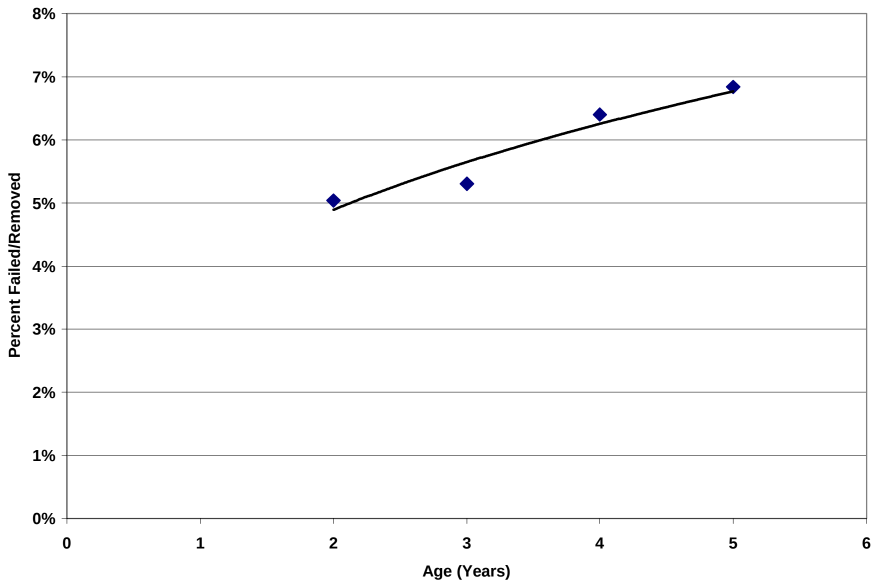
Plot of Hazard Rates for Pumps in Industrial/Agricultural Sector



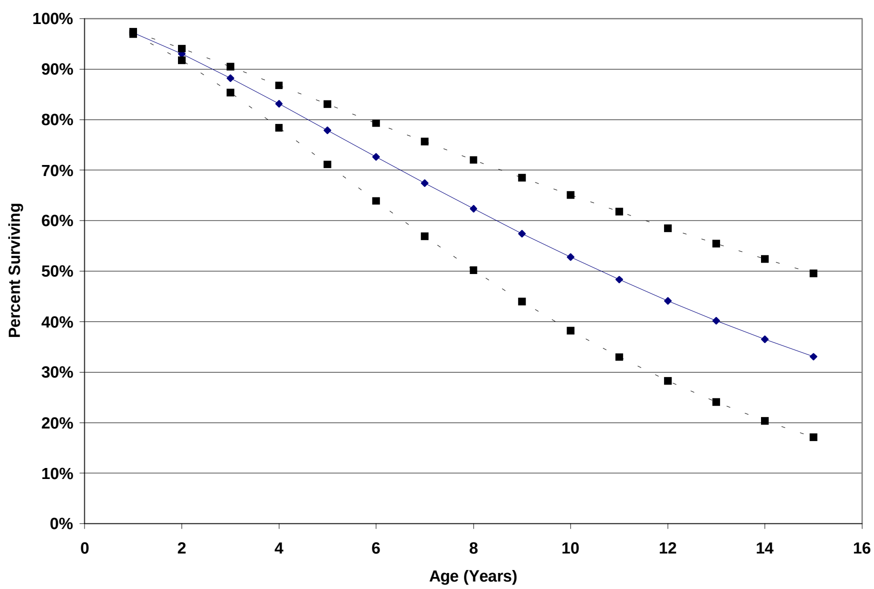
Survival Function Plot for Pumps in Industrial/Agricultural Sector

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%
2	139	7	5.0%
3	132	7	5.3%
4	125	8	6.4%
5	117	8	6.8%



Plot of Hazard Rates for ASDs in Industrial/Agricultural Sector



Survival Function Plot for ASDs in Industrial/Agricultural Sector

APPENDIX D
PROTOCOL TABLES 6 AND 7

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

D.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 D-1.

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

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

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

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

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

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

Table D-1. Required Information per Protocols Table 6

Measure	End Use	SCE Ex Ante Useful Life		Estimated Median Life			Ex Post EUL for 3rd & 4th 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)
Commercial Sector									
T8 lighting fixtures	Lighting	11	1997 AEAP, Table C	4.90	9.59	29.35	11	1	None
T8 lamps	Lighting	5	Protocol, App. F, Table 1	4.01	5.82	9.64	5	1	None
Electronic ballasts	Lighting	10	Protocol, App. F, Table 1	4.38	10.93	74.93	10	1	None
CF fixtures (modular)	Lighting	12	Protocol, App. F, Table 1	6.42	11.50	27.51	12	1	None
CF lamps	Lighting	2.2	Protocol, App. F, Table 1	4.45	6.34	10.08	6.34	2.88	None
Delamping/reflectors	Lighting	10	Protocol, App. F, Table 1	5.78	55.82	> 100	10	1	None
Adjustable speed drives	Motors	10	Protocol, App. F, Table 1	2.05	7.98	> 100	10	1	None
HVAC EMS	HVAC	15	Protocol, App. F, Table 1	*	> 5	*	15	1	None
Chillers	HVAC	20	Protocol, App. F, Table 1	*	> 5	*	20	1	None
Industrial Sector									
T8 lighting fixtures	Lighting	11	1997 AEAP, Table C	4.83	12.04	75.99	11	1	None
T8 lamps	Lighting	5	Protocol, App. F, Table 1	3.71	5.78	10.98	5	1	None
Electronic ballasts	Lighting	10	Protocol, App. F, Table 1	7.12	15.24	54.99	10	1	None
Adjustable speed drives	Motors	10	Protocol, App. F, Table 1	8.04	10.62	14.85	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	*		*	15	1	None
Air compressors	Process	15	Tracking System	*	> 5	*	15	1	None
Agricultural Sector									
Pumps/pump system improvements	Pumping	15	1997 AEAP, Table C	2.24	9.21	> 100	15	1	None
Adjustable speed drives	Motors	10	Protocol, App. F, Table 1	8.04	10.62	14.85	10	1	None

D.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
Fourth-Year Retention Study

Study ID No. is:
CEC Study Id #553

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 E).

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 D-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 were collected through a longitudinal survey effort over five years. Data on whether installed measures were still in place and operable were collected through on-site visits and telephone surveys over the five-year period. (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 D-2. Measures and End Uses Covered by Sector

Commercial Sector	
T8 lighting fixtures	Lighting
T8 lamps	Lighting
Electronic ballasts	Lighting
CF fixtures (modular)	Lighting
CF lamps	Lighting
Delamping/reflectors	Lighting
Adjustable speed drives	Motors
HVAC EMS	HVAC
Chillers	HVAC
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 D-3 and D-4 show the number of customers included in the study from each sector and program year.

Table D-3. Numbers of Sites from 1993 and 1994 Program Years Surveyed in 1999 by Type of Measure

	1993 Commercial	*1993 Industrial/ Agricultural*	*1994 Commercial*	*1994 Industrial/ Agricultural*	*All Sites*
Total Number of Sites	356	179	253	149	937
<u>Numbers of Sites with Specified Measures</u>					
ASDs	78	49	64	42	233
T8 Lamps	145	59	114	41	359
Electronic Ballasts	98	52	114	41	305
Compact Fluorescent Bulbs	79		50		129
Delamping/Reflectors	72		28		100
Chillers	17		21		38
HVAC Energy Management Systems	94		84		178
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

Table D-4. Numbers of Sites from 1996 and 1997 Program Years Surveyed in 1999 by Type of Measure

	1996 Commercial	*1996 Industrial/ Agricultural*	*1997 Commercial*	*1997 Industrial/ Agricultural*	*All Sites*
Total Number of Sites	73	31	178	51	333
<u>Numbers of Sites with Specified Measures</u>					
Electronic ballasts	25		70		95
CF lamps			77		77
Adjustable speed drives	1	3	18	6	28
HVAC EMS	46	-	93	4	143
Lighting EMS	48	-	93	4	146
Injection molding machines	-	5	-	4	9
Plastic extrusion equipment	-	3	-	6	9
Process cooling	-	2	-	3	5
Process equipment insulation	-	2	-	-	2
High efficiency chillers	-	2	-	5	7
Air compressors	-	14	-	7	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 D-5 for the commercial sector and in Table D-6 for the industrial/agricultural sectors.

Table D-5. Numbers of Measure Occurrences in Analysis Set for Commercial Sector

Type of Measure	*1993*	*1994*	*1996*	*1997*
T8 lighting fixtures	1,248	263	0	0
T8 lamps	3,155	2,157	0	0
Electronic ballasts	1,362	216	249	704
CF fixtures (modular)	832	110	0	0
CF lamps	1,025	553	0	742
Delamping/reflectors	766	84	0	0
HVAC EMS	96	1	46	93
Lighting EMS	0	0	48	93
Chillers	25	0	0	0
Adjustable speed drives	129	15	2	34

Table D-6. 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	82	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 over five years. The data that were collected through on-site visits and telephone surveys from 1995 through 1999 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 D-1, D-2, and D-3.

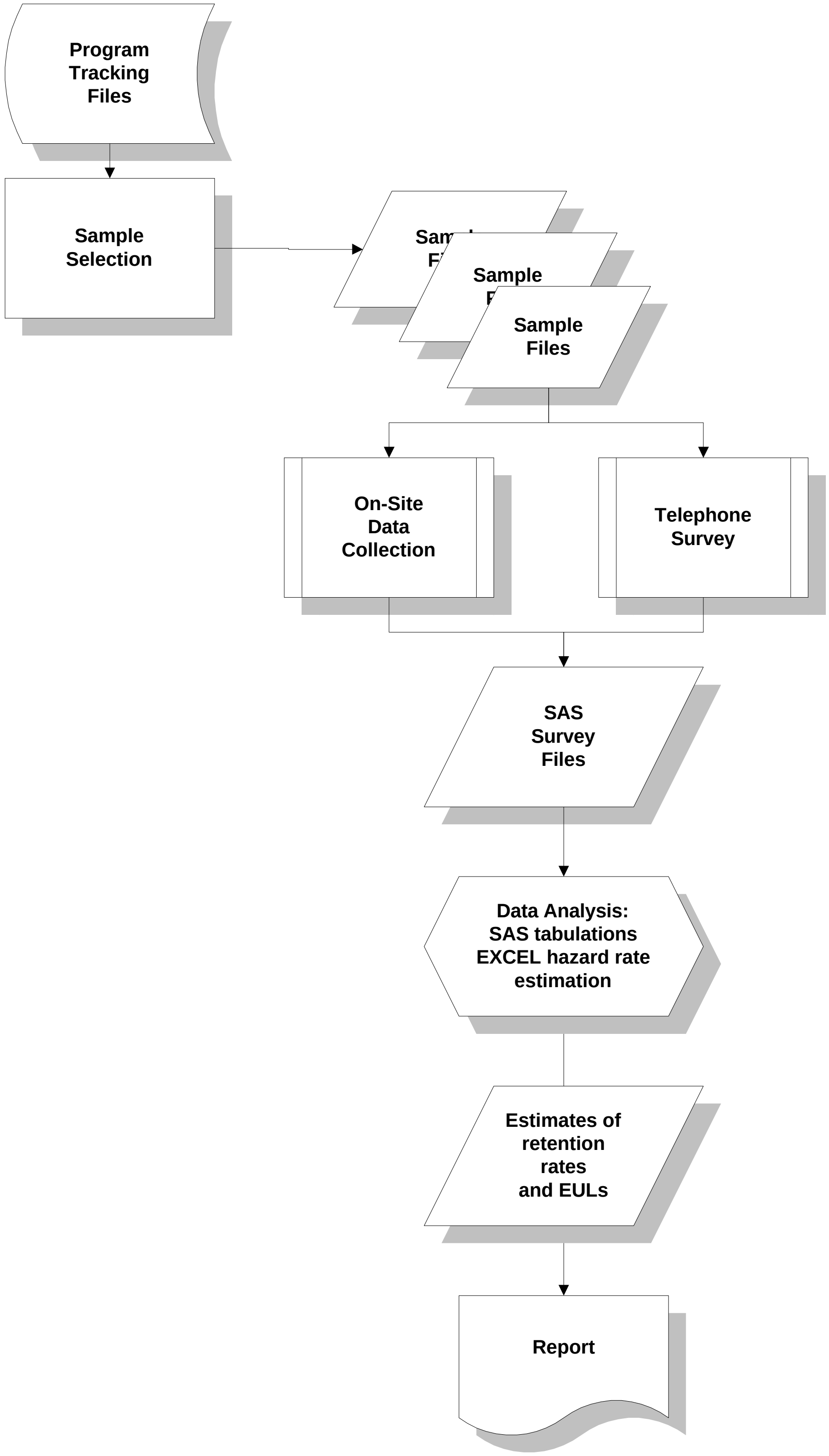


Figure D-1. Overall Data Preparation Process

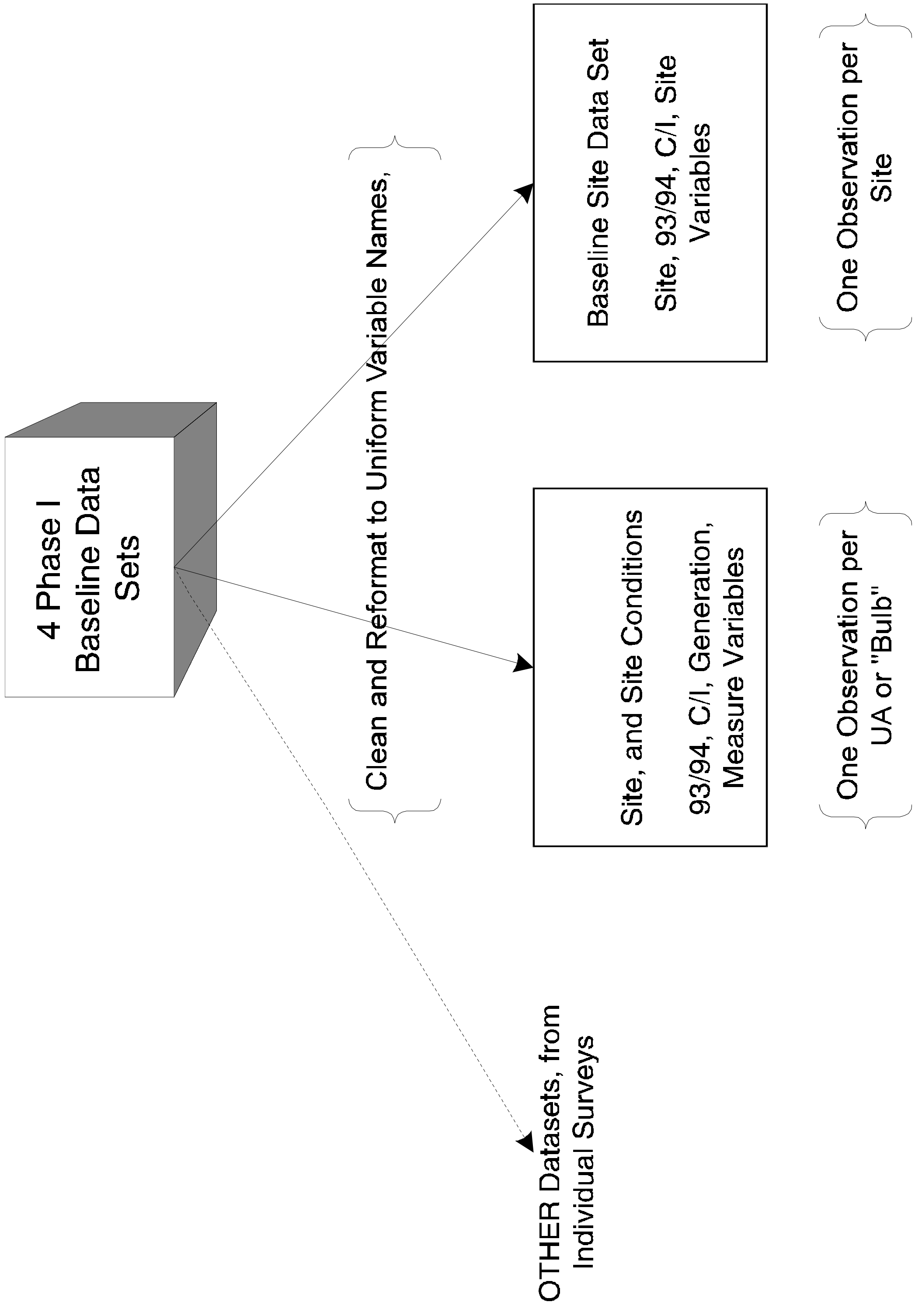


Figure D-2. Baseline Data Sets

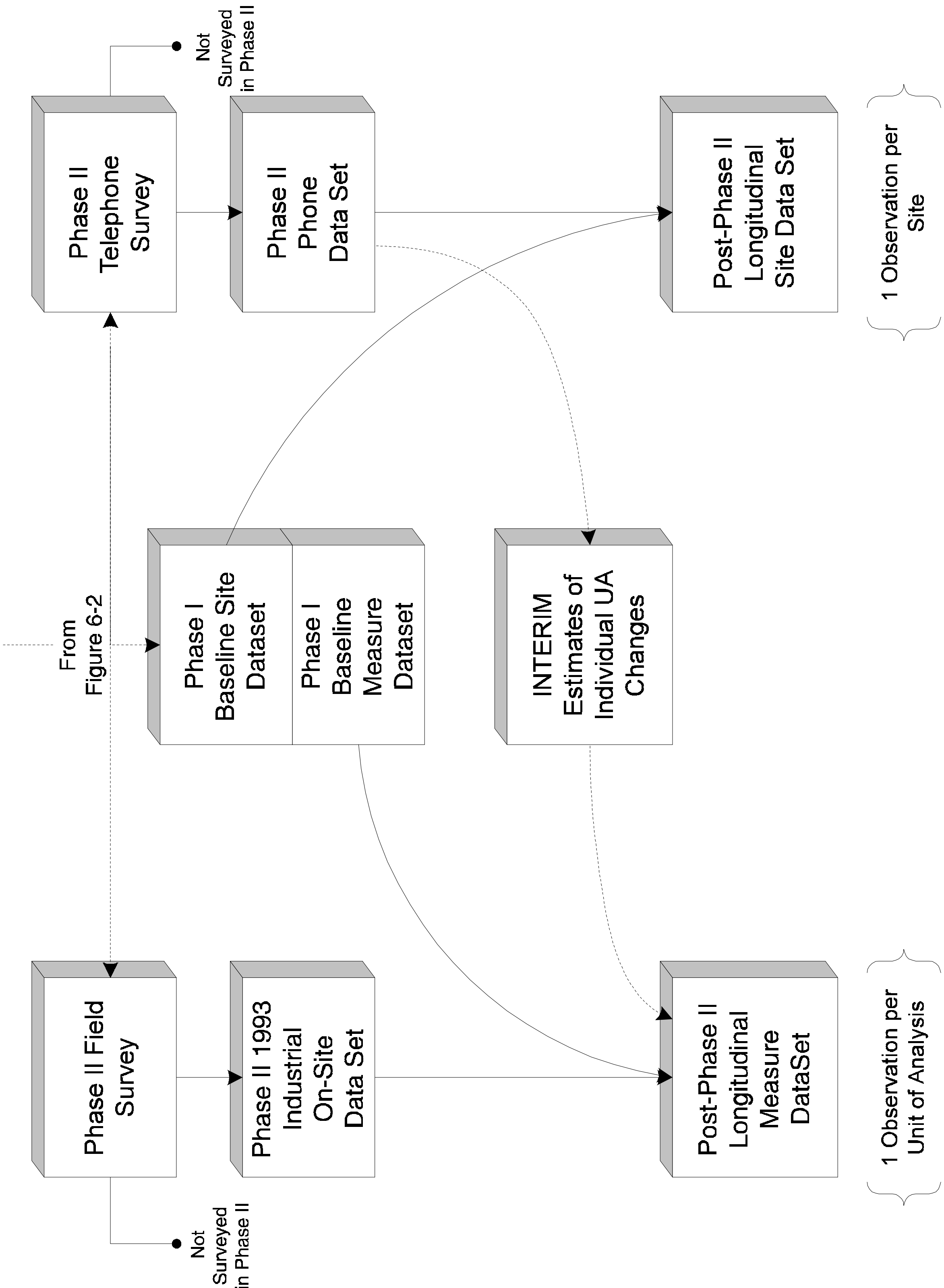


Figure D-3. Creation of Longitudinal Site and Measure Data Sets *c.* *Describe the internal/organizational data quality checks and data quality procedures used to match customers and surveys, participation records, and any other data used in the analysis.*

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.

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 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 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. These tables are provided in Appendix A.

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 and telephone 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 D-*7* reports the overall attrition from the sample at the end of 1999.

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 1999 are summarized for the various measures in Table D-8.

Table D-7. Overall Attrition from Sample as of End of 1999

Disposition of Contact	*1993*		*1994*	
	Commercial	*Industrial/ Agricultural*	*Commercial*	*Industrial/ Agricultural*
1 – No Answer			3	
4 – Not in service			2	
20 – Complete	313	176	239	142
22 – Permanent Refusal	3			1
23 – Site Closed	2	2		2
24 – Business Closed	1	1	6	2
25 – Building Torn Down	1			2
99 – Not Complete	4		3	
Totals	324	179	253	149

Table D-8. Removal/Failure Rates by End of 1999
for C/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 1999*	*Type of Measure*	*Percentage Removed or Failed by End of 1999*
Commercial Measures		Commercial Measures	
T8 lighting fixtures	16.30%	Adjustable speed drives	0.00%
T8 lamps	62.20%	HVAC EMS	0.70%
Electronic ballasts	14.20%	Lighting EMS	0.00%
CF fixtures (modular)	12.20%	Electronic ballasts	0.00%
CF lamps	51.50%	CF lamps	4.20%
Delamping/reflectors	9.90%	Industrial Measures	
HVAC EMS	1.10%	Adjustable speed drives	0.00%
Chillers	0.00%	Lighting EMS	0.00%
Adjustable speed drives	10.20%	Injection molding machines	0.00%
Industrial Measures		Plastic extrusion equipment	0.00%
T8 lighting fixtures	16.10%	Process cooling	0.00%
T8 lamps	59.90%	Process equipment insulation	0.00%
Electronic ballasts	11.70%	High efficiency chillers	0.00%
Adjustable speed drives*	21.60%	Air compressors	0.00%
Lighting EMS	9.10%	Agricultural Measures	
Injection molding machines	18.50%	Adjustable speed drives	0.00%
Plastic extrusion equipment	37.50%	Hardware to lower temperature	0.00%
Process cooling	0.00%	Pump system controls	50.00%
Process equipment insulation	20.00%	Water service EMS	0.00%
High efficiency chillers	0.00%		
Air compressors	16.70%		
Agricultural Measures			
Pumps/pump system improvements	18.90%		
Adjustable speed drives*	21.60%		

*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 D-7 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 D-3, D-4, D-5 and D-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 D-9.

Table D-9. Summary of Hazard Function Estimation

Type of Measure	*Power Curve Fit*			*Weibull Distribution Parameters*	
	A	*b*	*R-squared*	*α (Scale)*	*β (Shape)*
Commercial Measures					
T8 lighting fixtures	0.00152	2.2279	0.803	0.00047	3.2279
T8 lamps	0.00631	2.3549	0.921	0.00188	3.3549
Electronic ballasts	0.00198	1.8946	0.642	0.00068	2.8946
CF fixtures (modular)	0.00251	1.7103	0.841	0.00092	2.7103
CF lamps	0.00469	2.3614	0.934	0.00139	3.3614
Delamping/reflectors	0.01370	-0.0326	0.001	0.01416	0.9674
Adjustable speed drives	0.00008	4.1573	0.927	0.00002	5.1573
Industrial Measures					
T8 lighting fixtures	0.00935	1.0118	0.633	0.00465	2.0118
T8 lamps	0.00152	3.3212	0.907	0.00035	4.3212
Electronic ballasts	0.00624	0.9798	0.656	0.00315	1.9798
Adjustable speed drives	0.03825	0.3546	0.916	0.02823	1.3546
Agricultural Measures					
Pumps/pump system improvements	0.00630	1.5362	0.504	0.00248	2.5362
Adjustable speed drives	0.03825	0.3546	0.916	0.02823	1.3546

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, 4.3, and 5.3. An illustrative example is provided in Section 2.4.2.

For some measures, the numbers of removals or failures observed over the period from 1995 through 1999 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. This phenomenon was most apparent for delamping/reflectors, where the r-squared for the power curve fit was relatively low because of the sawtooth pattern in the data. 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 E
RETROACTIVE WAIVER PERMITTING EXCLUSION OF 1995 PROGRAM

This appendix provides the retroactive waiver excluding the 1995 C/I/A EEI Program from the study requirement.

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.