1996 AND 1997
NONRESIDENTIAL
DSM BIDDING
RETENTION STUDY

CEC Study ID #555

Final Report

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EXECUTIVE SUMMARY

This report provides the results of the retention study for Southern California Edison's 1996 and 1997 Nonresidential DSM Bidding Program. The objectives of the study were twofold:

- To estimate the percent of all selected measures installed in the 1996 and 1997 DSM Bidding Program that are still in place and operable; and
- To estimate the effective useful lives of selected efficiency measures, which included lighting measures and HVAC measures.

Data for the study were obtained from program documentation for individual projects (i.e., Project Installation Reports and Annual Power Savings Reports) and collected through both a telephone survey and an on-site data collection effort. The data collected were used to determine the percent retention for each measure. These data showed that the retention rates for both lighting and HVAC measures were high over the three years covered by the program.

Another objective of the study was to estimate effective useful life (EUL) for the measures and to determine if the estimated EULs were different from expected EULs.

- For lighting measures, a review of the available data showed that there significant problems in deriving empirical estimates of effective useful lives. These problems included substantial attrition from the analysis sample over the three years of the program and relatively high rates of retention that precluded application of standard techniques for survival analysis. However, analysis of the data did indicate that the pattern for retention of lighting measures was similar to that estimated for lighting measures installed under SCE's commercial/industrial/agricultural energy efficiency program. The analysis indicated that it was appropriate to use SCE's estimate of 15 years as the useful life for lighting measures installed under the DSM Bidding Program.
- For HVAC measures, the data showed that all measures installed under the DSM Bidding Program were still in place and operable. Consequently, there was no evidence for replacing SCE's *ex ante* estimates of useful lives for HVAC measures installed under the DSM Bidding Program.

1. INTRODUCTION

Under the DSM Measurement Protocols[1] adopted by the California Public Utilities Commission, Southern California Edison (SCE) is required to conduct studies to better understand the typical modes of savings erosion associated with energy-efficiency measures. In line with this requirement, ADM Associates, Inc. (ADM) has performed a study of the retention of measures installed at the facilities of SCE customers in 1996 or 1997 under SCE's Nonresidential DSM Bidding Program.

In the Nonresidential DSM Bidding Program, Energy Services Companies (ESCOs) provided energy-efficiency services to SCE's industrial and large commercial customers. ESCOs were invited to submit bids to SCE for delivering kWh and kW savings. Payments to ESCOs were based on verified savings using measurement techniques consistent with NAESCO standards. Eligible measures include, but were not limited to, indoor lighting-system replacement, lighting efficiency modifications, packaged air conditioners, heat pumps, window treatment, daylighting controls, electronic adjustable-speed drives, electric motors, electric chillers, and thermal energy storage.

The objectives of this retention study were twofold:

- To estimate the percent of all selected measures installed in the 1996 and 1997 DSM Bidding Program that are still in place and operable; and
- To estimate the effective useful lives of selected efficiency measures, which included lighting measures and HVAC measures.

Data from various sources were used for this study.

- One source of data was the verification data that ESCOs were required to provide to SCE. For each project, an ESCO provided a Project Installation Report and Annual Power Savings Reports that documented the savings that were being achieved with the measures they had installed.
- Primary data were also collected through both an on-site data collection effort (for lighting measures) and a telephone survey (for non-lighting measures).

The data from these different sources were used to determine the following:

[1] 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.

- Historic percent retention for each measure, as a function of time;
- Effective useful life (EUL) for each measure; and
- If the estimated EULs are different from expected EULs at an 80% level of statistical significance

The retention rates for the measures were determined through tabulations of the data from the different sources. To develop estimates of effective useful lives for the measures, hazard functions and survival functions were developed for different types of measures.

This final report presents and discusses the methodology used and results achieved through this study. The report is organized into the following sections.

- Section 2 contains a discussion of the methods used to collect data for the study.
- Section 3 presents and discusses the results of the analysis of the data collected.
- Appendix A contains copies of the forms used for the data collection.
- Appendix B provides the information required by Protocol Tables 6 and 7.
- Appendix C provides documentation for the data used for the study.

2. DATA COLLECTION METHODOLOGY

Data for the study were collected from project documentation provided to SCE by ESCOs participating in the DSM Bidding Program and through primary data collection (i.e., on-site data collection and telephone surveying).

2.1 DATA AVAILABLE FROM ESCO VERIFICATION REPORTS

For each project conducted under the DSM Bidding Program, an ESCO submitted several reports to SCE that documented the measures being installed and the savings being achieved.

When the measures have been installed, an ESCO submits a Project Installation Report (PIR) to SCE. The PIR includes the following:

- Project description and schedule, including any updated descriptions of the site, baseline measures, and installed measures as well as revised estimated baseline, post-installation usage and savings (kW and kWh) for the project;
- Post-installation site survey, which provides an inventory of the equipment that was replaced and the equipment that was installed at a site;
- Baseline and post-installation energy use calculations and estimates of annual kWh and kW savings, based on actual installation reported in the post-installation site survey; and
- Site-specific M&V plan that provides details on how project savings will be measured and verified.

Each year after the measures have been installed for a project, the ESCO conducts "true-up" measurement and verification activities. The results of these activities are documented in an Annual Power Savings Report (APSR) that the ESCO submits to SCE. Each APSR includes measurement-based estimates of kW and kWh savings. SCE uses the annual report data to correct, if necessary, the previous year's payments to the ESCO. The data in the APSR are also used for projecting energy savings for the next 12 months and are the basis for the following year's contract payments.

Taken together, the PIR and the APSRs provide data for tracking the savings from a project over time. Most projects in the DSM Bidding Program have a PIR and three APSRs (although some projects have less than three).

The PIRs and APSRs (along with other documentation) for projects in the 1996 and 1997 DSM Bidding Program were made available for this retention study by

Schiller Associates, SCE's contractor for administering the DSM Bidding Program.

2.2 PRIMARY DATA COLLECTION PROCEDURES

There were two aspects to the primary data collection for the DSM Bidding Retention Study.

- As one aspect, on-site visits were made to a sample of customer facilities at which energy efficiency measures for lighting had been installed through the 1996 and 1997 Nonresidential DSM Bidding Program.
- As a second aspect of the data collection, telephone interviews were conducted with those customers identified through program records as having had installed energy efficiency measures for HVAC.

To determine the sample allocation and project selection for the primary data collection, use was made of files that SCE staff and Schiller Associates had prepared that contain information on the participants in the 1996 and 1997 Nonresidential DSM Bidding Program. Sampling frames for selecting the sample sites for lighting measures and for HVAC measures were created from these files.

There were 137 projects with savings from lighting measures. The data on expected savings reported in PIRs for these projects indicated that there was a relatively small number of projects that accounted for a high percentage of the estimated savings. The cumulative distributions of expected savings from lighting measures for all projects with those measures is shown in Figure 2-1. As can be seen, the distribution of expected savings from lighting measures was skewed, with projects with large savings accounting for significant percentages of total savings. The sampling plan for lighting measures was designed to take such skewness into account.

To accomplish the sampling, an approach suggested by Hidiroglou[1] was used. With this approach, a number of projects with the largest savings was selected for the sample with certainty, and a random sample was taken of the remaining projects. An analysis of alternative sampling allocations showed that a precision of 9.6 percent could be met at the 90% confidence level by taking a sample of 45 projects, with 20 of the projects with the largest savings being selected with certainty and 25 other projects selected randomly. The 20 projects with the largest

[1] See Hidiroglou, M. A., "The Construction of a Self-Representing Stratum of Large Units in Survey Design," **The American Statistician**, February 1986, Vol. 40, pp. 27-31.

savings from lighting measures accounted for nearly two-thirds of the expected savings for projects having such measures.

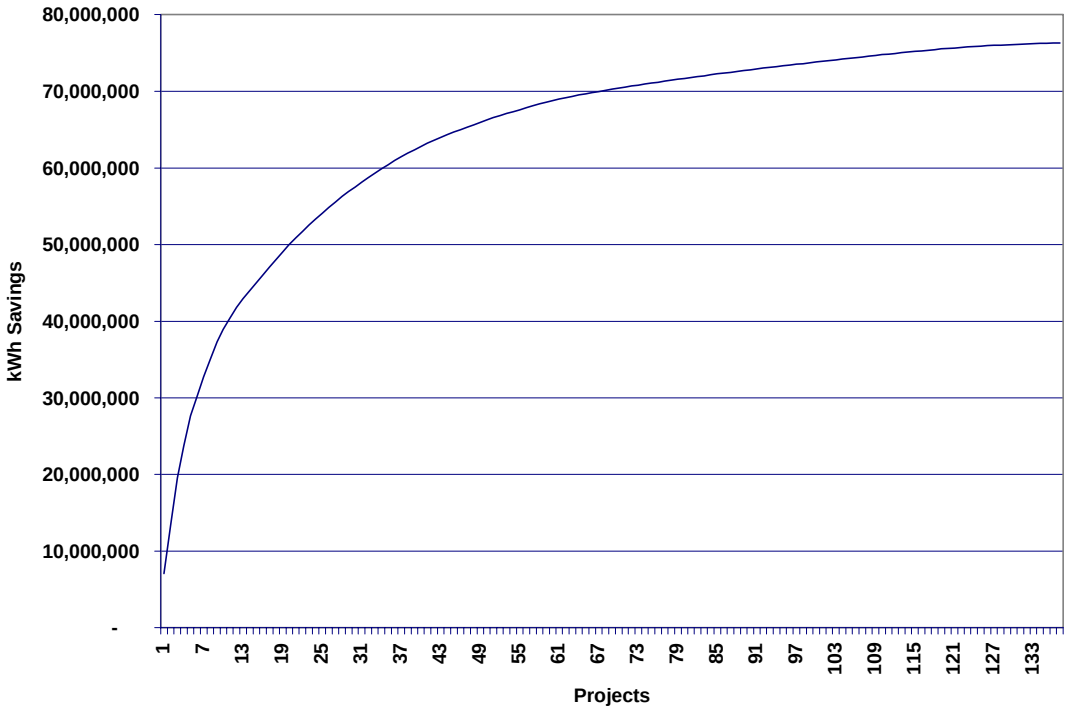

Figure 2-1. Cumulative Distribution of Expected Savings from Lighting Measures for All Projects with Lighting Measures in 1996 and 1997 DSM Bidding Program

To further improve the precision of the sampling, the 25 non-certainty projects were selected for the sample through systematic random sampling. That is, a random sample of projects remaining after the certainty projects had been selected was selected by ordering the non-certainty projects according to the magnitude of their savings from lighting measures and using systematic random sampling. Sampling systematically from a list that was ordered according to the magnitude of savings ensured that any sample selected would have some projects with high savings, some with moderate savings, and some with low savings. Samples could not result that had concentrations of projects with atypically high savings or atypically low savings.

There were 20 projects with non-interactive savings from HVAC measures. All of these projects were chosen for the sample.

For the on-site data collection for facilities where lighting energy efficiency measures had been installed, the field surveyors were provided with a lighting inventory data form that showed the type of lighting and number of fixtures for a sample of different usage areas within a selected facility. These inventory data were extracted from the Project Installation Reports that had been filed by the

different ESCO's. An example of this form is provided in Appendix A. From retrospective questioning and from inspection of the various usage areas, the field surveyors determined how many, if any, of the installed measures had been removed or had failed. In effect, for the sampled inventory of installed measures at a site, data were collected regarding removals or failures in different usage areas, the reasons for the removals or failures, and the date when the removals or failures occurred.

A survey form was also prepared for conducting telephone interviews of personnel at facilities where HVAC energy efficiency measures had been installed. A copy of this survey form is also included in Appendix A.

3. ANALYSIS AND RESULTS

This chapter presents and discusses the results of analyzing the data collected on the retention of energy efficiency measures installed through the 1996 and 1997 Nonresidential DSM Bidding Program. Section 3.1 presents the results of the analyses of retention rates and effective useful lives for lighting measures. Section 3.2 presents and discusses the results of the analyses for HVAC measures.

3.1 ANALYSIS AND RESULTS FOR LIGHTING MEASURES

This section presents and discusses the results of analyzing retention rates and effective useful lives for lighting measures installed under the DSM Bidding Program.

3.1.1 Retention Estimates for Lighting Measures

The data collected on-site for a sample of projects in the 1996 and 1997 DSM Bidding Program allowed the calculation of retention rates for particular types of lighting fixtures installed as measures under the program. These retention rates are reported in Table 3-1. The absolute numbers of course represent only the projects included in the sample. However, the percentages can be interpreted as applying to the full population of projects.

In calculating the retention rates shown in Table 3-1, a distinction has been made between removals of fixtures and replacement of the fixtures. As can be seen, removal rates vary among types of fixtures, being lowest for 4-foot fluorescents with one lamp and highest for compact fluorescents. There is a high replacement rate for 4-foot fluorescents with four lamps, but most of these fixtures were replaced with other energy efficient fixtures, primarily 4-foot fluorescents with two lamps.

Table 3-1. Retention Rates for Lighting Fixtures Installed as Measures under 1996 and 1997 Nonresidential DSM Bidding Program (Calculated from data collected on-site for sample of 35 projects)

Type of Fixture	*For Sample of Projects*			*Percentages Calculated from Sample Data*		
	Number of Fxitures Installed	*Number of Fixtures Removed by 2000*	*Number of Fixtures Replaced by 2000*	*Percentage of All Fixtures Removed by 2000*	*Percentage of All Fixtures Replaced by 2000*	*Percentage of Fixtures Retained after 2000*
4-foot fluorescent, 1 lamp	4,472	186	68	4.2%	1.5%	94.3%
4-foot fluorescent, 2 lamps	14,081	1,190	1,640	8.5%	11.6%	79.9%
4-foot fluorescent, 4 lamps	5,807	675	4,205	11.6%	72.4%	16.0%
Compact fluorescent	646	188	55	29.1%	8.5%	62.4%

3.1.2 Analysis of Effective Useful Lives for Lighting Measures

The other aspect of the analysis of lighting measures was to arrive at estimates of the effective useful lives of the lighting measures.

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 percent 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 arose in trying to derive a survival function for the lighting measures was that the amount of data available was relatively limited. There were 100% of the measures in place and operable under baseline conditions. Moreover, estimates of the percentage of measures still in place after four years could be determined from the data collected on-site (as reported in Table 3-2).

In an effort to build a time series of removals and/or replacements for lighting measures during the three years of the program, the Project Installation Reports and Annual Power Savings Reports that were prepared for the projects in the DSM Bidding Program were reviewed. Although most of the projects had PIRs, not all of the projects had more than one APSR.

- All of the 137 projects with lighting measures had PIRs.
- Out of the 137 projects, there were 15 that had no APSRs. That is, there were were 122 projects that had at least one APSR. This group included projects for a major retail chain that was bought by another company after the first year

of the program; all of the stores that were in program were remodeled by the buying company and no further APSRs were prepared. There were 40 projects associated with this retail chain.

- There were 75 projects that had APSRs for the first and second years of their participation in the program..
- There were 73 projects that had APSRs for all three years of their participation in the program.

This attrition from the panel of projects in the program created a problem of possible bias in that the projects for which there is not a full set of data have not dropped from the program randomly. As noted above, many of the projects for which there was only one APSR were those for a single retail chain. However, data collected for SCE's nonresidential measure retention study showed that retention rates for T8 lighting fixtures for retail stores are lower than for schools and hospitals. Thus, eliminating a large number of retail stores from the analysis panel would bias the estimates of effective useful lives for the program as a whole.

Another problem with using the program documentation data to estimate useful lives was that the level of removals or replacements appeared to be low over the program period. Evidence of this is provided by considering changes over time in kW reductions resulting from lighting measures installed for projects in the program. These data on aggregate kW reductions were reported in project PIRs and APSRs. In theory, removals of lighting measures from a project facility should have been reflected in changes in the kW reductions associated with the project.

Summary statistics on the changes in kW reductions were calculated for the various groups of projects noted above (i.e., for groups defined by the number of APSRs available for a project). These statistics are reported in Table 3-2. As would be expected for the types of lighting measures installed by the ESCOs, there is relatively little change in kW reductions over the report periods. For example, for projects where all three APSRs were available, the kW reductions at the end of the third year were 96.8 percent of the original reductions. Interpreted in terms of retention rates, these statistics indicate that the rates at which kW reductions from lighting measures were retained are relatively high.

Table 3-2. kW Reductions by Report Period for Nonresidential DSM Bidding Projectswith Lighting Measures

Report Periodt	*Sites with APSR1 n=122*		*Sites with APSR2 n=75*		*Sites with APSR3 n=73*		*Sites with All APSRs n=73*	
	KW Reduction	*As Percent of PIR Reduction*	*KW Reduction*	*As Percent of PIR Reduction*	*KW Reduction*	*As Percent of PIR Reduction*	*KW Reduction*	*As Percent of PIR Reduction*
PIR	14,589		11,688		11,553		11,553	
APSR 1 (Year 1)	14,040	96.2%					11,056	95.7%
APSR 2 (Year 2)			11,299	96.7%			11,168	96.7%
APSR 3 (Year 3)					11,189	96.8%	11,189	96.8%

That kW reductions changed little over the three-year period of the program implies that removals of lighting measures (as documented in the APSRs) were relatively low and did not vary over time. That is, measuring APSR kW reductions as percentages of the PIR kW reduction is similar to measuring the survival rates of the PIR kW reductions. Because lighting measures were apparently retained at relatively high rates for the three years after installation, non-parametric methods of estimating survival functions were not appropriate. Non-parametric methods can give an accurate estimate of median survival time only when more than 50 percent of the measures are no longer in place and operable.

Another possibility for the analysis was to use parametric methods to estimate a median survival time for a measure. However, the difficulty with the parametric approach was 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 data cover, a variety of functions that imply significantly different survival patterns and median lives can be fitted through the data.[1]

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

1 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.

function to develop an associated survival function.[2] The steps in this parametric procedure for estimating the effective useful lives are as follows:

- Prepare data for calculation of hazard rate function;
- Calculate hazard rate function;
- Use hazard rate function to determine a 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.[3] Two of the distributions commonly used for survival analysis are the exponential distribution and the Weibull distribution[4].

The data reported in Table 3-2 for projects with all three APSRs suggests that the hazard rate for lighting measures was relatively constant over the three years of the program. An exponential distribution can be used to represent a hazard rate that is constant; the associated survival function is also exponential. The difficulty, however, is that applying the exponential function when early rates of removal are low can imply unreasonbly long lives for measures.[5]

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[2] ADM has used this approach in the measure retention studies it has conducted for SCE's commercial/industrial/agricultural energy efficiency program.

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

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

[5] See, for example, RLW Analytics, *SCE NonResidential NewConstruction Persistence Study, Final Report*, Prepared for Southern California Edison, January 1999, p.30.

As this discussion illustrates, there are severe limitations in using the program documentation data to develop estimates of effective useful lives for lighting measures installed under the DSM Bidding Program. However, the data reported in Tables 3-1 and 3-2 taken together appear to be consistent with the retention pattern observed in the retention studies performed for SCE's commercial/industrial/agricultural energy efficiency hardware rebate program. Table 3-3 reproduces data from the most recent retention study for that program that shows the retention pattern for T8 lighting fixtures in the commercial and industrial sectors.[6]

Table 3-3. Retention Patterns for T8 Fixtures Installed in Commercial and Industrial Facilities under SCE's C/I/A Energy Efficiency Program

Year	*Fixtures Installed at Start of Year*	*Fixtures Removed during Year*	*Cumulative Number of Fixtures Removed*	*Percentage of Fixtures Removed*	*Percentage of Fixtures Retained*
1	3,656	0	-	-	100.0%
2		42	42	1.1%	98.9%
3		134	176	4.8%	95.2%
4		248	424	11.6%	88.4%
5		139	563	15.4%	84.6%
6		124	687	18.8%	81.2%
7		22	709	19.4%	80.6%

The retention rates shown in Table 3-3 for the first three years are relatively high. At the end of the third year, 95 percent of the cohort of fixtures installed under the C/I/A energy efficiency program were still in place and operable. This is consistent with the pattern shown for the DSM Bidding Program in Table 3-2, which showed a retention rate of nearly 97 percent after three years (based on kW reductions).

Table 3-3 shows a pronounced decline in the retention rate for T8 fixtures in the fourth year. This decline is consistent with the lower retention rates that were shown in Table 3-1 for lighting measures installed under the DSM Bidding Program. That is, the data on which Table 3-1 is based were collected at the end of the fourth year after the beginning of the DSM Bidding Program. The decline in the retention rate shown in Table 3-1 is somewhat more pronounced than the

[6] ADM Associates, Inc. *Southern California Edison Commercial / Industrial/Agricultural Energy Efficiency Incentives Program Retention Study*, January 2001.

decline shown in Table 3-3. However, this can be explained in part by the compositions of the samples. The sample for the on-site data collection for the DSM Bidding Retention Study included several stores of a retail chain that had been purchased by another company, which subsequently closed some of the stores. Although some facilities in the C/I/A measure retention study were also closed, such stores were a smaller percentage of the sample than were the closed facilities in the DSM Bidding retention sample.

The evidence therefore suggests that the retention pattern for lighting measures installed under the DSM Bidding Program is consistent with the retention pattern for lighting measures installed under SCE's C/I/A energy efficiency program. That is, the data reported in Table 3-2 indicated a relatively high rate of retention for lighting measures over the first three years after their installation. The data reported in Table 3-1 suggest that retention rates for the lighting measures installed under the DSM Bidding Program begin to drop after the third year.

This analysis implies that the effective useful lives estimated in the C/I/A retention study can be applied as well to the lighting measures installed under the DSM Bidding Program. These estimates of effective useful lives are reproduced in Table 3-4, where they are compared to SCE's *ex ante* estimates of effective useful lives.

Table 3-4. Effective Useful Lives as Estimated for C/I/A Energy Efficiency Program Compared to SCE's Ex Ante Estimates for Effective Useful Lives (Lives in years)

Type of Measure	*SCE Ex Ante Estimate of EUL*	*Estimated EUL*	*Ex Ante Different from Ex Post?*
T8 lighting fixtures	11.0	38.94	No
T8 lamps	5.0	6.32	No
Electronic ballasts	10.0	11.98	No
CF fixtures (modular)	12.2	14.11	No
CF lamps	2.2	6.55	Yes
Delamping/reflectors	10.0	29.01	No

For the DSM Bidding Program, the *ex ante* estimate of the life of measures installed as part of an indoor lighting system replacement or modification was 15 years, which is somewhat longer than the *ex ante* estimates shown in Table 3-4. However, as can be seen, the EULs estimated in the C/I/A energy efficiency program retention study were generally longer than the *ex ante* estimates. Accordingly, the *ex ante* estimate of 15 years for the life of lighting measures installed under the DSM Bidding Program can be accepted.

3.2 ANALYSIS AND RESULTS FOR HVAC MEASURES

This section presents and discusses the results of analyzing retention rates and effective useful lives for HVAC measures installed under the DSM Bidding Program.

3.2.1 Retention Estimates for HVAC Measures

There were 20 projects where HVAC measures had been installed. The types of measures and numbers of projects where they were installed are shown in Table 3-5. Some projects involved installation of multiple HVAC measures.

All of the projects where HVAC measures had been installed were included in the telephone survey to determine whether the measures were still in place and operable. The results of the telephone survey showed that all of the HVAC measures were still in place; none of the measures had been removed or replaced.

Table 3-5. HVAC Measures Installed

HVAC Measure	*Number of Projects Where Installed*	*Number of Projects Where HVAC Measure Still in Place*
Conversion to VAV system	14	14
Cooling tower replacement/upgrade	5	5
Pump replacement/upgrade	5	5
Chiller replacement/upgrade	4	4
Economizer installed	3	3
Fan replacement/upgrade	2	2
VFDs on AHU	2	2
Miscellaneous	1	1

3.2.2 Analysis of Effective Useful Lives for HVAC Measures

With none of the HVAC measures installed during the 1996 and 1997 DSM Bidding Program having been removed or replaced, the data were not sufficient to support the estimation of effective useful lives for the HVAC measures. The DSM Bidding Program's *ex ante* estimates of effective useful lives for these measures are therefore applicable. These *ex ante* estimates are shown in Table 3-6.

Table 3-6. DSM Bidding Program Ex Ante Estimates of Useful Lives for HVAC Measures

HVAC Measure	*Useful Life (Years)*
Air Side Economizer	15
Chiller Plant	15
Chiller Plant Replacement/Upgrade	20
Cooling Tower	15
Double Duct Conversion to VAV	15
Energy management system	15
Fans/Pumps	15
Heat Pump Installation	10
High Efficiency Motors	20
HVAC Supply Fan Adjustable Speed Drives	15
Install VFDs for 16 AHU fan motors	15
New Central Cooling Plant	20
Outside Air Economizer	15
Pump System Controls	15
VAV Conversion of Existing Air System	15
VAV Retrofits and Recommissioning	15

Appendix A

DATA COLLECTION FORMS

The types of data collection and survey instruments used for the 1996 and 1997 Nonresidential DSM Bidding Program Retention Study included the following:

- On-site data collection form used to collect information on removals of lighting energy efficiency measures; and
- Telephone survey form for interview of personnel at facilities where HVAC energy efficiency measures had been installed.

On-Site Data Collection Form

Site Name								
Type of Lighting	**Floor**	**Room/Area Description**	**Usage Type**	**Number of Fixtures per Inventory**	**Number of Fixtures per ADM Count**	**Reason for any difference in Fixture Count**	**Number of Ballasts Replaced Since Fixtures Installed**	**Number of Lamps Replaced Since Fixtures Installed**

Telephone Survey Form

Southern California Edison

DSM Bidding Program Measure Retention Study

Telephone Survey
for HVAC Sites

Final Version: 12/06/2000

Instructions to Interviewer:

Before calling a customer, review HVAC conservation measures for that customer's facility, their number, where they are located, and in which building.

When you understand the data for this facility, call the customer and say something close to:

Hello, my name is _____ from ADM Associates. I am calling on behalf of Southern California Edison. May I speak to _____*(the contact person*)?

If the contact person is not available, schedule a callback.

If the contact person will not be available later, ask:

Could you tell me who is most familiar with your electric systems or equipment at this location?

If the person is not available, schedule a callback.

If the interview is successful confirm mailing address and the phone number:

Name: _____

Position: _____

Company _____

Phone ( ) _____

Once the contact has been made, start:

I am _____, calling on behalf of Southern California Edison. We are checking on the HVAC energy efficiency measures that were installed in this facility in 1996 or 1997 by an energy services compnay. We are conducting this survey to see how long energy conservation measures are effective, and we are grateful for your cooperation. This should take only a few minutes.

Edison's records show that the HVAC measures installed at this facility in 1996 or 1997 include [*mention measures from list*].

1. Have these HVAC energy efficiency measures been affected by major changes in the facility's structure, equipment or operating hours? (*Check all that apply.*)
   - ❑ No *Go to 2*
   - ❑ Yes

     ⬇

     What changes were made in facility's structure or equipment? _____

     _____

     _____

     ⬇

     What effect did these changes have on the HVAC energy efficiency measures?

     ⬇

     - ❑ Measures were removed and not replaced.
     - ❑ Measures were replaced.

       ⬇

       What were the measures replaced with?
       (*Specify*) _____
     - ❑ Other (*Specify*) _____

2. Have any other actions occurred at this facility that affected the operation of the HVAC energy efficient measures installed at this facility? (*Check all mentioned. Prompt if necessary*)
   - ❑ No *Go to end.*
   - ❑ Yes

     ⬇

     What actions were these? _____

     _____

     ⬇

     What effect did these actions have on the operation of the HVAC energy efficiency measures?

     ⬇

     - ❑ Measures were removed and not replaced.

       ⬇

       Why were the measures removed and not replaced?
       - ❑ Equipment required major repair.
       - ❑ Had to change to non-CFC refrigerant.
       - ❑ There was a change to distribution system that required change to HVAC equipment.
       - ❑ There was a change in cooling requirements.
       - ❑ Other (*Specify*) _____

       ⬇

       When were the measures removed? _____ *(Specify Date)*

❑ Measures were replaced with different types of measures.
⬇

Why were the HVAC energy efficiency measures replaced with different types of measures?

❑ Equipment required major repair.
❑ Had to change to non-CFC refrigerant.
❑ There was a change to distribution system that required change to equipment that affected installed measures.
❑ There was a change in cooling requirements.
❑ Other (*Specify*) _____
⬇

What were the measures replaced with?
(*Specify*) _____
⬇

When were the HVAC energy efficiency measures replaced? _____ *(Specify Date)*

❑ Other (*Specify*) _____

End. That is all the information I need to get. Thank you for your cooperation.

Appendix B

INFORMATION FOR PROTOCOL TABLES 6 AND 7

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

B.1 Information Required per Table 6 of M&E Protocols

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

1. *Identify the studied measures and the end uses they belongs to.*
   The measures studied were lighting and HVAC measures. Lighting measures included primarily indoor lighting replacements. HVAC measures included conversions of dual duct or constant volume air distribution systems to variable-air-volume.
2. *Identify the ex ante expected useful life and the source of the ex ante expected useful life.*
   SCE's program documentation for the DSM Bidding Program gives 15 years as the *ex ante* estimate of the useful life of indoor lighting replacements. The *ex ante* estimates for HVAC measures are reported in Table 3-6.
3. *Identify the ex post expected useful life estimated in the study.*
   The evidence developed through the analysis in this study indicated that the *ex ante* estimates are appropriate to be used as *ex post* estimates.
4. *Identify the ex post expected useful life to be used by the utility in the third and fourth earnings claim.*
   The *ex ante* estimates should be used as the *ex post* expected useful lives.
5. *Identify the standard error associated with the ex post expected useful life.*
   The data available for this study did not support statistical analysis. Hence no standard errors were calculated.
6. *Provide the 80% confidence interval associated with the ex post expected useful life.*
   The data available for this study did not support statistical analysis. Hence no confidence intervals were calculated.
7. *Provide the p-value associated with the ex post expected useful life.*
   The data available for this study did not support statistical analysis. Hence no p-values can be reported.
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.*
   The *ex post* is the same as the *ex ante.* Thus, the realization rate is 1.
9. *Identify all the "like" measures associated with the studied measure.*
   There are no "like" measures.

B.2 Information Required per Table 7 of M&E Protocols

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

1. *a. Study Title and Study ID No.*

Study title is:

Southern California Edison
1996/1997
Nonresidential DSM Bidding Program
Retention Study

Study ID No. is:
CEC Study Id #555

b. Program, Program years, and program description

Program is:
Nonresidential DSM Bidding Program

Program Years are 1996 and 1997.

Program Description:
This study examined the retention rates and effective useful lives for measures installed by energy services companies (ESCOs) at facilities operated by SCE commercial or industrial customers under SCE's Nonresidential DSM Bidding Program.

c. End Uses and Measures Covered:

The end uses covered were lighting and HVAC. Measures included indoor lighting-system replacement, lighting efficiency modifications, packaged air conditioners, heat pumps, window treatment, daylighting controls, electronic adjustable-speed drives, electric motors, electric chillers, and thermal energy storage

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 from program documentation (i.e., Project Installation Reports and Annual Power Savings Reports), through on-site data collection for a sample of facilities with lighting measures, and through a telephone survey of all facilities with HVAC measures.

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 measures and to determine if the estimated EULs were different from expected EULs. Several approaches to estimating EULs were examined in the light of the available data: direct estimation of survival functions from the collected data and indirect estimation through hazard function analysis. This analysis showed that there was a relatively small number of measures removed, thus precluding extensive statistical analysis. However, the analysis did show that the pattern of retention for lighting measures was similar to that

estimated for lighting measures in SCE's commercial/industrial/agricultural energy efficiency program measure retention study.

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.*
The total number of projects with lighting measures was 137. Program documentation was reviewed for all of these projects. In addition, a sample of 45 projects was selected, and on-site visits were completed at 35 facilities to verifiy whether the installed lighting measures were still in place and operable.

There were 20 facilities with projects where HVAC measures were installed. Program documentation was reviewed for all of these projects, and all 20 facilities were surveyed by telephone to determine whether the HVAC measures were still in place and operable.

2. a. *Identify the specific data sources used for each data element.*
Data for the study were collected from program documentation (i.e., Project Installation Reports and Annual Power Savings Reports), through on-site data collection for a sample of facilities with lighting measures, and through a telephone survey of all facilities with HVAC measures.

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 differerent data sources are used (e.g., surveys and program records), appropriate attrition categories should be used (e.g., response rates for surveys).*
The data development and attrition process are shown in Figure B-1.

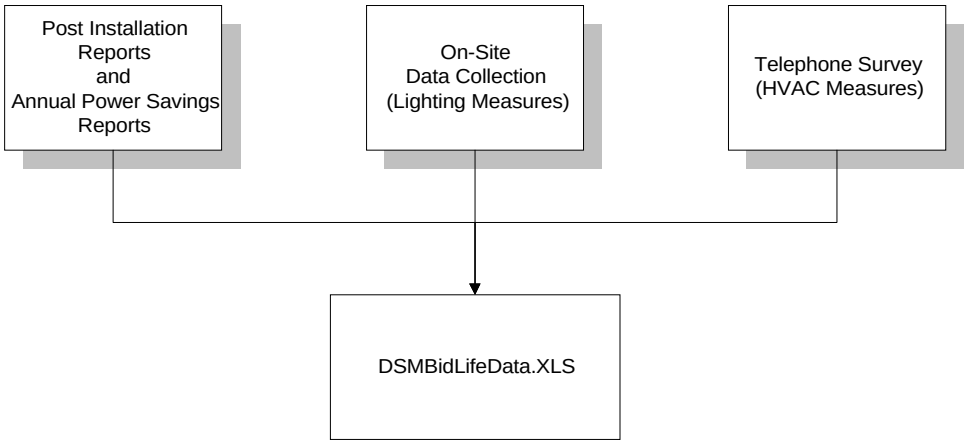

Figure B-1. Data Development and Attrition Process

In an effort to build a time series of removals and/or replacements for lighting measures during the three years of the program, the Project Installation Reports and Annual Power Savings Reports that were prepared for the projects in the DSM Bidding Program were

reviewed. Although most of the projects had PIRs, not all of the projects had more than one APSR.

- All of the 137 projects with lighting measures had PIRs.
- Out of the 137 projects, there were 15 that had no APSRs. That is, there were were 122 projects that had at least one APSR. This group included projects for a major retail chain that was bought by another company after the first year of the program; all of the stores that were in program were remodeled by the buying company and no further APSRs were prepared. There were 40 projects associated with this retail chain.
- There were 75 projects that had APSRs for the first and second years of their participation in the program..
- There were 73 projects that had APSRs for all three years of their participation in the program.

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.*

Program documentation was provided by SCE and its administrative contractor (Schiller Associates) that contained information on the customers who participated in the 1996 and 1997 Nonresidential DSM Bidding Program. Each project was identified by a unique identifier that was used as the key by which to match customer information across program 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 are provided in Appendix A of the final report. 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.*

To determine the sample allocation and project selection for the primary data collection, use was made of files that SCE staff and Schiller Associates had prepared that contain information on the participants in the 1996 and 1997 Nonresidential DSM Bidding Program. Sampling frames for selecting the sample sites for lighting measures and for HVAC measures were created from these files.

There were 137 projects with savings from lighting measures. The data on expected savings reported in PIRs for these projects indicated that there was a relatively small

number of projects that accounted for a high percentage of the estimated savings. The distribution of expected savings from lighting measures was skewed, with projects with large savings accounting for significant percentages of total savings. The sampling plan for lighting measures was designed to take such skewness into account.

A number of projects with the largest savings was selected for the sample with certainty, and a random sample was taken of the remaining projects. An analysis of alternative sampling allocations showed that a precision of 9.6 percent could be met at the 90% confidence level by taking a sample of 45 projects, with 20 of the projects with the largest savings being selected with certainty and 25 other projects selected randomly. The 20 projects with the largest savings from lighting measures accounted for nearly two-thirds of the expected savings for projects having such measures.

To further improve the precision of the sampling, the 25 non-certainty projects were selected for the sample through systematic random sampling. That is, a random sample of projects remaining after the certainty projects had been selected was selected by ordering the non-certainty projects according to the magnitude of their savings from lighting measures and using systematic random sampling. Sampling systematically from a list that was ordered according to the magnitude of savings ensured that any sample selected would have some projects with high savings, some with moderate savings, and some with low savings. Samples could not result that had concentrations of projects with atypically high savings or atypically low savings.

There were 20 projects with non-interactive savings from HVAC measures. All of these projects were chosen for the sample.

For the on-site data collection for facilities where lighting energy efficiency measures had been installed, the field surveyors were provided with a lighting inventory data form that showed the type of lighting and number of fixtures for a sample of different usage areas within a selected facility. These inventory data were extracted from the Project Installation Reports that had been filed by the different ESCO's. An example of this form is provided in Appendix A.

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 are provided in Appendix A of the final report.

c. *Statistical descriptions. For the key variables that were used in the final models, provide descrptive 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 retention rates at the end of a four-year period are summarized for various lighting measures in Table 3-1.

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

No diagnostics were used to identify outliers.

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

Economic factors were important in causing substantial attrition in the panel of projects available for analysis in that 40 of the 137 projects with lighting measures were associated with a retail chain that was bought after the first year in the program. This was a non-random event that could not be controlled for.

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 program documentation data set that was used for the analysis.

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

Because of data limitations, no statistical models could be developed.

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 considered for the the study are presented and discussed in Chapter 3.

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.)*

Measurement error was not a major consideration, except in that use was made of savings estimates included in program documentation.

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

Influential data points were associated with the 40 lighting projects that fell out of the analysis panel at the end of the first year of the program. However, this was a non-random attrition.

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 study was based on program documentation for *all* projects, sampling precision and calculation of standard errors was not required.

Appendix C

DATA DOCUMENTATION

This appendix documents the data used for the study. These data are contained in the DSMBidLifeData.xls, an Excel workbook that is an attachment to this report.

Data from various sources were used for this study.

- One source of data was the verification data that ESCOs were required to provide to SCE. For each project, an ESCO provided a Project Installation Report and Annual Power Savings Reports that documented the savings that were being achieved with the measures they had installed.
- Primary data were also collected through both an on-site data collection effort (for lighting measures) and a telephone survey (for non-lighting measures).

DSMBidLifeData.XLS contains four spreadsheets pertaining to these data.

- Lighting Sites APSR Analysis contains the kW reductions data that were taken from the Post Installation Reports and Annual Power Savings Reports for sites with lighting measures.
- Lighting Data Collected On-Site contains the data collected on-site regarding lighting fixtures, ballasts, and lamps. These data allow a comparison between the numbers of fixtures installed as part of the retrofit of a facility (by usage area) and the numbers of fixtures shown by the on-site data collection.
- Lighting Removed or Replaced is a cross-tab of the data from Lighting Data Collected On-Site in which data observed on-site regarding type of fixture is compared to type of fixture installed during the retrofit. Removed fixtures were calculated by comparing the number of fixtures where no indication of a new type of fixture was given. Replaced fixtures are counted as fixtures where the data showed that the type of fixture had changed from old to new.
- HVAC Sites identifies the sites where HVAC measures were installed, and the types of measures. The telephone survey of these sites showed that none of the measures had been removed or replaced.