1996 Commercial Energy Management Hardware Rebate Program Impact Evaluation

Study 540

Submitted to:

Southern California Edison
300 North Lone Hill Avenue
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Executive Summary

1. Overview

This report presents an impact evaluation of Southern California Edison's (SCE) 1996 Commercial Energy Management Hardware Rebate Program. The program provided monetary incentives to commercial utility customers for installing certain energy efficient equipment as part of a retrofit program. Regional Economic Research, Inc. conducted the analysis under contract to SCE. Mr. Pierre Landry was SCE's Project Manager. ADM Associates, Inc. conducted on-site surveys and engineering analyses of savings.

2. Program Description

SCE's 1996 Commercial Energy Management Hardware Rebate Program provided monetary incentives to commercial utility customers for installing certain energy efficient equipment as part of a retrofit program. Measures eligible for financial incentives include the following:

- Compressed air systems,
- Industrial relighting,
- Chilled water systems,
- Energy management systems,
- Supermarket energy optimization,
- Hydraulic pumping systems, and
- Component incentives,

with the predominant measures being adjustable speed drives for motors and space conditioning equipment, energy management systems for space conditioning and lighting, disconnecting/rewiring lamps, and LED exit signs.

3. Study Objectives

The project focused on both gross and net energy and demand impacts. An extensive integrated database was developed comprised of data from several sources including billing and weather records, program records, on-site surveys, and engineering analyses. A realization rate model was estimated with data on both participants and nonparticipants, and a net-to-gross analysis was used to derive net program savings.

Key objectives for this study included the following:

- To estimate the gross and net energy and demand impacts of the program at the whole-building and end-use levels,
- To produce estimates as described in Table 6 of the Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs (Protocols), as adopted by the California Public Utilities Commission (D-93-05-063) and revised January 1997, and
- To produce documentation as described in Table 7 of the Protocols.

4. General Evaluation Issues

Defining Energy Efficiency

A portion of the evaluation of any DSM program focuses on the different choices of energy efficiency made by participants and nonparticipants. Defining energy efficiency for participants and nonparticipants requires reference points. In this study, energy efficiency was measured relative to compliance with building and appliance efficiency. This does not mean that standards comprise the overall baseline for the evaluation; they merely comprise convenient intermediate baselines for the gross savings analysis.

Defining Gross Ex Ante, Gross Ex Post, and Net Program Impacts

The CPUC Protocols refer to gross and net impacts and comment on *ex ante* and *ex post* estimates of savings. Some confusion can be avoided if clear definitions are adopted of three concepts: gross *ex ante* impacts, gross realized impacts, and net realized impacts. In the remainder of this report, these terms are used in the following ways:

- ***Gross ex ante savings*** are those expected on the basis of prior assumptions on the behavior of direct program participants. The gross *ex ante* savings estimates referenced in this study are those submitted by SCE in its first-year earnings claim. These program *ex ante* estimates are restricted to measures adopted through the program.
- ***Gross realized savings*** are those estimated after the fact on the basis of actual observations on the behavior of direct program participants. They are *ex post* in the sense that they have somehow been "verified" after the fact. We will refer to them as *gross realized* savings. As will be seen, these estimates of gross realized savings are developed through the use of a realization rate analysis that involves both engineering and statistical analyses. For measures covered by the program, these realized savings estimates may differ from the gross *ex ante* estimates because of the violation of assumptions underlying the *ex ante* estimates. Like *ex ante* estimates, gross *ex post* program impacts can be derived explicitly for measures adopted through the program. However, we also need to estimate realized savings

stemming from other program-eligible DSM activities conducted by both participants and nonparticipants, since these estimates will be needed for the net-to-gross analysis.

- ***Net impacts*** are those actually attributable to the program. They can differ from gross realized (*ex post*) savings because of free ridership and free drivership. In this context, *free ridership* would indicate that some of the measures adopted through the program would have been adopted in the absence of the program. Free drivership can take two forms. *Participant free drivership* would be conveyed through the adoption of measures by participants (in participating buildings) outside the program. *Nonparticipant free drivership* could also operate through the program's influence on measure adoptions for nonparticipating buildings. As shown in the remainder of this report, net impacts were defined as gross realized savings adjusted for the effects of free ridership and the first type of free drivership.

5. Data

The integrated database used in the evaluation of the SCE's 1996 Hardware Rebate Program (96 EMHRP) has five major elements.

- ***On-Site Survey Data.*** On-site survey data was collected for 269 participant and 308 nonparticipant commercial sites.
- ***Participant File Data.*** This data includes 96 EMHRP program records for all participating commercial sites.
- ***Billing Data.*** Consumption histories were collected from the SCE billing frame for the surveyed participant and nonparticipant sites.
- ***Weather Data.*** This includes actual weather data from the SCE weather stations and *TMY* data from CEC weather zones.
- ***Engineering Estimates.*** DOE-2 and standard engineering algorithms were used to develop engineering estimates of savings from data collected during the on-site surveys and from data in the participant files.

These data were used to develop an integrated database containing 16,936 observations representing 476 commercial sites.

6. Overview of Approach

The overall methodology was designed to comply with both the principles of good evaluation and the stipulations of the Protocols. The methodology consisted of three primary elements.

- ***On-Site Survey.*** An on-site survey was conducted to collect information on participants and nonparticipants. The survey was used to collect detailed information on DSM measures installed over the study period, as well as changes in equipment stocks, building characteristics, operating schedules, and occupancy rates. Completed samples of 269 participants and 308 nonparticipants were obtained. Moreover, the collection of end-use metered data at key sites was included to supplement the survey data.

- ***Engineering/Simulation Analysis.*** Engineering analysis was utilized to develop initial estimates of *gross program impacts*. Gross impacts can be interpreted as the effects of DSM measures on participants' and nonparticipants' energy use, without regard to the attribution of these impacts to participation in the program.
- ***Statistical Analysis.*** Two kinds of statistical analysis were conducted, as described below.
  - First, engineering estimates of the *gross impacts* of the program were refined using a statistical calibration step. This approach entails the use of regression analysis to statistically reconcile these engineering estimates with billing information. This element of the statistical analysis is sometimes called *realization rate analysis* to reflect the fact that the adjustment coefficients associated with some of the engineering estimates of savings can be considered rates at which these estimates are "realized" in the form of actual reductions in energy consumption. Realization rate analysis is a form of load impact regression analysis, and clearly satisfies the CPUC Protocols. The specific form of the analysis used in this study deals with the various practical problems raised by Edison in the Request for Proposals.
  - Second, a difference of differences approach was used to translate the realized gross impact estimates into estimates of *net program impacts*. Net program impacts are those that are attributable to the program.

The analysis utilized four types of primary data: 96 EMHRP participant records, data collected during the on-site surveys, SCE billing file records, and weather data. These data elements were used to develop engineering estimates of savings by end use for each surveyed site. The engineering savings estimates were developed from DOE-2 simulations and standard engineering algorithms. These engineering estimates, along with billing and weather data, were then used in the realization rate analysis. This analysis yielded realization rates as well as gross realized savings by end use. The net-to-gross analysis was completed using the difference of differences approach, which involves comparing participant and nonparticipant savings from program-eligible measures. The results of the net-to-gross analysis are net-to-gross factors and estimates of net realized savings by end use.

7. Preview of Results

Table 1 and Table 2 present a summary of the estimated program energy savings and demand impacts. Included in the table are gross realized savings and net realized savings by end use.

SCE's *ex ante* and net verified program savings estimates are included for comparison. Conclusions made on the basis of these results are the following.

- ***Energy.*** Annual gross realized program savings were estimated to be just over 40 GWh (roughly 70% of SCE's *ex ante* estimate). Net program savings were estimated to be 33.9 GWh, which is approximately 59% of SCE's *ex ante* estimate and 80% of SCE's net verified energy savings.
- ***Demand.*** Gross realized peak demand savings is 6.6 MW (approximately 20 % higher than SCE's *ex-ante* demand savings estimate). Net program demand savings were estimated to be 5.5 MW, which is about 1 % higher than SCE's *ex-ante* estimate and 38 % higher than SCE's net verified demand savings.
- ***Lighting Estimates.*** The difference in lighting estimates stems primarily from the low realization rate derived for lighting measures. The low rate is probably attributable to one of two problems: errors in SCE's characterization of pre-retrofit lighting densities or changes in operating hours associated with major reductions in lighting densities.
- ***HVAC Estimates.*** RER's lower estimate of HVAC savings is a result of the fact that ADM's engineering estimates of HVAC savings were considerably lower than SCE's, especially for EMS measures.
- ***Refrigeration Estimates.*** RER's lower estimate of refrigeration savings is attributable to differences in the engineering analyses conducted by SCE and ADM.

Table 1: Summary of Estimated Program Savings by End Use (kWh)

Program Measure	SCE Gross Ex Ante Savings (kWh)	SCE Net Verified Savings (kWh)	RER Gross Realized Savings (kWh)	RER Net Realized Savings (kWh)
Lighting				
Indoor Ltg.	*22,079,125*		*17,147,470*	*13,635,918*
LED Ltg. Only	*2,612,422*		*2,612,422*	*1,880,063*
Outdoor Ltg. Only	*1,009,730*		*1,009,730*	*695,744*
Total Lighting	***25,701,277***	***17,677,000***	***20,769,622***	***16,131,726***
HVAC	24,670,308	19,595,000	13,950,105	12,886,960
Refrigeration	3,245,731	2,484,000	2,179,294	2,179,294
Process	1,042,335	798,000	1,042,335	798,012
Miscellaneous	2,366,077	1,875,000	2,366,077	1,879,399
All	**57,025,728**	**42,429,000**	**40,307,432**	**33,875,390**

Table 2: Summary of Estimated Program Savings by End Use (kW)

Program Measure	SCE Gross Ex Ante Savings (kW)	SCE Net Verified Savings (kW)	RER Gross Realized Savings (kW)	RER Net Realized Savings (kW)
Lighting				
Indoor Ltg.			*4,085*	*3,249*
LED Ltg. Only			*299*	*206*
Outdoor Ltg. Only			*8*	*6*
Total Lighting	***4,573***	***3,260***	***4,392***	***3,460***
HVAC *	707	580	1,785	1,649
Refrigeration	66	50	298	298
Process	108	90	108	83
Miscellaneous			22	17
All	**5,453**	**3,980**	**6,605**	**5,507**

* *SCE savings for HVAC include Miscellaneous*

1

Introduction

1.1 Introduction

This report presents an impact evaluation of Southern California Edison's (SCE) 1996 Commercial Energy Management Hardware Rebate Program. Regional Economic Research, Inc. conducted the analysis under contract to SCE. Mr. Pierre Landry was SCE's Project Manager. ADM Associates, Inc. conducted on-site surveys and engineering analyses of savings.

The remainder of this section defines the study objectives, describes the program, discusses general evaluation issues, provides an overview of the data and methodology used in the study, presents a summary of the results, and previews the remainder of the study.

1.2 Study Objectives

The project focused on both gross and net energy and demand impacts. An extensive integrated database was developed comprised of data from several sources, including billing and weather records, program records, on-site surveys, and engineering analyses. A realization rate model was estimated with data on both participants and nonparticipants, and a net-to-gross analysis was used to derive net program savings.

At the start of the project, a number of key objectives were established. These included the following:

- To estimate the gross and net energy and demand impacts of the program at the whole-building and end-use levels,
- To produce estimates as described in Table 6 of the Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs (Protocols), as adopted by the California Public Utilities Commission (D-93-05-063) and revised January 1997, and
- To produce documentation as described in Table 7 of the Protocols.

The approach used in the study was well suited to the achievement of these objectives.

1.3 Program Description

SCE's 1996 Commercial Energy Management Hardware Rebate Program (96 EMHRP)[1] provided monetary incentives to commercial utility customers for installing certain energy-efficient equipment as part of a retrofit program. Measures eligible for financial incentives include the following:

- ***Compressed Air Systems.*** These include air compressors and air compressor systems.
- ***Industrial Relighting.*** Indoor and outdoor lighting system replacements and modifications and daylight system controls are eligible.
- ***Chilled Water Systems.*** These systems include chillers, chilled water pumps, condenser pumps, cooling towers, and air handling distribution system improvements.
- ***Energy Management Systems (EMS).*** Hardware and software systems that control energy usage within a building or process include lighting controls, space conditioning controls, commercial refrigeration controls, process controls, and water services controls.
- ***Supermarket Energy Optimization (SEO).*** SEO applies to most aspects of food stores including lighting, space conditioning, and commercial refrigeration.
- ***Hydraulic Pumping Systems.*** Adjustable speed drives (ASD) provide energy savings for hydraulic pumping systems in agricultural and water service uses.
- ***Component Incentives.*** Lighting incentive measures include outdoor lighting system replacements and modifications, LED exit signs, and delamping. Space conditioning incentive measures include air- and water-cooled air conditioners.

Although some of the categories were designed for specific sectors (e.g., industrial relighting), participants in other sectors (like commercial customers) were permitted on occasion to apply for these category-specific incentives.

There were roughly 312 coupons written under the 96 EMHRP program. These coupons were written not only for individual sites but for companies with chain outlets and multiple accounts at the same sites. As part of this study, these coupons were identified as covering 775 different sites.[2]

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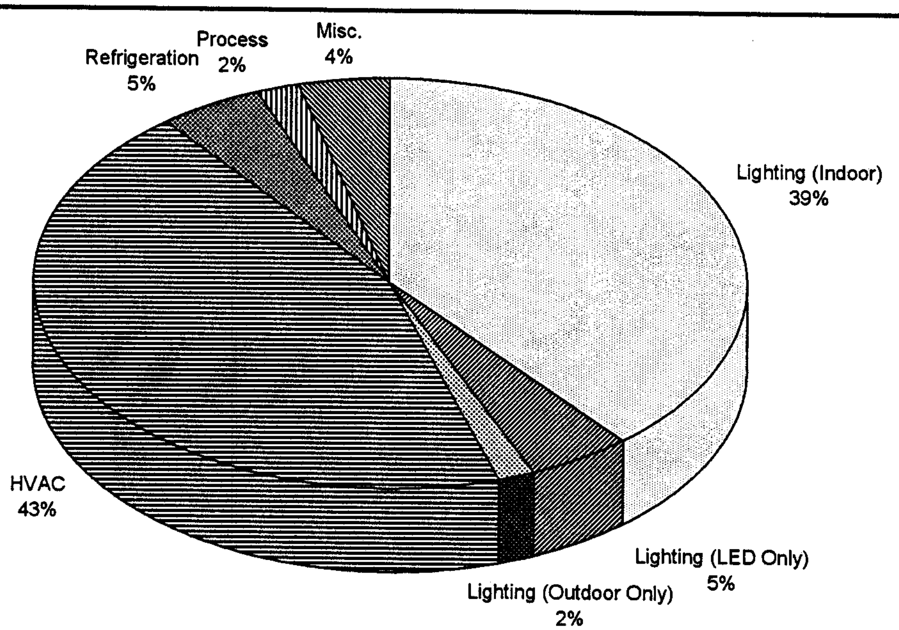
[1] Although the 1996 Energy Management Hardware Rebate Program was open to commercial, industrial, and agricultural/water service customers, in this report the term "96 EMHRP" refers only to customers in the commercial sector (as defined by the California Energy Commission).

[2] A site is defined as a premise or premises served by a single account or group of accounts where the service name is the same, and the premise or premises are on the same side of the street and/or share the same transformer.

The measures installed in the 96 EMHRP were predominantly ASDs for motors and space conditioning equipment, energy management systems for space conditioning and lighting, disconnecting/rewiring lamps, and LED exit signs. SCE's total estimate of verified net program savings for the 96 EMHRP is 39,293 MWh and 3.755 MW. Figure 1-1 presents SCE's verified net program savings by proportion of end use.

Figure 1-1: Percent of SCE's 96 EMHRP Program Verified Net Savings by End Use



1.4 General Evaluation Issues

Defining Energy Efficiency

A portion of the evaluation of any DSM program focuses on the different choices of energy efficiency made by participants and nonparticipants. Defining energy efficiency for participants and nonparticipants requires reference points. In this study, energy efficiency was measured relative to compliance with building and appliance efficiency. This does not mean that standards comprise the overall baseline for the evaluation; they merely comprise convenient intermediate baselines for the gross savings analysis.

Defining Gross Ex Ante, Gross Ex Post, and Net Program Impacts

The CPUC Protocols refer to gross and net impacts and comment on *ex ante* and *ex post* estimates of savings. Some confusion can be avoided if clear definitions are adopted of three concepts: gross *ex ante* impacts, gross realized impacts, and net realized impacts. In the remainder of this report, these terms are used in the following ways:

- ***Gross ex ante savings*** are those expected on the basis of prior assumptions on the behavior of direct program participants. The gross *ex ante* savings estimates referenced in this study are those submitted by SCE in its first-year earnings claim. These program *ex ante* estimates are restricted to measures adopted through the program.
- ***Gross realized savings*** are those estimated after the fact on the basis of actual observations on the behavior of direct program participants. They are *ex post* in the sense that they have somehow been "verified" after the fact. We will refer to them as *gross realized* savings. As will be seen, these estimates of gross realized savings are developed through the use of a realization rate analysis that involves both engineering and statistical analyses. For measures covered by the program, these realized savings estimates may differ from the gross *ex ante* estimates because of the violation of assumptions underlying the *ex ante* estimates. Like *ex ante* estimates, gross *ex post* program impacts can be derived explicitly for measures adopted through the program. However, we also need to estimate realized savings stemming from other program-eligible DSM activities conducted by both participants and nonparticipants, since these estimates will be needed for the net-to-gross analysis.
- ***Net impacts*** are those actually attributable to the program. They can differ from gross realized (*ex post*) savings because of free ridership and free drivership. In this context, *free ridership* would indicate that some of the measures adopted through the program would have been adopted in the absence of the program. Free drivership can take two forms. *Participant free drivership* would be conveyed through the adoption of measures by participants (in participating buildings) outside the program. *Nonparticipant free drivership* could also operate through the program's influence on measure adoptions for nonparticipating buildings. As shown in the remainder of this report, net impacts were defined as gross realized savings adjusted for the effects of free ridership and the first type of free drivership.

1.5 Data

The integrated database used in the evaluation of the SCE's 96 EMHRP has five major elements.

- ***On-Site Survey Data.*** On-site survey data were collected for 269 participant and 305 nonparticipant commercial sites.
- ***Participant File Data.*** These data include 96 EMHRP program records for all participating commercial sites.

- ***Billing Data.*** Consumption histories were collected from the SCE billing frame for the surveyed participant and nonparticipant sites.
- ***Weather Data.*** This includes actual weather data from the SCE weather stations and typical meteorological year (TMY) data from CEC weather zones.
- ***Engineering Estimates.*** DOE-2 and standard engineering algorithms were used to develop engineering estimates of savings from data collected during the on-site surveys and from data in the participant files.

These data were used to develop an integrated database containing information for 574 sites.

1.6 Overview of Approach

The overall methodology was designed to comply with both the principles of good evaluation and the stipulations of the Protocols. The methodology consisted of three primary elements.

- ***On-Site Survey.*** An on-site survey was conducted to collect information on participants and nonparticipants. The survey was used to collect detailed information on DSM measures installed over the study period, as well as changes in equipment stocks, building characteristics, operating schedules, and occupancy rates. Completed samples of 269 participants and 305 nonparticipants were obtained. Moreover, the collection of end-use metered data at key sites was included to supplement the survey data.
- ***Engineering/Simulation Analysis.*** Engineering analysis was utilized to develop initial estimates of *gross program impacts*. Gross impacts can be interpreted as the effects of DSM measures on participants' and nonparticipants' energy use, without regard to the attribution of these impacts to participation in the program.
- ***Statistical Analysis.*** Two kinds of statistical analysis were conducted, as described below.
  - First, engineering estimates of the *gross impacts* of the program were refined using a statistical calibration step. This approach entails the use of regression analysis to statistically reconcile these engineering estimates with billing information. This element of the statistical analysis is sometimes called *realization rate analysis* to reflect the fact that the adjustment coefficients associated with some of the engineering estimates of savings can be considered rates at which these estimates are "realized" in the form of actual reductions in energy consumption. Realization rate analysis is a form of load impact regression analysis and clearly satisfies the CPUC Protocols.
  - Second, a levelized savings approach was used to translate the realized gross impact estimates into estimates of *levelized net program impacts*. Net program impacts are those that are attributable to the program.

Figure 1-2 presents an overview of the impact evaluation approach. As shown, the analysis utilized four types of primary data: 96 EMHRP participant records, data collected during the on-site surveys, SCE billing file records, and weather data. These data elements were used to develop engineering estimates of savings by end use for each surveyed site. The engineering savings estimates were developed from DOE-2 simulations and standard engineering algorithms. These engineering estimates, along with billing and weather data, were then used in the realization rate analysis. This analysis yielded realization rates as well as gross realized savings by end use.

The net-to-gross analysis used the difference-of-differences approach for the *first year* of savings, which involves comparing participant and nonparticipant savings from program-eligible measures. These first-year net-to-gross ratios were used in the remainder of the analysis along with the realization rates, useful lives of the measures, and approximate discount rates to derive an overall net-to-gross ratio. This approach takes into account the nature of the retrofit program.[3] The results of the net-to-gross analysis are net-to-gross factors and estimates of net realized savings by end use.

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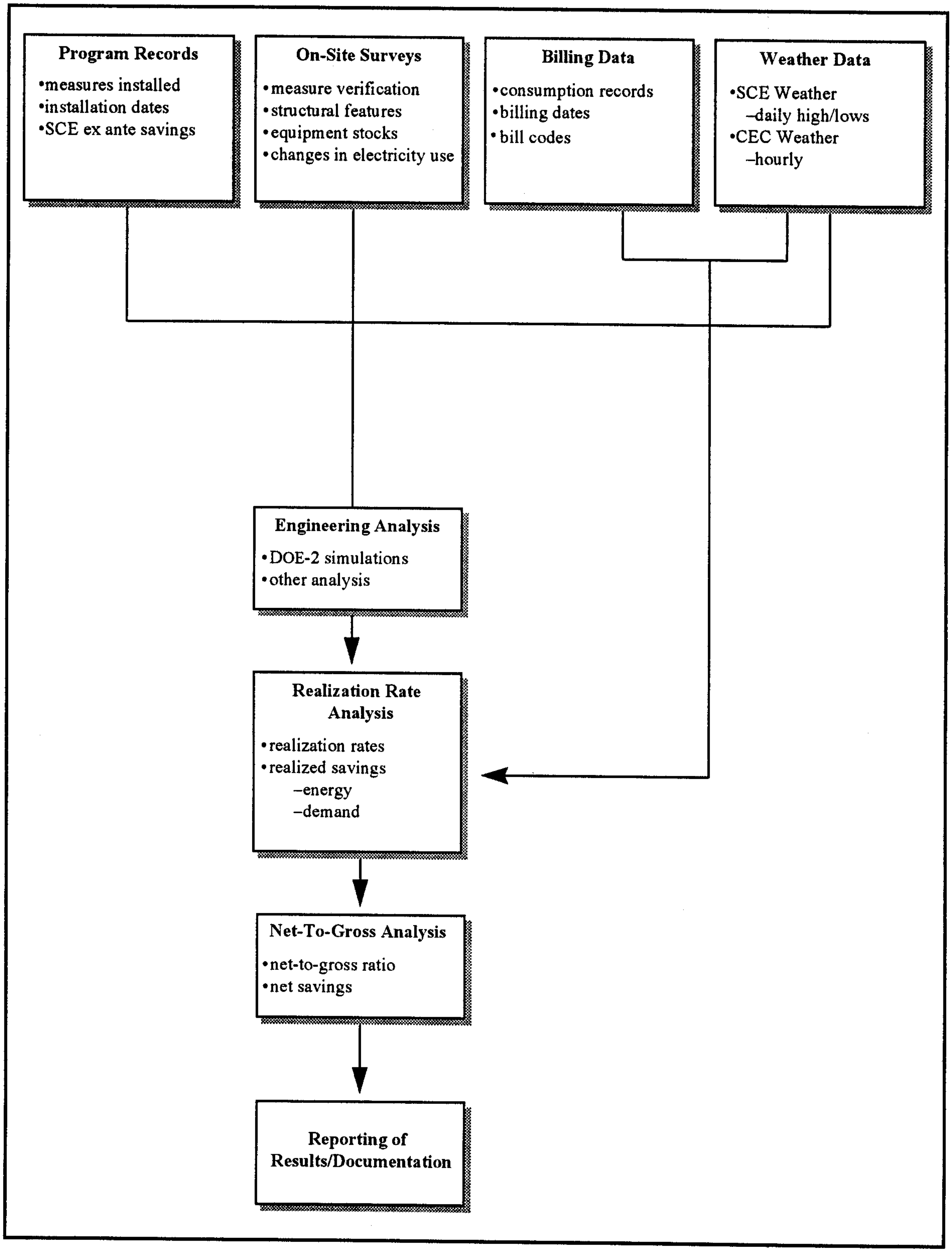
3 Approximately 97% of program savings are due to retrofit measures.

Figure 1-2: Overview of Impact Evaluation Approach



1.7 Preview of Results

Realized savings estimates for HVAC measures, refrigeration, and sites with indoor lighting measures were developed in this study. In conformance with Table C-9 of the Protocols, estimates for process measures, the two water pumping sites, and sites with exit signs and/or outdoor lighting but no indoor lighting were developed using SCE's reported *ex ante* estimates and net-to-gross ratios.[4]

Table 1-1 presents a summary of the estimated program energy and demand savings. Included in the table are engineering estimates of program savings, gross realized savings, and net realized savings by end use for energy and demand impacts.

- ***Energy.*** Annual gross realized program savings were estimated to be just over 40 GWh. This is roughly 70% of SCE's *ex ante* estimate. Net program savings were estimated to be 33.9 GWh, which is 80% of SCE's net verified energy savings.
- ***Demand.*** Gross realized peak demand savings are 6.6 MW. This is approximately 20% higher than SCE's *ex ante* demand savings estimate. Net program demand savings are estimated to be 5.5 MW, which is roughly 38% higher than SCE's net verified demand savings.

Reasons for the lower energy and higher demand savings estimates will be discussed in Sections 4 and 5 of this report.

4 Feeder Sheets to Table E-2 and E-3 in Application 97-05-004, Edison's Earnings Claim (as adjusted by the ORA) in the 1997 Annual Earnings Assessment Proceeding (CPUC decision pending).

Table 1-1: Summary of Estimated Program Savings by End Use (kWh)

Program Measure	SCE Gross Ex Ante Savings (kWh)	SCE Net Verified Savings (kWh)	RER Gross Realized Savings (kWh)	RER Net Realized Savings (kWh)
Lighting				
Indoor Ltg.	*22,079,125*		*17,147,470*	*13,635,918*
LED Ltg. Only	*2,612,422*		*2,612,422*	*1,880,063*
Outdoor Ltg. Only	*1,009,730*		*1,009,730*	*695,744*
Total Lighting	***25,701,277***	***17,677,000***	***20,769,622***	***16,131,726***
HVAC	24,670,308	19,595,000	13,950,105	12,886,960
Refrigeration	3,245,731	2,484,000	2,179,294	2,179,294
Process	1,042,335	798,000	1,042,335	798,012
Miscellaneous	2,366,077	1,875,000	2,366,077	1,879,399
All	**57,025,728**	**42,429,000**	**40,307,432**	**33,875,390**

Table 1-2: Summary of Estimated Program Savings by End Use (kW)

Program Measure	SCE Gross Ex Ante Savings (kW)	SCE Net Verified Savings (kW)	RER Gross Realized Savings (kW)	RER Net Realized Savings (kW)
Lighting				
Indoor Ltg.			*4,085*	*3,249*
LED Ltg. Only			*299*	*206*
Outdoor Ltg. Only			*8*	*6*
Total Lighting	***4,573***	***3,260***	***4,392***	***3,460***
HVAC *	707	580	1,785	1,649
Refrigeration	66	50	298	298
Process	108	90	108	83
Miscellaneous			22	17
All	**5,453**	**3,980**	**6,605**	**5,507**

** SCE savings for HVAC include Miscellaneous*

1.8 Organization of the Report

The remainder of this report is organized as follows:

- Section 2 describes the data used in the analysis.
- Section 3 provides a discussion of the engineering estimates developed for use in the analysis.
- Section 4 provides a general description of the realization rate approach, the specific model, and presents the gross realized savings.
- Section 5 describes the net-to-gross analysis and presents the net realized energy and demand savings.
- Appendix A discusses the building type identifiers used in the study.
- Appendix B contains a copy of the on-site survey instrument.
- Appendix C contains site information sheets and the program participation coupon.
- Appendix D presents a comparison of ADM and SCE HVAC engineering savings.
- Appendix E summarizes weather data.
- Appendix F discusses the aggregation of sites.
- Appendix G details the net-to-gross analysis.

2

Data

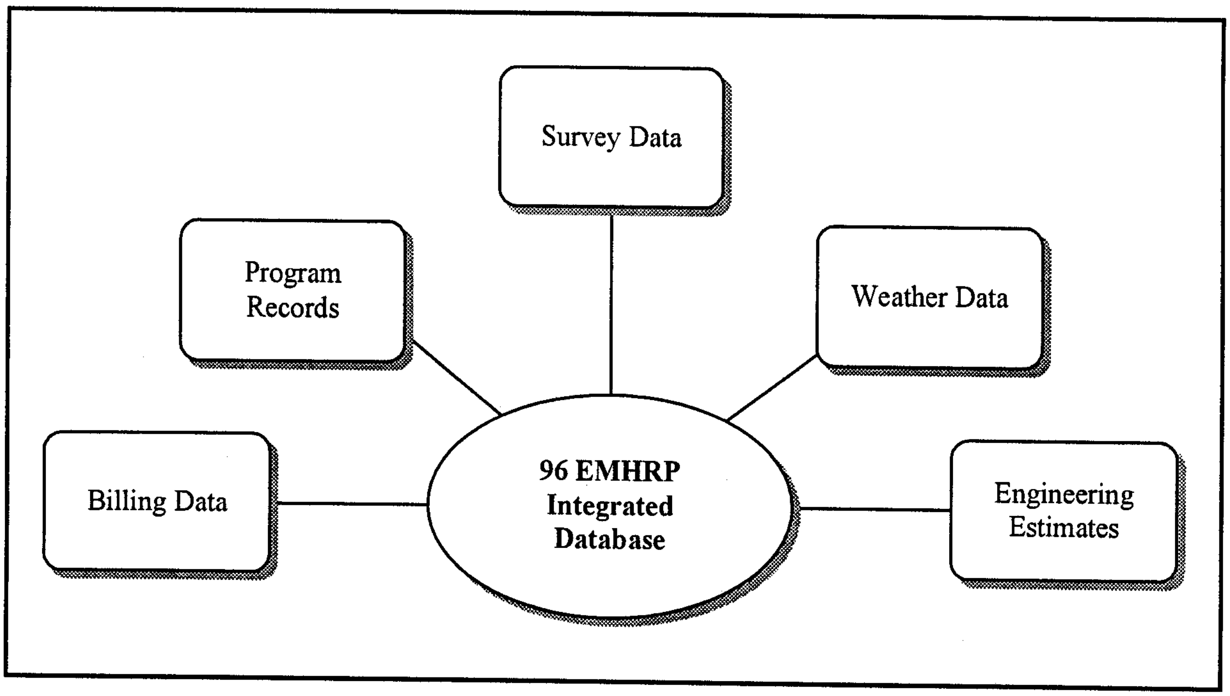
2.1 Overview

This section describes the development process of the integrated database used in the evaluation of SCE's 1996 Commercial Energy Management Hardware Rebate Program (96 EMHRP). The components required to construct the database are as follows:

- Survey data,
- Program records,
- Billing records,
- Weather data, and
- Engineering estimates.

These components are illustrated in Figure 2-1.

Figure 2-1: Overview of Database Construction



Annual engineering estimates of savings for lighting and refrigeration and monthly engineering estimates of savings for HVAC are calculated at the site level. These are described further in Section 3.

2.2 On-Site Survey of Commercial Sites

Survey data were collected through on-site surveys by ADM Associates, Inc. and include the following general information on the commercial sites surveyed:

- Industry type,
- Year established,
- Building specifications,
- Major changes and renovations at the site after 1994,
- Operating schedules,
- Usage characteristics, and
- Verification of equipment used before and after retrofitting.

Survey instruments were developed and pre-tested from the perspective of their ultimate use in assessing energy loads and impacts. The participant and nonparticipant samples were then developed and stratified by building type and annual consumption. A subsample of 50 sites was then monitored for operating hours and other information to supplement the survey data. Finally, case weights were developed for each building type and strata level to expand the surveyed sample back to the population.

Development of Survey Instruments

An on-site survey questionnaire was designed to satisfy four objectives:

- To collect information on energy efficiency decisions to be used in the net-to-gross analysis,
- To assess the implementation of program and non-program measures,[1]
- To collect current information on the facility to support the analysis of energy usage and realized DSM impacts, and
- To ascertain site changes that could affect energy usage over the period covered by the billing analysis.

[1] Program measures include all measures covered by the 1996 Hardware Rebate Program that were installed by at least one 1996 participant. Further, collected information should include data on incentivized and non-incentivized program measures.

The on-site instrument is comprehensive in addressing facility characteristics, modes and schedules of operation, and electrical and mechanical systems. The level of information derived from on-site characteristics depends to some extent on the uses of the data. In this study, the survey instrument focused primarily on site features that were particularly relevant to the performance of the DSM measures. For lighting measures, emphasis was placed on inventories, controls, and hours of operation. For HVAC measures, the focus was on equipment features, operating schedules, and general building characteristics.

Information on changes at the site was also collected so that billing analyses could be designed to control for these changes in the course of assessing program impacts. These changes include changes in equipment stocks, structural alterations, changes in occupancy rates and schedules, and DSM activities outside the program.

Pre-Testing

RER conducted a pre-test of the survey instrument on 20 customers mutually agreed upon by the Project Manager, RER, and ADM. RER supplied ADM with a list of 60 participants that represented the full range of conservation project types. ADM completed on-site visits for ten sites with HVAC conservation measures and ten with indoor lighting measures. The pre-test on-site surveys were performed by ADM engineers who documented questions and observations on the survey instrument. Further, the engineers noted any additional information that should be included in the survey. SCE project management staff accompanied the ADM engineers on one on-site visit to observe the effectiveness of the survey and survey protocol.

RER, ADM, and SCE project staff reviewed the results of the pre-test from the perspective of their ultimate use in assessing energy loads and impacts. Once the on-site pre-tests were completed, RER issued a memorandum to the Edison Project Manager documenting the results of the pre-test and outlining any modifications made to the survey instruments. Upon the Project Manager's approval, the instruments were finalized. A copy of the final On-Site Survey Instrument[2] is provided in Appendix B.

Participant/Nonparticipant Sample Design

The sample design required an attempted census of participants who installed HVAC, indoor lighting, and/or refrigeration measures and a completed sample of 300 nonparticipants matched to participants by stratifying the participant sample on annual consumption and building type.

2 A draft on-site survey instrument was designed by ADM and RER. Copies were sent to SCE staff for comments and edits that were then incorporated into the final version.

Participant Group Sampling Plan

The first step of the participant group sampling plan was to define the unit of sampling and the sample frame.

Sampling Unit. The sampling unit (site) is defined to be a premise or premises served by a single account or group of accounts where the service name is the same, the premise or premises are on the same side of the street, and/or share the same transformer. This definition is consistent with SCE's streetwalk algorithm.[3]

Sample Frame. The participant sample frame consists of a screened list of all commercial 1996 program participant sites.[4] The unscreened list of sites was developed from program participant files and hard copy program coupons provided by SCE. Coupons are tracked by Customer Incentive Reference (CIR) number[5] and there are three types of participant coupons.

- ***Regular.*** These coupons cover sites that have only a single CSS account.[6] Sites for regular accounts were identified by mapping CSS accounts to the streetwalk identifier on the SCE billing frame. There are 266 regular coupons in the participant database that were mapped to 266 sites.
- ***Multiple.*** These coupons cover situations where there are multiple sites with one or more CSS accounts all in the same general location. Good examples of multiple accounts are malls or office complexes. Sites for multiple coupons were developed by identifying all accounts associated with each coupon and mapping these to the streetwalker identifier on the SCE billing frame. This process required a review of the hard copy coupon data by RER and SCE program staff. There are 26 multiple coupons in the participant database that were mapped to 189 sites.
- ***Chain.*** Coupons written for chains are characterized by a single coupon covering many site accounts—all of which are at different locations. Good examples of a chain coupon are chain grocery stores and chain drug stores. These coupons were handled in the same manner as multiple accounts. Again, a case-by-case review by RER and SCE program staff was made to ensure all sites and accounts associated with each chain coupon were identified. There are 20 chain coupons in the participant database that were mapped to 343 sites.

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3 *Rebuild of Custloc, Modification of Streetwalk to Include Customer Names*, J. Peterson, SCE internal memo, February 1997. Sites for this study were aggregated based on streetwalk identifier *GRP2IDX*.

4 The 1996 program participant database was screened to include only commercial customers (CUSTID = "C").

5 Customer Incentive Reference (CIR) numbers are SCE's identifiers for coupons. In most cases, the CIR number is identical to the RER site identifier; however, in some cases sites were combined so that a single RER site may represent more than one CIR site and hence more than one coupon.

6 A service account in the Customer Service System (CSS) that represents usage of a single kWh meter or other distinct service.

Aggregation of the sites from the regular, multiple, and chain coupon breakouts was required. In particular, cases where more than one regular coupon was written for the same site, or where a regular coupon was written for a chain or multiple site, were aggregated. The process of identifying sites from coupons resulted in a database containing 775 sites. The following screens were used to develop the participant frame from this broader database.

- ***HVAC, Indoor Lighting, and Refrigeration Measures.*** The database was screened to include only sites that installed an HVAC, indoor lighting, or refrigeration measure. This approach is consistent with the CPUC protocols requiring the reporting of the impacts of indoor lighting and HVAC end-use elements.[7]
- ***LED Exit Signs.*** Sites that installed LED exit sign measures were also screened from the database.

For purposes of stratification, a building type identifier[8] was attached to each site. A summary sorted by building type (ten types) of the participant database screening process is presented in Table 2-1.

The final participant sample frame consists of 366 sites. However, 83 of these sites are attributable to two relatively homogeneous types of sites.

- ***Drug Store Chain.*** There are 54 drug stores in this chain and all are covered by the same coupon included in the participant sample. Further, these sites are relatively homogeneous within four store types[9] and all stores except one had indoor lighting and space conditioning program measures installed.
- ***Food Store Chain.*** There are 29 food stores in this chain in the participant sample frame. These stores are covered by two coupons. One coupon covers 24 stores—all with space conditioning, refrigeration, and indoor lighting measures. The other coupon covers five stores—all with space conditioning measures.

The approach used to sample participants is to attempt a census of all non-chain stores and a completed sample of ten of the drug stores and nine of the food stores to represent the chain stores. The target sample of ten drug stores includes three of each store type and the store with refrigeration measures installed. The target sample of food stores includes five with space conditioning and indoor lighting and four with space conditioning only.

7 Protocols and Procedures for the Verification of Costs, Benefits and Shareholder Earnings from Demand-Side Management Programs, as adopted by California Public Utilities Commission Decision 93-05-063, January 1997, *Table C-4*.

8 A detailed description of the derivation of building type identifiers is provided in Appendix A.

9 Southern California Edison's Verification Study of the 1996 Commercial, Industrial, and Agricultural Rebate Program, Ridge and Associates, 1997.

Table 2-1: Summmary of Participant Frame Screening Process

Building Type	All Sites		All Sites with Refr., HVAC, or Indoor Lighting Measures		No Sites with LED Exit Light Measures Only	
	Sites	CIRs	Sites	CIRs	Sites	CIRs
Office	295	132	148	120	103	98
Restaurants	15	10	12	7	11	6
Retail	11	35	109	33	104	30
Food Stores	38	11	38	11	38	11
K-12 Schools	64	19	59	18	50	10
Colleges/Universities	10	13	10	11	9	10
Warehouse	14	15	13	14	13	14
Hospital/Clinic	19	22	19	22	10	13
Hotel/Motel	10	10	9	9	1	1
Miscellaneous	199	75	189	38	27	27
Total	**775**	**312**	**606**	**283**	**366**	**220**

For purposes of sampling a comparable nonparticipant group, the participant sample was stratified by building type and annual pre-program consumption (high and low).[10] The high/low break points were derived using the following approach.[11]

- ***Offices (1,000 MWh).*** Large offices are considered to be 50,000 square feet or above with an annual intensity of 20 kWh per square foot.
- ***Restaurants (150 MWh).*** Large restaurants are assumed to be greater than 2,500 square feet with an average annual intensity of 60 kWh per square foot.
- ***Retail (600 MWh).*** Large retail sites are considered to be above 30,000 square feet with an annual intensity of roughly 17 kWh per square foot.
- ***Food Stores (1,000 MWh).*** Large food stores are assumed to be larger than 20,000 square feet with an annual intensity of 50 kWh per square foot.

[10] Pre-program participation consumption data were used to develop estimates of annual consumption. For the majority of sites, 1995 consumption data were used. For sites with incomplete 1995 data, an average of pre-participation monthly use was used to estimate annual use.

[11] Annual intensities were consistent with annual averages developed in the *Commercial Data Development Handbook*, EPRI, 1993.

- ***Warehouse (500 MWh).*** Large warehouses are assumed to be larger than 20,000 square feet with an annual intensity of 25 kWh per square foot.
- ***K-12 Schools (500 MWh).*** Large K-12 schools are assumed to be greater than 50,000 square feet with an annual intensity of 10 kWh per square foot.
- ***Colleges and Universities (500 MWh).*** Large colleges and universities were assumed to be greater than 50,000 square feet with an annual intensity of 10 kWh per square foot.
- ***Hospitals and Clinics (2,500 MWh).*** Inspection of the participant data revealed a clear break point in the participant data between what appear to be small clinics and hospitals. This break point implies that large hospitals and clinics are greater than 125,000 square feet with an annual intensity of 20 kWh per square foot.
- ***Hotels and Motels (500 MWh).*** Large motels are assumed to be greater than 33,333 square feet with an annual intensity of 15 kWh per square foot.
- ***Miscellaneous (1,000 MWh).*** Large miscellaneous sites are assumed to be greater than 66,000 square feet with an annual intensity of 15 kWh per square foot.

Table 2-2 presents a summary of the targeted participant sample by annual pre-program consumption and building type.

Table 2-2: Participant Sample Targets

Building Type	kWh Strata	Sites	Percent
Office	High (> 1,000 MWh)	43	14.33
	Low (<= 1,000 MWh)	59	19.67
Restaurant	High (> 150 MWh)	4	1.33
	Low (<= 150 MWh)	4	1.33
Retail	High (> 600 MWh)	23	7.67
	Low (<= 600 MWh)	30	10.00
Food Stores	High (> 1,000 MWh)	14	4.67
	Low (<= 1,000 MWh)	4	1.33
Warehouse	High (> 500 MWh)	4	1.33
	Low (<= 500 MWh)	7	2.33
K-12 Schools	High (> 500 MWh)	11	3.67
	Low (<= 500 MWh)	27	9.00
College/University	High (> 500 MWh)	8	2.67
	Low (<= 500 MWh)	2	0.67
Hospital/Clinics	High (> 2,500 MWh)	5	1.67
	Low (<= 2,500 MWh)	4	1.33
Hotel/Motel	High (> 500 MWh)	1	0.33
	Low (<= 500 MWh)	0	0.00
Miscellaneous	High (> 1,000 MWh)	11	3.67
	Low (<= 1,000 MWh)	39	13.00
Total	**High**	**124**	**41.33**
	Low	**176**	**58.67**
	ALL	**300**	**100.00**

Nonparticipant Sampling Plan

The nonparticipant sample design requires a completed sample size of 300 sites. Sites were determined by SCE staff from streetwalker identifiers on the SCE billing frame. All accounts associated with each site were grouped using a single identifier. The frame used for the nonparticipants is a *screened* sample of commercial sites. In particular, the following two screens were applied to all active accounts. Any sites associated with a screened account were omitted from the nonparticipant frame.

Screen 1. Accounts on the SCE commercial billing frame were screened by the following criteria:

- Participation in other SCE 1996 DSM programs,
- Site contains account payable by SCE,
- Participation in on-site survey conducted by SCE in last 12 months, and
- Eligibility for the DSM Bidding Pilot Program (mostly offices).

Screen 2. Accounts that passed through Screen 1 were then screened for sufficient billing data. In particular, accounts (and the associated sites) that were not active in December of 1994 were omitted from the frame.

Table 2-3 presents a summary of the nonparticipant frame by building type.

Table 2-3: Summary of Nonparticipant Frame Screening Process

Building Type	All Sites	Screen 1	Screen 2	Percent
Office	72,297	48,261	33,268	19.7
Restaurant	15,675	15,528	9,812	5.8
Retail	29,502	29,028	17,703	10.5
Food Stores	8,099	7,922	5,300	3.1
Warehouse	13,196	13,030	7,916	4.7
K-12 Schools	4,014	3,864	3,095	1.8
College/University	1,474	1,424	918	0.5
Hospital/Clinics	2,385	2,269	1,642	1.0
Hotel/Motel	2,506	2,445	1,903	1.1
Miscellaneous	123,371	122,206	87,258	51.7
Total	**273,519**	**245,977**	**168,815**	**100.0**

The nonparticipant sample was drawn from the frame in the same proportion by building type and annual consumption as participants. Table 2-4 summarizes the targeted nonparticipant sample by building type and consumption strata.

Table 2-4: Nonparticipant Sample Targets

Building Type	kWh Strata	All Sites	Target	Percent
Office	High (> 1,000 MWh)	496	43	14.33
	Low (<= 1,000 MWh)	32,775	59	19.67
Restaurant	High (> 150 MWh)	3,090	4	1.33
	Low (<= 150 MWh)	6,722	4	1.33
Retail	High (> 600 MWh)	1,013	30	10.00
	Low (<= 600 MWh)	16,690	23	7.67
Food Stores	High (> 1,000 MWh)	517	14	4.67
	Low (<= 1,000 MWh)	4,783	4	1.33
Warehouse	High (> 500 MWh)	327	4	1.33
	Low (<= 500 MWh)	7,589	7	2.33
K-12 Schools	High (> 500 MWh)	359	11	3.67
	Low (<= 500 MWh)	2,736	27	9.00
College/University	High (> 500 MWh)	48	8	2.67
	Low (<= 500 MWh)	870	2	0.67
Hospital/Clinics	High (> 2,500 MWh)	68	5	1.67
	Low (<= 2,500 MWh)	1,604	4	1.33
Hotel/Motel	High (> 500 MWh)	216	1	0.33
	Low (<= 500 MWh)	1,687	0	0.00
Miscellaneous	High (> 1,000 MWh)	530	11	3.67
	Low (<= 1,000 MWh)	86,728	39	13.00
Total	**High**	**6,631**	**131**	**43.67**
	Low	**162,184**	**169**	**56.33**
	ALL	**168,815**	**300**	**100.00**

End-Use Metering Sample. End-use metering of 50 sites (25 with lighting and 25 with HVAC measures) was performed as part of the on-site data collection effort. The end-use metering sample design was structured around expected savings. In particular, the expected savings by measure for the participant sample of 300 were calculated. The sample of 25 lighting and 25 HVAC sites was then distributed across measures by percent of total savings. Table 2-5 and Table 2-6 summarize the break out of the metering sample by measure type and end use for lighting and HVAC, respectively. Within each measure type, sites were recruited by total savings, with larger sites being recruited first. This was done until strata targets were reached.

Table 2-5: End-Use Metering Sample Design: Lighting Measures

Measure	Total Savings	Percent Savings	Sample
Component - Disconnect Lamp-Fixture Replacement	1,787,468	9.02%	2
Component - Disconnect Lamp-Rewire	9,020,668	45.53%	11
Component - LED Exit Signs	930,698	4.70%	0
Component - Outdoor Lighting System Modification	249,103	1.26%	1
Component - Outdoor Lighting System Replacement	1,457,701	7.36%	2
Component -Delamp From 8 To 4 Feet	1,641,850	8.29%	2
Component -Delamp From FB40 To F17T8	434,514	2.19%	1
Daylighting System	118,936	0.60%	0
EMS (Lighting)	2,938,973	14.84%	4
Indoor Lighting System - Modification	406,207	2.05%	1
Indoor Lighting System - Replacement	811,903	4.10%	1
Occupancy Sensor - Indoor	12,468	0.06%	0
Total	**19,810,489**	**100.00%**	**25**

Table 2-6: End-Use Metering Sample Design: HVAC Measures

Measure	Total Savings	Percent Savings	Sample
Air Distribution System	807,739	4.13%	1
ASD (Space Conditioning)	9,150,067	46.83%	12
Chilled Water Controls	293,108	1.50%	0
Chiller 200 - 600 Ton	267,003	1.37%	0
Chiller 75 - 200 Ton	114,198	0.58%	0
Component - Air Cooled Single Package A/C	341,331	1.75%	1
Economy Cycle	902,716	4.62%	1
Miscellaneous (Space Conditioning)	7,621,922	39.01%	10
Motors (HVAC) - 3 Phase	41,306	0.21%	1
Total	**19,539,390**	**100.00%**	**25**

Survey Implementation

Personnel from ADM Associates, Inc. conducted and implemented the on-site surveys. Their efforts included the following:

- Preparing the data collection instrument,
- Selecting and training field staff,
- Scheduling on-site visits,
- Reviewing program documentation,
- Collecting characteristic data on site,
- Conducting end-use monitoring,
- Coding and verifying the data collected, and
- Validating, editing, and processing the data.

Field staff used in the data collection effort consisted of staff engineers who have collected data for on-site data collection projects for SCE and other utilities. Each member of the field staff has a degree in engineering and has experience collecting data on end uses in a variety of industrial facilities. Training sessions were held to instruct field staff in requirements specific to the SCE Hardware Rebate Program.

An ADM staff member scheduled visits for the engineers by contacting the customer, explaining the purpose of the visit, screening prospective sites for targeted activities (replacements and acquisitions), and arranging the date and time for the data collection visit.

RER provided documentation to ADM's field staff to be reviewed before visiting each site.[12] The program coupons were reviewed by the analysis engineers and compared to the Edison database to assess the measures for which data needed to be collected and to verify the information in the Edison program database. Information verified includes building square footage, addition and remodel areas (if applicable), building type, and program measures. Special attention was given to distinguishing rebated measures *versus* recommended measures. A complete list and descriptions of the rebated and recommended measures were provided to the survey engineers. During the on-site surveys, the engineers verified the installation of the rebated measures and assessed whether the recommended measures were installed.

[12] A site-specific summary sheet containing all relevant data were developed by RER. RER provided these sheets, SCE program records, and 1996 Hardware Rebate Coupons to ADM. Examples of these sheets and the program coupons are presented in Appendix C.

During the on-site data collection visit, the field staff accomplished two major goals. First, they verified that the measures that were rebated were indeed installed, that they were installed correctly, and that they still functioned properly. Second, they collected the data needed to analyze the energy savings that have been realized from the installed measures.

In verifying that measures were installed and that the installation had been done correctly, ADM's field staff examined the following:

- For lighting measures, ADM checked and verified the installation of lamps, ballasts, reflectors, and controls. ADM also estimated lighting levels.
- For HVAC measures for packaged systems, ADM obtained nameplate information for the installed equipment. Using this information, ADM obtained the manufacturer's data on efficiencies, which were then checked against the efficiency claimed on the application. For measures that apply to built-up systems, ADM checked fan and pump motors to verify their efficiency and capability for variable speed drive.
- For motors, information pertaining to efficiency was obtained from nameplates. Motors with adjustable speed drives (e.g., as used in variable air volume distribution systems, distribution pumps, or industrial processes) were connected to a controller box that varies the speed according to load requirements, or a clamp-on voltage meter was used to measure the variation in voltage provided by the controller box to the motor.
- For control measures, ADM checked for proper installation and enumerated the type and number of control points installed.

In some cases, the survey team worked with site management and the installation contractor to establish that installed measures were indeed working properly. Manual intervention was also required in some instances to start and/or stop an HVAC system, actions that required working with site management.

As the second aspect of the on-site visit, data were collected on a wide variety of other factors that affect energy use by end uses. Data on these factors were needed in order to analyze and to verify the energy savings of rebate measures.

- For lighting, important factors include the numbers and types of fixtures, lamps, and ballasts, and the usage patterns for lighting in different parts of a site. Outside lighting was surveyed as part of this effort.
- For space cooling, energy use varies according to the type of cooling equipment and distribution systems and depends moreover on a building's type, size, age, structural characteristics, and weather conditions.

Data were also needed pertaining to the present pattern of and recent changes in energy use at a site. To support this component of the survey, RER provided ADM with energy-use histories for each site. Data for 12 previous months (if available) were used to establish any seasonal aspects in the pattern of energy use, and to identify major changes in usage that could be linked to structural, operational or other factors.

Several sources of data were utilized during the on-site visits.

- ***Interview with Facility (Site) Staff.*** Data were collected first through interviews with the site's staff. These interviews provided information on occupancy schedules, lighting schedules, ventilation schedules, equipment schedules, operational practices, maintenance practices, and a number of other "human factors" associated with energy use at the site.
- ***Review Site-Specific Documentation.*** Surveyors also reviewed documents or records at the site, including basic building plans and dimensions from structural and architectural drawings (if available), and wall, window, roof, and floor material characteristics from architectural drawings. These data also include information on HVAC systems and equipment, lighting, and hot water systems from mechanical, electrical, and plumbing plans.
- ***Visual Inspection.*** Visual inspections were made of control settings, lighting levels, inventory of end-use appliances and equipment, ventilation rates, building population, occupancy level, and other parameters.

Photographs of a site and of its electrical and mechanical systems were also taken during the on-site visits as a means of verifying the data collected.

ADM used a number of quality control procedures throughout the on-site data collection effort to ensure that the data collected were of high quality. Each completed data collection form was thoroughly reviewed by the field staff supervisor. Care was taken to ensure that a form was completely filled out and that the data collected were of acceptable quality. Other checking procedures were used once the data were entered into the database management system.

Completed data collection forms were coded and verified in ADM's offices. In-house coders were provided guidelines on items to check for possible inconsistencies in responses and were given procedures for following up on missing responses and apparent inconsistent answers. After a completed data collection form was coded, the data were entered into a computerized database.

Survey Dispositions

Table 2-7 presents a summary of the disposition of each sampled nonparticipant site. The survey protocol required that a maximum of three contact attempts be made to each sample site. As shown, 1,116 sites were contacted and a total of 1,875 calls were made in order to obtain a survey group of 308 nonparticipants. These results yield a response rate of 28 percent.

Table 2-7: Disposition of Nonparticipant Survey Contacts

Disposition	First Call	Second Call	Third Call	Total
Completed Survey	154	99	55	308
Scheduled Callback	52	16	13	81
Left Message	246	173	121	540
Busy	16	17	4	37
Answering Machine	10	3	1	14
No Answer	68	40	33	141
Call Back Later	108	29	16	153
Over Quota	2	0	5	7
Not Qualified	61	11	1	73
Wrong Number	132	5	1	138
Initial Refusal	203	60	51	314
Mid-Terminate	1	0	0	1
Business/Fax	14	1	0	15
Disconnected Number	42	3	0	45
Language Barrier	7	0	1	8
Total	1,116	457	302	1,875

Completed Sample Structure

Table 2-8 and Table 2-9 present an overview of the completed sample as compared to the target for participants and nonparticipants, respectively. Each table includes the number of completed surveys for each building type and strata, in addition to the strata target.

Table 2-8: Summary of Completed Participant Sample

Building Type	kWh Strata	All Sites	Targeted		Completed		Case Weights
			No.	Percent	No.	Percent	
Office	High (> 1,000 MWh)	496	43	14.33	37	13.75	1.21
	Low (<= 1,000 MWh)	32,775	59	19.67	54	20.07	1.07
Restaurant	High (> 150 MWh)	3,090	4	1.33	3	1.12	2.86
	Low (<= 150 MWh)	6,722	4	1.33	4	1.49	1.00
Retail	High (> 600 MWh)	1,013	30	10.00	19	7.06	1.79
	Low (<= 600 MWh)	16,690	23	7.67	26	9.67	1.04
Food Stores	High (> 1,000 MWh)	517	14	4.67	14	5.20	1.00
	Low (<= 1,000 MWh)	4,783	4	1.33	2	0.74	1.73
Warehouse	High (> 500 MWh)	327	4	1.33	4	1.49	1.00
	Low (<= 500 MWh)	7,589	7	2.33	7	2.60	1.00
K-12 Schools	High (> 500 MWh)	359	11	3.67	10	3.72	1.04
	Low (<= 500 MWh)	2,736	27	9.00	27	10.04	1.00
College/ University	High (> 500 MWh)	48	8	2.67	7	2.60	1.00
	Low (<= 500 MWh)	870	2	0.67	2	0.74	1.00
Hospitals/ Clinics	High (> 2,500 MWh)	68	5	1.67	4	1.49	1.02
	Low (<= 2,500 MWh)	1,604	4	1.33	3	1.12	1.43
Hotel/Motel	High (> 500 MWh)	216	1	0.33	0	0.00	1.10
	Low (<= 500 MWh)	1,687	0	0.00	0	0.00	1.08
Misc.	High (> 1,000 MWh)	530	11	3.67	10	3.72	1.10
	Low (<= 1,000 MWh)	86,728	39	13.00	36	13.38	1.08
Total	**High**	**6,631**	**131**	**43.67**	**108**	**40.15**	
	Low	**162,184**	**169**	**56.33**	**161**	**59.85**	
	ALL	**168,815**	**300**	**100.00**	**269**	**100.00**	

Table 2-9: Summary of Completed Nonparticipant Sample

Building Type	kWh Strata	All Sites	Selected Sites	Targeted		Completed		Case Weights
				No.	Percent	No.	Percent	
Office	High (> 1,000 MWh)	496	430	43	14.33	43	14.10	2.37
	Low (<= 1,000 MWh)	32,775	590	59	19.67	59	19.02	8.25
Restaurant	High (> 150 MWh)	3,090	40	4	1.33	4	1.31	1.49
	Low (<= 150 MWh)	6,722	40	4	1.33	4	1.31	1.84
Retail	High (> 600 MWh)	1,013	300	30	10.00	24	7.87	1.49
	Low (<= 600 MWh)	16,690	230	23	7.67	32	10.49	2.83
Food Stores	High (> 1,000 MWh)	517	140	14	4.67	14	4.59	1.45
	Low (<= 1,000 MWh)	4,783	40	4	1.33	4	1.31	0.40
Warehouse	High (> 500 MWh)	327	40	4	1.33	4	1.31	3.44
	Low (<= 500 MWh)	7,589	70	7	2.33	7	2.30	4.32
K-12 Schools	High (> 500 MWh)	359	110	11	3.67	11	3.61	1.38
	Low (<= 500 MWh)	2,736	270	27	9.00	28	9.18	1.22
College/ University	High (> 500 MWh)	48	48	8	2.67	9	2.95	29.31
	Low (<= 500 MWh)	870	40	2	0.67	2	0.66	2.58
Hospitals/ Clinics	High (> 2,500 MWh)	68	39	5	1.67	6	1.97	2.15
	Low (<= 2,500 MWh)	1,604	40	4	1.33	4	1.31	38.73
Hotels/ Motels	High (> 500 MWh)	216	10	1	0.33	1	0.33	4.08
	Low (<= 500 MWh)	1,687	0	0	0.00	0	0.00	4.33
Misc.	High (> 1,000 MWh)	530	110	11	3.67	11	3.61	4.08
	Low (<= 1,000 MWh)	86,728	390	39	13.00	41	12.79	4.33
Total	**High**	**6,631**	**1,266**	**131**	**43.67**	**127**	**41.64**	
	Low	**162,184**	**1,710**	**169**	**56.33**	**181**	**58.36**	
	ALL	**168,815**	**2,976**	**300**	**100.00**	**308**	**100.00**	

Case Weights

Weights were used to compare results based on sample analysis with the population. These weights were based on pre-participation annual consumption, using data provided by SCE. The weights were calculated for each building type and consumption strata as the sum of kWh for the population of participants over the sum of kWh for the sample (for both participants and nonparticipants).

The sample groups and case weights used are listed in the final three columns of Table 2-8 and Table 2-9 for participants and nonparticipants, respectively. Population groups are the sample frames of 300 participants and 2,976 nonparticipants. Additional information on how the case weights were derived is provided in Appendix G.

2.3 Weather Data

Actual daily high and low temperatures by weather zone were obtained from SCE's weather files. The data covered the period January 1991 through September 1997 for each of 24 weather zones.[13] Monthly high and low temperatures by weather zone were used to construct heating degree days (HDD) and cooling degree days (CDD).[14]

Typical meteorological year (TMY) weather data by California Energy Commission (CEC) weather zones were used as normal weather. A standard TMY of weather data is constructed by reviewing individual months of weather data from each weather station over a 23-year period. A typical month for each of the 12 calendar months from the long-term period of record is chosen and combined to form the TMY. Selection basis for a typical month consists of 13 daily indices calculated from the hourly values of dry-bulb and wet-bulb temperature, wind velocity, and solar radiation. Month/year combinations with statistics "close" to the long-term statistics are candidates for typical months. Final selection of a typical month includes consideration of persistence of weather patterns.

Figure 2-2 presents actual annual CDDs and HDDs averaged over all SCE weather stations represented in the evaluation sample during 1994, 1995, 1996, and 1997, and compared with the average normal TMY HDD and CDD.

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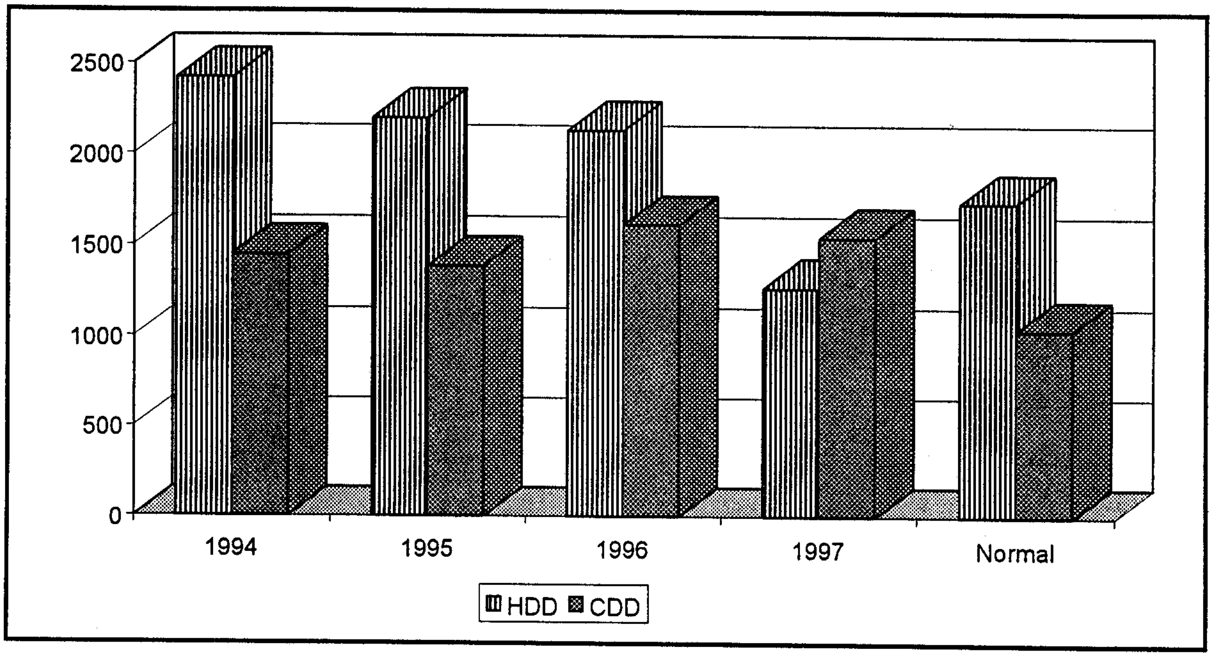
[13] Missing temperature values were calculated for a representative weather station (8495004) by averaging the previous and subsequent days' values. The representative station was then used as a regressor to predict missing values for other stations.

[14] Heating and cooling degree days are computed as follows:

HDD base 60 = max{0, (60 - daily average temperature)}
CDD base 60 = max{0, (daily average temperature - 60)}
daily average temperature = (daily maximum temperature + daily minimum temperature) / 2.

Weather data were merged with other database components by SCE weather station account numbers[15] and read dates. Additional details on the weather data are described in Appendix E.

Figure 2-2: Annual HDD and CDD for 1994 - 1997



2.4 Consumption Data

SCE provided consumption data for participants and nonparticipants. This included billing cycle data for usage, meter numbers, read dates, and number of billing days by premise ID for the December 1994 through September 1997 period.

The consumption data in the final database were derived directly from customer billing files. These billing records, while reasonably accurate, contain some anomalies that can be troublesome in the analysis. The billing records of the sample were inspected closely for the following problems:

- Erroneous billing days and/or read dates,
- Abnormal monthly consumption, and
- Missing or zero electricity usage (the latter may indicate an inactive account).

[15] Missing weather stations for 32 sites were supplied through a mapping of zip codes to weather station numbers.

Anomalies including high reads, inconsistencies due to new accounts, and transfers of accounts to new tenants were found. Considerable time was spent with SCE to line up the consumption figures properly with the sites. This entailed checking individual meters on approximately 50 sites and adding or deleting meters from sites where appropriate. Five related groups of sites were aggregated due to inconsistencies in their consumption data that prevented matching individual meters to specific locations. A description of the aggregated sites is given in Appendix F.

Typical building intensities were compared to building intensities calculated from the data. Anomalies were investigated along with inconsistencies in square footage. With the help of additional information from SCE, changes were made in the square footage of approximately 50 sites. Table 2-10 compares building intensities in the sample by building type and participant status.

Table 2-10: Summary of Average Building Intensities

Building Type	No. in Sample	Mean
Participants		
Offices	64	16
Restaurants	2	70
Retail Stores	42	20
Food Stores	14	56
Warehouses	9	7
K-12 Schools	28	6
Colleges & Universities	1	12
Hospitals & Clinics	4	30
Hotels & Motels	0	0
Miscellaneous	31	23
Subtotal Participants	195	
Nonparticipants		
Offices	78	15
Restaurants	8	55
Retail Stores	55	18
Food Stores	20	64
Warehouses	16	6
K-12 Schools	39	7
Colleges & Universities	9	13
Hospitals & Clinics	11	28
Hotels & Motels	0	0
Miscellaneous	45	18
Subtotal Nonparticipants	281	
Total	**476**	

Consumption data were merged with weather data by weather station account and bill date. The merged data were then calendarized using read dates and number of billing days in order to maintain consistency with the monthly engineering estimates of usage and savings.

2.5 SCE Hardware Rebate Program Participant Files

Program data were provided by SCE at a measure level in hard-copy and computer-readable format. It was collapsed to the site level and used along with billing data to provide information sheets to ADM to facilitate the on-site surveys. Typical information provided included the following:

- Identification of the business,
- Building characteristics,
- Description of the installed measures,
- A listing of meters on the premises, and
- Estimated annual consumption.

Program coupons consisting of approximately 312 records were mapped into 775 individual sites. Site identification numbers were developed from coupon CIR numbers in the following manner. First, coupons representing commercial sites were divided into three types: regular, multiple, and chain.

- Regular sites are those with a single CSS account. There were 266 coupons representing regular sites and these were mapped to 266 site identification numbers.
- Multiple sites are sites such as malls and office buildings with more than one business at the same location represented by one or more CSS account. There were 26 coupons representing multiple sites, and these were mapped to 189 site identification numbers.
- Chain sites are sites such as grocery and drug stores that have a single coupon covering many business locations. There were 20 coupons representing chain sites, and these were mapped to 343 site identification numbers.

From this broader database, the sites were screened to include only those that had installed an HVAC, indoor lighting, or refrigeration measure. In addition, sites that had installed only LED exit sign measures were screened from the database.

The database contained two groups of chain stores: a drug store chain comprised of 54 stores and a food store chain comprised of 29 stores. Due to (a) the large number of chain stores in the sample that had essentially the same installed equipment and operating patterns and (b) the inability or reluctance of some of these stores to accompany ADM engineers on survey visits, a subsample of these stores was selected to represent the rest. Ten drug chain stores and nine food chain stores were selected to represent the total group of 83 chain stores.

Building identifiers were added to the database along with consumption strata levels of high and low for the purpose of stratifying the sample. The following ten building identifiers were used:

- Offices,
- Restaurants,
- Retail stores,
- Food stores,
- Warehouses,
- K-12 schools,
- Colleges and universities,
- Hospitals and clinics,
- Hotels and motels, and
- Miscellaneous.

Information from this database was used to produce summary sheets for each site. These summaries were given to ADM Associates, Inc. to facilitate the on-site surveys.[16]

In addition, SCE's reportable savings are part of the database. These have been summarized to the site level, and can also be further collapsed to end use. Table 2-11 and Figure 2-3 show a breakdown of the savings by end use.

The measures installed in the 96 EMHRP were predominantly ASDs for motors and space conditioning equipment, energy management systems for space conditioning and lighting, disconnecting/rewiring lamps, and LED exit signs. SCE's gross *ex ante* estimates of savings for the 96 EMHRP were 57,025,728 kWh and 5,453 kW.[17]

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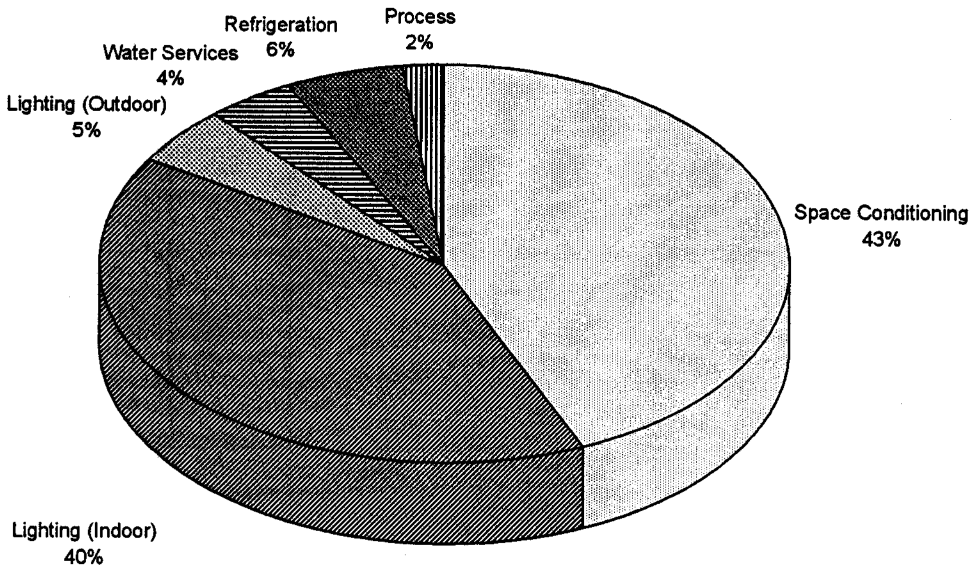
16 A sample is in Appendix C.

17 Protocols and Procedures for the Verification of Costs, Benefits and Shareholder Earnings from Demand-Side Management Programs, as adopted by California Public Utilities Commission Decision 93-05-063, January 1997, *Table C-4.*

Table 2-11: SCE Gross Ex-Ante Savings by Measure

Program Measure	Percentage of End Use	Ex-Ante Savings (kWh)	Ex-Ante Savings (kW)
Space Conditioning			
ASD	43	10,715,013	0
EMS	36	8,971,830	16
Misc.	9	2,203,297	169
Economy cycle	4	902,716	0
Air distribution system	3	769,891	87
Air cooled single pkg A/C	2	391,946	224
Chilled water controls	1	293,108	0
Chiller 200 - 600 ton	1	267,003	120
Chiller 75 - 200 ton	0	114,198	62
Motors - 3 phase	0	41,306	6
Lighting (Indoor)			
Disconnect lamp - rewire	39	8,945,863	2,695
EMS	23	5,274,428	0
LED exit signs	15	3,543,786	406
Disconnect lamp fixture - replacement	8	1,785,591	728
Delamp from 8' to 4'	7	1,699,012	436
System replacement	4	811,903	137
Delamp from F840 to F17T8	2	434,514	108
System modification	2	406,207	56
Daylighting system	1	118,936	0
Occupancy sensor	0	12,468	0
Lighting (Outdoor)			
Lighting system replacement	73	1,944,145	8
Lighting system modification	27	724,424	0
Water Services			
ASD	95	2,239,834	0
Pump system controls	5	126,243	22
Refrigeration			
EMS	46	1,484,034	0
Anti-sweat heater	27	887,643	38
ASD	17	543,880	1
Misc.	10	330,174	27
Process			
Air compressor system	51	534,481	46
Misc.	25	265,086	30
Air compressor	14	146,000	15
Cooling tower	9	96,768	16
Total		57,025,728	5,453

Figure 2-3: SCE Gross Ex-Ante Savings



2.6 Database Preparation

RER staff worked with SCE to correct anomalies in the data by examining inconsistencies in billing data, square footage, and building intensities. Observations with strong influences on realization rate estimations were identified and considered. These efforts resulted in the following modifications to the database used for the realization rate analysis.

- Approximately 25 sites were omitted due to the inability to line up billing meters with the surveyed and rebate-affected space. This includes sites with shared meters and sites where a small area was surveyed within a larger complex.
- Approximately 25 sites were omitted due to meter change-outs and long periods with zero consumption or inconsistent patterns of consumption.
- After lining up billing meters and square footage, and in some cases working with SCE to correct inconsistent billing data, approximately 25 sites still had unusual intensities. Specifically, when compared with average intensities from EPRI's *Commercial End-Use Data Development Handbook*, intensities were judged to be unusually high or low. These sites were omitted.
- Two sites were omitted due to being closed at the time of the on-site survey work – one for remodeling and one no longer in business.
- Approximately 325 observations from the remaining sites were omitted due to anomalous consumption data. Specifically, these were unexplained patterns of increases or decreases in consumption that were inconsistent with other site characteristics.

- The aggregation of six groups of sites reduced the total number of sites by 26.[18]

It is important to note that although these sites were omitted from the realization rate analysis, they were not deleted from the database. In determining program savings, they were included in the analysis since they contained valid engineering estimates of savings. There were, however, three nonparticipant sites deleted from the database due to their type of business being inconsistent with the realization rate analysis. Specifically, two were irrigation pumps and one was an open air power station.

To ensure consistency across customer accounts with different read dates, the following data transformations were performed:

- Historical consumption and weather data were normalized to a 30.4-day billing period with the use of billing days and read dates.
- Weather data were converted to billing cycle degree-day measures with the use of billing days and meter read dates. In order to make these values consistent with the usage levels contained in billing records, degree days were also normalized to a 30.4-day billing period.
- Monthly HVAC savings estimates were also normalized to a 30.4-day billing period to maintain consistency with usage levels.

2.7 Final Database Structure

The data sections were merged by site identification number and time period into one integrated panel database. This final database contains unique (constant over time) site characteristics that have been "fanned out" with monthly consumption and weather data, thereby creating monthly observations for each site. The final integrated database used for the realization rate analysis consists of 16,936 observations representing 476 commercial sites.

[18] These sites are explained in detail in Appendix F.

3

Engineering Estimates of Savings

3.1 Overview

This section discusses the methods used to develop engineering estimates of savings by measure and site for all eligible and non-eligible DSM measures. In particular, the data collected on-site (and, if available, monitored data) were used to develop engineering estimates of the energy and demand savings of the various energy conservation measures installed by customers participating in the 96 EMHRP Program. The major types of measures to be analyzed include the following:

- HVAC measures,
- Refrigeration measures, and
- Lighting measures.

Engineering estimates of three levels of usage for each eligible program measure were developed:

- ***Post-Retrofit Usage.*** This is the level of energy consumption (*POSTKWH*) and demand (*POSTKW*) for the installed high-efficient measure.
- ***Pre-Retrofit Usage.*** This is the level of energy consumption (*PREKWH*) and demand (*PREKW*) for the replaced measures.
- ***Baseline (Minimum Standard) Usage.*** This is the level of energy consumption (*BASEKWH*) and demand (*BASEKW*) for measures using equipment that just meets state and national standards.

These levels of usage were used to develop the following savings estimates.

- ***Customer Savings.*** Customer energy ($KWHCUST_j$) and demand ($KWCUST_t$) savings for each measure (j) are the difference between pre- and post-energy consumption and demand, respectively. This is the savings that are expected in the customer's bill from each measure. Note that in the case of net new purchases, this may be an increase in usage (pre-retrofit usage equals 0). Specifically,

$$KWHCUST_j = PREKWH_j - POSTKWH_j$$

$$KWCUST_j = PREKW_j - POSTKW_j$$

- **Reportable Savings.**[1] Reportable energy ($KWHREP_j$) and demand ($KWREP_j$) savings are the difference between baseline and post-retrofit energy use and demand, respectively. These estimates will be used to convert the estimates of realized savings to the savings relative to code. Specifically,

$$KWHREP_j = BASEKWHj - POSTKWH_j$$

$$KWREP_j = BASEKWj - POSTKW_j$$

A detailed description of the development of these engineering estimates for each major type of measure is presented in Section 3.3. To further calibrate these savings, on-site monitoring data were collected and utilized.

3.2 End-Use Monitoring

To supplement the on-site data collection, some end-use monitoring was conducted. The monitoring was used to obtain information on operating hours and other important factors for lighting measures and for package HVAC measures.

Procedures for Monitoring Lighting

For lighting measures, ADM monitored the post-retrofit hours of operation as the basis for calculating lighting efficiency savings. For this monitoring, ADM used Time-of-Use (TOU) data loggers manufactured by Pacific Science and Technology. The TOU loggers provided a time profile of on/off usage and, therefore allowed the calculation of kWh usage according to peak/off-peak periods. (In practice, the loggers sense when a fixture is on by detecting the light emitted while it is operating.)

For each facility with lighting efficiency measures that was selected for monitoring, a sampling plan was developed for monitoring a sample of "last points of control" for retrofitted fixtures in different types of usage areas to determine average operating hours of such fixtures. The degree of homogeneity among fixtures within a defined usage area should be high, thus requiring that only a few fixtures be monitored to determine hours of operation. However, there should be some degree of variation in operating hours among usage areas.

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[1] SCE uses the reportable savings as the basis for reporting program savings. However, over the course of the program year, there were some instances where the 96 EMHRP was credited with only a portion of the reportable energy and demand savings. This was due to changes in the procedures for reporting savings. As an example, in cases where lighting fixtures have been delamped and retrofit with high efficiency lamps and ballasts, only the delamping is credited to the 96 EMHRP. The savings from the installation of high efficiency lamps and ballasts are credited to SCE's 1996 Energy Management Services (EMS) Program. In these cases, the reportable savings were adjusted to include all savings, and the savings reported in the 1996 EMS Program were adjusted downward accordingly.

Procedures for Monitoring HVAC

ADM's approach for HVAC monitoring involved (1) making one-time measurements of voltage, current, and power factor of the motor, and (2) conducting continuous measurements of amps over a period of time in order to obtain the data needed to develop motor load profiles and calculate demand and energy savings.

One-time measurements required the use of portable or hand-held measurement equipment. Measurements of voltage, current, and power factor were made on the motor in question. The power is calculated from the one-time measurements.

$$(1) \quad Power = Voltage \times Amps \times Power\ Factor \times SQRT(Phase)$$

The factors in this equation were measured as follows:

- Voltmeters were used to measure the electrical potential difference or voltage of a circuit. ADM used Fluke Model 87 True RMS Digital Multimeters.
- One-time measurements of current were made using clamp-on current probes of an ammeter. ADM used Fluke Model 33 True RMS Digital Ammeters.
- One-time measurements of power factor were made using a hand-held power factor meter to measure the phase shift (in degrees) between the electric current and the voltage and to report the COS. ADM used an AEMC power factor meter, AEMC true power meter, or an Electronic Development Corp.'s model 4760 Power Analyzer and Monitor.
- Amp monitoring was accomplished using ACR Stick-On Smart Loggers.

Procedures for Monitoring ASDs

The monitoring approach for ASDs typically lasted four weeks and involved the following procedures:

- Making one-time measurements of voltage, current, and power factor of the ASD/motor, and
- Conducting continuous measurements of power over a period of time in order to obtain the data needed to develop ASD load profiles and calculate energy savings.

Measurements of voltage, current, and power factor were made on the ASD using portable or hand held measurement equipment. Electrical measurements were taken prior to the ASD, because the voltage and current signals are cleaner prior to the ASD than the output of the ASD to the motor, thus improving accuracy of the measurement. The power was calculated from the one-time measurements, as follows:

$$Power = Voltage \times Amps \times Power\ Factor \times SQRT(Phase)$$

One-time measurements of power were made for different percent speed settings to account for the motor loading changes. Power and percent speed or frequency (depending on ASD display options) were recorded for as wide a range of speeds as the customer would allow the process to be controlled. An attempt was made by the engineer to get readings from 40% to 100% speed in 10% to 15% increments.

The equipment used to measure power usage for ASDs was comprised of a data logger with built-in watt-hour capabilities, current transformers (CT), and potential transformers (PT). A data logger is the central piece of the in-field data acquisition system. Synergistics Control Systems Model C-140 meter/recorders were used. These recorders are capable of correctly calculating true power in a harmonic rich environment and allow collection of 15-minute load profile data. The watt-hour transducers used to monitor ASDs had to be sensitive enough to measure the true power of loads with several orders of harmonics.

CTs and PTs were used with watt-hour transducers to accommodate the ratings encountered during installation. CTs are actual sensors used to detect alternating electrical current in the circuit with the load. For monitoring of ASDs, split-core CTs were used to minimize interruptions to the customer's processing.

3.3 Engineering Savings Analysis and Building Simulations

Lighting Savings

Analyzing the savings from lighting measures requires data for retrofitted fixtures on (1) wattages before and after retrofit and (2) hours of operation. To determine these baseline and post-retrofit demand values for lighting efficiency measures, MARS[2] data on standard wattages of lighting fixtures and ballasts were used. These data provide information on wattages for common lamp and ballast combinations.

Energy Savings. Post-retrofit, pre-retrofit, and baseline[3] usage levels were calculated for each lighting measure. Per-fixture baseline demand, retrofit demand, and appropriate post-retrofit operating hours were used to calculate these annual energy consumption levels. These values were used to calculate customer, reportable, and credited savings as discussed above.

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[2] SCE provided ADM with the version of MARS used by SCE staff to calculate savings from the 96 EMHRP program. ADM used the same specifications on equipment standards to calculate baseline usage.

[3] A working assumption that sites need not meet system-wide density requirements, but must meet national equipment standards was used for lighting baseline estimates of usage and demand.

Peak Period Demand Savings. Peak period demand savings were derived similarly to energy savings. In particular, pre-retrofit, post-retrofit, and baseline peak demand levels were estimated. Baseline and post-installation average demands were calculated by dividing the total kWh usage during the peak period by the number of hours in the peak period. These pre-retrofit, post-retrofit, and baseline demand levels were then used to calculate customer, reportable, and credited peak demand savings.

Secondary Lighting Impacts. In cases where there is electric space conditioning, secondary impacts from the installation of lighting measures are calculated. A secondary impact factor ($LSECFAC_k$) equal to the ratio of the percent of time the building is in cooling mode while the lights are on (CLF) to the cooling equipment efficiency (EFF_k) were derived for each space cooling equipment type (k). Specifically,

$$LSECFAC_k = \frac{CLF}{EFF_k}$$

These factors were applied to the energy savings for sites based on whether or not they have electric space conditioning and by space conditioning equipment type to derive a secondary impact.

HVAC Savings

Incentives were provided for chiller replacement, high efficiency motors, ASDs, cooling tower improvements, air distribution improvements, packaged air conditioners, and energy management systems. One or more of these measures could be present at any customer location. Information collected through the on-site survey and the program information database were used to develop "before" and "after" conditions for the rebated measures. The information on these conditions was then used to conduct a DOE-2 analysis of kWh and kW savings for each site receiving an HVAC related measure. These included runs for both incentivized and non-incentivized eligible measures.

Title 20 equipment standards[4] were used to develop the baseline or minimum standards DOE-2 estimates of usage. The following DOE-2 parametric runs were performed:

- Post-retrofit,
- Rebated measure baseline (per California state code levels),
- Rebated measures - pre-retrofit (as described in the program documentation),
- Non-rebated measures baseline (per California state code levels), and

[4] *Energy Efficiency Standards for Residential and Nonresidential Buildings*, California Energy Commission, July 1995 (Tables B-13 and B-14).

- Non-rebated pre-retrofit (as described in item 4 below).

The non-rebated pre-retrofit conditions were obtained during the on-site surveys through an interview with the site contact. In cases where this information was not available, values described in the program documentation for similar rebated measures were used.

Weather Data

Typical meteorological year (TMY) weather files were used for the DOE-2 simulations. TMY data are based on historical weather from 1952 to 1975 and are constructed from individual months rather than entire years. TMY data contain measures of solar insolation and are a good representation of historical weather data (Huang 1996). TMY weather data for the simulations were obtained from the California Energy Commission (CEC 1992, CEC 1995) and are based on weather data from the National Climatic Data Center, in Asheville, North Carolina (NCDC 1995).

Refrigeration Savings

The 96 EMHRP provided incentives to supermarkets for refrigeration. In most cases, estimates of pre-retrofit, post-retrofit, and baseline energy usage and demand were modeled in DOE-2. In instances where DOE-2 was unable to be used to derive impacts, engineering estimates of savings were developed using simplified engineering algorithms and data from product literature and previous studies of savings for these measures.

3.4 Summary of Engineering Estimates

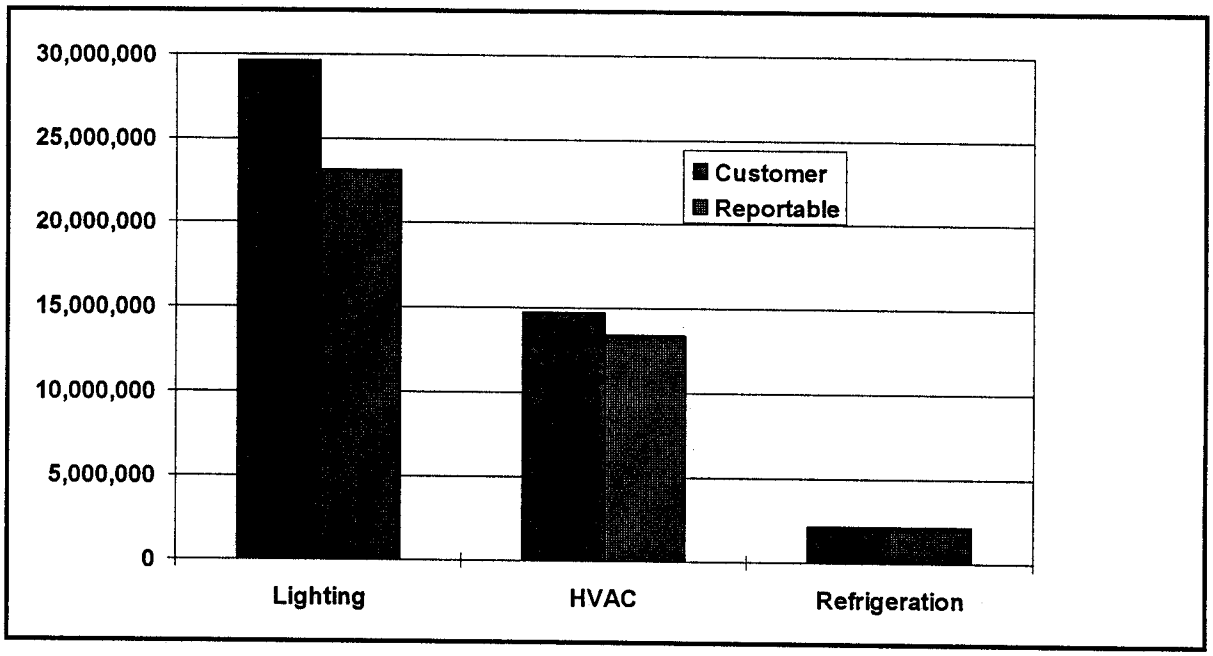
A summary of engineering estimates by end use and building type is presented in Table 3-1 and in Figure 3-1. Both customer and reportable savings estimates are presented and have been weighted to represent the population of participants.[5]

[5] Weights used are shown on Table 2-8 and Table 2-9. Their derivation is described in Appendix G.

Table 3-1 : Summary of Engineering Estimates of Energy Savings

	Lighting		HVAC		Refrigeration	
Building Type	**Customer (kWh)**	**Reportable (kWh)**	**Customer (kWh)**	**Reportable (kWh)**	**Customer (kWh)**	**Reportable (kWh)**
Offices	13,561,345	10,478,826	5,848,487	5,576,071	0	0
Restaurants	54,786	39,222	95,912	58,564	0	0
Retail Stores	4,117,215	3,365,203	3,211,698	3,117,349	7,094	7,094
Food Stores	2,256,369	2,226,092	1,465,470	1,459,955	2,128,196	2,128,196
Warehouses	909,491	748,687	0	0	0	0
K-12 Schools	2,587,038	1,781,659	257,170	214,041	0	0
Colleges	375,884	347,021	1,862,332	1,231,468	0	0
Hospitals	514,721	427,595	1,748,977	1,498,145	0	0
Misc.	5,291,360	3,748,017	226,662	224,333	0	0
Total	**29,668,209**	**23,162,321**	**14,716,707**	**13,379,926**	**2,135,290**	**2,135,290**

Figure 3-1: Savings Estimates by End Use



4

Realization Rate Analysis

4.1 Introduction

This section presents the results of the analysis of realized savings. The analysis consists of the application of the realization rate approach, a means of calibrating engineering estimates of savings to changes in consumption, and controlling for other changes at the sites in question. Sections 4.2 and 4.3 discuss the background of the analysis and provide a general description of the logic and application of the realization rate approach. Section 4.4 discusses model specification and the estimation of the SCE Hardware Rebate realization rate model. The gross realized savings developed from this analysis are presented in Section 4.5.

4.2 Background

Section 3 described how the engineering analyses were calibrated against billing and end-use metering data. However, even calibrated engineering estimates ignore the possibility that engineering biases may differ across levels of efficiency, in which case calibration to pre- or post-installation consumption and/or metering results will not fully calibrate estimates of *savings* derived from the engineering model. While calibrated engineering estimates can play an important role in the assessment of gross program impacts, this approach was supplemented with another statistical adjustment process termed the realization rate approach.[1]

The principal advantages of the realization rate approach relative to other techniques are (a) it can be used to estimate realized savings for individual conservation measures or groups of measures, (b) to the extent that it takes advantage of detailed engineering information, it increases the efficiency of the overall estimation process, (c) it is relatively efficient in preserving degrees of freedom, (d) it is amenable to the analysis of a heterogeneous set of program participants receiving a broad range of DSM measures, and (e) it generates end-use-specific realization rates that can be generalized and applied to engineering estimates developed for other comparable sites.

[1] For further discussion, see Frederick D. Sebold and Eric W. Fox, "Realized Savings from Residential Conservation Activity," *Energy Journal* no. 6, pp. 73-88, 1985.

4.3 The General Realization Rate Approach

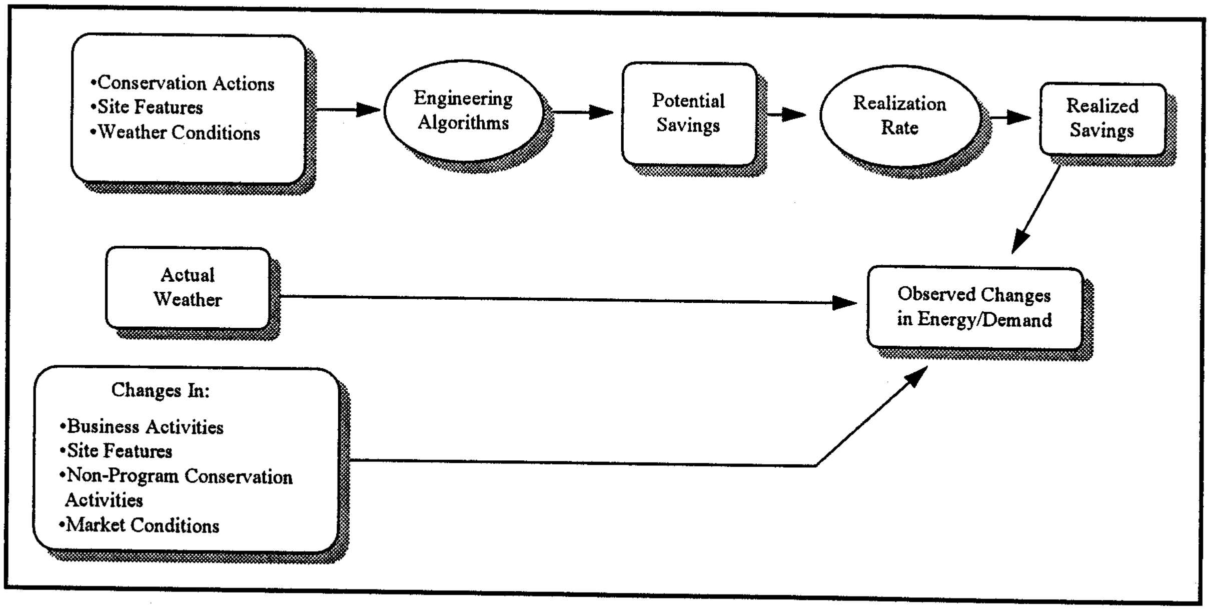
General Logic and Model Specification

The realization rate model is illustrated in Figure 4-1. In this application, the model relates changes in energy consumption to conservation activities and a series of other factors. Prior engineering estimates of conservation impacts are included directly in the model. Other variables are included to control for installations of other (non-program) conservation measures and changes in weather conditions, site square footage, occupancy, hours of operation, and other appliance stocks. For the purposes of this analysis, the realization rate model is represented as:

$$(1) \quad \Delta KWH_{it} = \sum_{k=1}^{K} f_k \begin{pmatrix} SAV_{ikt}, \Delta SC_{it}, \Delta OC_{it}, \Delta WC_{it}, \Delta MC_{it}, \Delta S_{ikt}, \\ SC_{it}, OC_{it}, WC_{it}, MC_t, S_{ikt}, \varepsilon_{it} \end{pmatrix}$$

where ΔKWH_{it} is the change in energy consumption for site i over a 12-month period, SAV_{ikt} is a set of engineering estimates of expected savings in month t for end use k and site i, SC_{it} is a set of site characteristics such as square footage or number of floors, OC_{it} is a set of variables representing operating characteristics such as thermostat settings, WC_{it} is an indicator of weather conditions, MC_t is a vector of market conditions, S_{ikt} is a binary indicator of the presence of the kth electric end use, and ε_{it} is a random error. Note that in this general model, both the levels of and changes in the explanatory variables are included. The levels would constitute interaction terms, playing the role of conditioning the effects of changes. For instance, the site square footage and HVAC system indicators would be interacted with the change in weather conditions.

Figure 4-1: The Realization Rate Model



Model Estimation

The realization rate model is estimated with data covering both participants and nonparticipants. In the course of estimation, both conceptual and statistical issues need to be resolved. Key conceptual issues are as follows:

- **Bases for ROB Savings.** As noted earlier, two types of engineering estimates of savings were developed for replace-on-burnout measures. The first uses the site's previous equipment as a baseline, while the second uses the state building and appliance codes as a reference. The first type of savings estimate is included in the realization rate model to reflect the fact that observed changes in usage reflect these savings. However, it will also be necessary to convert the resultant estimates of realized savings into the realized savings relative to code.
- **Deferred Load.** Net acquisitions of energy-efficient equipment defer loads. Net acquisitions will be represented in the realization rate model with engineering estimates of usage, given the actual efficiency of the equipment. Then, savings will be derived by contrasting this usage with the level that would have been experienced had the equipment just met Title 20 standards.
- **Definition of Pre- and Post-Installation Periods.** The realization rate method makes use of information on expected savings-specific DSM measures, rather than relying on simple binary pre- and post-program indicators. As a result, the pre- and post-installation periods are defined specifically with respect to individual measures. If a site installs three measures at different times, each measure essentially has its own pre- and post-installation period. For this reason, it is important to collect reasonably reliable information on the timing of DSM actions.

Application of the Realization Rate Model

Deriving Gross Impacts. Once the realization rate model is estimated, the realized savings associated with the installation of a set of conservation measures relating to end use *k* for site *i* can be derived as:

$$(2)\quad Impact_{ikt} = \left[\partial \Delta KWH_{it} / \partial SAV_{ikt}\right] SAV_{ikt}$$

where $\partial \Delta KWH_{it} / \partial SAV_{ikt}$ can be considered a *realization rate* for the measure(s) in question. This realization rate can be specified to vary across conditions and sites. As explained later, this characteristic allows the weather normalization of impacts, as well as the assessment of factors contributing to realization rates significantly different from one. The results of the realization rate analysis can also be converted to reflect the appropriate baseline for gross savings – the prevailing code.

Weather-Normalizing Impacts. The general realization rate formulation recognizes that realized program savings can vary across sites. To some extent, this is picked up by the fact that the *ex ante* engineering estimate of savings (SAV_{ikt}) varies across sites. However, it can also be recognized that the realization rate may vary across sites. That is, the model can be specified so that:

$$(3)\quad Realization\ Rate_{ikt} = \partial \Delta KWH_{ikt} / \partial SAV_{ikt} = h_k\left(SC_{it}, OC_{it}, WC_{it}, MC_t, S_{ikt}\right)$$

One implication of this specification is the ability to weather normalize impacts. That is, the model can be designed so that the impact of a DSM measure depends upon prevailing weather conditions, and the impact can be simulated under the assumption of normal weather.[2] In practice, this procedure entails two steps: first, the savings estimate SAV_{ikt} is defined with respect to normal weather; and second, the realization rate function (3) is specified to include a term representing the deviation of actual weather from normal weather. This approach supports the estimation process in that it accounts for the dependence of actual savings on actual weather. It also accommodates weather normalization of the estimated impact through the solution of the impact expression under the assumption of normal weather (i.e., zero deviation of actual from normal weather). This is the approach used in this study.

Adjusting Estimates for Efficiency Standards. For some DSM measures, the impact derived from the realization rate model will not directly represent gross *ex post* program savings relative to the appropriate baseline. Given the reliance on billing data, which reflect conditions at the site, the savings estimate included in the realization rate model (SAV_{ikt}) indicates savings relative to pre-installation conditions, and the model yields a corresponding realized savings estimate. However, savings relative to code can be inferred by multiplying the initial engineering estimate of savings relative to code by the realization rate on the savings variable included in the model. Moreover, deferred savings from net acquisitions can be simulated by multiplying the realization rate on estimated usage by the corresponding engineering estimate of savings from efficiency above code.

4.4 SCE Hardware Rebate Program Realization Rate Model

Model Specification

The specific realization rate model used in this study was designed to cover all eligible space conditioning, indoor lighting, and refrigeration program measures. These eligible measures included both rebated and non-rebated measures. The model specification covers eligible as

[2] See, for example, Frederick D. Sebold, Boqing Wang, and Thomas A. Mayer, "Evaluating the Impacts of Northwest Commercial New Construction Programs," *National Energy Program Evaluation Conference*, Chicago, IL, August 1995.

well as non-eligible lighting and space conditioning measures, but provides for separate realization rates for eligible and non-eligible measures. This approach was used because more detailed engineering analyses were conducted for eligible measures, partly due to the availability of more detailed information relating to these measures.

The SCE Hardware Rebate Program (96 EMHRP) realization rate model is specified as:

$$(4)\quad \Delta\left[\frac{KWH_{it}}{SQFT_i}\right] = \beta_0 + \beta_1 ESH_i \Delta HDD_{it} + \beta_2 EAC_i \Delta CDD_{it}$$

$$+\begin{bmatrix} \beta_3 + \beta_4 ESH_i (HDD_{it} - NHDD_{it}) \\ + \beta_5 EAC_i (CDD_{it} - NCDD_{it}) \end{bmatrix} \frac{\Delta ESAVHVAC_{it}}{SQFT_i}$$

$$+\beta_6 \frac{\Delta ESAVLIT_{it}}{SQFT_i} + \beta_7 \frac{\Delta ESAVREF_{it}}{SQFT_i} + \beta_8 \frac{\Delta SQFT_{it}}{SQFT_i} + \beta_9 \Delta OPHOURS_{it}$$

$$+\beta_{10} \frac{\Delta NELIGBLIT_{it}}{SQFT_i} + \beta_{11} \frac{\Delta NELIGBCOOL_{it}}{SQFT_i} COOLSEAS_t$$

$$+\beta_{12} \frac{\Delta NELIGBHEAT_{it}}{SQFT_i} HEATSEAS_t + (\beta_{13} OFFICE_i$$

$$+\beta_{14} REST + \beta_{15} RETAIL_i + \beta_{16} FOOD_i + \beta_{17} WARE_i$$

$$+\beta_{18} K12_i + \beta_{19} COLL_i + \beta_{20} HOSP_i) EAC_i \Delta CDD_{it}$$

$$+(\beta_{21} OFFICE_i + \beta_{22} REST_i + \beta_{23} RETAIL_i + \beta_{24} FOOD_i$$

$$+\beta_{25} WARE_i + \beta_{226} K12_i + \beta_{26} COLL_i$$

$$+\beta_{27} HOSP_i) ESH_i \Delta HDD_{it} + \beta_{28} OFFICE_i$$

$$+\beta_{29} REST_i + \beta_{30} RETAIL_i + \beta_{31} FOOD_i$$

$$+\beta_{32} WARE_i + \beta_{33} K12_i + \beta_{34} COLL_i + \beta_{35} HOSP_i + \varepsilon_{it}$$

where:

ΔKWH_{it}	=	12-month change in monthly consumption (KWH_{it} - KWH_{it-12})
$SQFT_i$	=	Total site square footage
ESH_i	=	Binary variable equal to 1 if the site has electric space heating; 0 otherwise
HDD_{it}	=	Monthly heating degree days (base 65)
ΔHDD_{it}	=	12-month change in HDD_{it})
EAC_i	=	Binary variable equal to 1 if the site has electric space cooling; 0 otherwise
CDD_{it}	=	Monthly cooling degree days (base 65)
ΔCDD_{it}	=	12-month change in CDD_{it}
$NHDD_{it}$	=	Monthly heating degree days based on CEC monthly TMY weather data (base 65)
$NCDD_{it}$	=	Monthly cooling degree days based on CEC monthly TMY weather data (base 65)
$\Delta ESAVHVAC_{it}$	=	12-month change in monthly engineering estimate of kWh savings from installation of HVAC conservation measures (kWh)
$\Delta ESAVLIT_{it}$	=	12-month change in monthly engineering estimate of kWh savings from installation of lighting conservation measures (kWh)
$\Delta ESAVREF_{it}$	=	12-month change in monthly engineering estimate of kWh savings from the installation of refrigeration conservation measures
$\Delta SQFT_{it}$	=	12-month change in $SQFT_{it}$($SQFT_{it}$- $SQFT_{it-12}$)
$\Delta OPHOURS_{it}$	=	12-month change in operating hours
$\Delta NELIGBLIT_i$	=	12-month change in savings from installation of non-eligible lighting DSM measures (estimated as kW savings)
$\Delta NELIGBCOOL_{it}$	=	12-month change in savings from installation of non-eligible HVAC cooling DSM measures (estimated as kW savings)
$COOLSEAS_t$	=	Binary variable equal to 1 if the month is in the cooling season (April through September); 0 otherwise.
$\Delta NELIGBHEAT_{it}$	=	12-month change in savings from installation of non-eligible HVAC heating DSM measures (estimated as kW savings)
$HEATSEAS_t$	=	Binary variable equal to 1 if the month is in the heating season (October through April); 0 otherwise.
$OFFICE_i$	=	Binary variable equal to 1 if the site is an office; 0 otherwise
$REST_i$	=	Binary variable equal to 1 if the site is a restaurant; 0 otherwise
$FOOD_i$	=	Binary variable equal to 1 if the site is a food store; 0 otherwise
$RETAIL_i$	=	Binary variable equal to 1 if the site is a retail store; 0 otherwise
$WARE_i$	=	Binary variable equal to 1 if the site is a warehouse; 0 otherwise

$K\text{-}12_i$	=	Binary variable equal to 1 if the site is a K-12 school; 0 otherwise
$COLL_i$	=	Binary variable equal to 1 if the site is a college or university; 0 otherwise
$HOSP_i$	=	Binary variable equal to 1 if the site is a hospital or medical clinic; 0 otherwise.

Correction for Autocorrelation. Autocorrelation, which is the correlation of the error term over time for individual sites, is typical in analysis of energy usage over time. This problem was mitigated with generalized least squares, a standard remedy.[3] Both of the models discussed below were corrected for autocorrelation.

Model Estimation

Two versions of the 96 EMHRP realization rate model were estimated: the 12-month change form presented in equation (4), and a level form. The level form of the model is essentially the change form of the model with the 12-month lagged usage ($LAG12KWH_{it}$) moved to the right-hand side of the model. This approach is designed to account for *regression to the mean*. In general, a site's energy consumption can be subject to a variety of random influences over time. As a result, the time pattern exhibited by consumption will have periods of unusually high or low levels of usage followed by a return to normal levels (regress to the mean), thus high (low) levels of consumption are more likely to be followed by decreases (increases) in usage. This phenomenon is referred to as regression to the mean. Using the level-form specification, a coefficient on the 12-month lagged usage term that is less than one provides evidence of this factor.

A number of modifications were made to the initial model specification during the estimation process, including the following:

- The variables in the initial model specification designed to weather adjust the engineering estimates to actual weather [(HDD_{it}-$NHDD_{it}$) and (CDD_{it}-$NCDD_{it}$)] were modified. In particular, these terms were interacted with an estimate of the weather sensitivity of the HVAC savings estimate by site ($PKCOOL_i$ and $PKHEAT_i$).

[3] A good treatment of the impacts and remedies of autocorrelated error structures in estimating models using panel data is presented in *Analysis of Panel Data*, Cheng Hsiao, Econometric Society Monograph, Cambridge University Press, 1966.

where

$$PKHEAT_i = \frac{(SVMON8_i - MNSVMON_i)}{MNSVMON_i}$$

$$PKCOOL_i = \frac{(SVMON1_i - MNSVMON_i)}{MNSVMON_i}$$

where

$SVMON8_i$ = HVAC engineering estimate of savings for August.
$MNSVMON_i$ = MEAN monthly engineering estimate of HVAC savings.
$SVMON1_i$ = HVAC engineering estimate of savings for January.

Ultimately, only the cooling-related terms proved to be significant in the model estimation. The heating degree day-related terms were therefore dropped from the model.

- The stand-alone HVAC savings term ($ESAVHVAC_{it}$) and the refrigeration savings term ($ESAVREF_{it}$) were combined in the final model specification. This approach was used because all but two of the sites with refrigeration savings used in the model also installed HVAC measures. The resultant multicollinearity led to an unrealistically high realization rate for refrigeration, so the two terms were combined.[4]
- Interaction terms for the presence of space conditioning equipment, weather and building type were added to the model. In particular, cooling degree days were interacted with building type binary variables and with electric space cooling indicator variables. Further, heating degree days were interacted with building type binary variables and with electric space heating indicator variables. These variables were designed to control for the differences in heating and cooling weather sensitivities across building types. This approach led to the addition of 18 interaction terms ($ESH_i\Delta HDD_{it}$ and $EAC_i\Delta CDD_i$ interacted with nine building types). However, only eight of these terms were significant in the final model: $ESH_i\Delta HDD_{it}FOOD_i$, $EAC_i\Delta CDD_{it}OFFICE_i$, $EAC_i\Delta CDD_{it}REST_i$, $EAC_i\Delta CDD_{it}RETAIL_i$, $EAC_i\Delta CDD_{it}WARE_i$, $EAC_i\Delta CDD_{it}K\text{-}12_i$, $EAC_i\Delta CDD_{it}COLL_i$, and $EAC_i\Delta CDD_{it}HOSP_i$.
- SCE weather zone indicators and heating and cooling degree interaction terms were added to the model. These variables were designed to account for differing contemporaneous weather sensitivities across SCE weather zones. Weather sensitivities may vary across weather zones due mainly to differences in building

[4] It should be noted that the final realization rate models were estimated with separate refrigeration and HVAC terms. As expected, the resulting overall savings from HVAC and refrigeration is essentially the same. However, the breakout by end uses differs between models.

shell attributes. Although interaction terms for both heating and cooling and six SCE weather zones were tried in the model, only the following three were significant.

$WSTAT11_iCDD_{it}$	=	Binary variable for SCE weather zone 5195003 interacted with cooling degree days.
$WSTAT9_iHDD_{it}$	=	Binary variable for SCE weather zone 4695029 interacted with heating degree days.
$WSTAT11_iHDD_{it}$	=	Binary variable for SCE weather zone 5195003 interacted with heating degree days.

- Building type binary variables for nine of the ten building types were included in the initial model specification. However, only $RETAIL_i$, $FOOD_i$, $COLL_i$, and $HOSP_i$ proved to be significant in the change form model. Similarly, in the level-form model, these four variables plus $REST_i$ and $WARE_i$ were significant. In addition, $K\text{-}12_i$ was marginally significant and retained in the level-form model.

In estimating the models, particular care was given to the potential for errors due to the timing of the installation of measures. Errors in timing can make estimation of impacts difficult. The installation dates were taken from the participation files and in some cases crossed checked with hard copy coupon data. As noted earlier, in some cases installation dates were overridden based on inspection of the coupon data. Given this approach, the installation dates should be reasonably accurate but may still contain some small errors. To allow for this, a one-month deadband was used to omit the month of adoption from the model estimation process.

Table 4-1 and Table 4-2 present the estimation results for the two versions of the 96 EMHRP realization rate model prior to and after correction for autocorrelation, respectively.

- ***Version A.*** 12-month change-form model.
- ***Version B.*** Level form of the 12-month change-form model.

As shown in Table 4-1 and Table 4-2, all of the coefficients on variables relating to the eligible measures savings are significant and have the correct sign. The non-eligible measures for lighting and cooling measures are also significant in each of the models. However, the heating-related non-eligible measures proved to be insignificant.

Version A of the model corrected for autocorrelation is used for all subsequent calculations in this report. Using Version B of the model would have affected the relative savings across end uses, but would not have a material effect on the overall estimates of program savings.

Table 4-1: Model Estimation – Prior to Autocorrelation Correction

Dependent Variables	Version A $\Delta(KWH_{it}/SQFT_i)$	Version B $KWH_{it}/SQFT_i$
Explanatory Variables	**Coefficient** ***(t-stat)***	**Coefficient** ***(t-stat)***
Intercept	0.011 *(3.37)*	0.040 *(7.99)*
$ESH_i \Delta HDD_{it}$	0.000117 *(0.96)*	0.000106 *(0.87)*
$EAC_i \Delta CDD_{it}$	0.00140 *(10.41)*	0.00142 *(10.62)*
$(\Delta ESAVHVAC_{it} + \Delta ESAVREF_{it}) / SQFT_i$	-1.132 *(-17.89)*	-1.088 *(-17.24)*
$EAC_i(CDD_{it}-NCDD_{it})(\Delta ESAVHVAC_{it} / SQFT_i)$ $PKHEAT_i$	0.000141 *(0.11)*	0.000375 *(0.30)*
$\Delta ESAVLIT_{it} / SQFT_i$	-0.731 *(-35.91)*	-0.715 *(-35.15)*
$\Delta SQFT_{it} / SQFT_i$	1.062 *(6.29)*	1.063 *(6.32)*
$\Delta OPHOURS_{it}$	0.000778 *(2.92)*	0.000753 *(2.84)*
$\Delta NELIGBLIT_{it} / SQFT_i$	-81.719 *(-4.74)*	-78.290 *(-4.56)*
$\Delta NELIGBCOOL_{it}\ COOLSEAS_t / SQFT_i$	-228.324 *(-5.81)*	-223.650 *(-5.73)*
$\Delta NELIGBHEAT_{it}\ HEATSEAS_t / SQFT_i$	87.450 *(0.04)*	-137.930 *(-0.07)*
$FOOD_i ESH_i \Delta HDD_{it}$	-0.000636 *(-1.50)*	-0.000599 *(-1.42)*
$OFFICE_i EAC_i \Delta CDD_{it}$	-0.000300 *(-1.67)*	-0.000353 *(-1.98)*
$REST_i EAC_i \Delta CDD_{it}$	0.00315 *(8.34)*	0.00296 *(7.82)*
$RETAIL_i EAC_i \Delta CDD_{it}$	-0.000128 *(-0.70)*	-0.000159 *(-0.87)*
$WARE_i EAC_i \Delta CDD_{it}$	-0.00136 *(-4.87)*	-0.00131 *(-4.65)*
$K\text{-}12_i EAC_i \Delta CDD_{it}$	-0.000827 *(-4.24)*	-0.000873 *(-4.45)*

Table 4-1 (cont'd.): Model Estimation – Prior to Autocorrelation Correction

Dependent Variables	Version A $\Delta(KWH_{it}/SQFT_i)$	Version B $KWH_{it}/SQFT_i$
Explanatory Variables	**Coefficient** ***(t-stat)***	**Coefficient** ***(t-stat)***
$COLL_iEAC_i\Delta CDD_{it}$	-0.000855 *(-2.22)*	-0.000909 *(-2.38)*
$HOSP_iEAC_i\Delta CDD_{it}$	-0.000205 *(-0.58)*	-0.000244 *(-0.70)*
$WSTAT11C_{it}$	0.000453 *(1.67)*	0.000401 *(1.49)*
$WSTAT9H_{it}$	0.000855 *(1.09)*	0.000801 *(1.03)*
$WSTAT11H_{it}$	0.00195 *(2.70)*	0.00192 *(2.68)*
$REST_i$		0.107 *(5.56)*
$RETAIL_i$	-0.0213 *(-3.22)*	-0.0186 *(-2.67)*
$FOOD_i$	0.0460 *(4.34)*	0.127 *(9.42)*
$WARE_i$		-0.0355 *(-2.89)*
$K\text{-}12_i$		-0.0126 *(-1.58)*
$COLL_i$	0.0745 *(4.30)*	0.0698 *(4.02)*
$HOSP_i$	0.0197 *(1.33)*	0.0409 *(2.72)*
$LAG12KWH_{it} / SQFT_i$		0.978 *(442.91)*
Adjusted R-Squared	0.2310	0.9802

Table 4-2: Model Estimation – Autocorrelation Corrected

Dependent Variables	Version A $\Delta(KWH_{it}/SQFT_i)$	Version B $KWH_{it}/SQFT_i$
Explanatory Variables	**Coefficient** *(t-stat)*	**Coefficient** *(t-stat)*
Intercept	0.00483 (1.92)	0.0356 (9.27)
$ESH_i \Delta HDD_{it}$	0.0000116 (0.11)	-0.000000652 (0.01)
$EAC_i \Delta CDD_{it}$	0.00151 (12.86)	0.00146 (12.56)
$\Delta ESAVHVAC_{it} + \Delta ESAVREF_{it} / SQFT_i$	-1.031 (-9.57)	-0.941 (-8.81)
$EAC_i(CDD_{it}-NCDD_{it})\ \Delta ESAVHVAC_{it} / SQFT_i$ $PKHEAT_i$	0.000705 (0.23)	0.00153 (0.52)
$\Delta ESAVLIT_{it} / SQFT_i$	-0.676 (-18.91)	-0.647 (-18.22)
$\Delta SQFT_{it} / SQFT_i$	0.479 (1.93)	0.452 (1.84)
$\Delta OPHOURS_{it}$	0.000253 (0.77)	0.000243 (0.74)
$\Delta NELIGBLIT_{it} / SQFT_i$	-31.698 (-1.51)	-29.195 (-1.40)
$\Delta NELIGBCOOL_{it}\ COOLSEAS_t / SQFT_i$	-221.849 (-4.43)	-214.539 (-4.33)
$\Delta NELIGBHEAT_{it}\ HEATSEAS_t / SQFT_i$	-100.150 (-0.04)	-179.186 (-0.08)
$FOOD_i ESH_i \Delta HDD_{it}$	-0.000808 (-2.22)	-0.000722 (-2.00)
$OFFICE_i EAC_i \Delta CDD_{it}$	-0.000545 (-3.51)	-0.000549 (-3.57)
$REST_i EAC_i \Delta CDD_{it}$	-0.00233 (7.29)	0.00225 (7.09)
$RETAIL_i EAC_i \Delta CDD_{it}$	-0.000367 (-2.37)	-0.000373 (-2.32)
$WARE_i EAC_i \Delta CDD_{it}$	-0.00136 (-6.04)	-0.00130 (-5.82)
$K\text{-}12_i EAC_i \Delta CDD_{it}$	-0.000100 (-6.00)	-0.000963 (-5.83)
$COLL_i EAC_i \Delta CDD_{it}$	-0.000702 (-2.17)	-0.000704 (-2.21)

Table 4-2 (cont'd.): Model Estimation – Autocorrelation Corrected

Dependent Variables	Version A $\Delta(KWH_{it}/SQFT_i)$	Version B $KWH_{it}/SQFT_i$
Explanatory Variables	**Coefficient** *(t-stat)*	**Coefficient** *(t-stat)*
$HOSP_iEAC_i\Delta CDD_{it}$	-0.000411 (-1.43)	-0.000394 (-1.39)
$WSTAT11C_{it}$	0.000327 (1.38)	0.000303 (1.29)
$WSTAT9H_{it}$	0.00173 (2.64)	0.00169 (2.62)
$WSTAT11H_{it}$	0.00186 (3.00)	0.00181 (2.96)
$REST_i$		0.193 (5.92)
$RETAIL_i$	-0.0246 (-2.17)	-0.0195 (-1.65)
$FOOD_i$	0.0325 (1.77)	0.213 (9.29)
$WARE_i$		-0.0665 (-3.20)
$K\text{-}12_I$		-0.0348 (-2.57)
$COLL_i$	0.0799 (2.73)	0.0689 (2.35)
$HOSP_i$	0.0331 (1.33)	0.0777 (3.08)
$LAG12KWH_{it} / SQFT_i$		0.952 (265.43)
Adjusted R-Squared	0.2908	0.9504

4.5 Gross Realized Savings

As previously discussed, the 96 EMHRP realization rate model can be used to develop estimates of gross realized savings by end use. The specific approaches to developing estimates of gross realized energy and demand savings are discussed below.

General Approach

The 96 EMHRP was predominantly a retrofit program with over 97% of *ex ante* savings attributable to retrofit measures. As such, gross savings were developed based on the useful life of each measure, customer and reportable savings. In particular, initially, total customer savings are realized since the newly installed measures replace existing working measures. In this case, the site's previous equipment is used as a baseline to measure savings. After a period of time, during which it is assumed that the lives of the previously existing measures would expire, reportable savings are realized. During this period, state building and appliance codes are used as a baseline for measures covered by these state and national standards.

In order to derive gross savings, customer and reportable savings for each site surveyed were weighted and summed. Weights were developed to expand the savings estimates for the sample of surveyed sights to represent the targeted group of 300 participants. Weights were developed for each building type and consumption stratum and were based on pre-program annual consumption.[5]

Using the weighted savings and useful lifetimes of the program measures, a timeline of savings was created for each measure. Figure 4-2 illustrates the procedure used to derive gross savings. Table 4-3 lists the useful lives of the program measures used in this analysis.[6] This stream of savings was then collapsed to its present value and used to calculate a constant annual savings amount.[7] This constant or *levelized* annual savings amount is the estimated gross savings.

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[5] The sample group and case weights used are listed in Table 2-8. A description of how the weights were derived is in Appendix G.

[6] Lifetimes were provided by SCE in Feeder Sheets to Table E-2 and E-3 in Application 97-05-004, Edison's Earnings Claim (as adjusted by the ORA) in the 1997 Annual Earnings Assessment Proceeding (CPUC decision pending). The analysis assumes customer savings will be realized during half the useful life, and reportable savings during the remaining half.

[7] A discount rate of 3% was assumed to calculate present value and annuity installments.

Figure 4-2: Gross Savings

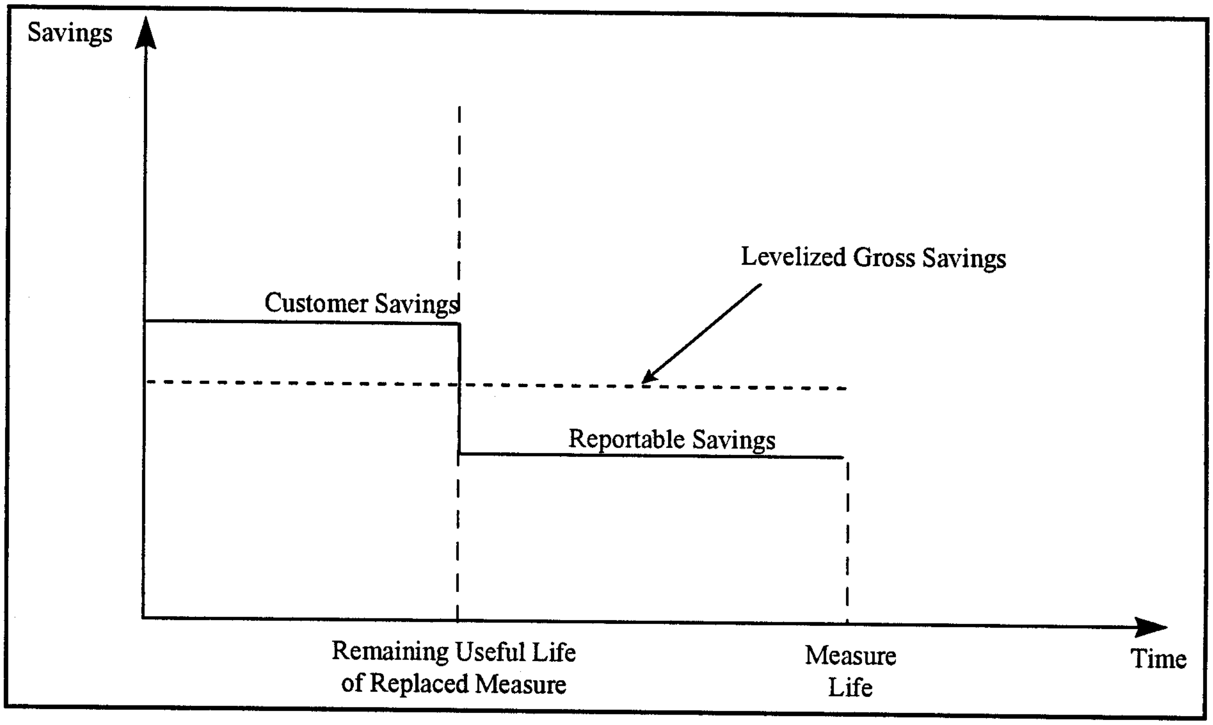


Table 4-3: Useful Lives of Program Measures

Program Measure	Useful Life (in years)
Indoor Lighting	10
HVAC	15
Refrigeration	15

Gross Realized Energy Savings

Table 4-4 presents the estimated *gross realized* savings by end use for the 96 EMHRP program. Included in the table are engineering estimates of gross savings, estimated realization rates, and gross realized savings. In addition, SCE's gross *ex ante* savings are presented for purposes of comparison.

Table 4-4: Gross Realized 96 EMHRP Program Energy Savings by End Use

Program Measure	RER Gross Savings (kWh)	Realization Rate	RER Gross Realized Savings (kWh)	SCE *ex ante* Gross Savings (kWh)
Lighting				
Indoor Ltg.	*25,216,868*	*0.68*	*17,147,470*	*22,079,125*
LED Ltg. Only	*2,612,422*	*1.00*	*2,612,422*	*2,612,422*
Outdoor Ltg. Only	*1,009,730*	*1.00*	*1,009,730*	*1,009,730*
Total Lighting	28,839,020		20,769,622	25,701,277
HVAC	13,543,791	1.03	13,950,105	24,670,308
Refrigeration	2,115,819	1.03	2,179,294	3,245,731
Process	1,042,335	1.00	1,042,335	1,042,335
Miscellaneous	2,366,077	1.00	2,366,077	2,366,077
All	**47,907,042**		**40,307,432**	**57,025,728**

Gross Realized Lighting Energy Savings. Gross realized lighting savings were estimated in three components.

- ***Indoor Lighting.*** Indoor lighting covers all sites with at least some indoor lighting measures installed. These sites were covered explicitly by the realization rate analysis and site-specific *ex ante* engineering savings estimates were derived for all surveyed sites. Savings for these sampled sites were expanded to total program gross *ex ante* indoor lighting savings using the appropriate case weights. The gross realized savings were then estimated as the product of the realization rate and the total *ex ante* gross realized savings. Indoor lighting accounts for roughly 83% of gross realized lighting savings.
- ***Outdoor Lighting Only.*** Sites with outdoor lighting only were not surveyed as part of this study. For these cases, we adopted SCE's *ex ante* gross savings estimates. Further, the realization rate used to calculate gross realized savings was

assumed to be equal to one. Outdoor lighting accounts for just over 5% of gross realized lighting savings.

- ***LED Exit Sign Only.*** Sites with LED exit signs only were also not surveyed as part of the study. For these sites, we adopted SCE's *ex ante* gross savings estimates and applied a realization rate of 1.0. LED exit sign only lighting accounts for approximately 13% of gross realized lighting savings.

By design, the LED exit sign only and outdoor lighting only sites have the same gross realized savings as SCE's *ex ante* gross savings. However, estimated gross realized savings for indoor lighting is roughly 78% of SCE's *ex ante* estimate. This difference is mainly attributable to the estimated realization rate of 68%. Our engineering estimate of gross savings for indoor lighting is roughly 14% higher than SCE's *ex ante* gross savings.

In view of the low realization rate on lighting, the engineering estimates of lighting savings developed by both SCE and the project team were reviewed thoroughly, with particular attention paid to the comparison of operating hours and post-installation equipment data. With few exceptions, the operating hours assumed by SCE staff and those recorded during the on-site visit matched closely. Similarly, the post-installation equipment counts and connected load data matched up well between on-site inspections and SCE coupon data. The missing link is the pre-retrofit condition of the treated space. In particular, every effort was made by the on-site surveyor to collect data on the replaced lighting equipment. However, in the majority of cases these data were not available due to changes in site staff since the retrofit and the on-site representative's inability to recall detailed information on the replaced equipment. In these cases, SCE's coupon data were used to develop the pre-retrofit connected loads. The results were that numerous sites had very high lighting energy use densities relative to typical buildings of similar type in the pre-retrofit case. This can cause an overstatement of savings for two reasons:

- First, some pre-retrofit lighting densities (Watts per square foot) were unusually high and may have been erroneous. If so, this overstatement of lighting loads in the pre-retrofit case would lead to an exaggeration of savings.
- Second, if the high pre-retrofit lighting energy use densities were accurate, the major reduction in lighting densities may have led to significant reductions in lighting output and may have induced significant changes in hours of use. For at least a few sites, for instance, two lighting systems (fluorescent and HID) appear to have been replaced by one (high efficiency fluorescents). In these cases, the pre-retrofit systems may have been redundant, and applying post-retrofit lighting hours of use to their combined connected loads would overstate energy usage and lead to a biased estimate of savings. In more general terms, whenever pre-retrofit lighting systems have controls that allow the partial use of the system (say, using half of the fixtures or some of the lamps), major changes in lumen capacities may lead to increases in average hours of use.

Gross Realized HVAC Energy Savings. Gross realized HVAC savings account for roughly 35% of all gross realized program savings. The HVAC gross realized savings estimated in this study are roughly 60% of SCE's *ex ante* savings. Insofar as the estimated realization rate on ADM's engineering estimates of savings is close to one, this difference can be attributed to the differences between SCE's estimates and the engineering estimates of HVAC savings developed by the project team. The most common reasons for differences between SCE's and this study's engineering savings estimates include the following:

- ***Differences In Operating Hours.*** There are a number of sites where ADM assumes different hours of operation than SCE's hours of operation ADM's source of hours of operation are the schedules collected during the on-site survey. The differences in operating hours occur as both overstatements and understatements; however, in the extreme cases, ADM reported lower operating hours than SCE.
- ***ADM's More Detailed Approach to Modeling EMS Systems*** The ADM savings estimates were determined using DOE-2 and data on changes in operating schedules and/or changes in set-point temperatures (based on on-site survey information). Additionally, for a few cases, the post-retrofit models were further refined by utilizing the monitored data. A review of the approach used in determining the SCE savings indicates that in a majority of cases, the effect of the EMS on the operation of an HVAC system was simply modeled as a reduction in the number of operating hours, and all other relevant parameters were kept constant. The approach used by ADM results in significantly lower estimates of savings.
- ***ADM's More Detailed Approach to Modeling Cooling Tower System Usage.*** There is a significant difference in the algorithms used by DOE-2 and MARS to model cooling tower usage. ADM used the more accurate (and more complicated) DOE-2 algorithm and estimates considerably lower savings.
- ***Differences Due to Savings Not Being Adjusted for Standards.*** In some cases, SCE did not use minimum standards for reportable savings. That is, SCE used the difference of pre- and post-usage as an estimate for savings that disregarded applicable equipment state and national standards.
- ***Differences in Assumed Equipment Efficiencies.*** The ADM on-site inspections revealed different equipment efficiency values than those used by SCE to calculate engineering savings
- ***Differences in Assumptions Due to the Use of Monitoring at Some Sites Covered by the Study.*** The engineering estimates of savings were adjusted based on the results of end use metering. This adjustment resulted in the savings for some VSDs on air handlers being considerably lower than anticipated.

Each of these factors is explained more fully in Appendix D. The discussion includes specific examples of sites where the engineering estimates differed substantially.

Gross Realized Refrigeration Savings. Gross realized refrigeration savings account for roughly 5% of savings. The estimated gross realized savings for this end use are roughly two-thirds of SCE's *ex ante* savings. Insofar as the realization rate on ADM's engineering estimates is close to one, this difference can be attributable to the differences in the engineering estimates. The majority of the differences in the two estimates of savings are attributable to a misallocation of savings at a single site: SCE claimed refrigeration savings at a site where the on-site survey attributed the savings to HVAC.

Gross Realized Process and Miscellaneous Energy Savings. Gross realized savings for process and miscellaneous measures were not covered by the realization rate analysis. Therefore, per Protocol Table C-9, it is assumed that the gross realized savings from this end use are equal to SCE's gross *ex ante* savings estimates.

Gross Realized Demand Savings

Table 4-5 presents the gross realized demand savings for the 96 EMHRP program. The gross demand savings were estimated as the product of the realization rates discussed above and engineering estimates of demand impacts developed by the project team or (when project estimates were unavailable) extracted from SCE's program records.

Gross Realized Lighting Demand Savings. Gross realized demand savings were estimated for indoor lighting sites only. As explained above, SCE *ex ante* estimates and a realization rate of one were used for sites with outdoor lighting only and LED exit signs only. As shown in Table 4-5, the estimated demand impact for the program's lighting measures amounts to just under 4.4 MW. This estimate is roughly 96% of SCE's *ex ante* estimate.

Gross Realized HVAC Demand Savings. Gross realized demand savings for HVAC measures is 1.785 MW. This is more than twice as large as SCE's *ex-ante* estimate. This difference is attributable to EMS and VSD measures. In general, SCE claims no peak demand savings for EMS or VSD measures. However, the DOE-2 simulated estimates of savings revealed substantial peak demand savings from both EMS and VSDs. This is due mainly to the oversizing of HVAC equipment which allows the VSDs to capture some savings even during peak usage. Further, EMS equipment provides demand savings from the efficient use of set points and through indoor air or return air resets. The reset features of the EMS equipment optimize the cycling of the HVAC equipment. EMS systems were modeled on a site by site basis and the individual features of the EMS equipment were modeled directly in DOE-2.

Gross Realized Refrigeration Demand Savings. Estimated demand savings from refrigeration measures are 298 kW. This accounts for approximately 5% of program demand savings. The estimated gross savings are substantially higher than SCE's *ex ante* estimate of savings. The refrigeration measures are predominantly anti-sweat heaters. These measures were modeled directly in DOE-2 and resulted in significant demand savings.

Gross Realized Process and Miscellaneous Demand Savings. Gross realized demand savings for miscellaneous and process measures were developed from SCE *ex ante* estimates and realization rates of one. These two measures account for only about 2% of demand savings.

Table 4-5: Gross Realized 96 EMHRP Program Demand Savings by End Use

Program Measure	RER Gross Savings (kW)	Realization Rate	RER Gross Realized Savings (kW)	SCE *ex ante* Gross Savings (kW)
Lighting				
Indoor Ltg.	6,008	0.68	4,085	
LED Ltg. Only	299	1.00	299	
Outdoor Ltg. Only	8	1.00	8	
Total Lighting	6,315		4,392	4,573
HVAC*	1,733	1.03	1,785	707
Refrigeration	289	1.03	298	66
Process	108	1.00	108	108
Miscellaneous	22	1.00	22	
All	**8,467**		**6,605**	**5,453**

** SCE savings for HVAC include Miscellaneous*

Confidence Intervals

The CPUC M&E Protocols require the specification of confidence intervals for both gross and net savings estimates. This is not a straightforward exercise when a realization rate model is specified with separate adjustment factors on individual end uses, insofar as the standard error of total realized savings depends on the variances and covariances of all of the estimated realization rates. Confidence intervals were developed for gross realized savings using the following approach:

- First, the SAE model (Version 1) was re-estimated using a composite of all of the savings variables, each multiplied times its own coefficient from

- First, the SAE model (Version 1) was re-estimated using a composite of all of the savings variables, each multiplied times its own coefficient from Table 4-2. That is, the composite (SAV_{bt}) was defined as:

  $$SAV_{bt} = \sum_{k} \hat{\delta}_k SAV_{kbt}$$

  where $\hat{\delta}_k$ is the estimated coefficient from Table 4-2 and SAV_{kbt} is the savings term for end use k. Of course, the expected coefficient of this composite variable is 1.0, since this form of the model is equivalent to Version 1.

- Second, the standard error of the composite variable, which is a relative standard error in the sense that the coefficient is normalized to 1.0, was used to develop a confidence interval for gross realized savings.

5

Net-to-Gross Analysis

5.1 Introduction

Gross program savings estimates reflect savings obtained from measures adopted by participants, without regard to the influence of the program on these adoptions. To the extent that these measures would have been adopted in the absence of the program, their savings will include some free-rider effects. These impacts must be netted out of the estimates to derive reasonable estimates of net program impacts. Further, it is possible that program participation induces the adoption of non-rebated eligible measures; to this extent, savings from these measures should be included in net program impacts.

Options for Estimating Net Savings

Gross savings are typically converted to net savings through the application of net-to-gross ratios. There are several ways of estimating net-to-gross ratios, including the use of self-reported estimates of program influence, the implementation of the difference-of-differences approach, and the application of statistical modeling approaches.

The difference-of-differences approach was used to calculate the net-to-gross ratio for the first year of program savings. In this approach, participants and comparable nonparticipant efficiency choices are related to derive estimates of a net-to-gross ratio. The behavior of similar nonparticipants is used as a proxy for the behavior of participants in the absence of the program.

For the remaining years of savings, an overall net-to-gross ratio was developed using the first-year net-to-gross ratios in conjunction with the realization rates, useful lives of the measures, and approximate discount rates. This approach takes into account the nature of the program as a retrofit program. The results of the net-to-gross analysis are net-to-gross factors and estimates of net realized savings by end use.

5.2 Summary of Net-to-Gross Results

First-Year Net-to-Gross Ratio

The first-year net-to-gross ratios are calculated using a difference-of-differences approach where participant and nonparticipant savings for the same time period are compared in the following way:

$$(1)\quad net\text{-}to\text{-}gross\ ratio_{first\,year} = \frac{\dfrac{participant\ savings}{participant\ sq.\ ft.} - \dfrac{nonparticipant\ savings}{nonparticipant\ sq.\ ft.}}{\dfrac{participant\ savings}{participant\ sq.\ ft.}}$$

where savings and square footage are population estimates derived through the application of case weights to reportable savings and square footage, respectively. A separate net-to-gross ratio is calculated for each end use: lighting, HVAC, and refrigeration. In the case of refrigeration, the summation is over only the building types in which participants have installed refrigeration measures (grocery stores and restaurants). A technical description of the derivation is presented in Appendix G.

Table 5-1 presents the results of the difference-of-differences net-to-gross analysis. As shown, the three net-to-gross ratios range from 0.953 for lighting to 1.00 for refrigeration. This is typical for retrofit decisions, where inertia discourages conservation activities. It should be kept in mind that these estimates (like others based on difference-of-differences and modeling approaches) apply to the program year in question and do not necessarily reflect the possibility that retrofits would have been made in some future year had the program been unavailable. Even when equipment replacement decisions are made, customers are unlikely to exceed standards given the new prevalence of high minimum efficiency standards for lighting, motors, and other energy equipment.

Table 5-1: First-Year Net-to-Gross Ratios by End Use

Program Measure	Net-to-Gross Ratio
Indoor Lighting	0.953
HVAC	0.989
Refrigeration	1.000

Overall Net-to-Gross Ratio

Each year of program savings includes savings realized by participants who *free-ride* or realize program incentives for actions they would have initiated apart from the program. Because participants enter the program with existing equipment in various stages of usefulness, each year a different number of them would face the decision of whether or not to retrofit their existing equipment had they not entered the program. In order to account for this subsequent-year free ridership, a method using the first-year net-to-gross ratio, customer savings, reportable savings, and measure lifetimes was used to develop an estimate of total program net-to-gross ratios.

In particular, the first-year net-to-gross ratio is used to estimate this proportion in the first year. For subsequent years, the proportion is estimated on the remaining population still faced with the retrofit decision. For each year, net savings are calculated as follows:

$$(2) \quad \textit{gross realized savings} \times \textit{net-to-gross ratio}^{\textit{year of savings}}$$

and the overall net-to-gross ratio is the sum of these net savings for the life of the measure over the sum of gross realized savings. A technical description of the derivation is presented in Appendix G. Table 5-2 presents the overall net-to-gross ratios by end use. Note that for those measures where SCE's gross *ex ante* estimates were adopted (outdoor lighting only, LED lighting only, process and miscellaneous), SCE's net-to-gross ratios were used.[1]

Table 5-2: Overall Net-to-Gross Ratios by End Use

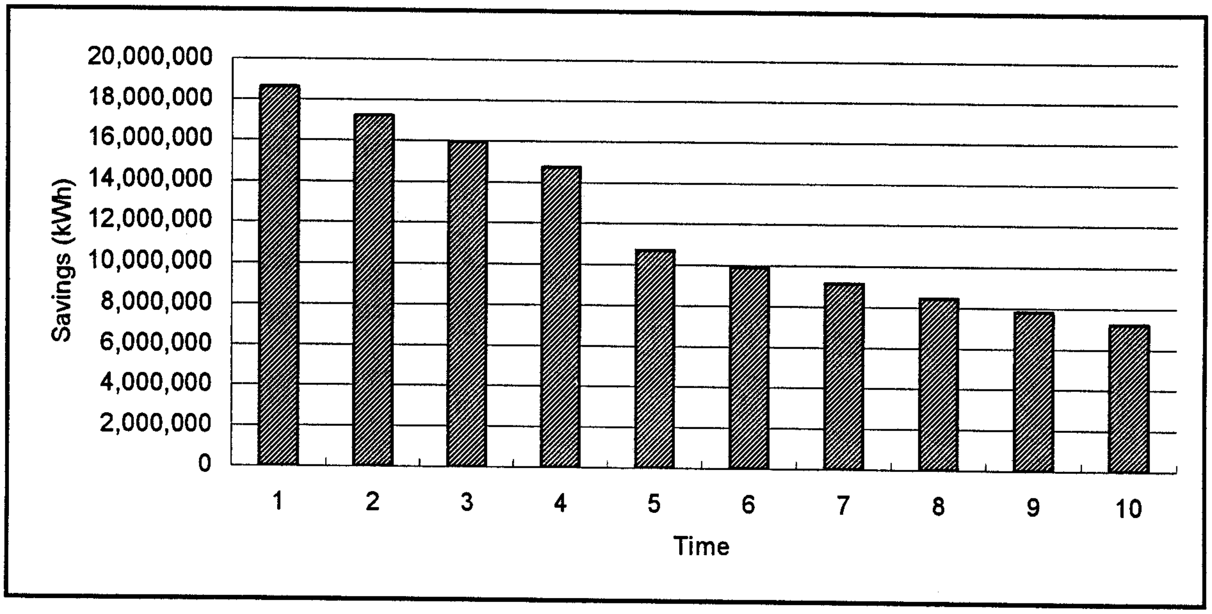
Program Measure	Net-to-Gross Ratio
Indoor Lighting	0.795
LED Lighting Only *	0.689
Outdoor Lighting Only *	0.689
HVAC	0.924
Refrigeration	1.000
Process *	0.766
Miscellaneous *	0.794

* *SCE's net-to-gross ratios.*

[1] Because SCE's net estimates are derived using a verification factor of .957, this factor has been applied to their net-to-gross ratio to obtain a modified net-to-gross ratio that includes the verification factor.

As an example, Figure 5-1 illustrates the diminishing net savings over the measure lifetime for lighting. As shown, each year of savings represents that portion attributable to the program after accounting for free-ridership effects.

Figure 5-1: Net Realized Savings for Lighting (kWh)



5.3 Summary of Net Program Savings

Energy

Table 5-3 provides a summary of program savings by end use. The table presents realized savings per measure, total realized gross savings, net-to-gross ratios, and estimated net savings. SCE estimates are also presented for purposes of comparison. Comments are provided below, organized by end use:

- ***Lighting.*** As shown, RER's estimates of gross lighting savings are roughly 20% lower than SCE's *ex ante* estimates. This difference stems primarily from the low realization rate on lighting. As noted in Section 4, RER's low realization rate was probably attributable to one of two problems: errors in SCE's characterization of pre-retrofit lighting densities, or changes in operating hours associated with major reductions in lighting densities. On the other hand, RER's estimate of net program savings is only 8% lower than SCE's estimate.
- ***HVAC.*** RER's estimate of gross HVAC savings is 43% lower than SCE's estimate. This result traces to the fact that ADM's engineering estimates of HVAC savings were considerably lower than SCE's estimates, especially for EMS measures. RER's estimate of net HVAC savings is 34% lower than SCE's estimate.

- ***Refrigeration.*** RER's estimate of gross refrigeration savings is 33% lower than SCE's *ex ante* estimate. This is attributable to differences in the engineering analyses conducted by SCE and ADM. RER's net savings estimate is 12% lower than SCE's estimate.
- ***Process and Miscellaneous.*** No analysis was conducted for these end uses. As a result, SCE's estimates of net and gross savings were adopted for measures falling under these end uses.
- ***All End Uses.*** The estimates of gross realized savings developed in this study fall approximately 30% below the *ex ante* estimates developed by SCE. The net savings estimate is 20% lower than SCE's estimate.

Table 5-3: Net Realized Energy Savings

	SCE Estimates			RER Estimates		
End Use	Ex-Ante Gross Savings (kWh)	Net-to Gross Ratio*	Verified Net Savings (kWh)	Gross Realized Savings (kWh)	Overall Net-to Gross Ratio	Net Realized Savings (kWh)
Lighting						
Indoor Ltg.	*22,079,125*			*17,147,470*	0.795	*13,635,918*
LED Ltg. Only	*2,612,422*			*2,612,422*	0.689	*1,800,063*
Outdoor Ltg. Only	*1,009,730*			*1,009,730*	0.689	*695,744*
Total Lighting	***25,701,277***	***0.689***	***17,677,000***	***20,769,622***	***0.777***	***16,131,726***
HVAC	24,670,308	0.794	19,595,000	13,950,105	0.924	12,886,960
Refrigeration	3,245,731	0.766	2,484,000	2,179,294	1.000	2,179,294
Process	1,042,335	0.766	798,000	1,042,335	0.766	798,012
Miscellaneous	2,366,077	0.794	1,875,000	2,366,077	0.794	1,879,399
Total Miscellaneous*				***5,587,706***	***0.869***	***4,856,705***
All	**57,025,728**		**42,429,000**	**40,307,432**	**0.840**	**33,875,390**

** SCE's net-to-gross ratios include a verification factor of .957.*
*** Total Miscellaneous includes refrigeration, process, and miscellaneous.*

Demand

Demand savings were derived in a similar fashion. This approach assumes that demand savings are subject to the same realization rates and the same net-to-gross ratios by end use. The results are displayed in Table 5-4.

As indicated in Table 5-4, RER's overall estimate of gross realized peak demand savings is roughly 20 % higher than SCE's *ex-ante* peak demand savings. As a consequence of the high net-to-gross ratios derived in the study, RER's net demand savings estimate is higher than SCE's verified net program savings estimate.

Table 5-4: Net Realized Demand Savings

	SCE Estimates			RER Estimates		
End Use	Ex-Ante Gross Savings (kW)	Net-to Gross Ratio	Verified Net Savings (kW)	Gross Realized Savings (kW)	Net-to Gross Ratio	Net Realized Savings (kW)
Lighting						
Indoor Ltg.				*4,085*	0.795	3,249
LED Ltg. Only				*299*	0.720	215
Outdoor Ltg. Only				*8*	0.720	6
Total Lighting	*4,573*	***0.689***	*3,260*	*4,392*		*3,470*
HVAC**	707	0.794	580	1,785	0.924	1,649
Refrigeration	66	0.766	50	298	1.000	298
Process	108	0.766	90	108	0.800	86
Miscellaneous		0.794		22	0.830	18
All	**5,453**		**3,980**	**6,605**		**5,521**

* *SCE's net-to-gross ratios include a verification factor of .957*

** *SCE savings for HVAC include Miscellaneous*

Appendix H

Regulatory Tables

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M&E PROTOCOLS TABLE 6 - RESULTS USED TO SUPPORT PY96 SECOND EARNINGS CLAIM FOR THE COMMERCIAL ENERGY MANAGEMENT HARDWARE REBATE PROGRAM

FIRST YEAR LOAD IMPACT EVALUATION, FEBRUARY 1998, STUDY ID NO. 540

				5. A. 90% CONFIDENCE LEVEL				5. B. 80% CONFIDENCE LEVEL			
				LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND
1. Average Participant Group and Average Comparison Group		PART GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP
A. Pre-install usage:	Pre-install kW	na	na	na	na	na	na	na	na	na	na
	Pre-install kWh	na	na	na	na	na	na	na	na	na	na
	Base kW	na	na	na	na	na	na	na	na	na	na
	Base kWh	na	na	na	na	na	na	na	na	na	na
	Base kW/ designated unit of measurement	na	na	na	na	na	na	na	na	na	na
	Base kWh/ designated unit of measurement	na	na	na	na	na	na	na	na	na	na
B. Impact year usage:	Impact Yr kW	na	na	na	na	na	na	na	na	na	na
	Impact Yr kWh	na	na	na	na	na	na	na	na	na	na
	Impact Yr kW/designated unit	na	na	na	na	na	na	na	na	na	na
	Impact Yr kWh/designated unit	na	na	na	na	na	na	na	na	na	na
2. Average Net and Gross End Use Load Impacts		AVG GROSS	AVG NET	AVG GROSS	AVG GROSS	AVG NET	AVG NET	AVG GROSS	AVG GROSS	AVG NET	AVG NET
	A. i. Load Impacts - kW	6,605	5,507	6,094	7,116	5,081	5,933	6,207	7,003	5,175	5,839
	A. ii. Load Impacts - kWh	40,307,432	33,875,390	37,191,063	43,423,801	31,256,314	36,494,466	37,878,748	42,736,116	31,834,262	35,916,518
	B. i. Load Impacts/designated unit - kW										
	Lighting (kW/sqft)	0.00008	0.00006	0.00007	0.00009	0.00006	0.00007	0.0001	0.0001	0.0001	0.0001
	HVAC (kW/sqft)	0.00003	0.00003	0.00002	0.00004	0.00002	0.00003	0.0000	0.0000	0.0000	0.0000
	Miscellaneous (kW/project)	31.2	29.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	B. ii. Load Impacts/designated unit - kWh										
	Lighting (kWh/sqft)	0.3857	0.2995	0.3521	0.4192	0.27348	0.32560	0.3595	0.41	0.2792	0.3198
	HVAC (kWh/sqft)	0.2721	0.2463	0.2254	0.3189	0.20395	0.28864	0.2357	0.31	0.2133	0.2793
	Miscellaneous (kWh/project)	247,818	229,024	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	C. i. a. % change in usage - Part Grp - kW	na	na	na	na	na	na	na	na	na	na
	C. i. b. % change in usage - Part Grp - kWh	na	na	na	na	na	na	na	na	na	na
	C. ii. a. % change in usage - Comp Grp - kW	na	na	na	na	na	na	na	na	na	na
	C. ii. b. % change in usage - Comp Grp - kWh	na	na	na	na	na	na	na	na	na	na
D. Realization Rate:	D.A. i. Load Impacts - kW, realization rate	1.2113	1.3837	1.1176	1.3049	1.2767	1.4906	1.1383	1.2842	1.3003	1.4670
	D.A. ii. Load Impacts - kWh, realization rate	0.7068	0.7984	0.6522	0.7615	0.7367	0.8601	0.6642	0.7494	0.7503	0.8465
	D.B. i. Load Impacts/designated unit - kW, real rate										
	Lighting (kW/sqft)	0.9604	1.0613	0.8769	1.0440	0.9690	1.1537	0.9026	1.0183	0.9974	1.1253
	HVAC (kW/sqft)	2.5559	2.8724	2.1165	2.9953	2.3786	3.3663	2.3826	2.7291	2.6777	3.0671
	Miscellaneous (kW/project)	2.3333	2.7214	1.9322	2.7345	2.2535	3.1893	2.0207	2.6460	2.3568	3.0861
	D.B. ii. Load Impacts/designated unit - kWh, real rate										
	Lighting (kWh/sqft)	0.8081	0.9126	0.7378	0.8332	0.8332	0.9920	0.7594	0.8568	0.8576	0.9676
	HVAC (kWh/sqft)	0.6614	0.7536	0.5477	0.6240	0.6240	0.8831	0.6165	0.7062	0.7025	0.8047
	Miscellaneous (kWh/project)	0.7513	0.9072	0.6221	0.7512	0.7512	1.0631	0.6506	0.8520	0.7856	1.0287
3. Net-to-Gross Ratios		RATIO		RATIO	RATIO			RATIO	RATIO		
	A. i. Average Load Impacts - kW	0.8400		0.775	0.905			0.789	0.891		
	A. ii. Average Load Impacts - kWh	0.8400		0.775	0.905			0.789	0.891		
	B. i. Avg Load Impacts/designated unit of measurement - kW										
	Lighting (kW/sqft)	0.777		0.709	0.845			0.724	0.830		
	HVAC (kW/sqft)	0.924		0.765	1.083			0.800	1.048		
	Miscellaneous (kW/project)	0.869		0.720	1.018			0.753	0.985		
	B. ii. Avg Load Impacts/designated unit of measurement - kWh										
	Lighting (kWh/sqft)	0.777		0.709	0.845			0.724	0.830		
	HVAC (kWh/sqft)	0.924		0.765	1.083			0.800	1.048		
	Miscellaneous (kWh/project)	0.869		0.720	1.018			0.753	0.985		
	C. i. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kW	na		na	na			na	na		
	C. ii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kWh	na		na	na			na	na		
4. Designated Unit Intermediate Data		PART GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP	PART GRP	PART GRP	COMP GRP	COMP GRP
	A. Pre-install average value	na	na	na	na	na	na	na	na	na	na
	B. Post-install average value	na	na	na	na	na	na	na	na	na	na
6. Measure Count Data		NUMBER									
	A. Number of measures installed by participants in Part Group	Attached									
	B. Number of measures installed by all program participants in the 12 months of the program year	Attached									
	C. Number of measures installed by Comp Group	Attached									
7. Market Segment Data		SIC or CZ	PERCENT								
	Distribution by 3 digit SIC - Commercial/Industrial	See Attached									

Southern California Edison

M&E PROTOCOLS TABLE 6 - RESULTS USED TO SUPPORT PY96 SECOND EARNINGS CLAIM FOR THE COMMERCIAL ENERGY MANAGEMENT HARDWARE REBATE PROGRAM
FIRST YEAR LOAD IMPACT EVALUATION, FEBRUARY 1998, STUDY ID NO. 540

6. Measure Count Data

	Measure	A. Number of measures installed by participants in Part Group (n=269)	B. Number of measures installed by all program participants in the 12 months of the program year (n=775)	C. Number of measures installed by Comparison Group (n=308)
	Air Compressor	-	1	-
	Air Compressor System	-	4	-
	Air distribution system	48	48	-
	Anti-sweat heater	225	418	-
	ASD (refrigeration)	-	4	-
	ASD (space conditioning)	85	156	1
	ASD (water services)	-	4	-
	Chilled water controls	1	1	-
	Chiller 200-600 ton	1	3	-
	Chiller 75-200 ton		2	-
	Component - air cooled single pkg AC	46	85	1
	Component - disconnect lamp fixture rep	6,665	7,486	-
	Component - disconnect lamp - rewire	27,917	33,963	720
	Component - LED exit signs	351	10,642	-
	Component - outdoor lght system mod	1	244	324
	Component - outdoor lght system rep	3	226,804	6
	Component - delamp from 8 to 4 ft	168	6,700	-
	Component - delamp from fb40 to f17t8	-	1,574	788
	Cooling tower	-	1	-
	Daylighting system	48	48	-
	Economy cycle	1	3	-
	EMS (lighting)	19	87	-
	EMS (refrigeration)	-	25	-
	EMS (space conditioning)	9	90	3
	Indoor lght system - mod	4,696	4,696	-
	Indoor lght system - rep	84	87	-
	Misc (process)	-	4	-
	Misc(refrigeration)	6	7	1
	Misc (space conditioning)	278	408	-
	Motors (HVAC) - 3 phase	-	3	-
	Occupancy sensor - indoor	-	12	4
	Pump system controls	-	3	-
	Total	40,652	293,613	1,848

Southern California Edison

M&E PROTOCOLS TABLE 6 - RESULTS USED TO SUPPORT PY96 SECOND EARNINGS CLAIM FOR THE COMMERCIAL ENERGY MANAGEMENT HARDWARE REBATE PROGRAM
FIRST YEAR LOAD IMPACT EVALUATION, FEBRUARY 1998, STUDY ID NO. 540

7. Market Segment Data		
B. Distribution of Participants by Commercial Bldg Type	Building Type	Percentage
	Office	33.8
	Restaurant	2.6
	Retail	16.7
	Food Stores	5.9
	Warehouse	4.1
	K-12 Schools	13.8
	College/University	3.3
	Hospitals/Clinics	2.6
	Hotels/Motels	0.0
	Misc	17.1

Southern California Edison

M&E PROTOCOLS TABLE 6 - RESULTS USED TO SUPPORT PY96 SECOND EARNINGS CLAIM FOR THE COMMERCIAL ENERGY MANAGEMENT HARDWARE REBATE PROGRAM

FIRST YEAR LOAD IMPACT EVALUATION, FEBRUARY 1998, STUDY ID NO. 540

7. Market Segment Data		
B. Distribution of Participants by Industry (3-digit SIC)	3-digit SIC	Percentage
	078	2.2
	208	0.4
	271	0.4
	399	0.4
	431	1.1
	472	0.4
	473	0.4
	481	2.2
	504	0.4
	506	1.5
	507	0.4
	508	0.4
	513	0.4
	514	0.7
	523	3.7
	531	3.0
	533	0.4
	539	1.9
	541	5.6
	551	0.7
	553	0.7
	571	0.7
	581	2.6
	591	4.1
	592	0.4
	593	0.4
	594	0.7
	599	0.4
	602	0.7
	641	0.4
	651	21.2
	653	1.9
	656	0.4
	734	0.4
	737	0.7
	738	1.5
	781	0.4
	792	0.4
	801	0.7
	802	0.7
	804	0.4
	806	2.2
	811	0.4
	821	16.7
	822	2.6
	823	0.4
	832	0.7
	836	0.4
	866	1.1
	873	1.1
	874	0.4
	911	0.7
	941	0.7
	999	6.3

Table 7: Data Quality and Processing Documentation for 1996 Commercial Energy Management Hardware Rebate Program
February 1998
Study ID No. 540

7.A Overview Information

1. Study Title and Study ID No.

   1996 Commercial Energy Management Hardware Rebate Program Impact Evaluation, Study 540.

2. Program, program year (or years) and program description.

   The program year is 1996. The Commercial Energy Management Hardware Rebate Program (EMHRP) provided monetary incentives to commercial utility customers for installing certain energy efficient equipment as part of a retrofit program. Predominant measures include ASDs for motors and space conditioning equipment, energy management systems for space conditioning and lighting, disconnecting/rewiring lamps, and LED exit signs. See section 1.3 for a detailed program description.

3. End uses and / or measures covered.

   The measures and end uses covered by this analysis are the following. Indoor lighting includes disconnect lamp - rewire, EMS, LED exit signs, disconnect lamp fixture - replacement, delamp from 8' to 4', system replacement, delamp from F840 to F17T8, system modification, daylighting system, occupancy sensor. HVAC includes ASD, EMS, misc., economy cycle, air distribution system, air cooled single package air conditioning, chilled water controls, chiller 200 - 600 ton, chiller 75 - 200 ton, and motors - 3 phase. Refrigeration includes EMS, anti-sweat heater, ASD, and misc. Additionally, SCE's records on outdoor lighting, LED exit signs, process and miscellaneous measures are included. Outdoor lighting includes lighting system replacement and lighting system modification. Process includes air compressor system, misc., air compressor, and cooling tower. Miscellaneous includes ASD and pump system controls.

4. Methods and models used.

   The realization rate approach, a specific type of mixed engineering/statistical method, was used in this evaluation. This model relies on engineering estimates developed from DOE-2 simulations and standard engineering algorithms using data collected from on-site surveys. The development of engineering estimates is detailed in Section 3. The model also makes use of information on factors that might affect the realization of the engineering estimates of usage under these scenarios and the associated DSM-related savings. The model produces a set of adjustment coefficients (or adjustment functions) that translate engineering estimates into estimates consistent with observed energy usage and savings. These coefficients reflect the proportion of the engineering-based savings estimates actually realized in the form of reduced site usage. See Section 4.4 for a summary of the realization rate model specification.

Table 7 (cont'd.): Data Quality and Processing Documentation for 1996 Commercial Energy Management Hardware Rebate Program February 1998 Study ID No. 540

5. Participant and comparison group definition.

   In this analysis, participants are a group of commercial sites who participated in 1996 EMHRP and who installed indoor lighting, HVAC, and/or refrigeration measures. A site is defined as a premise or premises served by a single account or group of accounts where the service name is the same, and the premise or premises are on the same side of the street and/or share the same transformer. Nonparticipants are a screened sample of comparable sites chosen from similar locations and industries. Section 2.2 details the screening process and sample frame for both groups.

6. Analysis sample size.

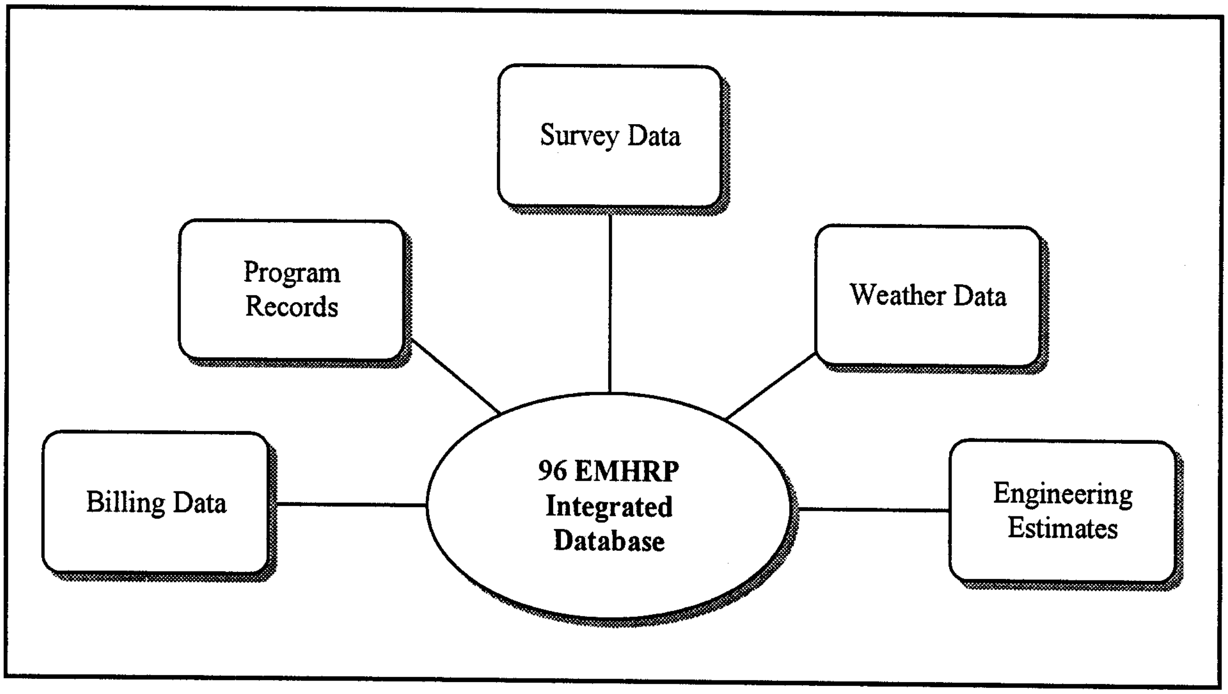
   As described in Section 2, a total of 366 sites participated in 96 EMHRP that had indoor lighting, HVAC, and/or refrigeration measures. We attempted a census of these sites. Data was collected on 269 participants and 308 nonparticipants. Of these, 12 sites had refrigeration measures, 210 had indoor lighting measures, and 98 had HVAC measures. The final database used for analysis consisted of 16,936 observations representing 476 sites.

7.B Database Management

1. Description and flow chart illustrating relationships between data elements.

   The evaluation of 96 EMHRP required several types of data. The integrated database for the evaluation is comprised of five components: (1) program records, (2) billing records, (3) on-site survey data, (4) engineering estimates, and (5) weather data including both actual weather observations and normal weather data. The following figure provides an overview of the integrated database.

Overview of Database Construction



2. Identify the specific data sources for each data element.

   The RER project team collected the on-site survey data and the engineering estimates. Program records, billing records, and actual weather data was provided by SCE. The CEC provided normal weather data.

3. Diagram and description of the data attrition process.

   The participant group consisted of 366 sites. Of these, 83 were chain stores and were represented by a selected sample. The final sample design included 300 participants and 300 comparable nonparticipants.

4. Description of internal/organizational data quality checks and data quality procedures.

   As described in Section 2, a number of checks were done on billing and weather data. Specifically, data was screened for missing information, erroneous billing days and/or read dates, and abnormal monthly consumption. Data were then merged and calendarized.

5. Summary of data collected specifically for the analysis but not used.

   Not applicable.

7.C Sampling

1. Sampling procedures and protocols.

   For participants, a census was attempted of the 366 sites. The group was stratified by building type and level of consumption. A comparable sample of nonparticipants were obtained by screening by the following criteria: 1) participation in other SCE 1996 DSM programs, 2) presence of an account payable by SCE, 3) participation in on-site survey conducted by SCE, and 4) participation in DSM Bidding Pilot Program. Finally, nonparticipants were screened for sufficient billing data and then chosen in the same proportion by building type and level of consumption as participants. Section 2.2 describes this process in detail.

2. Survey information.

   A copy of the survey used is provided in Appendix B. For participants, a census was attempted of the 300 sites; 90% of which were surveyed (269 sites). For nonparticipants, the response rate was 28%. Table 2-7 lists the reasons for refusals. Because the survey was conducted on-site, item non-response was not a problem.

Table 7 (cont'd.): Data Quality and Processing Documentation for 1996 Commercial Energy Management Hardware Rebate Program February 1998 Study ID No. 540

3. Statistical descriptions.

Means and standard deviations of model variables are presented below.

Regression Model Variables Descriptive Statistics

Explanatory Variables	Mean	Standard Deviation	Minimum	Maximum
$\Delta(KWH_{it}/SQFT_i)$	-0.0119	0.2652	-1.7598	2.3740
$ESH_i \Delta HDD_{it}$	-0.9240	22.9340	-446.3436	195.5148
$EAC_i \Delta CDD_{it}$	9.2429	42.3820	-340.9169	287.9241
$(\Delta ESAVHVAC_{it} + \Delta ESAVREF_{it}) / SQFT_i$	0.0078	0.0422	-0.0002	0.4862
$EAC_i(CDD_{it}-NCDD_{it}) (\Delta ESAVHVAC_{it} / SQFT_i) PKHEAT_i$	0.0601	2.0613	-8.2484	143.1636
$\Delta ESAVLIT_{it} / SQFT_i$	0.0354	0.1270	0.0000	1.4477
$\Delta SQFT_{it} / SQFT_i$	0.0013	0.0152	0.0000	0.6473
$\Delta OPHOURS_{it}$	-0.0723	9.6072	-168.0000	180.0000
$\Delta NELIGBLIT_{it} / SQFT_i$	0.0000	0.0001	-0.0024	0.0053
$\Delta NELIGBCOOL_{it}\ COOLSEAS_t / SQFT_i$	0.0000	0.0001	-0.0012	0.0017
$\Delta NELIGBHEAT_{it}\ HEATSEAS_t / SQFT_i$	0.0000	0.0000	-0.0001	0.0000
$FOOD_i ESH_i \Delta HDD_{it}$	-0.0536	6.3126	-148.5800	131.6933
$OFFICE_i EAC_i \Delta CDD_{it}$	2.8835	21.1320	-155.8213	257.7220
$REST_i EAC_i \Delta CDD_{it}$	0.1586	7.2582	-130.4788	250.6475
$RETAIL_i EAC_i \Delta CDD_{it}$	1.9655	20.8625	-340.9169	266.3356
$WARE_i EAC_i \Delta CDD_{it}$	0.4528	10.4312	-152.8907	151.5198
$K\text{-}12_i EAC_i \Delta CDD_{it}$	1.1642	17.9007	-213.9403	265.2604
$COLL_i EAC_i \Delta CDD_{it}$	0.1926	7.1936	-149.1096	168.7380
$HOSP_i EAC_i \Delta CDD_{it}$	0.3135	8.0833	-157.1584	161.9290
$WSTAT11C_{it}$	0.5339	9.8984	-340.9169	141.7175
$WSTAT9H_{it}$	-0.0722	3.2852	-149.2679	73.0774
$WSTAT11H_{it}$	0.0313	3.6063	-100.2326	144.4402
$RETAIL_i$	0.2059	0.4044	0.0000	1.0000
$FOOD_i$	0.0680	0.2517	0.0000	1.0000
$COLL_i$	0.0234	0.1511	0.0000	1.0000
$HOSP_i$	0.0327	0.1778	0.0000	1.0000

7.D Data Screening and Analysis

1. Description of procedures used for the treatment of outliers, missing data points, and weather adjustment.

   The following kinds of anomalies qualified an observation for deletion from the realization rate analysis: (1) inability to line up billing meters with surveyed areas, (2) meter change-outs and long periods with zero consumption, (3) unusual intensities, (4) unavailability for the on-site survey, and (5) anomalous consumption data. These anomalies resulted in the omission of 75 sites from the realization rate database and an additional 325 observations from the remaining sites. Six groups of sites were aggregated, resulting in a further reduction of 26 sites. Section 2.6 describes these omissions.

   Missing temperature values from the actual weather data were calculated for a representative weather station by averaging previous and subsequent values. The values for this station were then used as predictors for other stations' missing values.

2. Description of controls for the effects of background variables.

   By using a control group in this analysis, we controlled for economic and political activity.

Table 7 (cont'd.): Data Quality and Processing Documentation for 1996 Commercial Energy Management Hardware Rebate Program February 1998 Study ID No. 540

3. Description of procedures used to screen data for inclusion into the final analysis dataset.

Program participants numbered 775. We screened to include only those that installed an HVAC, indoor lighting, or refrigeration measure. Further, sites that installed only LED exit sign measures were also screened from the database. The final participant sample frame consisted of 366 sites. However, 83 of these are made up of two types of chain stores and so a sample of chain stores was selected to represent the 83. The target sample consisted of 300 sites. Of these, 269 were surveyed.

The nonparticipant sample design requires a completed sample size of 300 sites. Sites were determined by SCE staff from streetwalker identifiers on the SCE billing frame. All accounts associated with each site were grouped using a single identifier. The frame used for the nonparticipants is a *screened* sample of commercial sites. In particular, the following two screens were applied to all active accounts. Any sites associated with a screened account were omitted from the nonparticipant frame.

a) Screen 1: Accounts on the SCE commercial billing frame were screened by the following criteria:

- Participation in other SCE 1996 DSM programs,
- Site contains account payable by SCE,
- Participation in on-site survey conducted by SCE in last 12 months, and
- Participation in DSM Bidding Pilot Program.

b) Screen 2: Accounts that passed through Screen 1 were then screened for sufficient billing data. In particular, accounts (and the associated sites) that were not active in December of 1994 were omitted from the frame.

The following table shows the results of the screening process. A final nonparticipant sample of 2,976 sites was drawn from this frame in the same proportion by building type and annual consumption as participants. Of these, 308 were surveyed.

Table 7 (cont'd.): Data Quality and Processing Documentation for 1996 Commercial Energy Management Hardware Rebate Program
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Summary of Nonparticipant Frame Screening Process

Building Type	All Sites	Screen 1	Screen 2
Office	72,297	48,261	33,268
Restaurant	15,675	15,528	9,812
Retail	29,502	29,028	17,703
Food Stores	8,099	7,922	5,300
Warehouse	13,196	13,030	7,916
K-12 Schools	4,014	3,864	3,095
College/University	1,474	1,424	918
Hospital/Clinics	2,385	2,269	1,642
Hotel/Motel	2,506	2,445	1,903
Miscellaneous	123,371	122,206	87,258
Total	**273,519**	**245,977**	**168,815**

4. Regression statistics.

Regression statistics for the realization rate analysis are presented in the below.

Model Estimation: Autocorrelation Corrected

Dependent Variables	Version A $\Delta(KWH_{it}/SQFT_i)$
Explanatory Variables	
Intercept	0.00483 *(1.92)*
$ESH_i \Delta HDD_{it}$	0.0000116 *(0.11)*
$EAC_i \Delta CDD_{it}$	0.00151 *(12.86)*
$\Delta ESAVHVAC_{it} + \Delta ESAVREF_{it} / SQFT_i$	-1.031 *(-9.57)*
$EAC_i(CDD_{it}\text{-}NCDD_{it})\ \Delta ESAVHVAC_{it} / SQFT_i\ PKHEAT_i$	0.000705 *(0.23)*
$\Delta ESAVLIT_{it} / SQFT_i$	-0.676 *(-18.91)*
$\Delta SQFT_{it} / SQFT_i$	0.479 *(1.93)*
$\Delta OPHOURS_{it}$	0.000253 *(0.77)*
$\Delta NELIGBLIT_{it} / SQFT_i$	-31.698 *(-1.51)*
$\Delta NELIGBCOOL_{it}\ COOLSEAS_t / SQFT_i$	-221.849 *(-4.43)*
$\Delta NELIGBHEAT_{it}\ HEATSEAS_t / SQFT_i$	-100.150 *(-0.04)*
$FOOD_i ESH_i \Delta HDD_{it}$	-0.000808 *(-2.22)*
$OFFICE_i EAC_i \Delta CDD_{it}$	-0.000545 *(-3.51)*
$REST_i EAC_i \Delta CDD_{it}$	-0.00233 *(7.29)*
$RETAIL_i EAC_i \Delta CDD_{it}$	-0.000367 *(-2.37)*
$WARE_i EAC_i \Delta CDD_{it}$	-0.00136 *(-6.04)*
$K\text{-}12_i EAC_i \Delta CDD_{it}$	-0.000100 *(-6.00)*

Table 7 (cont'd.): Data Quality and Processing Documentation for 1996 Commercial Energy Management Hardware Rebate Program
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(cont'd.): Model Estimation: Autocorrelation Corrected

Dependent Variables	Version A $\Delta(KWH_{it}/SQFT_i)$
Explanatory Variables	
$COLL_iEAC_i\Delta CDD_{it}$	-0.000702 *(-2.17)*
$HOSP_iEAC_i\Delta CDD_{it}$	-0.000411 *(-1.43)*
$WSTAT11C_{it}$	0.000327 *(1.38)*
$WSTAT9H_{it}$	0.00173 *(2.64)*
$WSTAT11H_{it}$	0.00186 *(3.00)*
$RETAIL_i$	-0.0246 *(-2.17)*
$FOOD_i$	0.0325 *(1.77)*
$COLL_i$	0.0799 *(2.73)*
$HOSP_i$	0.0331 *(1.33)*
Adjusted R-Squared	0.29

5. Specification.

   Realization rate analysis is presented in Section 4, with the rationale for the model specification detailed in Section 4.4. The net-to-gross analysis is presented in Section 5.

6. Error in measuring variables.

   The use of an on-site survey mitigates measurement error, as trained professionals were used to collect information on specific types of equipment. However, another issue is the potential for errors due to the timing of the installation of measures. Installation dates were taken from program files and in some case cross checked with hard copy coupon data. In some cases, this resulted in overriding the program data based on inspection of the coupon data. Installation dates should thus be reasonably accurate. To allow for any additional small errors, a one-month deadband was used to omit the month of adoption from the model estimation process.

Table 7 (cont'd.): Data Quality and Processing Documentation for 1996 Commercial Energy Management Hardware Rebate Program February 1998 Study ID No. 540

7. Autocorrelation.

   Autocorrelation, which is the correlation of the error term over time for individual sites, is typical in analyses of energy usage over time. This problem was mitigated with generalized least squares, a standard remedy. All models presented in the study correct for the presence of autocorrelation. Section 4-4 includes a discussion of methodology employed to mitigate the problem of autocorrelated errors.

8. Heteroskedasticity.

   This analysis did not specifically address the issue of heteroskedasticity. This is seldom a problem in this type of analysis of changes in site-level usage.

9. Collinearity.

   The issue of collinearity was addressed in this analysis through careful specification of interaction terms and through omission of some variables found to be highly collinear with others.

10. Influential data points.

    The following kinds of influential data points qualified an observation for omission from the regression: long periods with zero consumption, and consumption data which exhibited inconsistent or anomalous patterns. Observations with these qualifications were set to missing.

11. Missing data.

    Observations set to missing, as described in item 10 above, were omitted from the regression. These anomalies resulted in the omission from the realization rate database of 75 sites and an additional 325 observations from the remaining sites. Six groups of sites were aggregated, resulting in a further reduction of 26 sites. Further explanation of these omissions is described in Section 2.6

12. Precision.

    Standard errors on estimated parameters are a standard output of statistical analysis packages. Table 4-1 and Table 4-2 present the t-statistics for each estimated parameter in the analysis.

7.E Data Interpretation And Application

1. Calculation of net impacts.

   Net program impacts are calculated to be 33,875,390 kWh and 5,507 kW. Table 1-1 and Table 1-2 summarize net realized savings per measure for both energy and demand impacts.

2. Description of process, choices made, and rational for choices made in Section E.1., above.

   Sections 4 and 5 detail the rationale for the realization rate model and the net-to-gross analysis, respectively. More specifically, Section 4.3 summarizes the rationale for the realization rate model, and section 4.4 discusses the EMHRP realization rate model in detail. Section 5.1 presents the rational for the net-to-gross method used and Section 5.2 summarizes the methodology in detail.