1996 Nonresidential New Construction Program

First-Year Load Impact Evaluation

Study ID No. 1004

Submitted to:

San Diego Gas & Electric Company
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San Diego, California 92123

February 25, 1998

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Introduction

1.1 Overview

This report presents the findings of an evaluation of the impacts of San Diego Gas & Electric Company's 1996 Nonresidential New Construction Program. The evaluation was conducted by a team consisting of three firms: Regional Economic Research, Inc. (RER), VIEWtech, Inc. (VIEWtech), and CIC Research, Inc. (CIC). The study was designed to comply closely with the provisions of the California Public Utilities Commission's *Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand-Side Management Programs* (the CPUC M&E Protocols).

San Diego Gas & Electric Company (SDG&E) initially filed for first-year earnings based on estimated net program savings of roughly 55.6 GWh, 8.9 MW, and 2,196 Mtherms. This study focused on the independent estimation of energy and demand savings, and did not consider gas savings. The results of the study suggest that the program generated net energy and demand savings very close to the estimates used in SDG&E's first-year earnings claim. This is consistent with the results of the 1996 Earnings Verification Study conducted by ECONorthwest and ECOTOPE, Inc. for the Office of Ratepayer Advocates of the California Public Utilities Commission

The remainder of this section provides a brief description of the 1996 Nonresidential New Construction Program, identifies evaluation objectives, presents an overview of the evaluation methodology, and previews the rest of the report.

1.2 Description of Program

Since 1995, the Nonresidential New Construction Program has been marketed as the Savings Through Design Program. The Savings Through Design Program is designed to encourage the incorporation of energy-efficient technologies into the design of commercial buildings by providing assistance with the review of building plans, offering cash incentives for standard and custom measures, and educating target audiences through a variety of communications tactics. The Program encourages the installation of new construction projects that exceed building energy efficiency standards, including California's Title 24 Standards. A total of 334 contracts were completed under the Savings Through Design Program in 1996.

In 1996, SDG&E continued to improve its communication with the architectural, engineering, and development communities through Title 24 seminars, the "Progress Through Design" newsletter, case studies, testimonials, and personal contacts. The new construction field office continued to serve the design and construction community. SDG&E also sponsored two seminars for the architectural and engineering communities. Program presentations were also made to such organizations as the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE), the American Institute of Architects (AIA), the Illumination Engineering Society (IES), and the Building Owners' Management Association (BOMA).

1.3 Evaluation Objectives

The fundamental purpose of the project was to estimate the impacts of the 1996 Savings Through Design Program. The evaluation had three specific objectives, including:

- Assembly of a comprehensive database relating to the behavior of participants and nonparticipants.
- Development of first-year gross realized energy and demand impacts of the measures installed under the program.
- Estimation of first-year net energy and demand impacts. These impacts were designed primarily to take into account free ridership and participant free drivership, although an attempt was also made to assess nonparticipant free drivership.

1.4 Overview of Methodology

The overall methodology will be designed to comply with both the principles of good evaluation and the dictates of the CPUC M&E Protocols. The methodology consisted of four primary elements.

- ***On-Site Survey.*** An on-site survey was conducted in order to collect information on participants and nonparticipants. The survey was used to collect detailed information on equipment stocks, building characteristics, operating schedules, occupancy rates, Title 24 compliance, and stocks of demand-side management (DSM) measures. In order to increase the robustness and precision of the savings estimates, data developed through the on-site surveys conducted in the course of the evaluation of the 1995 Program were integrated into this year's analysis.

- ***Decision-Maker Survey.*** A decision-maker survey was conducted to support the analysis of the net influence of the program on DSM behavior. The survey was completed for a large subsample of participant and nonparticipant sites. Again, the study was enhanced by the incorporation of decision-maker results from the 1995 Program evaluation into this year's study.
- ***Estimation of Gross Impacts.*** Gross impacts can be interpreted as the effects of DSM measures on participants' energy usage, without regard to the attribution of these impacts to participation in the program. The gross impacts of the program were estimated using a hybrid statistical/engineering approach. This approach entails the use of DOE-2 building simulations to develop preliminary estimates of measure impacts, and the use of a load impact regression model to statistically reconcile these simulation estimates with billing information. The reconciliation process yields a set of statistical adjustment coefficients that are used to modify the engineering estimates of savings.
- ***Estimation of Net Impacts.*** Net program impacts are those that are attributable to the program. They are typically derived through the adjustment of gross savings to account for free ridership, free drivership, and (in some studies) market transformation. The ratio of net impacts to gross impacts is sometimes characterized as a net-to-gross ratio. Net-to-gross ratios were estimated for each end use through two approaches: (1) the use of the difference-of-differences approach; and (2) the development and application of a set of efficiency models designed to discern the net influence of the program on adoptions of energy efficiency measures. The net-to-gross ratios ultimately chosen for the determination of net savings were those based on the efficiency modeling approach. It should be noted that for this year's evaluation, the modeling technique yielded *lower* net savings than the difference-of-differences approach; as a result, the estimates provided in this report should be considered conservative.

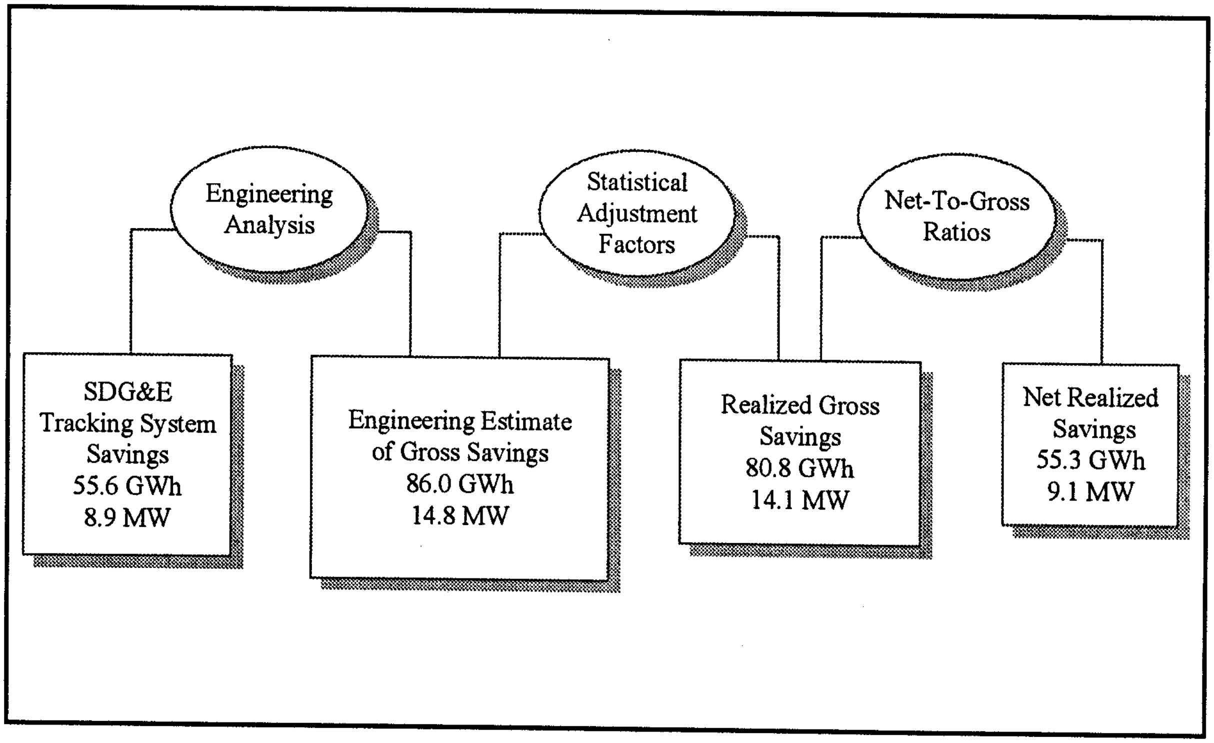
1.5 Summary of Results

The results of the study are summarized in Table 1-1 and illustrated in Figure 1-1. As indicated, SDG&E's tracking system recorded an estimated 55.6 GWh and 8.9 MW of net program savings. These savings were the basis for SDG&E's initial first-year earnings claim. The engineering estimates developed as part of this study amounted to 86.0 GWh and 14.8 MW. It should be recognized, however, that these estimates covered both incentivized and non-incentivized measures, and are not directly comparable to SDG&E's program estimates. The statistical adjustment analysis conducted as part of the study reconciled the engineering calculations against actual billing records. As depicted in Figure 1-1, this analysis had little impact on the estimates, reflecting that the overall adjustment rates on gross energy and demand savings were 0.939 and 0.949 respectively. The net-to-gross analysis indicated the presence of a substantial free-rider effect. After being adjusted for this effect, net savings from the program amounted to 55.3 GWh and 9.1 MW. Comparing these estimates to the estimates filed in SDG&E's first year earnings claim (55.6 GWh and 8.9 MW) we find overall energy and demand realization rates of 99.6% and 102.1%, respectively.

Table 1-1: Summary of Program Savings Estimates

Impact Measure	Engineering Estimate	Statistical Adjustment	Realized Gross Savings	Net-to-Gross Ratio	Net Savings
Total Program Savings					
Energy (GWh)	86.005	.939	80.758	0.685	55.297
Demand (MW)	14.831	.949	14.076	0.645	9.083
Savings per Eligible Square Foot					
Energy (kWh)	6.550	.939	6.150	0.685	4.211
Demand (W)	1.130	.949	1.072	0.645	0.692
Savings per Building					
Energy (kWh)	297,594	.939	279,438	0.685	191,339
Demand (kW)	51.318	.949	48.705	0.645	31.430

Figure 1-1: Overview of Estimate Program Savings



1.6 Preview of Remainder of Report

The remainder of this report is organized as follows:

- Section 2 discusses the development of the sample design underlying the collection of data on participants and nonparticipants,
- Section 3 describes the design and administration of the on-site survey,
- Section 4 discusses the use of building simulations and other engineering algorithms to develop engineering estimates of savings for program and non-program measures installed by participants and nonparticipants,
- Section 5 explains the use of a statistically adjusted engineering approach to estimate the gross realized savings associated with program and non-program measures,
- Section 6 discusses the estimation of net program impacts, and
- A series of appendices contain technical details on several aspects of the analysis.

2

Sample Design and Selection

2.1 Overview of Sample Design

This section describes the sample design used for the evaluation of the 1996 San Diego Gas & Electric Nonresidential New Construction Program. The sample used in this evaluation combines the samples developed for SDG&E's 1995 Nonresidential New Construction Program evaluation study[1] with a new sample of 1996 program participants and nonparticipants.

As detailed in last year's evaluation report, the sample design developed for the 1995 program evaluation entailed an attempted census of participants and a nonparticipant sample designed to match participant samples proportionally by building type. This effort resulted in a completed sample of 253 participants and 158 nonparticipants. Because of a relatively limited population of nonparticipants, however, the completed nonparticipant sample fell short of the design targets in some strata. The general sampling strategy for the 1996 evaluation was to select 150 participant and 100 nonparticipant sites, and to use the 100 nonparticipant sites to augment strata where completed surveyed sites fell short in 1995. The purpose of this design was to generate an overall nonparticipant sample that matches the combined 1995 and 1996 sample of participants reasonably well. SDG&E filed a waiver request relating to this combined sample design, and the request was approved by the California Demand-Side Management Advisory Committee (CADMAC) on August 22, 1997 (see Appendix I).

2.2 Participant Group Sampling Plan

Definition of Participant Sites. Information on participants was provided by SDG&E at the beginning of the project. The primary source of Program information was the Program tracking file, which contained information on measures installed and *ex ante* savings, by contract. Each contract record also specified one or more premise numbers. In some cases, a single contract covered a single customer premise; in other cases, a contract may have

1 Regional Economic Research, Inc. "1995 Nonresidential New Construction Program First-Year Load Impact Evaluation," SDG&E Marketing ID No. MPAP-95-P52-971-703, Study ID No. 971, March 1997.

encompassed several distinct premises; in yet other instances, multiple contracts applied to a single premise. Two other pieces of supporting information were also made available by SDG&E:

- ***Program Contracts.*** Individual contracts and supporting documentation were made available in hard-copy form.
- ***Account Information.*** SDG&E also provided a preliminary list of accounts and meter numbers associated with each premise. Billing records for these accounts were also merged into the participant database.

Based on this information, RER proceeded to define a set of unique sites for the purposes of the analysis. These sites were defined as the units at which the building simulation and statistical analyses were to be applied. These sites varied considerably in their general description, being various portions of buildings, entire buildings, or sets of buildings, depending on the specific circumstances. The following general rules of thumb were used to develop the definitions:

- If a single building was treated through the program (which would typically be the case if the participating site was truly new construction), and if the building was separately metered, then the building was defined as the relevant site.
- If a single building was treated, but was on a meter covering more than one building, the full multiple-building area covered by the relevant meter was defined as the relevant site as long as it was not more than five times as large as the treated building. If the metered area was more than five times as large as the treated building (which happened in only a few cases), the treated building was defined as the relevant site.
- If only a portion of the building was covered by the program (which could be the case for an addition, a major remodel, or tenant improvements), that portion of the building was used as the relevant site if it was separately metered or submetered. This was generally the case, insofar as tenant improvements and remodels tended to cover separately metered suites within buildings. If the relevant meter covered more than the space covered by the program, the larger metered area was defined as the appropriate site as long as it was not too much larger than the covered area. In the case of single-tenant buildings, the metered area was used if it was less than five times the size of the covered area. In the case of multi-tenant buildings, the metered area was used as long as it was less than twice the size of the covered area. Note, of course, that multi-tenant buildings are almost always metered separately for individual tenants, so this criterion was almost always met for such buildings.
- If multiple buildings were covered by the program at a single premise, each building was considered a distinct site as long as it was separately metered, and unless it was served by a central HVAC facility that also served other buildings at the premise. When central multi-building HVAC systems were encountered, all buildings served

by the HVAC facility were included in the site unless their total square footage exceeded five times the area of the covered building.

This process of converting contracts to sites yielded a total of 290 distinct participant sites.

Participant Sample Stratification

The participant sample frame was stratified by building type and estimated program savings. Building type was assigned to each site based on SDG&E's master billing file SIC identifier.[2] Four savings strata were determined using a two-step process. First, the *very large* savings stratum was identified to include seven sites that contributed more than 54% of the total *ex ante* program savings. Second, for the remaining 282 sites, three savings strata (*small, medium* and *large* strata) were developed using the Dalenius-Hodges[3] approach to define break points. The resulting four savings strata are defined as follows:

- Small - kWh Savings < 50,300
- Medium - 50,300 < kWh Savings < 350,000
- Large - 350,000 < kWh Savings < 1,4000,000
- Very Large - kWh Savings > 1,400,000

Table 2-1 depicts the distribution of 1996 program participant sites across strata. Both total energy savings and the corresponding numbers of sites are indicated. It should be noted that during the on-site survey process, two sites were identified as being at the same location. Since the preliminary sample design was based on a frame of 290 sites, that number of sites is used in the tables in this section of the report. When calculating the expansion factors, used in the analysis, the number of sites in the population is reduced to 289 to reflect the combination of these two sites into one.

2 Note that these SIC-based definitions of the strata were maintained for the purposes of defining case weights, even if the on-site survey indicated that these designations were incorrect.. This is consistent with the principles of statistics. Questions were raised with respect to this practice in the review of our evaluation of SDG&E's 1995 Nonresidential New Construction Program; however, the issue was discussed at a meeting of the CADMAC nonresidential new construction subcommittee, and it was agreed that this approach is appropriate.

3 Cochran, William D., *Sampling Techniques*, John Wiley and Sons, 1977.

Table 2-1: Stratification of 1996 Participant Frame

Building Type	Attribute	Largest Savings Class	Large Savings Class	Medium Savings Class	Small Savings Class	Total Gross Savings
Assembly	Sites Savings	2 7,260,197	7 5,425,331	9 1,712,649	12 13,702	**30 14,411,879**
Churches	Sites Savings				7 89,660	**7 89,660**
College	Sites Savings		2 1,605,306	3 697,288	7 103,893	**12 2,406,487**
Convenience	Sites Savings				10 65,302	**10 65,302**
Grocery	Sites Savings		6 2,635,043	7 744,813	8 242,563	**21 3,622,419**
Hospital	Sites Savings		1 599,309	3 308,076	5 100,573	**9 1,007,958**
Lodging	Sites Savings		1 464,456			**1 464,456**
Miscellaneous	Sites Savings	4 24,514,035	4 1,991,651	4 611,775	10 143,770	**22 27,261,231**
Offices	Sites Savings	1 4,880,440	7 4,695,571	21 2,642,737	40 784,261	**69 13,003,009**
Restaurant	Sites Savings			1 134,051	12 104,465	**13 238,516**
Retail	Sites Savings		1 668,457	10 1,162,661	55 1,085,377	**66 2,916,495**
School	Sites Savings			4 377,753	17 284,068	**21 661,821**
Warehouse	Sites Savings		1 1,354,526	3 242,061	5 100,082	**9 1,696,669**
Total Sites Total Gross Savings		**7 36,654,672**	**30 19,439,650**	**65 8,633,864**	**188 3,117,716**	**290 67,845,902**

Sample Allocation and Selection

The participant sample was designed to include a census of the seven largest sites. The remaining 143 sample sites were allocated proportionally across building type and allocated across savings strata using Neyman[4] allocation. Table 2-1 shows the distribution of 1996 participant sites and estimated savings across building type and savings strata.

In order to accommodate the billing analysis, an attempt was made to screen out sites for which no practical match with billing meters was thought to be possible. In general, these cases were very large campus-type premises covered by single meters. It was also necessary to exclude some sites for which participants were unwilling to allow on-site visits. These sites included military bases and a few high-technology firms with highly confidential manufacturing processes. Of the 290 sites in the sample frame, 232 were identified as being

4 Cochran, op. cit.

eligible for the sample selection process. Each site was assigned a random number. After ineligible sites were screened out, the database was sorted by this random number and the sites were recruited in the order in which they appeared in the database.

Table 2-2 summarizes the design of the 1996 participant sample. For reference, population counts are also provided.

Table 2-2: 1996 Participant Population and Sample Targets

Building Type	Population/ Sample	Largest Savings Class	Large Savings Class	Medium Savings Class	Small Savings Class	Total	% of Sample
Assembly	Population	2	7	9	12	30	
	Sample	2	1	7	6	16	10.67%
Churches	Population				7	7	
	Sample				4	4	2.67%
College	Population		2	3	7	12	
	Sample		1	0	3	4	2.67%
Convenience	Population				10	10	
	Sample				5	5	3.33%
Grocery	Population		6	7	8	21	
	Sample		5	5	1	11	7.33%
Hospital	Population		1	3	5	9	
	Sample		0	2	3	5	3.33%
Lodging	Population		1			1	
	Sample		0			0	0.0%
Miscellaneous	Population	4	4	4	10	22	
	Sample	2	2	1	6	11	7.33%
Offices	Population	1	7	21	40	69	
	Sample	1	6	18	11	36	24.00%
Restaurant	Population			1	12	13	
	Sample			1	6	7	4.67%
Retail	Population		1	10	55	66	
	Sample		1	10	24	35	23.34%
School	Population			4	17	21	
	Sample			2	9	11	7.33%
Warehouse	Population		1	3	5	9	
	Sample		1	2	2	5	3.33%
Total	**Population**	**7**	**30**	**65**	**188**	**290**	
	Sample	**5**	**17**	**48**	**80**	**150**	**100.0%**

Summary of Participant Sample Design

Table 2-3 presents a summary of the combined participant sample designed for use in the 1995/1996 new construction analysis. Included in the summary are the population and completed sample for 1995 and population and proposed completed sample targets for 1996. The 1996 evaluation combined the two samples into one set of participant sites.

Table 2-3: Combined Participant Sample Design (1995 and 1996)

	Population			Sample		
Building Category	1995	1996	Total	1995 Completed Sample	1996 Target Sample	Total Sample
Assembly Plant	32	30	62	20	16	36
Churches/Meeting	7	7	14	7	4	11
College/University	17	12	29	17	4	21
Convenience Stores	3	10	13	3	5	8
Grocery	18	21	39	18	11	29
Hospital	5	9	14	5	5	10
Lodging	4	1	5	3	0	3
Offices	59	69	128	51	36	87
Restaurant	26	13	39	26	7	33
Retail	37	66	103	37	35	72
School	38	21	59	38	11	49
Warehouse	6	9	15	4	5	9
Misc/Other	33	22	55	24	11	35
All Categories	**285**	**290**	**575**	**253**	**150**	**403**

1996 Participant Survey Response

Participants of the 1996 Program were recruited for both the on-site survey and the decision-maker survey by CIC Research, Inc. The overall response rate for the participant survey (defined as the proportion of contacted sites agreeing to the survey) was 96%. Completed samples are compared to target samples in Table 2-4. As shown, the recruiting process was extremely successful in that the completed sample sizes differ very little from the target values. In cases where the completed sample falls short of the target, there were insufficient secondary sites in the frame to permit the achievement of the target in question. Shortfalls were made up through small increases in sample sizes in other building categories.

Table 2-4: Targeted and Completed Participant Samples

Building Category	Target Sample	Completed Sample	Difference
Assembly Plant	16	15	-1
Churches/Meeting	4	4	0
College/University	4	3	-1
Convenience Stores	5	6	1
Grocery	11	13	2
Hospital	5	5	0
Lodging	0	0	0
Offices	36	36	0
Restaurant	7	7	0
Retail	35	36	1
School	11	11	0
Warehouse	5	5	0
Misc/Other	11	9	-2
All Categories	**150**	**150**	**0**

2.3 Nonparticipant Group Sampling Plan

The nonparticipant sampling plan was to use the additional sample of 100 nonparticipant sites to match the combined nonparticipant sample to the combined participant sample. Matching in this context means the achievement of similar distributions across building categories for the pooled samples of participants and nonparticipants. A waiver permitting this design was approved by CADMAC on August 22, 1997 (see Appendix I).

The nonparticipant frame was developed using the same method that was used in the 1995 evaluation. In particular, building permit records were obtained from the City and County of San Diego for construction completed in 1996. These records contain information on site name, address, and information on what type of permit was obtained. SDG&E staff screened the permit database to determine which sites met the new construction criteria. In particular, only those sites that could be identified as performing new construction or major tenant improvement and that were not 1996 program participants were retained in the nonparticipant database.[5]

Building type for each site was identified from the building permit database. Once the nonparticipant frame was determined, each building type strata was evaluated using the following method.

- The number of sites already populating each strata from the 1995 sample was determined.
- The number of additional sites that would be needed to match the participant distribution was established.
- The number of sites available for sampling in 1996 was determined.
- Stratum targets for the 1996 survey were developed as the counts that would meet the combined goal for that stratum, if possible.

The results of this process are presented in Table 2-5. Note that there are many strata for which it was unnecessary to sample more sites in order to satisfy the sampling strategy. Examples of this would be Churches/Meeting and Convenience Stores. For these strata, no further surveys were attempted. There were also some strata (e.g., Schools and Groceries) for which there were simply not enough sites to bring the stratum sample up to the desired level. Nothing more could be done to fill in these strata. As a result, the remaining sites were distributed across other strata to best match the distribution of participants in the 1995-96 participant sample.

[5] It should be noted that there was a considerable increase in new construction and major tenant improvement activity during 1996.

Table 2-5: Combined Nonparticipant Sample (1995 and 1996)

Building Category	Expected 1995 & 96 Participant Sample	% Dist	1995 Nonpart. Sample	1996 Nonpart. Frame	1996 Nonpart. Target Sample	Targeted Total Nonpart. Sample	% Dist
Assembly Plant	36	8.93	7	64	14	21	8.14
Churches/Meeting	11	2.73	12	13	0	12	4.65
College/University	21	5.21	1	12	10	11	4.26
Convenience Store	8	1.99	8	11	0	8	3.10
Grocery	29	7.20	3	11	11	14	5.43
Hospital	10	2.48	1	11	4	5	1.94
Lodging	4	0.99	5	23	0	5	1.94
Offices	87	21.59	24	272	30	54	20.93
Restaurant	33	8.19	32	94	0	32	12.40
Retail	71	17.62	20	92	24	44	17.05
School	49	12.16	2	7	7	9	3.49
Warehouse	9	2.23	10	19	0	10	3.88
Misc./Other Comm.	35	8.68	23	127	0	23	8.91
Other Process	0	0.00	1	15	0	1	0.39
Unclassified	0	0.00	9	99	0	9	3.49
All Categories	**403**	**100.00**	**158**	**870**	**100**	**258**	**100.00**

1996 Nonparticipant Survey Response. The overall response rate for 1996 nonparticipants was 78%. Nonresponse was partly due to the large number of sites that were disqualified for one reason or another from the survey. A total of 224 sites were contacted. Screening during the recruitment process revealed that 96 of the contacted sites were not qualified, in the sense that they had not done a major remodel, tenant improvement, or new construction at the site. This left only 128 qualified sites that were actually recruited. Of these, 100 agreed to the survey, yielding a response rate for qualified sites of 78%.

Table 2-6 summarizes the distribution of the completed nonparticipant sample and compares it to the targeted distribution. In spite of extensive efforts to fill targets, the completed sample does not match the targeted sample as closely as we would like. By the time sites were contacted and qualified for the survey, there were simply not enough survey candidates in some building categories to allow the achievement of the targets. For example, the shortfall in college/university sites resulted because there were only five qualified sites, even though all agreed to the survey. While the overall nonparticipant sample used in the 1996 evaluation mirrors the distribution of the participant sample better than the 1995 sample, it still differs to some degree. This issue will be discussed further in the section on net-to-gross analysis.

Table 2-6: Targeted and Completed Nonparticipant Samples

Building Category	Target Sample	Completed Sample	Difference
Assembly Plant	14	17	3
Churches/Meeting	0	0	0
College/University	10	5	-5
Convenience Stores	0	2	2
Grocery	11	7	-4
Hospital	4	3	-1
Lodging	0	0	0
Offices	30	32	2
Restaurant	0	0	0
Retail	24	27	3
School	7	2	-5
Warehouse	0	2	2
Misc/Other	0	3	3
All Categories	**100**	**100**	**0**

2.4 Final Sample Distributions

Table 2-7 depicts the final distributions of the combined participant and nonparticipant samples. As shown, the distributions are similar but not identical. In spite of the steps taken to ensure matching distributions, differences persist in several building categories. These differences are attributable primarily to the paucity of nonparticipant sites in some building categories like schools, colleges and grocery stores. The lesson here is that, while balancing samples is important, it is not always possible. As a result, steps should be taken to recognize and control for differences between participants and nonparticipants, especially in the net-to-gross analysis. This issue will be discussed further in Section 6.

Table 2-7: Final Sample Distributions

Building Category	Combined Participant Sample	% Distribution	Combined Nonparticipant Sample	% Distribution
Assembly Plant	35	8.7%	24	9.3%
Churches/Meeting	11	2.7%	12	4.7%
College/University	20	5.0%	6	2.3%
Convenience Stores	9	2.2%	10	3.9%
Grocery	31	7.7%	10	3.9%
Hospital	10	2.5%	4	1.6%
Lodging	3	0.7%	5	1.9%
Offices	87	21.6%	56	21.7%
Restaurant	33	8.2%	32	12.4%
Retail	73	18.1%	47	18.2%
School	49	12.2%	4	1.6%
Warehouse	9	2.2%	12	4.7%
Misc/Other	33	8.2%	36	14.0%
All Categories	**403**	**100.0%**	**258**	**100.0%**

2.5 Decision-Maker Survey

A decision-maker survey was conducted by telephone in order to gather information on decision-maker features and investment criteria used to evaluate energy efficiency investments. Participants and nonparticipants were recruited for the decision-maker survey only if they agreed to the on-site survey. In some cases, a single decision maker represented more than one distinct site. As shown in Table 2-8, 232 decision-maker surveys were completed for the 1995 study, representing 328 sites. In terms of sites, decision-maker surveys were completed for over 84% of the participants and 73% of the nonparticipants receiving an on-site survey in the course of the 1995 study. Similar results were achieved for 1996 participants and nonparticipants. A total of 139 individuals representing 194 sites were interviewed. Sites represented in the decision-maker survey accounted for 88% of the participant on-site sample and 62% of the nonparticipant on-site sample.

Table 2-8: Summary of 1995 Decision-Maker Survey Coverage

	Decision-Maker Survey Completions		On-Site Survey Completions	Decision-Maker Survey Completion Rate (%)
Category	**(Individuals)**	**(Sites)**	**(Sites)**	**(Sites)**
Participants				
1995	122	213	253	84%
1996	92	132	150	88%
Total	214	345	403	86%
Nonparticipants				
1995	110	115	158	73%
1996	47	62	100	62%
Total	157	177	258	69%
All Sites	**232**	**328**	**411**	**80%**

3

Data Collection

3.1 Overview

Three types of data were collected to support the analysis: on-site data for a sample of participants and nonparticipants; decision-maker data for the key decision makers associated with these sites; and auxiliary data such as billing histories, weather data, and information on participation in other SDG&E programs. The next three subsections discuss the collection of these elements of the overall project database.

3.2 On-Site Survey

Introduction

On-site visits were made in order to verify installation of program measures, identify other measures installed at the sites, and collect information on site features and operating schedules to be used in the building simulation and econometric analyses. The quality and comprehensiveness of the on-site survey was considered critical to the success of this evaluation.

Development of On-Site Survey Instrument

The survey instrument used in the on-site survey had to accommodate the rather stringent requirements of DOE-2. The same instrument was used for the 1996 evaluation as used last year for the evaluation of the 1995 program. The survey instrument used for the on-site survey is included in Appendix A.

Recruitment of Customers for the Survey

As a first step in recruitment, a letter from an SDG&E representative was sent to customers in the primary sample. These letters were staged to precede telephone contact by one to two weeks. The second step involved a telephone call to the customer location. This was performed by CIC. CIC used a centralized approach for recruiting customers. The centralized approach offered the following advantages:

- ***Careful and Consistent Treatment of Customers.*** The centralized approach was carried out by two or three people. These individuals are trained in recruitment techniques and have previous experience performing this task. The use of a small number of centralized recruiters ensured that customers were contacted in a consistent manner.
- ***Weekly Scheduling Updates.*** With a centralized approach, all scheduling information was maintained in one place. At the end of each week, all information was compiled and transmitted to the SDG&E project manager. The SDG&E project manager, in turn, disseminated scheduling information for the assigned accounts to the account executives and to other appropriate individuals at SDG&E.

CIC personnel executed the following recruitment procedure:

- Make contact with the customer and verify or identify the appropriate person for discussing participation in the study. Explain the purpose of the project.
- Solicit participation in the on-site survey. Indicate the amount of time needed during the visit from the contact person or from other individuals knowledgeable about the facility and business operations.
- Arrange a mutually acceptable time for data collection. In arranging the visit, care was taken not to schedule the visit during important activities at the facility.
- Request that selected information be made available for the surveyor to review. This information included copies of bills and blueprints and facility listings, if appropriate.

As the scheduling team established appointments, the master schedule and recruitment database were updated and reviewed by the VIEWtech project manager. The updated schedule and database were also provided to the RER field work manager, the SDG&E project manager, and the surveyors. In cases where it was not possible to schedule the survey, the reasons for refusal were included in the recruitment database. Once an appointment was made, a postcard was sent to the site contact confirming the date for the visit.

Training of On-Site Surveyors

A two-day training workshop was conducted for all engineers assigned to the project prior to the commencement of the field work. The training workshop was conducted using training manuals and materials developed specifically for this project. The instructors were the VIEWtech field supervisor and the RER field work manager. The training session addressed the following issues:

- Overall project purpose and scope.
- Roles and relationships of project parties (SDG&E, RER, and VIEWtech).

- Details to be recorded to describe mechanical systems and equipment for HVAC and non-HVAC end uses.
- The physical characteristics of the site, including construction materials, building geometry, and other characteristics relevant to estimating HVAC loads.
- The appropriate techniques for recording the technical information.
- Key elements in business operations including operating hours, system control settings, and estimated equipment usage levels and usage profiles.
- The appropriate interview techniques for eliciting information about business characteristics and operations.
- An explanation of the codes used on the survey form.
- The definition of the survey site as the entire customer premise at the service address and examples of how to configure forms for specific situations.
- Quality control procedures that must be exercised by the surveyors before the survey is considered "complete."

In addition, the RER field work manager explained how the data elements are used in the analysis. This understanding was critical to ensure that all data fields on the survey form are treated with equal care. Following the two-day workshop, the surveyors as a group went to several sites to review the data collection procedure using live cases. The sites were chosen to cover the full spectrum of equipment.

Remote Refrigeration Training

One additional training session was held to further familiarize VIEWtech surveyors with refrigeration measures. Remote refrigeration training of the VIEWtech surveyors was provided by a senior engineer and a refrigeration technician from VaCom Technologies. Several hours of classroom instruction covered refrigeration system basics and their application in commercial buildings. This was followed by on-site visits to two recently built supermarkets (a Ralphs and a Vons). Both stores had state-of-the-art remote refrigeration systems installed, so these were very productive visits. The compressor rooms were visited first. There, surveyors were shown how to identify the refrigeration schedule, compressor system types, condenser types, controls, and energy-saving features. This was followed by a tour of the display floor area. Examples of all refrigerated case types were pointed out and an explanation provided of how to count them for the survey instrument. Before leaving the last site, the instructors and surveyors discussed the equipment that had been observed and reviewed how to enter this data on to the survey form.

Preparation of Customer Information Sheets

All surveyors were provided with background information for each sample site prior to the on-site visit. The information was provided in the form of a Site Information Sheet that presented the following:

- Site descriptions, including site names, addresses, and square footage,
- Contact person information,
- Monthly billing data for electric and gas accounts at the site,
- A list of specific measures rebated for the site, and
- Comments relating to the site.

This information was provided to the surveyors for their review prior to the on-site visit. In addition, other information (e.g., site maps) was included for complex sites. Figure 3-1 depicts a sample Site Information Sheet.

Conduct On-Site Visits

The procedure used in on-site visits was as follows:

- Upon arrival, the surveyor interviewed the site contact about general site operations and characteristics. The interview portion roughly corresponds to the first section of the survey form presented in Appendix A. The interview usually took between 20 and 30 minutes.
- Upon completion of the interview, the surveyor walked through the facility and recorded equipment, building, and operating information. Depending on the wishes of the site contact, the surveyors proceeded by themselves, or the site contact or other representative accompanied the surveyor through the facility.

In addition to the interview and the walk through, data were obtained from other sources, including the following:

- ***Site Documents and Records.*** Structural and architectural drawings can provide data on building dimensions and construction materials. Mechanical, electrical, and plumbing plans can provide data about end-use equipment. Title 24 compliance documents can also offer considerable information about site design.
- ***Energy Usage Information.*** When necessary, energy bills were obtained from site contacts in order to facilitate the process of matching sites and usage.
- ***Measurements.*** The surveyor used measuring devices as necessary to record floor stock, lighting levels, and the presence of electronic ballasts.
- ***Photographs.*** Finally, surveyors took photographs of the exterior of the survey area and the HVAC equipment. This visual information was often useful input for the design of the building the simulations.

Figure 3-1: Site Information Sheet

San Diego Gas & Electric Company

1996 Nonresidential New Construction Survey

Auditor Site Information

RP11690

RER #:	RP11690
Building Type:	RETAIL 3.0
Customer:	OTHER RETAIL STORE
Address:	00000 MAIN STREET
City:	ANYWHERE
Zip Code:	
Contact:	JOHN DOE
Contact Phone:	(888)-555-1212

Building Information

Type:	RETAIL 3.0	
Size:		Sqft
Conditioned Spaces:	5,920	Sqft
Lighted Spaces:	5,920	Sqft
CI 96 Participant:	NO	
Construction Type:	RENOVATION	

Measures

End Use	Type	Installation Date
INTLIGHT	STANDARD	10/11/96

Electric Accounts

Account	Meter	Annual Billed kWh	Rate
04-7165-5350-00	E1568711	97,920	AP

Monthly Billing Data

		kWh
1996	**April**	
	May	
	June	
	July	
	August	
	September	
	October	4,880
	November	10,440
	December	9,680
1997	**January**	8,800
	February	7,160
	March	8,000
	Total / Max	*48,960*

Figure 3-1: Site Information Sheet (cont'd.)

San Diego Gas & Electric Company

1996 Nonresidential New Construction Survey

DSM Program Measures

RP11690

RER#: RP11690

Customer OTHER RETAIL STORE **City:** ANYWHERE

Building

Type: RETAIL 3.0 **Size:** **Sqft** **Conditioned Space:** 5,920 Sqft **Lighted Space:** 5,920 Sqft

Installed Measures

Line Number	Measure End Use	Type	Installed Date	Description	Size	Quantity	Location
A	INTLIGHT	STANDARD	10/11/96	32 Watt lamp		226	
B	INTLIGHT	STANDARD	10/11/96	CF-13Q Hardwire Fxtr		6	
C	INTLIGHT	STANDARD	10/11/96	Exit Sign Replacement (LED)		3	
D	INTLIGHT	STANDARD	10/11/96	T-8 El Bal (4ft/2la)		41	
E	INTLIGHT	STANDARD	10/11/96	T-8 El Bal (4ft/3la)		48	

Comments

All on-site survey data went through a two-stage quality control procedure. First, the survey data passed through the VIEWtech process, from surveyor to field supervisor, as discussed below. Then, these data were passed on to the RER team for further review. Quality control ran concurrently with the data collection effort, as described below.

All incoming surveys were monitored by VIEWtech and RER staff to ensure the quality of the responses. In the first stage of quality control, VIEWtech executed the following procedure for each site:

- Surveyors were required to perform a variety of "sanity checks" before they left the survey site. These included the following:
  - Compute overall electric intensity, using billing information and square footage estimates.
  - Compute equipment densities, including square feet per ton of cooling equipment and Watts per square foot of lighting equipment. Compare the sum of the equipment densities with the maximum recorded monthly demand.
  - Estimate annual energy use as the sum of the end-use components and compare it with the utility bill information.

  If the data did not pass these initial checks, the surveyor continued at the site to clear up any obvious discrepancies.
- The completed survey form was delivered to the VIEWtech field work supervisor. The supervisor reviewed the form and the sanity checks performed by the surveyor. Any missing data or apparent inconsistencies were resolved by the supervisor manager and the surveyor.
- During the data collection process, the VIEWtech field work supervisor periodically rode along with field surveyors to ensure ongoing compliance with survey procedures and to ensure survey continuity.

It was occasionally necessary to take follow-up steps to collect data that were missing or that appeared to be inaccurate from the initial data collection effort. The follow-up (by telephone or, when necessary, a second visit to the site) was conducted by the surveyor who did the initial survey work, or by the VIEWtech field work supervisor, depending on the specific circumstances of the case.

Communication. The following steps were taken to ensure that all members of the project team (RER, VIEWtech, CIC and SDG&E) were well informed:

- All field personnel carried pagers to facilitate communication between field staff and project management. Whenever possible, questions were handled at the time of the on-site survey to eliminate the need for repeat visits.

- Weekly project staff briefings were held to communicate pertinent information to field staff, and to obtain feedback and provide clarification on any issues which may have arisen during the on-site visits.
- During the field work, the VIEWtech field work supervisor was in daily contact with RER's project manager to provide a detailed progress update and to discuss any problems that may have arisen. In turn, the VIEWtech field supervisor and RER project manager kept close contact with the SDG&E project manager, to ensure that any questions or concerns are addressed in a timely manner.

Survey Data Entry and Database Preparation

As the incoming surveys were reviewed by the VIEWtech field work supervisor, they were also be precoded for data entry. All data, including comments in the margins and notes sections of the questionnaire, were reviewed. The survey data were entered into a database using SAS. All data, including comments in the margins and notes sections of the questionnaire, were entered into the database. The data entry system included data verification procedures that identify inappropriate or incorrect responses. The raw survey forms, the data entry system, and the resulting SAS databases were all provided to SDG&E.

A code book covering all datasets to be delivered by RER was also be prepared by CIC. The code book contained one section per dataset and listed the variable name, variable description, variable type, variable length, response range, and the corresponding value labels, describing each of the valid responses for each field. Other deliverables associated with the code book included (a) a copy of the survey form with annotations that provide all field names, and (b) a SAS program to create a SAS-format library including the value labels mentioned above.

Survey Data Validation

After the survey data were entered into the database, they were transferred to RER where they went through two stages of error checking:

- The first stage detects errors and inconsistencies in the data for a given facility. RER performed exhaustive premise-level analysis of the data as each survey was received from the field. This activity included data validation checks, such as flagging motor sizes or lamp wattages that are not available in the market, identification of space-utilization definitions that were not consistent with the site activity description, and similar checks on literally hundreds of other items that are potential sources of data pollution.
- The second stage was designed to detect internal inconsistencies within the database. Sites were grouped by type, and the data for sites of each type were processed through a set of statistical analysis routines.

Preparation of Inventory Reports

As part of the error-checking and review process, a series of inventory reports was produced. The purpose of these listings was to allow visual inspection of the raw data. These reports provided a comprehensive summary for each case in the database and summarized the types of equipment at each site and the corresponding connected loads. These listings are designed to allow project analysts to "zoom in" on the data for a specific topic or the data for a specific case. An example of an inventory report is contained in Appendix C.

Multiple Accounts Reconciliation

The linkage of billing data with surveyed sites was an absolutely critical step in the overall analysis of program impacts. No amount of elegant simulation and econometric analysis can overcome poorly matched billing data. Special emphasis was placed on the accurate identification of meters at the surveyed sites. Multiple-accounts reconciliation took place at five points during the project.

- First, accounts were aggregated to customer locations in the sample-design phase.
- Second, surveyors verified the account matching during the on-site visit. Changes in account numbers were recorded on the survey form.
- Third, for the sites for which the surveyors had complete billing information, they computed energy intensities while at the site. Intensities that were out of the "reasonable" range were investigated with the customer contact. Potential problem sites, or ones for which intensities could not be computed, were flagged for follow-up by the RER analysis team.
- Fourth, the billing information was reviewed by RER staff. Again, the intensities were reviewed and problems were flagged for follow-up with the SDG&E project manager.
- Finally, when the simulations were performed, the results were compared with the billing data. If the simulation and billing data differed substantially, and there appeared to be no problems with the survey data, these cases were reviewed further.

3.3 Decision-Maker Survey

The decision-maker survey was designed to collect information relating to the factors influencing the installation of DSM measures at the subject sites. Several types of questions were asked in the survey, which was administered by phone. For both participants and nonparticipants, the survey solicited information relating to the following issues:

- Total recent construction activity,
- Reason for constructing the site in question (owner occupancy, speculation, etc.),
- Importance of energy efficiency in making construction decisions,
- Methods used to evaluate energy efficiency improvements,
- Approaches to complying with Title 24 (performance v. prescriptive), and
- Sources of information on SDG&E's Savings Through Design Program.

For nonparticipants, questions were also included to ascertain possible participation at sites other than the subject site. Copies of the decision-maker survey instruments are included in Appendix B.

3.4 Other Data Collection

The following other kinds of data were also collected to support the analysis:

- ***Billing Data.*** Billing data were obtained from SDG&E for all participating and nonparticipating sites in the sample frames. These data were screened, inspected, and converted from billing cycle values to normalized (30.4 day) calendar month values. As noted earlier, considerable effort was expended to ensure that billing data matched the surveyed site. In cases where no such match was possible (primarily cases where the surveyed site was covered by a single large campus-style meter), billing data were set equal to missing.
- ***Weather Data.*** Weather data were collected for the period covered by the statistical analysis (1995-97), as well as for a Typical Meteorological Year (TMY). The TMY data were later used in the DOE-2 analysis, while both TMY and actual 1995-97 weather data were ultimately used in the statistical analysis.
- ***Other Program Information.*** Participant lists from SDG&E's other nonresidential programs were collected in order to assess the possible impacts of these programs on efficiency levels at surveyed sites. Participant lists were provided by SDG&E for all nonresidential Energy Efficiency Incentive programs. These lists were cross-referenced against the list of surveyed sites to identify any potential cross-program effects, and a variable representing participation in other programs was incorporated into the net-to-gross analysis.

4

Building Simulation and Engineering Analysis

4.1 Introduction

This section describes the building simulation and engineering analysis used to develop initial estimates of DSM measure savings. Building simulation analyses were conducted using the SITEPRO software system for all members of the on-site sample, both participants and nonparticipants. SITEPRO utilizes DOE-2 to model building HVAC loads and energy use, and uses well tested engineering algorithms for estimating non-HVAC energy use. For this project, simulations were developed under two basic scenarios:

- ***Scenario A: As-Built and Operated Case.*** Under this scenario, all DSM measures (both those incented through the program and those installed outside of the program) were assumed to be in place.
- ***Scenario B: Reference Case.*** This scenario assumes strict compliance with Titles 20 and 24 where applicable, and other reference conditions where an end use is not covered by Code. For cases where the site participated in a remodel or tenant improvements, only those areas of the site covered by codes were set to these reference conditions; others were kept at their as-built values.

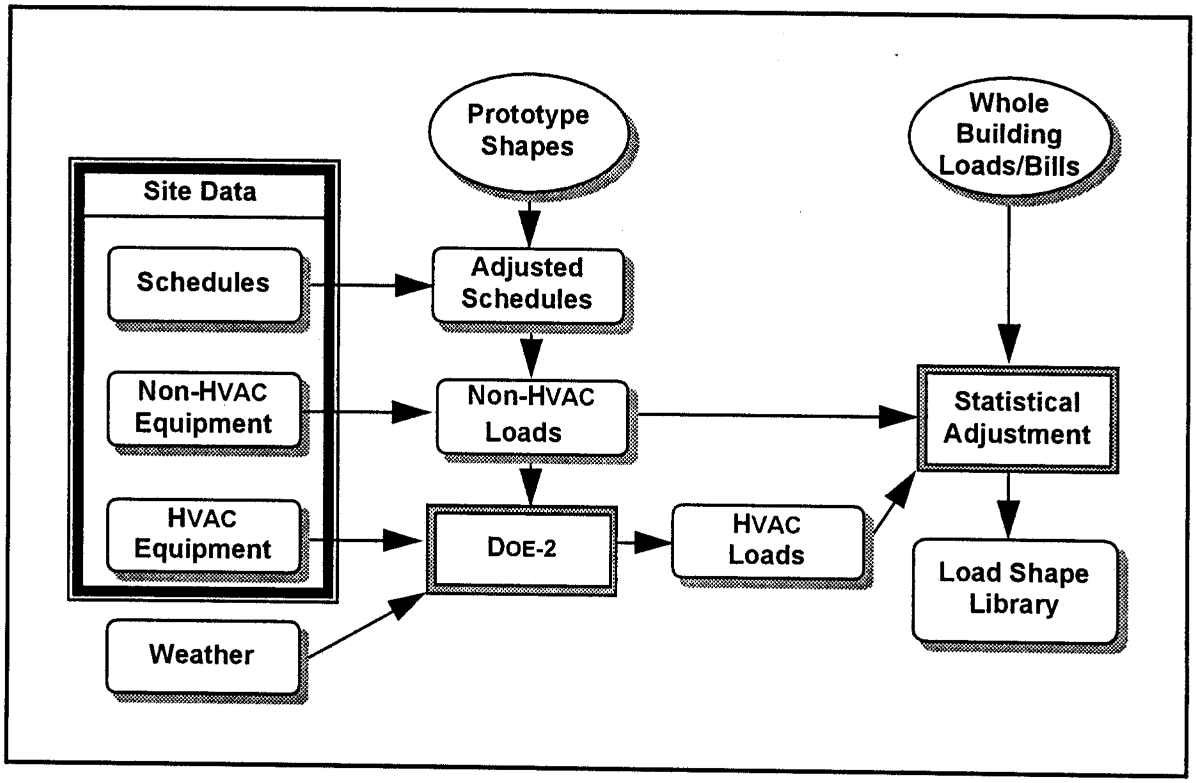
The difference between Scenario A and Scenario B was interpreted as an engineering estimate of total DSM savings. Note that simulations conducted for the evaluation of the 1996 Program were augmented with simulations developed last year for the 1995 program. This is in keeping with SDG&E's waiver on sample size (see Section 2).

The remainder of this section provides additional detail on SITEPRO, weather data used in the simulations, the assumptions used in the analysis of specific end uses and measures, and simulation results.

4.2 Overview of SITEPRO

The SITEPRO software is the best energy analysis system for utility survey data that is available in the industry today. It utilizes the industry's leading building simulation model (DOE-2) to estimate HVAC loads and energy use, and it utilizes well tested algorithms for estimating non-HVAC energy use. SITEPRO provides a framework for translating data about an individual site into reliable estimates of end-use loads for that site. This framework is illustrated in Figure 4-1, which is extracted from the *SITEPRO User's Guide*, a copy of which is provided in Appendix E.

Figure 4-1: SITEPRO Analysis Framework



Data used in SITEPRO include information on the following:

- Customer operations, including operating schedules and number of employees, and occupancy schedules,
- End-use equipment, including equipment counts, connected load estimates, equipment schedules, and hours of use, and
- Building geometry and thermal shell characteristics.

SITEPRO was executed in two steps as described below.

- In the first step, information about equipment inventories is combined with operating schedule data to develop hourly load profiles by day type for the non-HVAC end uses. Separate algorithms are applied for inside lighting, outside lighting, water heating, cooking, refrigeration, motors, air compressors, process equipment, office equipment, and miscellaneous equipment loads. These algorithms have been refined over the last five years with the help of industry experts and with reference to end-use metered data, where available.

- In the second step, HVAC loads are developed using the following information:
  - Thermal shell data,
  - HVAC system data,
  - Heating and cooling plant data,
  - Occupancy profiles, and
  - Usage profiles for lighting and other equipment.

  Based on these inputs and hourly weather, SITEPRO executes DOE-2 to estimate heat flows and energy usage on an hourly basis. The development of DOE-2 inputs from the survey data has been reviewed by developers of DOE-2 and by several experts in the area of building simulation using DOE-2.

SITEPRO performs a full hourly simulation (8,760 hours) for each end use. These results are summarized in 48-day format, defined by four daytypes in each month. The simulation results were compiled in a SAS database for use in the subsequent analysis.

It should be noted that SITEPRO has an additional feature that allows estimated loads to be calibrated to billing data on a site-by-site basis. This feature was not used in this study. However, a variety of reasonableness checks on the simulations were conducted. When large discrepancies between billed consumption and simulated usage occurred, or when simulated end use consumption seemed anomalous, assumptions were reviewed and further error checking was conducted. In some cases, survey information was refined through additional site visits. The reason for not calibrating as-built simulations against bills is that the realization rate analysis must be conducted with uncalibrated simulation results if the adjustment coefficients are to reflect engineering biases in estimating base usage and DSM savings. Indeed, the realization rate analysis can be considered a final calibration step. It is superior to site-by-site mechanical calibration because it can be used to differentiate between types of engineering biases as well as to yield insights on the sources of these biases (as represented by the arguments of the adjustment functions).

4.3 Weather Data

Typical meteorological year (TMY) weather data files were used for the DOE-2 simulation modeling. TMY data contain hourly data on various weather-related variables including dry bulb temperature, humidity, wind speed, and actual measured solar insolation. In particular, all simulations used 1988 weather data to represent TMY as per SDG&E staff. Because DOE-2 can not handle leap years, this data was further manipulated by deleting the data for February 29 and using a calendar year of 1983 for the DOE-2 runs. Two weather stations, the only ones for which the complete set of data required to run DOE-2 were available, were used and mapped to SDG&E climate zones as follows:

- ***San Diego (Lindbergh Field).*** This weather station was used for all Maritime climate zones.
- ***NAS Miramar.*** This weather station was used for Coastal and Transition climate zones.

Individual sites were assigned to these stations on the basis of a ZIP code mapping provided by SDG&E.

4.4 Specific Simulation Assumptions

Interior Lighting

As-Built Simulations. As-built simulations of interior lighting loads were conducted using information on connected loads, operating hours, and lighting controls. Assumptions on these features were determined as follows:

- ***Connected Loads.*** Connected loads for each lighting system were developed by utilizing a SITEPRO technical data table, which is a lookup table that keys off lamp type, lamp watts, tube diameter, tube length, ballast type, and number of lamps per fixture. This technical data table was derived from the *Lighting Handbook*[1] developed by the CEC, previous survey data information, and IES lighting handbooks. All lighting systems collected in the survey data were mapped to this technical data table to determine system watts. For those systems that did not match up to an existing system in the technical data table, one of two actions was taken: either the survey data were changed to map the typically errant lighting system to one in the table, or, in rare cases, a new entry was added to the technical data table
- ***Operating Hours.*** Operating hours were set on the basis of lighting and operating schedules reported in the on-site survey.
- ***Lighting Controls.*** Dimmers, occupancy sensors, and daylighting controls were simulated by applying a usage factor to the average weekly hours. These usage factors were derived from numbers obtained from Lawrence Berkeley Laboratory results/recommendations.[2] The algorithm used was as follows:
  - For dimmer-controlled lighting systems, a 0.8 factor was applied to the average weekly hours.
  - For daylighting-controlled lighting systems, a 0.65 factor was applied to the average weekly hours.

[1] *Advanced Lighting Guidelines, Second Edition,* California Energy Commission, March 1993

[2] *Technology Data Characterizing Lighting in Commercial Buildings: Application to End-Use Forecasting with COMMEND 4.0* (Draft), Lawrence Berkeley Laboratory Energy Analysis Program, Energy and Environment Division, June 1993

- For occupancy sensor-controlled lighting systems, the usage factor varied by building type as follows: Retail/Grocery/Restaurant/Lodging = 0.6, School = 0.8, Warehouse = 0.5, all other = 0.7.

Baseline Simulations. Baselines were defined to reflect strict adherence to Title 24 lighting densities in applicable areas and for applicable lighting systems. The process through which this was accomplished is described below:

- Use codes were verified, with special attention to the designation of lighting fixtures to display or advertising uses, which are exempt from Title 24 density limits.
- Densities for display, advertising, and exit lighting were maintained at their as-built levels.
- Densities in non-exempt lighting systems (area and task lighting) were set equal to their Title 24 maximum values and entered into a "Title 20 Allowed W/ft^2" table. This table, located in the survey database, contains default W/ft^2 values by Area ID based on the Title 24 Area Category Method (ACM).[3] These default values were generated from a map of RER space usage areas to Title 24 ACM Primary Function areas, but were redefined by the reviewer if necessary based on the description of the site and/or space activity area.
- In some cases, the survey covered areas other than those directly affected by the new construction, remodel, or tenant improvement in question. Lighting in these "untreated" areas was considered exempt from the Title 20 standards, and was left at its as-built density. As-built densities were also retained for some areas where the "treated" status of the lighting systems was indeterminate, as indicated by a W/ft^2 value that exceeded the Title 24 prescriptive values.

General HVAC System Strategy

As-Built and Baseline Simulations. Several simulation issues apply to all HVAC systems, as detailed below:

- ***Predominant HVAC System Type.*** In the SITEPRO/on-site survey system, HVAC systems were assigned to the "space usage areas" (i.e., Office, Warehouse, Retail, etc.) they serve, rather than to the exact thermal zones they serve. This was done to make the survey more manageable. However, the result of this simplification is that a "predominant" HVAC system type had to be selected from all those serving each space usage area. This was driven by the DOE-2 requirement that only one system type can serve a zone. SITEPRO logic determined the predominant system and created a composite HVAC system to represent all systems serving each space usage area. This method has been shown to yield satisfactory HVAC simulation results in previous survey/simulation projects.

[3] *Energy Efficiency Standards for Residential and Nonresidential Buildings*, California Energy Commission, July, 1995.

As a result of this process, the as-built/baseline simulations for some high-efficient equipment may not have predicted all the savings expected, especially where the incented systems were mixed in with existing, older, less-efficient systems. The high efficiency values may have been diluted or lost completely because package systems were not modeled individually. However, if the incented systems were negligible enough to not be selected as the predominant system, then these results are probably valid.

- ***Focus on Newer Systems.*** Special attention was paid to systems installed in or after 1994. That is, attention was paid to checking and obtaining proper capacities, efficiencies, and economizer status. Systems older than this were allowed to default to DOE-2 default values. For these newer systems, efficiency data were checked to ensure that each new system had only one as-built and one baseline value for efficiency.

Package HVAC Systems

Simulations of package HVAC systems utilized information on system type, cooling and heating equipment sizes and efficiencies, outside air percentages, thermostat settings and controls, economizers, and Title 24 minimum requirements, as described below:

- ***System Type.*** Survey data identifying the type of distribution system, cooling source, and heating source for each package unit were used in the simulations. SITEPRO is capable of modeling all major system types recognized by DOE-2.
- ***Make-Up Air Units.*** These units were identified in the data as Package Unit Ventilators (PUV) with no heating source, no cooling source, and 100% outside air.
- ***Cooling and Heating Equipment Sizes.*** Cooling and heating capacities taken directly from the survey data were used in the simulations. Missing capacities were autosized by DOE-2 via SITEPRO.
- ***Thermostat Settings.*** Thermostat settings were obtained from cooling and heating schedules specified in the on-site survey.

As-Built Simulations. For package systems, typically only the cooling efficiency, the heating efficiency, and the economizer status were changed from the as-built to the baseline run. Assumptions on these features were as follows:

- ***Cooling Efficiencies.*** The efficiencies reported on the survey were used unless they were below code or obviously errant data. For systems with a cooling capacity less than 65 kBtuh, if both an EER and a SEER were reported, the one that was the most consistent with Title 24 was used and the other one deleted from the data. For those systems of 1994 or later vintage, if the efficiency was missing or less than the Title 24 minimum, correct values were obtained from one of the following:

- SDG&E contract materials (if HVAC equipment was incented)
- CEC Appliance[4] database
- Title 24 minimums, especially if equipment was not incented

Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.

- ***Heat Pump Heating Efficiencies.*** Only heat pump heating efficiencies were of concern, since their efficiencies are covered by Title 24. The COP rating at 47°F[5] was used for DOE-2 simulations (there are two ratings in the standard, the other is at 17°F). Efficiencies reported on the survey were used unless they were below code or inconsistent with the Title 24 COP at 47°F. For systems with a cooling capacity less than 65 kBtuh, if both an HSPF and a COP were reported, the one that was the most consistent with Title 24 was used and the other one deleted from the data. For those systems of 1994 or later vintage, if the efficiency was missing or less than the Title 24 minimum, correct values were obtained from one of the following:
  - SDG&E contract materials (if HVAC equipment was incented)
  - CEC Appliance database
  - Title 24 minimums, especially if equipment was not incented

  Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.
- ***Economizer Status.*** If the cooling capacity was greater than 75 kBtuh, an economizer was automatically imposed to satisfy the Title 24 requirement.

Baseline Simulations. Baselines were defined to reflect strict adherence to Title 24 minimum efficiencies by system type and economizer requirements. General baseline assumptions were as follows:

- ***Cooling Efficiencies.*** For systems of 1994 vintage or later, the Title 24 minimum efficiencies for a given equipment type, cooling capacity, and electrical phase were used. For systems with a cooling capacity less than 65 kBtuh, an efficiency value corresponding to the one used for the as-built run was used, i.e., if an EER (instead of a SEER) was used for the as-built run, then an EER was used for the baseline run as well. Baseline efficiencies were substituted directly into the original data table containing the package information. Circa 1993 and older systems with missing efficiencies were left blank, and SITEPRO defaulted them to DOE-2 default efficiencies.

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4 California Energy Commission Appliance Bulletin Board Service Survey.
5 Per conversations with Steve Taylor, P.E. of Taylor Engineering, January 1997.

- ***Heat Pump Heating Efficiencies.*** For systems of 1994 vintage or later, the Title 24 minimum efficiencies (COP rating at 47°F not 17°F) for a given equipment type, cooling capacity, and electrical phase were used. For systems with a cooling capacity less than 65 kBtuh, an efficiency value corresponding to the one used for the as-built run was used, i.e., if a COP (instead of an HSPF) was used for the as-built run, then a COP was used for the baseline run as well. Baseline efficiencies were substituted directly into the original data table containing the package information. Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.
- ***Economizer Status.*** For units with economizers and a cooling capacity less than 75 kBtuh, the economizers were switched off, since economizers are not required on this size unit by Title 24.

Built-up HVAC Systems

Simulations of built-up cooling systems utilized information on system type, cooling and heating equipment sizes and efficiencies, and thermostat settings and controls, as described below:

- ***System Type.*** SITEPRO is capable of modeling all major system types recognized by DOE-2. Survey data identifying the type of distribution system, cooling source, and heating source for each package unit were used in the simulations.
- ***Cooling and Heating Equipment Sizes.*** Cooling and heating capacities direct from the survey data were used in the simulations. Missing capacities were autosized by DOE-2 via SITEPRO.
- ***Thermostat Settings and Controls.*** Thermostat settings were obtained from cooling and heating schedules specified in the on-site survey.

As-Built Simulations. For built-up systems, typically only the chiller efficiency, VAV system measures, and ASD/VSD pump controls were changed for the as-built to baseline run. Assumptions on these features were as follows:

- ***Chiller Efficiencies.*** The efficiencies reported on the survey were used unless they were below code or obviously errant data. For systems where both a kW/ton and a COP efficiency were reported the one that was the most consistent with Title 24 was used and the other one deleted from the data. For those systems of 1994 or later vintage, if the efficiency was missing or less than the Title 24 minimum, correct values were obtained from one of the following:
  - SDG&E contract materials (if HVAC equipment was incented)
  - Title 24 minimums, especially if equipment was not incented

  Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.

- ***VAV Distribution System Measures.*** For participants, a variable air volume (VAV) system consistent with SDG&E contractual materials was simulated, including any and all fan controls noted therein. In some instances, survey data was updated to be consistent with these materials. For nonparticipants that converted from Constant Volume (CV) to VAV, we simulated a VAV system consistent with the configuration and controls as noted on the survey form.
- ***ASD/VSD Circulation Pumps.*** These effects were simulated in DOE-2 by specifying the control of the circulation pumps as VSD in the survey data.

Baseline Simulations. Baselines were defined to reflect strict adherence to Title 24 minimum efficiencies. System type changes and ASD/VSD fan and pump changes were made consistent with SDG&E contract materials. General baseline assumptions were as follows:

- ***Chiller Efficiencies.*** For those chillers of 1994 or later vintage, the Title 24 minimum efficiencies based on chiller size and type were used. Circa 1993 and older systems with missing efficiencies were left blank, which SITEPRO defaults to DOE-2 default efficiencies.
- ***VAV Distribution System Measures.*** For participants, the baseline run was made consistent with the SDG&E contractual materials; if a CV system was assumed as the baseline system by SDG&E, a CV system was assumed as the baseline here. If only VAV system controls were assumed (i.e., typically VSD fan control), only the fan control type was changed for the baseline run. For nonparticipants a Constant Volume (CV) system was simulated per survey data.
- ***ASD/VSD Circulation Pumps.*** These pumps were baselined by switching control of the circulation pumps from VSD to single-speed via the survey data for the baseline run.

Building Shell

As-Built Simulations. The only building shell measures addressed were external walls and roofs insulated to exceed Title 24 prescriptive requirements and window tinting. The information from the survey form used for this simulation included a noted observation of above-code external wall or roof insulation and the associated R-values, and an observation of window tinting and the associated tint type on the glazing. Assumptions on these features were as follows:

- ***External Wall Insulation.*** Effects of external wall insulation were simulated only if it was reported as a measure and R-values were indicated on the survey form. The R-value reported in the survey form was used for the as-built run. If an R-value was not reported then the effects of this measure were not simulated.
- ***Roof Insulation.*** Effects of roof insulation were simulated only if it was reported as a self-reported measure and R-values were indicated on the survey form. The R-

value reported in the survey form was used for the as-built run. If an R-value was not reported, then this measure was not simulated.

- ***Window Tint.*** Effects of window tint were simulated only if reported as a self-reported measure, the building was older than 1994, and the tint was installed in 1994/1995 or the window tint was incented. The assumption here was that if it was a new building, then tint was probably required by code or at least part of the original Title 24 calculations and hence not a real measure. A glass type of tinted (=T) was used for the as-built runs. If window tint was reported as a measure but the glass type was not recorded as tinted, it was changed to tinted.

  The best way to determine whether or not window tint was required was to look at the Relative Solar Heat Gain (RSHG) values allowed by the standard, then determine from these values what the minimum allowable glazing configuration might be.[6] Since the values of this parameter for Climate Zones 6-10 and 11-13 (San Diego areas) of 0.71 and 0.57, respectively, are consistent with tinted/reflective windows, one might assume that tinted windows were the base. However, the RSHG can be lowered via overhangs/fins such that a clear glass window could actually meet the standard (and there are in fact many such sites in the survey). In lieu of this fact, the approach taken seemed the most reasonable one.

Baseline Simulations. Baselines were defined to reflect strict adherence to Title 24 prescriptive requirements for external wall and roof insulation. Assumptions on these features were as follows:

- ***External Wall Insulation.*** The baseline value used was either R-11 (for Zones 6-10, which cover most San Diego areas) or R-13 (for Zones 11-13, the transition-desert regions).
- ***Roof Insulation.*** The baseline value used was either R-11 (for Zones 6-10, which cover most San Diego areas) or R-19 (for Zones 11-13, the transition-desert regions).
- ***Window Tint.*** For the baseline run, glass type was changed to clear (=C) in the survey data.

Remote Refrigeration

As-Built and Baseline Simulations. Remote refrigeration is not simulated by DOE-2. Instead, remote refrigeration load shapes[7] and on-site data were used to estimate energy use. In particular, the daily profile (hourly fraction for a typical day in each month) and daily energy use (kWh/day/kBtuh of case load) were combined with case loads (kBtuh) based on

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6 Per conversation with Steve Taylor, P.E. of Taylor Engineering, January 1997.

7 These load shapes were developed by Doug Scott of VaCom Technologies and based on TMY weather for San Diego.

the refrigerated case and walk-in inventories (lineal ft, ft^2, or number of glass doors) at a site, to yield energy use. Assumptions on these features were as follows:

- ***Compressor, Condenser, and Associated Measures.*** For participant sites where the refrigeration measures were typically well documented, as-built and baseline runs were made consistent with the "Refrigeration Energy Savings Alternatives"[8] reports prepared by VaCom Technologies and obtained from the SDG&E contract materials. This detailed report analyzed the different options available to a remote refrigeration user, as well as defining a "baseline system" to which the various options were compared. This baseline system was typically (although not always) an air-cooled, multiplex system without any subcooling or floating head pressure (FHP) control. For nonparticipants, whenever remote refrigeration system measures were identified, an air-cooled, multiplex system without any subcooling or FHP control was assumed as the baseline configuration.
- ***Defrost Measures.*** Gas defrost systems, wherever noted as a measure, were switched to electric defrost for the baseline run.
- ***Case Measures.*** Case measures, such as high efficiency case fans, were simulated in SITEPRO by again utilizing information from the "Refrigeration Energy Savings Alternatives" reports from the SDG&E contract materials.

Motors

As-Built and Baseline Simulations. Simulations of motors utilized information on motor size, efficiency type, and control type. Assumptions on these features were as follows:

- ***High Efficiency Motors.*** SITEPRO utilizes a motor technical data table to obtain efficiency as a function of a motor's size (in HP), and its efficiency type (Standard or High Efficiency) as identified in the survey data, and its load factor (which is a default keyed off of the motor service type). However, this data only applies to motors entered in the *Motors/Engines* table of the survey form. For the as-built run, the "High Efficiency" data field is set to "Y" and changed to "N" for the baseline run. For sites utilizing high efficiency motors not entered on the *Motors/Engines* table, the *techdata* table was simply utilized to "adjust" the effective motor HP to reflect these higher efficiencies (the only way to do this in SITEPRO).
- ***ASD/VSD Motors.*** ASD/VSD control is simulated via the *PartLoadElasticity* field in another SITEPRO technical data table. This is an exponential value (α) to which the load factor is raised that describes the shape of the load factor versus kW-draw curve. For ASD/VSD motors, an elasticity that yielded a 25% reduction in energy use for the operating load factor was used. This was implemented in the simulations by using a motor control type of *Electronic VSD (E)* for the as-built run and a control type of *On/Off Switch (S)* for the baseline run. For pumps, this

[8] These reports were prepared by VaCom Technologies for SDG&E to evaluate refrigeration alternatives for specific sites.

physically represents a switch from an ASD-controlled, variable-flow configuration for the as-built scenario to a constant-speed, throttle-valve controlled configuration for the baseline scenario.

- ***CO Sensors.*** This type of control for garage exhaust fans was simulated by applying a factor of 0.10 to the baseline weekly operating hours of 168 hours, consistent with SDG&E contract materials and CEC guidelines.

4.5 Results

Simulated End-Use Intensities

Table 4-1 summarizes the results of the engineering analysis and depicts simulated end-use intensities for both participants and nonparticipants. For the purposes of this table, both 1995 and 1996 sampled sites are included. The results are weighted, and thus reflect the corresponding populations of participants and nonparticipants. As shown, baseline and as-built usage for most end uses are very similar for participants and nonparticipants. However, process usage differs substantially between these two groups. This is the result of a few large participants with very large process usage and relatively low square footage. The differences in end-use intensities suggest that comparisons of participant and nonparticipant savings must be made carefully, as discussed below.

Table 4-1: Weighted Simulated Intensities (kWh/ft^2), All Sites

	Surveyed Participants (1995 and 1996)		Surveyed Nonparticipants (1995 and 1996)	
End Use	Title 20/24	As-Built	Title 20/24	As-Built
Interior Lighting	6.885	4.981	5.381	4.376
Space Cooling	4.213	3.556	3.569	3.283
Space Heating	0.242	0.263	0.321	0.335
Ventilation	2.377	2.095	1.836	1.825
Refrigeration	2.474	2.260	1.963	1.963
Process	15.700	14.648	4.869	4.850
Other	1.365	1.365	1.931	1.931
All End Uses	**33.257**	**29.168**	**19.870**	**18.563**

Engineering Estimates of DSM Savings

Engineering estimates of DSM savings are very important components of the analysis. Savings estimates for participants are central to the analysis of gross program savings, and comparisons of participant and nonparticipants play an important role in the net-to-gross analysis. Given the pooled sampling approach used in this study, and given the availability of several ways of normalizing savings, a variety of savings measures could be used. Two issues need to be resolved in this respect: the use of 1995 participant savings, and the choice of a measure of relative savings activity of participants and nonparticipants.

- ***1995 Participant Savings.*** The first issue is how savings estimates for 1995 participants should be used. Obviously, these savings estimates cannot be attributed to the 1996 program. However, simulations for 1995 participants can be used in the realization rate analysis, insofar as there is no reason to assume that the realization rates differ between 1995 and 1996. On the other hand, these savings should not be used in comparisons of participants and nonparticipants, for two reasons.
  - ***End-Use Mix of Program Savings.*** First, the end-use mix of conservation activity differed fairly substantially between 1995 and 1996 participants. In 1995, two-thirds of participant savings were comprised of lighting savings, while only 36% of participant savings were associated with lighting in 1996. Process measures accounted for 5% of participant savings in 1995 and 37% in 1996.
  - ***Controversy Over 1995 Case Weights.*** Second, there was some controversy last year relating to estimated savings for participants. While the ORA's consultant did not raise objections with RER's engineering analysis of *sampled* sites, the consultant did question SDG&E's *ex ante* savings estimates for *non-sampled* sites. As a result, the consultant objected to the use of SDG&E's *ex ante* savings to develop weights for 1995 participants.[9] Since case weights must be used in the development of net-to-gross ratios, whether they are based on difference-of-difference approaches or modeling approaches, it seems prudent to avoid past controversies by limiting the net-to-gross analysis to the comparison of 1996 participants with 1995 and 1996 nonparticipants. In what follows, then, we will focus on such comparisons.
- ***Measures of Savings Activity.*** There are several measures of savings activity that could be used in the net-to-gross analysis. Savings per site square foot is a common measure of savings activity, and is traditionally used in the difference-of-differences approach to the development of net-to-gross ratios. Only one issue needs to be raised with respect to the implementation of this approach. If only part of the site is eligible for the program, in the sense that only part is subject to new

[9] There was also some confusion over the appropriate building category indicators used in the definition of case weights. Note that the SIC designators from SDG&E's master file are used to define building categories for the purpose of developing case weights.

construction, major remodel or tenant improvements, *total site square footage* is not appropriate as a denominator.[10] Instead, one should use *eligible square feet* to normalize savings. This is the practice RER has used in the difference-of-differences analysis.[11]

Table 4-2 provides a preliminary view of the engineering analysis of participant and nonparticipant savings. In keeping with the above comments, participant savings reflect only the savings of 1996 participants. All estimates are weighted, and thus reflect the savings activities of participant and nonparticipant populations. As indicated in Table 4-2, there is an appreciable difference between savings per surveyed square foot and savings per eligible square foot. This arises because only a fraction of the surveyed area in many of the sites in the sample had been newly constructed, remodeled, or TIed. As also indicated, there are major differences between participants and nonparticipants with both savings measures. These differences will be analyzed at length in Section 6.

Table 4-2: Comparisons of Engineering Estimates of Savings

	Savings per Surveyed Square Foot		Savings per Eligible Square Foot	
End Use	**Particip**	**Nonpart**	**Particip**	**Nonpart**
Lighting	1.5403	1.0044	2.3498	1.2883
Space Cooling	0.6487	0.2855	0.9896	0.3663
Space Heating	0.0086	-0.0142	0.0131	-0.0182
Ventilation	0.3947	0.0115	0.6021	0.0147
Refrigeration	0.1095	0.0003	0.1671	0.0004
Process/Other	1.5916	0.0194	2.4281	0.0249
All End Uses	**4.2934**	**1.3069**	**6.5498**	**1.6764**

[10] Note, though, that total site square footage should be used to develop as-built or baseline intensities, however, since these estimates relate to total surveyed area.

[11] As explained in Section 6, another measure of savings—savings as a proportion of baseline end use consumption—is probably superior to both savings per square foot measures.

Engineering Estimates of Total Participant Savings

Table 4-3 summarizes the simulation estimates of total participant savings. Savings for sampled sites were expanded to program totals through the application of the appropriate case weights. Also presented are SDG&E's *ex ante* savings estimates of program savings, as filed in the Company's first-year earnings claim. Three central points should be made with respect to any comparisons of these simulation estimates of gross program savings with SDG&E ex ante estimates.

Table 4-3: Engineering Estimates of Total 1996 Participant Savings

End Use	SDG&E *ex ante* Savings Estimates	Project Engineering Estimates
Total Savings (GWh)		
Interior Lighting	12.189	30.855
Cooling	25.136	12.995
Heating	0.066	0.172
Ventilation	2.110	7.906
Refrigeration	2.354	2.194
Process and Other	25.916	31.883
Total Whole Building	**67.846**	**86.005**
Eligible Square Feet	**13,130,828**	**13,130,828**
Savings per Eligible Square Foot (kWh)		
Lighting	0.928	2.350
Cooling	1.914	0.990
Heating	0.005	0.013
Ventilation	0.161	0.602
Refrigeration	0.179	0.167
Process and Other	1.973	2.428
Total Whole Building	**5.167**	**6.550**
Total Participants	**289**	**289**
Savings per Participant (kWh)		
Lighting	42,176	106,764
Cooling	86,976	44,964
Heating	228	596
Ventilation	7,301	27,356
Refrigeration	8,145	7,593
Process and Other	89,675	110,321
Total Whole Building	**234,761**	**297,594**

- First, the engineering estimates contained in Table 4-3 are not directly comparable to SDG&E's estimate filed with its first year earnings claim because they cover all savings estimated for participants, not just savings from incented measures. As such, it is much more broadly defined than SDG&E's *ex ante* savings estimate. However, this broadening of the savings estimate will be adjusted in the net-to-gross analysis, where participant savings are compared against savings experienced by nonparticipants using the same standards. The reason for this approach is that it is virtually impossible to disaggregate lighting savings from program and non-program measures if the correct baseline for savings is used. Title 24 lighting standards are written in terms of lighting densities, rather than the prescription of specific lighting types (although some lighting types are no longer permitted to be manufactured). Title 24 baselines were simulated by using the allowed densities for the space types in question. If a site has a density of, say, 20% below its Title 24 allowance, there is no good way to attribute this density reduction to incented and non-incentivized measures. Of course, it could simply be assumed that the incented measures were not in place. However, this requires the specification of a specific baseline lighting technology, and this approach can yield implausible results.
- Second, estimates of savings per participant or per square foot presented in Table 4-3 may differ from corresponding estimates found elsewhere. The reason is that we used our own estimates of square footage and participants. The estimate of square footage is just the weighted sum of eligible square footage as determined in the course of the survey. The number of participants refers to the number of distinct participating sites, rather than the number of contracts.
- Third, the distributions of estimated savings across end uses differ partly because of differences in the end-use categorization of savings between the tracking system and our own simulations. For instance, in at least a few major cases, SDG&E seems to have assigned process cooling and/or ventilation savings to the cooling end use. This largely accounts for the discrepancies across these end uses.

4.6 Summary

This section has described the process of developing engineering estimates of the savings from measures found at participant and nonparticipant sites. The estimates suggest that total participant savings amounted to just over 86 GWh. As explained, these estimates cover both incented and nonincented measures, and are not directly comparable to SDG&E's *ex ante* savings estimates. In Section 5, we turn to the calibration of estimated savings with billed consumption. Then, in Section 6, we use comparisons of the calibrated savings estimates between participants and nonparticipants to estimate a set of net-to-gross ratios.

5

Estimation of Gross Realized Savings

5.1 Introduction

While the simulation results were cross checked against billing data in order to identify data errors and/or mismatches between the surveyed site and the site covered by the billing data, even the final engineering estimates can be biased due to errors in reported schedules or other operating conditions. Moreover, engineering estimates ignore the possibility of rebound, or snap-back, effects as well as the possibility that engineering biases may differ across levels of efficiency. Although engineering estimates provide important information on gross program impacts, these estimates were further refined with a statistically adjusted engineering (SAE) approach statistical adjustment process. The approach entails the use of actual customer consumption to develop a set of adjustment factors on the engineering estimates of savings from both incentivized and non-incentivized measures.[1] The application of these adjustment factors to the engineering estimates yields a set of estimates of gross realized savings. Two aspects of the analysis should be noted carefully. First, it should be recognized that the base for the adjustment factors developed in this chapter is the project team's engineering estimates of savings, not SDG&E's *ex ante* estimates. Second, it should be understood that the analysis yields estimates of gross (*ex post*) savings without regard to the reasons why these measures were installed.

In the rest of this section, the application of the SAE approach to estimate gross realized program savings is described. Subsection 5.2 provides an overview of the SAE approach. Subsection 5.3 discusses the specific SAE model developed in this evaluation. Subsection 5.4 presents the estimates of gross program savings developed through the use of the model.

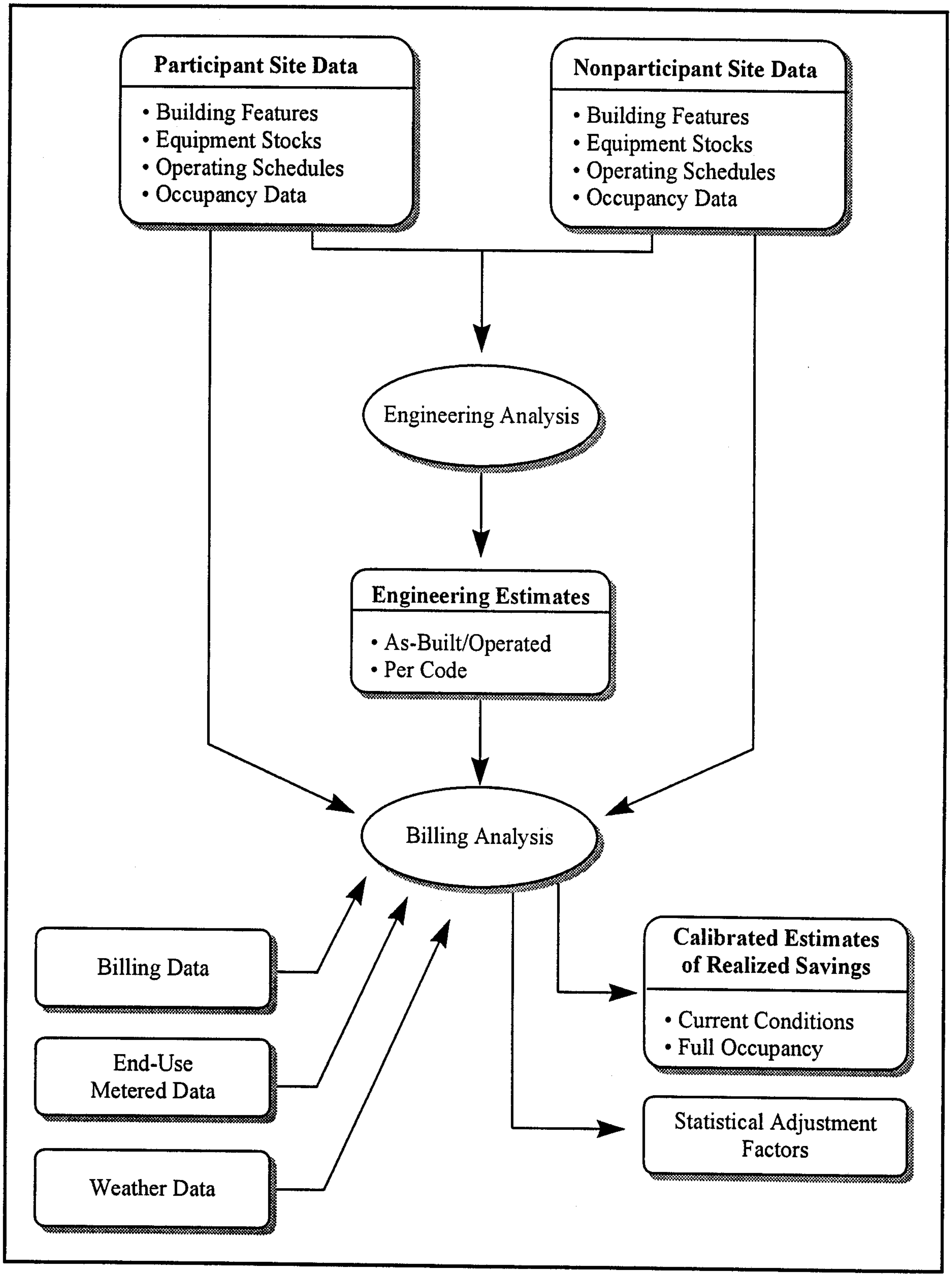
[1] The specific variant of SAE used for this study is sometimes called the "realization rate" approach to connote that the adjustment factors are rates at which the engineering estimates of savings are realized in the form of actual reductions in usage. In order to avoid confusing these realization rates with the realization rates defined for use in Table 6 of the reporting protocols, however, we will refer to them as adjustment factors in this report. For other applications of this approach, see Sebold and Fox, 1985; and Sebold, Wang and Mayer, 1995.

5.2 Overview of the SAE Model

General Logic

The general logic of the SAE approach (as applied to new construction programs) is illustrated in Figure 5-1. The first step of the analysis entails the development of engineering estimates of end-use consumption levels. As was discussed in Section 4, these estimates are based on information about building features, equipment stocks, operating schedules, and occupancy data. As shown in Figure 5-1, the SAE model relies on estimates of end-use consumption under two scenarios: the as-built scenario and the reference scenario, which entails minimal compliance with building standards. The model can also make use of information on site characteristics (e.g., square footage), as well as weather conditions and occupancy characteristics that might affect the realization of the engineering estimates of baseline usage and DSM-related savings. The model produces a set of adjustment coefficients (or adjustment functions) that translate these engineering estimates into estimates consistent with observed energy usage (realized savings). As explained below, the adjustment coefficients on savings reflect the proportion of engineering-based savings estimates actually realized in the form of reduced site usage.

Figure 5-1: Overview of the Realization Rate Model



Model Specification

To derive the new construction SAE model, we begin with the standard SAE specification:

$$(1)\quad E_{bt} = \sum_{e} \alpha_e EEACTUAL_{bet} + \varepsilon_{bt}$$

where E_{bt} is whole-building energy consumption at site b in time t, and $EEACTUAL_{bet}$ is an engineering estimate of consumption through end use e at the site based on assumptions reflecting the actual design and operation of the building. The presence of the adjustment coefficient (α_e) reflects the possibility of general engineering bias. The model can be expanded by decomposing the engineering estimates into two elements:

$$(2)\quad EEACTUAL_{bet} = EEBASE_{bet} - EESAV_{bet}$$

where $EEBASE_{bet}$ represents an engineering estimate of usage under a baseline assumption with respect to the presence of energy conservation measures and $EESAV_{bet}$ represents an engineering estimate of savings from energy efficiency beyond the baseline. There are several ways of defining the baseline for savings. One option in this regard would be to let this estimate reflect minimal compliance with standards.[2] The specification shown in (2) simply splits the engineering estimate into a baseline estimate and an estimate of the savings associated with the energy conservation beyond baseline levels. Substituting (2) into (1), we obtain:

$$(3)\quad E_{bt} = \sum_{e} \alpha_e [EEBASE_{bet} - EESAV_{bet}] + \varepsilon_{bt}$$

Once the model is put into this form, possible modifications are apparent. First, the basic adjustment coefficient on the estimated energy savings should be allowed to be different from the adjustment coefficient of the baseline engineering estimate. Second, these adjustment coefficients should be permitted to vary across sites as conditions vary. One possible version of the revised model is as follows:

$$(4)\quad E_{bt} = \sum_{e} \alpha_e (X_{bt}) [EEBASE_{bet} - \beta_e EESAV_{bet}] + \varepsilon_{bt}$$

where β_e is an adjustment coefficient reflecting the bias in engineering savings estimates *relative* to the bias in the baseline energy usage estimates. Note also that the overall adjustment function ($\alpha_e(X_{bt})$) is assumed to be a function of relevant factors. These factors

[2] As explained above, this scenario is only a reference point for the realized savings analysis. The true baseline for the overall program evaluation is the participant's usage in the absence of the program, and this may differ from the level associated with standards compliance.

could include site characteristics, like occupancy rates, as well as weather, building category dummies, or other variables thought to affect the overall accuracy of baseline engineering calculations.

Estimation of the New Construction SAE Model

The new construction SAE model can be estimated by applying regression analysis to data on a sample of sites for which billing data, comprehensive engineering estimates, and site data are available. For this study, the model was estimated using all sites for which DOE-2 analyses are conducted and for which comparable billing records were available. It is fairly common to encounter several statistical problems in the course of estimating this type of model, and it is important to deal with these effectively. Typical problems are discussed later in this section.

Use of the Model to Infer Adjustment Factors

Given this simple yet flexible framework, the end use-specific realized savings associated with differences between baseline efficiency levels and the levels of efficiency found in the buildings covered by the analysis would be:

$$(5)\quad REALIZED\ SAVINGS_{bet} = \hat{\alpha}_e(X_{bt})\ \hat{\beta}_e EESAV_{bet}$$

where $\hat{\alpha}_e$ is the estimated overall adjustment function for the site and end use in question and $\hat{\beta}_e$ is the estimated value of β_e. The associated adjustment function can be defined as:

$$(6)\quad ADJUSTMENT\ FUNCTION_{bet} = \hat{\alpha}_e(X_{bt})\ \hat{\beta}_e$$

There are several points to note about this approach:

- It directly integrates the results of building simulations. To the extent that it takes advantage of the detailed information used as inputs into these simulations, it should increase the efficiency of estimation of realized gross savings. This, of course, depends on the quality of the simulations, an issue that was addressed in Section 4.
- It is relatively efficient in preserving degrees of freedom (compared, for instance, to complex conditional demand models).
- It can be used to estimate realized savings for individual conservation measures or groups of measures, unlike approaches that focus on differences in energy usage between participants and nonparticipants.
- It is more amenable to the analysis of a heterogeneous set of program participants receiving a broad range of DSM measures than most other statistical approaches like conditional demand analysis.

- It can be used directly to weather-normalize realized savings. The approach used for this purpose is straightforward. Engineering estimates of base usage ($EEBASE_{bet}$) and DSM savings ($EESAV_{bet}$) are developed through DOE-2 simulations using normal weather conditions. Then, the general adjustment function ($\alpha_e(X_{bt})$) is specified to contain terms representing the deviation of actual weather from normal weather in the billing period in question. This step accommodates the fact that billing data reflect actual weather conditions, whereas simulated usage estimates reflect normal weather. Once the adjustment function is estimated, the weather deviation is set to zero and the model is solved for the realization rate and the associated weather-normalized value of realized savings.
- Adjustment functions and coefficients derived for a representative sample of participants are applicable to other participants for whom engineering estimates are similarly derived. Thus, these rates can be used to transform engineering estimates of overall gross program savings (adjusted for differences between evaluation engineering estimates and program estimates) into calibrated estimates of realized savings.

5.3 Savings Through Design Program SAE Model

Model Specification

The specific model used in this SAE analysis is a fairly simple form of the general model presented above. The model is given by:

$$
\begin{aligned}
(7)\quad E_{bt} = {} & \beta_0 + \beta_1 EET24LT_{bt} + \beta_2 EEELTSAV_{bt} + \beta_3 EET24HT_{bt} \\
& + \beta_4 EET24HT_{bt} HDDRAT1_{bt} + \beta_5 EET24HT_{bt} HDDRAT2_{bt} + \beta_6 EEHTSAV_{bt} \\
& + \beta_7 EEHTSAV_{bt} HDDRAT1_{bt} + \beta_{87} EEHTSAV_{bt} HDDRAT2_{bt} + \beta_9 EET24CL_{bt} \\
& + \beta_{10} EET24CL_{bt} CDDRAT1_{bt} + \beta_{11} EET24CL_{bt} CDDRAT2_{bt} + \beta_{12} EECLSAV_{bt} \\
& + \beta_{13} EECLSAV_{bt} CDDRAT1_{bt} + \beta_{14} EECLSAV2_{bt} CDDRAT_{bt} + \beta_{15} EET24VT_{bt} \\
& + \beta_{16} EEVTSAV_{bt} + \beta_{17} EEBREF_{bt} + \beta_{18} EEREFSAV_{bt} + \beta_{19} EEPRAB_{bt} \\
& + \beta_{20} EEEXLTAB_{bt} + \beta_{21} EECKAB_{bt} + \beta_{22} EECOOKAB_{bt} + \beta_{23} EEWHAB_{bt} \\
& + \beta_{24} EEEQUAB_{bt} + \beta_{22} EEMISCAB_{bt} + \mu_{bt}
\end{aligned}
$$

where the following are engineering estimates based on the SITEPRO analysis:

$EET24LT_{bt}$	=	lighting usage per square foot under the Title 24 scenario
$EELTSAV_{bt}$	=	lighting savings relative to Title 24

$EET24HT_{bt}$	=	heating usage per square foot under the Title 24 scenario
$EEHTSAV_{bt}$	=	heating savings relative to Title 24
$EET24CL_{bt}$	=	cooling usage per square foot under the Title 24 scenario
$EECLSAV_{bt}$	=	cooling savings relative to Title 24
$EET24VT_{bt}$	=	ventilation usage per square foot under the Title 24 scenario
$EEVTSAV_{bt}$	=	ventilation savings relative to Title 24
$EEBREF_{bt}$	=	baseline refrigeration usage per square foot
$EEREFSAV_{bt}$	=	refrigeration savings relative to the baseline
$EEPRAB_{bt}$	=	process usage (process, water heating, compressors) under the as-built scenario
$EEEXLTAB_{bt}$	=	exterior lighting usage under the as-built scenario
$EECKAB_{bt}$	=	cooking usage under the as-built scenario
$EEWHAB_{bt}$	=	water heating usage under the as-built scenario
$EEEQUAB_{bt}$	=	office equipment usage under the as-built scenario
$EEMISCAB_{bt}$	=	miscellaneous usage under the as-built scenario

and where the weather terms are:

$HDDRAT1_{bt}$	=	deviation of actual heating degree-days from monthly normal degree-days, as a proportion of average annual normal heating degree days
$CDDRAT1_{bt}$	=	deviation of actual cooling degree-days from monthly normal values, as a proportion of average annual normal cooling degree days
$HDDRAT2_{bt}$	=	deviation of actual heating degree-days from *average* monthly normal degree-days, as a proportion of average monthly normal heating degree days
$CDDRAT2_{bt}$	=	deviation of actual cooling degree-days from *average* monthly normal values, as a proportion of average monthly normal cooling degree days

Note that the interaction of $HDDRAT1_{bt}$ and $CDDRAT1_{bt}$ with baseline usage and savings accounts for the fact that the engineering estimates were based on normal (TMY) weather, whereas actual space conditioning usage reflects actual weather. The expected sign of both of these terms is negative. The interaction of $HDDRAT2_{bt}$ and $CDDRAT2_{bt}$ with baseline usage allows the realization rate to vary across weather conditions. A positive sign indicates that actual cooling/heating loads are more sensitive to degree-days than the engineering estimates, while a negative sign indicates that actual loads are less sensitive than simulated loads.

The model was estimated with data on both 1995 and 1996 participants and nonparticipants. These data were pooled in order to increase the precision and robustness of the estimation of adjustment functions. Pooling was justified on the grounds that, given the use of the same engineering algorithms in 1995 and 1996, adjustment functions should be the same across years. In the course of model estimation, a number of additional variables were defined to account for shortcomings in the 1995 engineering estimates. These variables (which were also used in the 1995 program evaluation) are as follows:

- Several site specific dummy variables were defined for sites with loads that had been identified but unquantified in the course of the 1995 survey. These loads included unsurveyed parking garage lighting (RP002, RP242), large pumping loads (RP602), pool pumping loads (RN159), campsite loads (RN164), unidentified cooking loads (RN444), open architecture (RP188), and unidentified cooking and miscellaneous loads (RP227 and RP248).
- Binary site variables were also defined to account for specific conditions at some biological or pharmaceutical labs surveyed in 1995: the presence of large humidifiers at some sites, and the presence of loads in areas that could not be surveyed. Three sites were affected: RP196, RP201, and RP216.

No such site-specific variables were needed for the 1996 sample, in that we took additional steps to ensure the comprehensiveness of the survey process (e.g., we surveyed parking garages if they were on the relevant meter).

Estimation Database

The SAE model was estimated by applying regression analysis to data on both participants and nonparticipants. A total of 411 sites were initially available from the 1995 sample, although four of the 1995 nonparticipant sites were excluded altogether from the engineering and statistical analysis because they did not really qualify as new construction, remodels, or tenant improvements. This left 407 of the 1995 sites as candidates. An additional 250 sites were available from the 1996 survey, leaving a total of 657 candidate sites. Some attrition in this sample was encountered, however, due to the unavailability of matching billing data. This problem occurred when the surveyed site was a small part of the area covered by an account, and was fairly common in campus settings and some large high-rise office buildings. For the 1995 sample, billing data could not be matched to the sites in 66 cases, thus leaving 349 sites. For the 1996 sample, only 14 of the 250 sites lacked matching billing data, due to the preliminary prescreening of participants for the availability of these data. This left 236 of the 1996 respondents for the realization rate analysis. Overall, then, 585 sites from the 1995 and 1996 samples were covered by the regression analysis.

The model was estimated with four types of data:

- ***Billing Data.*** Billing data for the most recent 13 months were used. However, one observation was lost for each site in the course of correcting for autocorrelation.
- ***Weather Data.*** Both actual and normal weather data were used for the same period of time. Weather was characterized in terms of heating- and cooling degree-days.
- ***Engineering Estimates.*** Engineering estimates of end use consumption under the as-built and the baseline scenarios were incorporated as regressors.
- ***Survey Square Footage.*** Survey square footage was indirectly incorporated into the model, insofar as the heteroskedasticity correction entailed weighting observations by a power of the inverse of square footage.

Model Estimation

Several statistical problems can be encountered when estimating billing models like this one. These problems and their resolutions are discussed briefly below.

- ***Self-Selection Bias.*** Self-selection bias can be a problem in some load impact regression models containing a participation variable, but should not affect a realization rate model like the one to be used here. When the model contains one or more participation variables, the coefficients of these variables are meant to indicate the net impact of participation on energy usage, and their coefficients can be biased by the presence of self-selection bias. However, in the SAE model, *ex ante* savings estimates from the adoptions of specific measures (by participants and nonparticipants) are included, rather than participation variables, and there is no reason for self selection to affect these coefficients. Self-selection bias will be addressed in Section 6, where the net impact of program participation on efficiency choices is assessed.
- ***Multicollinearity.*** Multicollinearity is an econometric problem arising from the correlation of explanatory variables with each other. In the presence of severe multicollinearity, it is difficult to statistically disentangle the separate effects of the offending (correlated) variables. In the context of this realized savings model, it was sometimes necessary to restrict some of the coefficients to mitigate collinearity.
- ***Autocorrelation.*** Autocorrelation (the correlation of site-specific residuals over time) can be a vexing problem in that it biases the standard errors downward and causes t-values to be overstated. A test for autocorrelation indicated its presence, and generalized least squares was used to mitigate the problem.
- ***Heteroskedasticity.*** Heteroskedasticity can also be troublesome in the analysis of nonresidential usage, partly because the scale of usage varies so sharply across sites. This problem was mitigated through the application of generalized least squares. The error variance was found to be positively correlated with site square footage, and the data were transformed by the appropriate power of this variable to mitigate the heteroskedasticity.

- ***Outliers.*** Residuals were reviewed extensively. Given the strong fit of the model, there were very few outliers. In general, these few extreme residuals arose from partial occupancy at the site, and occurred at the beginning of the consumption series for the sites in question. These specific monthly observations were set equal to missing for the SAE analysis, although the rest of the monthly observations for the affected sites were used in estimation.

Model Results

Table 5-1 presents the estimated coefficients and standard errors for the SAE model. Two versions of the model are presented, differing only in the use of parameter restrictions. These versions are discussed below.

Version 1. In Version 1, we simplify the model by assuming that there is no differential engineering bias between estimates of baseline usage and savings. This essentially means that we are assuming that β_e in equation (4) is equal to 1.0 for all end uses. These assumptions (which also impose the absence of behavioral rebound) are imposed through a set of restrictions on the individual coefficients of the parameters of the model. Note that the parameter estimates for baseline and savings are equal (with a sign reversal) for all end uses in this version as a result of these restrictions. In this model, the coefficients on the free-standing savings terms can be interpreted as adjustment coefficients. The coefficients of the heating and cooling degree-day interaction terms can be ignored because these terms would be equal to 0 under normal weather conditions. As shown, the interior lighting savings coefficient is equal to 1.14, which indicates that engineering estimates of savings are fully realized in the form of reductions in energy usage. The adjustment coefficient for process savings, which includes savings associated with air compressors, motors, and process heat, takes on a value of 0.84, which suggests some overstatement in the engineering estimates of savings. The relatively low adjustment coefficients on heating (0.73), cooling (0.79), and ventilation (0.80)are not completely unexpected. Similar results have been found in other studies. HVAC usage is often lower than engineering simulations would suggest, perhaps because of erroneous information on thermostat schedules. The refrigeration adjustment coefficient (0.88) may result from a general overestimate of refrigeration usage, and this may reflect the use of too high a diversity factor in the engineering calculations.

Version 2. In Version 2, we remove the parameter restriction on interior lighting, refrigeration and process. All other end uses were left in the as-built form, for two reasons. First, cooling and heating savings are highly collinear with lighting savings, insofar as they are strongly affected by lighting HVAC interactions, and this leads to instability in their coefficients. Second, other end uses have relatively low expected savings, and the associated adjustment coefficients on savings tend to lack robustness. As shown in Table 5-2, the adjustment coefficient on lighting is very stable, falling only slightly to 1.10. The adjustment coefficients on refrigeration and process savings, on the other hand, increase fairly substantially. While both versions of the model yield very similar savings overall, Version 1 was chosen as the final version. This choice was made because of substantial differences in the savings and base usage coefficients for refrigeration and process end uses did not appear plausible, since they imply values of β_e greater than 1. However, the results shown for Version 2 reinforce the general conclusions that lighting savings are slightly more than fully realized and that other savings have reasonably high rates of realization.

Table 5-1: Estimated SAE Model (t-values in parenthesis)

Variable	Version 1	Version 2
$EET24LT_{bt}$	1.143792 (57.54)	1.138030 (50.77)
$EELTSAV_{bt}$	-1.143792 (-57.54)	-1.097388 (-17.99)
$EET24HT_{bt}$	0.733064 (6.25)	0.803624 (6.93)
$EET24HT_{bt}\ HDDRAT1_{bt}$	0.238625 (0.22)	0.487929 (0.45)
$EET24HT_{bt}\ HDDRAT2_{bt}$	-0.134203 (-2.20)	-0.157021 (-2.60)
$EEHTSAV_{bt}$	-0.733064 (-6.25)	-0.803624 (-6.93)
$EEHTSAV_{bt}\ HDDRAT1_{bt}$	-0.238625 (-0.22)	-0.487929 (-0.45)
$EEHTSAV_{bt}\ HDDRAT2_{bt}$	0.134203 (2.20)	0.157021 (2.60)
$EET24CL_{bt}$	0.790881 (36.41)	0.803159 (37.10)
$EET24CL_{bt}\ CDDRAT1_{bt}$	0.886934 (9.94)	0.907615 (10.22)
$EET24CL_{bt}\ CDDRAT2_{bt}$	0.023523 (3.74)	0.022094 (3.53)
$EECLSAV_{bt}$	-0.790881 (-36.41)	-0.803159 (-37.10)
$EECLSAV_{bt}\ CDDRAT1_{bt}$	-0.886934 (-9.94)	-0.907615 (-10.22)
$EETCLSAV_{bt}\ CDDRAT2_{bt}$	-0.023523 (-3.74)	-0.022094 (-3.53)
$EET24VT_{bt}$	0.804575 (46.97)	0.736684 (37.95)
$EET24VT_{bt}\ CDDRAT2_{bt}$	0.033907 (5.76)	0.033697 (5.72)
$EEVTSAV_{bt}$	-0.804575 (-46.97)	-0.736684 (-37.95)
$EEVTSAV_{bt}\ CDDRAT2_{bt}$	-0.033907 (-5.76)	-0.033697 (-5.72)
$EEBREF_{bt}$	0.878719 (78.8)	0.887535 (72.15)
$EEREFSAV_{bt}$	-0.878719 (-78.8)	-1.061004 (-9.66)

Table 5-1 (cont'd.): Estimated SAE Model (t-values in parenthesis)

Variable	Version 1	Version 2
$EEPRT24_{bt}$	0.838684 (146.79)	0.931408 (67.73)
$EEPRSAV_{bt}$	-0.838684 (-146.79)	-1.088948 (-31.95)
$EEEXLTAB_{b}$	1.045646 (35.09)	1.021557 (33.63)
$EECKAB_{bt}$	1.002163 (82.60)	1.004119 (81.14)
$EEWHAB_{bt}$	2.158630 (8.83)	2.137787 (8.76)
$EEEQUAB_{bt}$	1.158500 (24.03)	1.154784 (24.17)
$EEMISCAB_{bt}$	1.356768 (37.12)	1.320625 (36.36)
$RP002_{bt}$	1.088411 (5.76)	1.061296 (5.68)
$RP242_{bt}$	1.052521 (6.72)	1.067345 (6.97)
RP602_{bt}	1.528441 (9.89)	1.529856 (10.07)
RN159_{bt}	0.526268 (3.30)	0.503838 (3.21)
RN164_{bt}	1.480250 (9.33)	1.500379 (9.62)
RN444_{bt}	1.486927 (4.48)	1.470763 (4.40)
RP188_{bt}	0.856281 (5.00)	0.878067 (5.20)
RP227_{bt}	0.937417 (6.49)	1.022438 (6.90)
RP248_{bt}	0.878610 (2.34)	0.786551 (2.15)
RP201_{bt}	2.394212 (9.85)	2.378169 (9.81)
RP196_{bt}	1.482977 (9.50)	1.542609 (10.03)
RP216_{bt}	0.947356 (6.90)	0.951502 (7.07)
Adjusted R^2	0.9279	0.9292

5.4 Estimated Gross Realized Program Savings

The results of the SAE model (Version 1) can be used to generate estimates of realized gross savings for participants. For HVAC end uses, these estimates are designed to be weather normalized. This is accomplished by making the incremental weather terms ($HDDRAT1_{bt}$, $HDDRAT2_{bt}$, $CDDRAT1_{bt}$ and $CDDRAT2_{bt}$) equal to zero (indicating that under normal weather conditions, deviations from the TMY weather are assumed to be zero). The results of these calculations are shown below in Table 5-2. Gross realized savings are presented for the full population of participants, and were developed using the appropriate case weights. Realized savings estimates are presented in three forms: as total energy saved, energy savings per square foot of eligible space, and energy savings per participant. Eligible space was defined to be the space under construction and covered by the program. This differs from surveyed space in that the area surveyed was dictated by both the space covered by the program and by the space covered by the meter. Note additionally that the number of participants reflects the number of sites, not the number of contracts. As a result, the savings per participant is defined somewhat differently from the estimated filed by SDG&E in its first year earnings claim.

As shown in Table 5-2, our engineering estimate of total energy savings for the participant sample amount to 86.005 GWh. Applying the end-use realization rates to the respective end-use engineering estimates, we obtain a total realized savings of 80.758. This implies an overall adjustment factor of 0.939.

Table 5-2: Estimated Gross Realized Program Energy Savings

End Use	Engineering Estimate of Program Savings	Statistical Adjustment Factor	Gross Realized Savings
Total Savings (GWh)			
Interior Lighting	30.855	1.144	35.292
Cooling	12.995	0.791	10.277
Heating	0.172	0.733	0.126
Ventilation	7.906	0.805	6.361
Refrigeration	2.194	0.879	1.928
Process	31.883	0.839	26.774
Total Whole Building	**86.005**	**0.939**	**80.758**
Savings per Eligible Square Foot (kWh)			
Interior Lighting	2.350	1.144	2.688
Cooling	0.990	0.791	0.783
Heating	0.013	0.733	0.010
Ventilation	0.602	0.805	0.484
Refrigeration	0.167	0.879	0.147
Process	2.428	0.839	2.039
Total Whole Building	**6.550**	**0.939**	**6.150**
Savings per Participant (kWh)			
Interior Lighting	106,765	1.144	122,117
Cooling	44,964	0.791	35,561
Heating	596	0.733	437
Ventilation	27,356	0.805	22,010
Refrigeration	7,593	0.879	6,672
Process	110,321	0.839	92,642
Total Whole Building	**297,594**	**0.939**	**279,438**

Table 5-3 depicts estimated demand savings. The peak fractions used to develop these estimates were derived from SITEPRO results. These peak fractions are:

- Interior Lighting: 0.000194
- Cooling: 0.000274
- Ventilation: 0.000108
- Heating: 0.000000
- Refrigeration: 0.000119
- Process: 0.000131

It was assumed that the energy realization rates also apply to demand savings. As indicated in Table 5-3, total realized demand impacts amount to 14.1 MW. This implies demand savings of 1.07 W per square foot of eligible space or just over 48.7 kW per participant.

Table 5-3: Estimated Gross Realized Program Demand Savings

End Use	Engineering Estimate of Program Savings	Statistical Adjustment Factor	Gross Realized Savings
Total Savings (MW)			
Lighting	5.9726	1.144	6.8314
Cooling	3.5662	0.791	2.8205
Heating	0.0000	0.733	0.0000
Ventilation	0.8565	0.805	0.6891
Refrigeration	0.2601	0.879	0.2285
Process	4.1753	0.839	3.5063
Total Whole Building	**14.8308**	**0.939**	**14.0758**
Savings per Eligible Square Foot (W)			
Lighting	0.4549	1.144	0.5203
Cooling	0.2716	0.791	0.2148
Heating	0.0000	0.733	0.0000
Ventilation	0.0652	0.805	0.0525
Refrigeration	0.0198	0.879	0.0174
Process	0.3180	0.839	0.2670
Total Whole Building	**1.1295**	**0.939**	**1.0720**
Savings per Participant (kW)			
Lighting	20.6665	1.144	23.6382
Cooling	12.3399	0.791	9.7594
Heating	0.0000	0.733	0.0000
Ventilation	2.9637	0.805	2.3845
Refrigeration	0.8999	0.879	0.7907
Process	14.4476	0.839	12.1324
Total Whole Building	**51.3176**	**0.939**	**48.7053**

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 Statistically Adjusted Engineering 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 Table 5-1. 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 5-1 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, is used to develop a confidence interval for gross realized savings.

The results of this exercise are shown in Table 5-4.

Table 5-4: Confidence Intervals for Estimated Gross Realized Savings

Measure of Savings	Point Estimate	90% Confidence Interval	80% Confidence Interval
Gross Realized Energy Savings			
Total Program (GWh)	80.758	78.740 to 82.776	79.185 to 82.331
per Square Foot (kWh/ft^2)	6.150	5.996 to 6.304	6.030 to 6.270
per Building (kWh)	279,438	272,456 to 286,420	273,996 to 284,880
Gross Realized Demand Savings			
Total Program (MW)	14.076	13.724 to 14.428	13.802 to 14.350
per Square Foot (W/ft^2)	1.072	1.045 to 1.099	1.051 to 1.093
per Building (kW)	48.705	47.488 to 49.922	47.757 to 49.654

6

Estimation of Net Realized Impacts

6.1 Introduction

The net impacts of the program are the savings that can be attributed to the program. Estimating net impacts of new construction programs is a complex process. New construction programs are multi-dimensional, covering multiple end uses and a variety of DSM equipment options and measures. Choices may also be interdependent in the sense that the choices of some measures may affect the evaluation of others. This interdependence can be linked to budgetary or design issues; however, it can also stem from performance-based paths of code compliance which permit substitution of efficiency within and across end uses.

Program net impacts may differ from the gross impacts discussed above for several reasons:

- ***Free Ridership.*** Decision makers at participating sites might have installed measures *at a participating site* in the absence of the program. If so, they would be considered *free riders.*
- ***Participant Free Drivership.*** Decision makers may install non-incentivized measures at participating sites as a result of the program's influence. If so, they would be considered *participant free drivers.*
- ***Nonparticipant Free Drivership.*** Decision makers who install non-incentivized measures at nonparticipating sites as a result of the program's influence would be considered *nonparticipant free drivers.*
- ***Market Transformation.*** The existence of a program may cause long-term changes in the marketplace for DSM technologies. This may occur because of program-induced changes in awareness, changes in vendor stocking patterns, or reductions in technology costs. While this impact may be important for some programs (especially those dealing with new technologies), it is extremely difficult to quantify.

Evaluation literature reveals a wide range of approaches for estimating net program impacts. Two approaches were implemented for this evaluation:

- Simple comparisons of participant and nonparticipant efficiency levels, sometimes referred to as the "difference-of-differences" approach, and
- Statistical modeling of efficiency choices.

These approaches are summarized below.

6.2 Comparisons of Efficiency Levels

An alternative means of estimating free ridership is to focus more directly on the relative efficiency levels chosen by participants and nonparticipants. This approach is recognized in the CPUC M&E Protocols as an option under the "Differences-of-Differences Approach." In the context of a new construction program like this one, the net-to-gross ratio is defined as:

$$\text{Net-to-Gross Ratio} = \frac{\text{Participant Savings} - \text{Nonparticipant Savings}}{\text{Participant Savings}}$$

where participant and nonparticipant savings are defined in turn as differences between baseline (Title 20/24) consumption and as-built consumption. For the purposes of this section, realized savings per eligible square foot are used to estimate net-to-gross ratios. This follows standard practice in the DSM literature, although (as we will argue below) this may not be the best approach under some circumstances.

Realized savings per eligible square foot for participants are drawn from the last column of Table 5-2. Realized savings per foot for nonparticipants are derived from the engineering estimates in Table 4-1, coupled with the realization rates in Table 5-2. It should be recalled that the nonparticipant estimates are derived from both 1995 and 1996 nonparticipants. It should also be noted that these nonparticipants have been screened for participation in other SDG&E programs. That is, we screened out 17 nonparticipants who were incented through other programs in the year in question (1995 for the 1995 sample and 1996 for the 1996 sample) and for the eligible space in question.[1]

The difference-of-differences approach takes account of free ridership and participant free drivership, but assumes that nonparticipant free drivership is zero. Table 6-1 presents a comparison of end-use savings per square foot for participants and nonparticipants, and indicates the implied net-to-gross ratios. The analysis is conducted on an end use basis. Note the following:

[1] We could have screened out all participants in other programs in the course of sample design, but didn't want to exclude nonparticipants who participated in other programs in other spaces. A screen at the point of sample design would have eliminated many large customers who participated in areas unaffected by the current analysis.

- ***Lighting savings*** are high for both participants and nonparticipants, leading to an implied net-to-gross ratio of only 45%. This is a function of the density-based Title 24 standard and is not surprising in new construction. For instance, participant lighting efficiencies tend to beat code even when no lighting incentives are paid to them. Keep in mind that a participant is defined as a site that was incented for any end use. This approach is necessary because of the tradeoffs across end uses in code compliance. Also keep in mind that the efficiencies listed in Table 6-1 reflect all savings relative to code, not just savings for which incentives were paid.
- ***Space heating savings*** are positive for participants but negative for nonparticipants. The negative value is not because builders are installing substandard equipment, but rather because the installation of high-efficiency lighting increases heating requirements. Indeed, the negative heating savings simply represent the heating penalty on lighting efficiency. It should be kept in mind, of course, that the Title 24 base heating usage is very low relative to lighting, so these efficiencies are not directly comparable. Heating savings per eligible square foot are only 0.010, whereas lighting savings per square foot are 2.688. Thus, the heating penalty is small relative to the lighting savings.
- ***Cooling savings*** are also reasonably high for both participants and nonparticipants, implying a net-to-gross ratio of only 63%. Since these values were based on actual and Title 20 equipment efficiencies, this suggests that nonparticipants are installing somewhat more efficient equipment than required by code. Again, though, it should be remembered that participant efficiency comes from not only incentivized but also non-incentivized equipment. Hence there is, in a sense, a common element of naturally occurring efficiency in both participant and nonparticipant savings. Moreover, it should be recalled that a substantial share of cooling savings take the form of cooling bonuses from lighting savings.
- ***Ventilation savings*** is considerably higher for participants than for nonparticipants, indicating a net-to-gross ratio of almost 98%. This is traceable primarily to VAV systems and VSDs on VAV systems, measures that were relatively rare in nonparticipating buildings.
- ***Refrigeration savings*** is also higher in participating sites than in nonparticipating buildings. Program data suggest that SDG&E may have been particularly active in promoting refrigeration measures. The refrigeration net-to-gross estimate based on this simple comparison is virtually equal to 100%.
- ***Process savings*** is much higher for participants than for nonparticipants. This is largely attributable to a few large process measures installed through the program. The associated net-to-gross ratio is 99%.
- ***Combined savings*** for all end uses is more than three times as high for participants as for nonparticipants. This suggests an overall average net-to-gross ratio just over 71%.

Table 6-1: Realized End-Use Savings per Eligible Square Foot

End Use	Participant Savings	Nonparticipant Savings	Implied Net-to-Gross Ratio
Interior Lighting	2.688	1.474	0.452
Space Cooling	0.783	0.290	0.630
Space Heating	0.010	-0.013	2.386
Ventilation	0.484	0.012	0.976
Refrigeration	0.147	0.000	0.997
Process	2.039	0.021	0.990
Whole Building	**6.150**	**1.783**	**0.710**

6.3 Efficiency Decision Modeling

While basing net-to-gross ratios on comparisons of savings satisfies the CPUC M&E Protocols, such comparisons of participants and nonparticipants may be affected by two kinds of bias. First, they ignore differences in site features that could influence efficiency levels. Second, they may suffer from self-selection bias. As explained in this section, it may be possible to mitigate these problems with a modeling approach. A statistical model can be used to characterize efficiency choices in terms of various levels of program participation and other determinants. The model can be designed to estimate the net impacts of participation on end-use specific efficiency levels, then used to develop a set of net-to-gross ratios reflecting both free-ridership and participant free-drivership effects. This efficiency model discussed below.

Refining the Indicator of Savings

The first step of the efficiency model design is the choice of an indicator of efficiency. We could, of course, use the simple savings per square foot variable. However, as was discussed in section 4, participants and nonparticipants differ with respect to baseline intensities. This difference may bias the estimation of net-to-gross ratios using savings per square foot. As a result, another set of indicators of savings was defined to mitigate this problem: end use realized savings as a proportion of baseline usage. Each efficiency indicator (EFF_{be}) is an estimate of proportional realized savings relative to the adjusted reference (baseline) consumption for an end use e and building b:

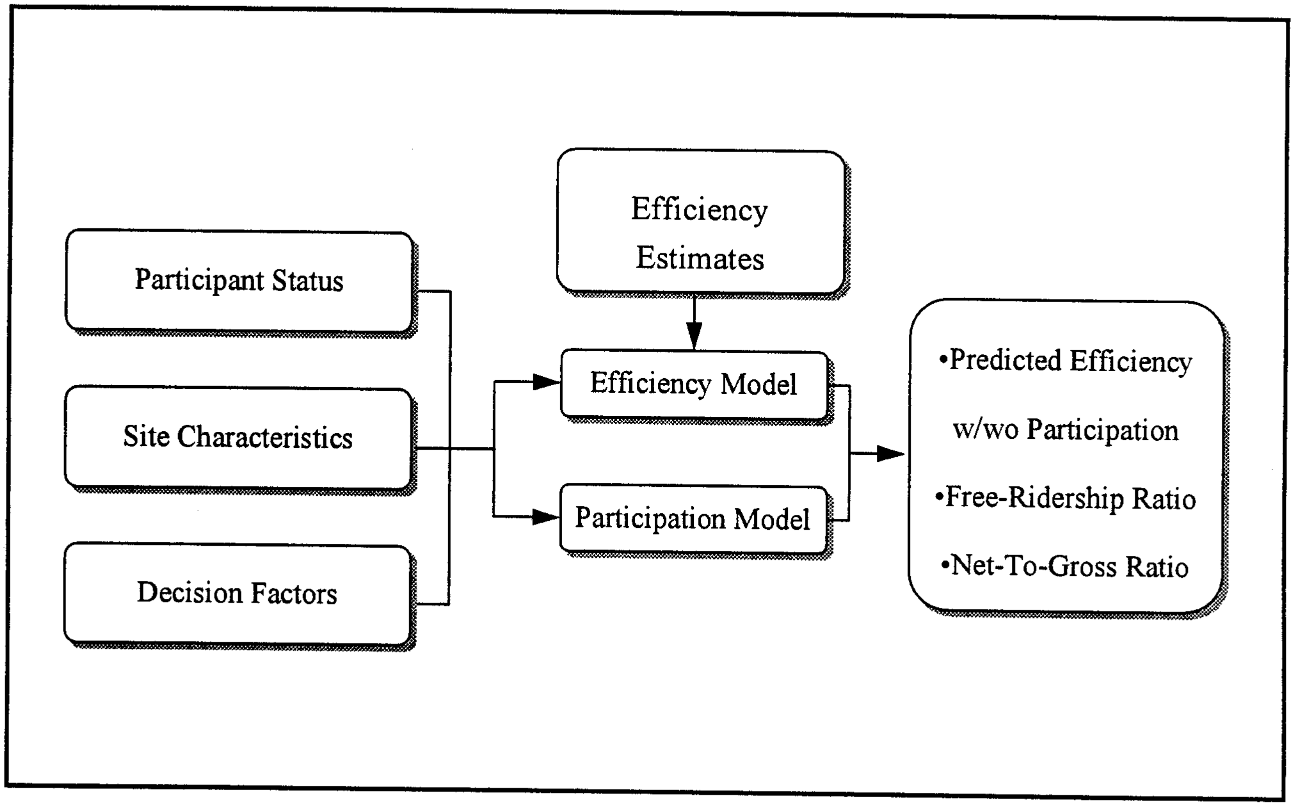
$$(1)\quad EFF_{be} = \hat{\alpha}_e(X_b)\hat{\beta}_e[EEBASE_{be} - EEACTUAL_{be}]/[\hat{\alpha}_e(X_b)EEBASE_{be}]$$

The numerator of this index represents realized savings, while the denominator reflects adjusted reference consumption.[2] In essence, the index for end use *e* and building *b* simply reflects the proportion by which the building's end-use load exceeds the applicable code. This means of quantifying savings acts to control for factors that affect both baseline usage and savings.

General Model Logic

The general logic of the efficiency model is illustrated in Figure 6-1. As shown, the model is designed to explain both participation decisions and efficiency decisions in terms of several drivers, including program participation, site characteristics, and decision factors. Once estimated, the model can be used to generate predictions of end-use efficiency levels for participants in the absence of the program. This prediction can be used to develop net-to-gross ratios and estimates of net program savings.

Figure 6-1: Efficiency Choice Model



[2] This is a general formulation for the efficiency index. Insofar as the SAE model chosen for this evaluation contains restrictions on the relative values of the coefficients on baseline usage and savings, the adjustment coefficients in this specification cancel out.

General Model Specification

For the purposes of modeling efficiency choices, efficiency is quantified in terms of the relative savings variable (savings as a proportion of baseline usage) discussed above. The efficiency model takes on the following algebraic form:

$$(2)\quad PART_b = f_e(EFF_{be}, DECISION_b, SITE_b, \varepsilon_b)$$

$$(3)\quad EFF_{be} = g_e(PART_b, SITE_b, DECISION_b, \mu_b)$$

where $PART_b$ is a binary indicator of participation in the program, EFF_{be} is a the efficiency index for building b and end use e, $DECISION_b$ is a set of decision variables, and $SITE_b$ is a set of site characteristics. Note that this specific modeling approach, like simple comparisons of participants and nonparticipants, ignores nonparticipant free drivership.

Estimation of the Efficiency Models

The participation equation and a set of efficiency equations can be estimated using data on efficiency levels, participation, site features, and decision-maker characteristics. In the context of this specification, it is recognized that efficiency decisions and participation decision are simultaneously determined. In statistical jargon, both efficiency levels and participation are endogenous. Because of the endogeneity of program participation and self selection of the participants and nonparticipants, the estimation technique must be designed to resolve self-selection bias. There are three options in this regard:

- ***Mills Ratio Approach.*** First, a self-selection correction term (an inverse Mills Ratio) could be included in the efficiency equation. This method is typically attributed to Heckman.[3] The simple application of the inverse Mills Ratio is a subject of some controversy in the evaluation literature. However, a recent paper by Goldberg and Train[4] suggests that the ratio should be entered twice in the energy change equation: once as a free-standing term and once interactively with the participation term. The logic of this specification is that the Mills Ratio affects the change in usage as well as the impact of the participation variable in the energy change equation. With this specification, the net impact of participation on the change in energy consumption is a function of the Mills Ratio.

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3 Heckman, J. (1976). "The Common Structure of Statistical Models of Truncation Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models," Annals of Economic and Social Measurement, 5/4, 1976.

4 Goldberg and Train (1995). "Net Savings Estimation: An Analysis of Regression and Discrete Choice Approaches," Report submitted by XENERGY, Inc. to CADMAC Subcommittee on Base Efficiency, August 1995.

- ***Train Approaches.*** Train[5] proposes two alternative means of mitigating this form of bias. The first approach is actually attributable to Hartman (1988), and involves an instrumental variables procedure where predicted participation is substituted for the participation variable in the efficiency equation. The second is an alternative (yet very similar) approach in which the adoption model is estimated simultaneously with a participation model using nonlinear least squares with instruments.
- ***Wang Approach.*** Third, the adoption model and the participation model could be estimated simultaneously using full information maximum likelihood estimation. This approach can be attributed to Wang.[6] While it is more efficient than the two-stage least squares or instrumental variables approaches, it is also far more difficult to implement.

The literature on self selection has not yet yielded a clear consensus on the appropriate means of dealing with this problem in program evaluation. While the other approaches are viable options, the net impact of program participation was estimated using the Goldberg and Train double Mills Ratio method.

Savings Through Design Efficiency Model

The specific model specified and estimated for this evaluation is designed to cover the following end uses: interior lighting, cooling, heating, ventilation, refrigeration and process. Together, these end uses comprise nearly all of the estimated realized savings from the program. The efficiency choice model is described below.

Participation Equation. First, the participation equation is given by:

$$(4)\quad PART_b = \frac{e^{\gamma X_{bi}}}{1 + e^{\gamma X_b}}$$

where:

$$(5)\quad \begin{aligned} \gamma X_b &= \gamma_0 + \gamma_1 OWNOCC_b + \gamma_2 LTOTSQFT_b + \gamma_3 FCOST_b + \gamma_4 ELIGSQFT_b \\ &+ \gamma_5 ADDPCTELIG_b + \gamma_6 EFFR_b + \gamma_7 PAYBACK_b + \gamma_8 OFF_b + \gamma_9 GRO_b \\ &+ \gamma_{10} WAR_b + \gamma_{11} EDU_b + \gamma_{12} PUB_b + \gamma_{13} SRV_b + \gamma_{14} MFG_b + \eta_b \end{aligned}$$

where the following definitions apply:

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5 Train, K (1994b)."Estimation of Net Savings from Energy Conservation Programs," *Energy*, vol.19, No., 1994.

6 Wang, B (1994). "Maximum Likelihood Estimation with Sample Selection", Ph.D. Dissertation, Washington State University.

$PART_b$	=	a binary variable indicating participation in the 1995 Savings Through Design Program
$OWNOCC_b$	=	a binary variable indicating that the building was built for owner-occupancy
$LTOTSQFT_b$	=	log of total new/renovated square footage supervised by decision maker in past 3 years
$FCOST_b$	=	the reported ranking of first cost as a determinant of construction design choices
$ELIGSQFT_b$	=	eligible square footage of the site in question
$ADDPCTELIG_b$	=	ratio of additional square feet to total eligible square feet at the site in question
$EFFR_b$	=	the ranking of energy efficiency as a determinant of construction design
$PAYBACK_b$	=	desired payback express by the decision maker when installing energy efficient equipment
η_b	=	a random error term

and where the remainder of the regressors are binary variables representing the following building categories: offices (OFF_b), grocery stores (GRO_b), warehouses (WAR_b), education (EDU_b), public assembly (PUB_b), services (SRV_b) and manufacturing (MFG_b).

Efficiency Equations. Efficiency equations were estimated for four groups of end uses:

- Interior lighting
- HVAC, which includes heating, ventilation and cooling
- Refrigeration
- Process and other.

The specific initial forms of these equations are presented below.

The lighting efficiency model is specified as follows:

(6)
$$\begin{aligned} EFFL_b = {} & \alpha_0 + \alpha_1 SQFTRATIO_b + \alpha_2 EET24LT_b + \alpha_3 OWNOCC_b + \alpha_4 FCOST_b \\ & + \alpha_5 ADDPCTELIG_b + \alpha_6 EFFR_b + \alpha_7 NOELIGSQ_b + \alpha_8 PART_b + \alpha_9 MR_b \\ & + \alpha_{10} MRPART_b + \mu_b \end{aligned}$$

where:

$EFFL_b$	=	the lighting efficiency ratio

$SQFTRATIO_b$	=	ratio of eligible square feet to surveyed square feet
$EET24LT_b$	=	baseline lighting usage
MR_b	=	mills ratio, calculated from the participation equation above, for site in question
μ_b	=	a random error term

HVAC were estimated as a single efficiency ratio for the purposes of the efficiency modeling. The associated efficiency model is given by:

$$\text{(7)}\quad \begin{aligned} EFFHVAC_b = {} & \sigma_0 + \sigma_1 SQFTRATIO_b + \sigma_2(EET24HT_b + EET24CL_b + EET24VT_b) \\ & + \sigma_3 OWNOCC_b + \sigma_4 FCOST_b + \sigma_5 EFFR_b + \sigma_6 NOELIGSQ_b + \alpha_7 PART_b \\ & + \alpha_8 MR_b + \alpha_9 MRPART_b + \varphi_b \end{aligned}$$

where:

$EFFHVAC_b$	=	an efficiency ratio for heating, air conditioning and ventilation
$EET24HT_b$	=	baseline heating usage
$EET24CL_b$	=	baseline cooling usage
$EET24VT_b$	=	baseline ventilation usage
φ_b	=	a random error term

The refrigeration efficiency model is represented as:

$$\text{(8)}\quad \begin{aligned} EFFR_b = {} & \omega_0 + \omega_1 EEBREF_b + \omega_2 OWNOCC_b + \omega_3 FCOST_b \\ & + \omega_4 ADDPCTELIG_b + \omega_5 EFFR_b + \omega_6 PART_b + \omega_7 MR_b + \omega_8 MRPART_b + \xi_b \end{aligned}$$

where:

$EFFR_b$	=	the refrigeration efficiency ratio
$EEBREF_b$	=	baseline refrigeration usage
ξ_b	=	a random error term.

Finally, the process/other efficiency model is represented as:

$$\text{(9)}\quad \begin{aligned} EFFP_b = {} & \psi_0 + \psi_1 SQFTRATIO_b + \psi_2 EEBPR_b + \psi_3 OWNOCC_b + \psi_4 FCOST_b \\ & + \psi_5 ADDPCTELIG_b + \psi_6 EFFR_b + \psi_9 PART_b + \psi_{10} MR_b + \psi_{11} MRPART_b + \zeta_b \end{aligned}$$

where:

$EFFP_b$ = the refrigeration/process efficiency ratio

$EEBPR_b$ = baseline process usage

ζ_b = a random error term.

Data Used in Estimation

Data on all participants and nonparticipants (other than the nonparticipants who participated in other SDG&E programs in the space and year in question) were used in the analysis. Most variables were developed from the on-site survey, but two (FCOST and EFFR) came from the decision-maker survey. Insofar as the decision maker survey was unavailable for some sites, values of the variables of these two variables were plugged using the means of responses for the individual building category and participation class.

Lighting Model. The estimated Savings Through Design interior lighting efficiency model is presented in Table 6-2. Two versions of the model are presented. Version 1 entails no correction for self-selection bias, while Version 2 involves the use of the Goldberg and Train double Mills Ratio technique. We will focus on Version 2.

Version 2 of the lighting model yields the following findings:

- The coefficient of the participation variable is positive and significant, which indicates that participation increases lighting efficiency. Note, however, that the impact of the program also feeds through the interactive Mills Ratio. Insofar as the Mills Ratio is negative for participants, the negative coefficient on this interactive term augments the estimate of net savings.
- Both Mills Ratios are significant, suggesting the presence of self-selection bias.
- Owner-occupancy has a significant positive effect on lighting efficiency.
- The ratio of eligible to total square feet has a significant impact on savings, which accounts for the fact that lighting lighting savings were estimated only for eligible spaces (spaces affected by new construction, remodeling or TIs).
- The ranking of energy efficiency as a design criterion has a significant negative effect on lighting efficiency. This is to be expected, since a low ranking (e.g., ranking of 1) indicates a high level of importance. Note that the ranking of first cost was deleted from the regression because of its collinearity with the efficiency ranking variable.

Table 6-2: Estimated Lighting Efficiency Model (t values in parentheses)

Explanatory Variable	Version 1	Version 2
Intercept	-0.055491 (1.395)	-0.055520 (1.403)
$PART_b$	0.075483 (4.190)	0.072270 (2.886)
MR_b	-	0.041098 (2.543)
$PART_b MR_b$	-	-0.070672 (3.319)
$SQFTRATIO_b$	0.291843 (9.421)	0.286448 (9.334)
EET24LTSQ	0.001066 (0.520)	0.000637 (0.308)
$OWNOCC_b$	0.050699 (2.925)	0.056489 (3.122)
$ADDPCTELIG_b$	0.000796 (0.042)	0.015285 (0.784)
$EFFR_b$	-0.010565 (1.138)	-0.019300 (2.015)
Adjusted R^2	0.2682	0.2852

HVAC Model. The estimated HVAC efficiency model is presented in Table 6-3. Again, two versions of the model are presented. Version 2 yields the following findings:

- The estimated coefficient on the participation variable is highly significant, indicating that the program had a significant effect on HVAC efficiency choices.
- Neither Mills Ratio term is significant.
- Owner-occupancy has a strong positive effect on HVAC efficiency.
- The ratio of eligible to total square feet has a significant positive influence on relative savings. Again, this is expected because HVAC savings were calculated only for eligible (affected) spaces. (When savings from central HVAC systems were assessed, of course, the entire space they serve was considered eligible.)
- The ranking of first cost as a factor in making energy efficiency decisions has a significant positive influence on HVAC savings. This is the expected sign, insofar as a low value of this variable (say, a rank of 1) indicates a high importance of first cost, and this would be expected to lead to low efficiency levels (all other things held equal). Note that the efficiency ranking variable was dropped from this equation because of collinearity with the first cost ranking and because the first cost variable performed the better of the two.

Table 6-3: Estimated HVAC Efficiency Model

Explanatory Variable	Version 1	Version 2
Intercept	-0.075034 (4.033)	-0.079843 (4.104)
$PART_b$	0.102180 (9.971)	0.110974 (7.688)
MR_b	-	0.008287 (0.905)
$PART_b\ MR_b$	-	-0.005455 (0.452)
$SQFTRATIO_b$	0.080481 (3.991)	0.080372 (3.975)
$EET24HVSQ_b$	0.000092 (0.536)	0.000118 (0.669)
$OWNOCC_b$	0.063815 (6.210)	0.062503 (5.819)
$FCOST_b$	0.019047 (2.925)	0.018391 (2.800)
Adjusted R^2	0.4121	0.4103

Refrigeration Model. The estimated refrigeration efficiency model is presented in Table 6-4. The model was estimated with only those sites with significant refrigeration loads. A significant load in this context was defined as a refrigeration intensity of at least 10 kW/ft^2. This screen was used because refrigeration savings were assessed only for remote refrigeration, which is typically associated with high intensities. As a check on this assumption, we inspected the full sample and found refrigeration savings in only one site with an intensity below this value. Version 2 suggests the following:

- Predicted participation has a significant impact on net efficiency. Again, note that the overall impact rests on both the coefficient of the participation term and the coefficient of the interaction term. .
- Owner-occupancy has a negative effect on efficiency. This result reflects the fact that grocery stores (which tend to exhibit the highest efficiency levels) are almost always leased.
- The ranking of energy efficiency (where low means more important) has a positive coefficient, but the coefficient is highly insignificant. The ranking of first cost was also insignificant, and was dropped from the equation to see if the significance of the efficiency ranking would improve.
- The size of baseline refrigeration usage has a positive but insignificant impact on efficiency.

- The percentage of square footage that was newly constructed has a positive and significant coefficient, suggesting that sites with high proportional savings tend to be newly constructed rather than remodels or TIs.

Table 6-4: Estimated Refrigeration Efficiency Model

Explanatory Variable	Version 1	Version 2
Intercept	-0.023963 (0.628)	-0.028801 (0.743)
$PART_b$	0.038257 (2.460)	0.058423 (2.447)
MR_b	-	0.007079 (0.641)
$PART_b\ MR_b$	-	0.002746 (0.159)
$EEBREFSQ_b$	0.000574 (0.975)	0.000611 (1.019)
$OWNOCC_b$	-0.075963 (4.315)	-0.077860 (4.353)
$ADDPCTELIG_b$	0.095919 (5.725)	0.087906 (4.185)
$EFFR_b$	0.002385 (0.218)	0.001109 (0.098)
Adjusted R^2	0.6034	0.5970

Process Efficiency Model

The process efficiency model covers all other end uses for which savings were found: process, motors, air compressors, and office equipment. Results suggest the following:

- Participation has a significant impact on process efficiency, with a net impact of 0.076 in proportional savings.
- Owner occupancy actually has a negative influence on process efficiency.
- The percentage of space that is new is strongly positively correlated with process savings.
- Proportional savings are positively associated with the base process usage.
- The proportion of eligible square feet has a positive influence on savings.

Table 6-5: Estimated Process Efficiency Model

Explanatory Variable	Version 1	Version 2
Intercept	0.003991 (0.142)	0.027204 (1.109)
$PART_b$	0.005479 (0.391)	0.076494 (5.107)
MR_b	-	-0.003997 (-0.348)
$PART_b MR_b$	-	0.069838 (5.564)
$SQFTRATIO_b$	0.084282 (3.426)	0.052906 (2.443)
$EEBPRSQ_b$	0.000141 (11.368)	0.000303 (16.722)
$OWNOCC_b$	-0.038124 (-2.994)	-0.096780 (-7.942)
$FCOST_b$	0.042461 (7.395)	0.023501 (3.673)
$ADDPCTELIG_b$	0.167408 (16.432)	0.097080 (8.960)
$EFFR_b$	-0.053127 (-9.205)	-0.034606 (-6.260)
Adjusted R^2	0.7579	0.8191

Use of the Model to Infer Net-to-Gross Ratios

Once the efficiency equation is estimated, it can be used to develop a set of estimates of net-to-gross ratios as:

$$(10)\ Net\text{-}to\text{-}Gross\ Ratio_{be} = (\partial EFF_{be} / \partial PART_b) / EFF_{be}$$

In the language of the CPUC M&E Protocols, the derivative of efficiency with respect to the participation variable is essentially a difference-of-differences calculation of net program impacts. That is, it represents the difference between participant and nonparticipant efficiency, *controlling for other factors in the equation.* Division of this estimated net impact by the gross efficiency level of participants thus yields a net-to-gross ratio consistent with the Protocols.

Net-to-gross ratios were developed for all participants and aggregated to the program level through the development of weighted averages of these ratios across sites. Note that the net impact on efficiency (the numerator of the net-to-gross ratio) is involves both the coefficient of the participation term as well as the coefficient of the interaction term. In the lighting model, for instance, this derivative is given by:

$$(12)\ \partial EFF_b / \partial PART_b = \hat{\alpha}_7 + \hat{\alpha}_8 MR_b$$

where $\hat{\alpha}_7$ is the estimated coefficient of the participation variable and $\hat{\alpha}_8$ is the estimated coefficient of the interaction term involving the Mills Ratio and the participation variable.

The results of this exercise are shown in Table 6-6. The findings are described below:

- As shown in Table 6-6, the net-to-gross ratios estimated for lighting is 0.455. This is virtually identical to the estimate based on the difference-of-differences approach.
- The net-to-gross ratio for HVAC is 0.651, which is somewhat lower than the weighted average of the three HVAC net-to-gross ratios shown in Table 6-3.
- The net-to-gross ratios derived for refrigeration is 0.805, which is considerably below the estimate based on difference-of-differences.
- The net-to-gross ratio for process end uses was actually estimated as equal to 1.00541. Since a net-to-gross ratio in excess of 1.0 is probably not reasonable, we have truncated this estimate to 1.0.
- Overall net-to-gross ratios are 0.685 for energy savings and 0.645 for demand savings. The reason these two ratios are different from each other is that energy and demand savings are distributed differently across end uses.

Table 6-6: Model-Based Estimated Net-to-Gross Ratios

End Use	Net Impact	Gross Impact	Net-to-Gross Ratio
Interior Lighting	0.12364	0.27184	0.45482
HVAC	0.11534	0.17720	0.65092
Refrigeration	0.05623	0.06982	0.80537
Process/Other	0.07429	0.07389	1.00000
Total Energy Savings			**0.68472**
Total Demand Savings			**0.64528**

Comparison of 1996 Estimates with 1995 Estimates

Table 6-8 compares the estimated net-to-gross ratios shown above with the estimates used in the evaluation of the 1995 program. As shown, the end-use specific ratios are very similar across the two evaluations. The 1996 lighting ratio is somewhat lower than the value estimated for the 1995 program. The composite HVAC ratio is also lower than the weighted average of the values used in last year's evaluation, if we use this year's weights. The refrigeration ratio is lower, and the process ratio is somewhat higher. The major difference between the two overall net-to-gross ratios can be traced to the composition of gross savings rather than differences in end-use specific ratios. That is, the heavy weight on process savings this year, coupled with the relatively lower importance of lighting savings, accounts for the higher overall net-to-gross ratio.

Table 6-7: Comparison of 1995 and 1996 Net-to-Gross Ratios

End Use	1995 Net-to-Gross	1996 Net-to-Gross
Interior Lighting	0.532	0.455
Cooling	0.584	0.651
Heating	0.956	0.651
Ventilation	0.880	0.651
Refrigeration	0.995	0.805
Process/Other	0.893	1.000
Total Energy Savings	**0.591**	**0.685**

6.4 Estimated Net Program Savings

Table 6-8 summarizes various estimates of savings yielded by the analysis. As shown, estimated net energy savings amount to 55.3 GWh, and the net demand impact is 9.08 MW.

Table 6-8: Estimated Net Realized Program Energy Savings

End Use	Gross Realized Savings	Net-to-Gross Ratio	Estimate of Net Realized Savings
Total Savings (GWh)			
Lighting	35.292	0.455	16.058
Cooling	10.277	0.651	6.690
Heating	0.126	0.651	0.082
Ventilation	6.361	0.651	4.141
Refrigeration	1.928	0.805	1.552
Process	26.774	1.000	26.774
Total Whole Building	**80.758**	**0.685**	**55.297**
Savings per Eligible Square Foot (kWh)			
Lighting	2.688	0.455	1.223
Cooling	0.783	0.651	0.510
Heating	0.010	0.651	0.006
Ventilation	0.484	0.651	0.315
Refrigeration	0.147	0.805	0.118
Other	2.039	1.000	2.039
Total Whole Building	**6.150**	**0.685**	**4.211**
Savings per Participant (kWh)			
Lighting	122,117	0.455	55,563
Cooling	35,561	0.651	23,150
Heating	437	0.651	284
Ventilation	22,010	0.651	14,328
Refrigeration	6,672	0.805	5,371
Other	92,642	1.000	92,642
Total Whole Building	**279,438**	**0.685**	**199,339**

Table 6-9: Estimated Net Program Demand Savings

End Use	Gross Realized Savings	Net-to-Gross Ratio	Estimate of Net Realized Savings
Total Savings (MW)			
Lighting	6.831	0.455	3.108
Cooling	2.820	0.651	1.836
Heating	0.000	0.651	0.000
Ventilation	0.689	0.651	0.449
Refrigeration	0.229	0.805	0.184
Other	3.506	1.000	3.506
Total Whole Building	**14.076**	**0.645**	**9.083**
Savings per Square Foot (kW)			
Lighting	0.520	0.455	0.237
Cooling	0.215	0.651	0.140
Heating	0.000	0.651	0.000
Ventilation	0.052	0.651	0.034
Refrigeration	0.017	0.805	0.014
Other	0.267	1.000	0.267
Total Whole Building	**1.072**	**0.645**	**0.692**
Savings per Participant (kW)			
Lighting	23.638	0.455	10.755
Cooling	9.759	0.651	6.353
Heating	0.000	0.651	0.000
Ventilation	2.385	0.651	1.552
Refrigeration	0.791	0.805	0.637
Other	12.132	1.000	12.132
Total Whole Building	**48.705**	**0.645**	**31.430**

The CPUC M&E Protocols require confidence intervals for both net and gross savings. Of course, building confidence intervals for net savings would require standard errors of net savings. Given the many calculations that enter into the estimation of net savings, however, true standard errors would be virtually impossible to obtain. Approximate net savings confidence intervals were derived as follows:

- *Relative* confidence intervals (intervals cast in terms of percentages of the point estimate) were developed for the estimates of net efficiency impacts flowing from the efficiency models presented in Section 6.3. They were developed by combining both participation terms, each weighted by its respective coefficient, then reestimating the equation to obtain a relative standard error on the overall impact of participation. This standard error was then multiplied times the relevant t value in order to obtain relative intervals for the estimates of net savings for each end use. These intervals are presented in Table 6-10.

- These relative confidence intervals were then weighted by estimated end use savings to obtain a whole-building relative interval.
- Finally, the relative interval was applied to the various measures of net savings. .

The results of this approach are presented in Table 6-11.

Table 6-10: Relative Confidence Intervals by End Use Group

End Use Group	90% Confidence Interval	80% Confidence Interval
Lighting	0.6347 to 1.3653	0.7153 to 1.2847
HVAC	0.7865 to 1.2135	0.8336 to 1.1664
Refrigeration	0.3372 to 1.6628	0.4835 to 1.5165
Process	0.8418 to 1.1582	0.8767 to 1.1233
Whole Building	**0.7565 to 1.2435**	**0.8103 to 1.1897**

Table 6-11: Confidence Intervals for Estimated Net Realized Savings

Measure of Savings	Point Estimate	90% Confidence Interval	80% Confidence Interval
Net Energy Savings			
Total Program (GWh)	55.297	41.835 to 68.759	44.806 to 65.788
per Eligible Square Foot	4.211	3.186 to 5.236	3.412 to 5.010
per Building (kWh)	191,339	144,757 to 237,921	155,036 to 227,642
Net Demand Savings			
Total Program (MW)	9.083	6.872 to 11.294	7.360 to 10.806
Watts per Square Foot	0.692	0.524 to 0.860	0.561 to 0.823
per Building (kW)	31.43	23.778 to 39.082	25.467 to 37.393

Appendix K

Table 6 for Program Year 1996

SAN DIEGO GAS & ELECTRIC
M&E PROTOCOLS TABLE 6 - RESULTS USED TO SUPPORT PY96 SECOND EARNINGS CLAIM FOR THE NONRESIDENTIAL NEW CONSTRUCTION PROGRAM
FIRST YEAR LOAD IMPACT EVALUATION, FEBRUARY 1998, STUDY ID NO. 1004

Designated Unit of Measurement: LOAD IMPACTS PER BUILDING
END-USE: WHOLE BUILDING

				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	14,076	9,083	13,724	14,428	6,872	11,294	13,802	14,350	7,360	10,806
	A. ii. Load Impacts - kWh	80,758,000	55,297,000	78,740,000	82,776,000	41,835,000	68,759,000	79,185,000	82,331,000	44,806,000	65,788,000
	B. i. Load Impacts/designated unit - kW	48.71	31.43	47.49	49.92	23.78	39.08	47.76	49.65	25.47	37.39
	B. ii. Load Impacts/designated unit - kWh	279,438	191,339	272,456	286,420	144,757	237,921	273,996	284,880	155,036	227,642
	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	1.3163	1.0234	1.2834	1.3493	0.7743	1.2725	1.2907	1.3420	0.8293	1.2175
	D.A. ii. Load Impacts - kWh, realization rate	1.1903	0.9939	1.1606	1.2201	0.7520	1.2359	1.1671	1.2135	0.8054	1.1825
	D.B. i. Load Impacts/designated unit - kW, real rate	1.2982	1.0093	1.2657	1.3305	0.7635	1.2550	1.2728	1.3234	0.8178	1.2007
	D.B. ii. Load Impacts/designated unit - kWh, real rate	1.1738	0.9802	1.1445	1.2032	0.7416	1.2188	1.1510	1.1967	0.7942	1.1662
3. Net-to-Gross Ratios		RATIO		RATIO	RATIO			RATIO	RATIO		
	A. i. Average Load Impacts - kW	0.645		0.488	0.802			0.523	0.768		
	A. ii. Average Load Impacts - kWh	0.685		0.518	0.851			0.555	0.815		
	B. i. Avg Load Impacts/designated unit of measurement - kW	0.645		0.488	0.802			0.523	0.768		
	B. ii. Avg Load Impacts/designated unit of measurement - kWh	0.685		0.518	0.851			0.555	0.815		
	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									

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Appendix L

Table 7 for Program Year 1996

Table 7: Data Quality and Processing Documentation for 1996 Nonresidential New Construction Program First Year Load Impact Evaluation
February 1998
Study ID No. 1004

7.A Overview Information
1. 1996 Nonresidential New Construction Program, Study ID number 1004.
2. The program year is 1996. The Nonresidential New Construction is designed to induce builders to increase energy efficiency in construction beyond the levels required by Titles 20 and 24. The program offers informational and training workshops for builders, and provides incentives for the installation of demand-side management (DSM) measures. See Section 1.2 for a detailed program description.
3. The program is targeted at a wide range of end uses, with most savings falling into the process, lighting and HVAC end uses. A variety of DSM measures are covered by the program, including high-efficiency lighting, high-efficiency cooling, VSDs for ventilation and pumping systems, and high efficiency motors.
4. A statistically adjusted engineering (SAE) approach was used to estimate gross savings in this evaluation. This model relies on engineering estimates developed under two scenarios for both participants and nonparticipants: the reference scenario (e.g., minimal compliance with building and appliance energy efficiency standards); and an as-built scenario (with all program and non-program measures in place). Engineering estimates were developed using RER's SitePro software system. SitePro utilizes DOE-2 to model HVAC loads and well-tested engineering algorithms for estimating non-HVAC loads. The development of engineering estimates is detailed in Section 4. The SAE model produces a set of adjustment coefficients (or adjustment functions) that translate SitePro 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 5 for a summary of the SAE model specification and parameter estimates.
5. In this analysis participants are defined as customers who participated in the 1996 Nonresidential New Construction Program. Nonparticipants are considered to be all sites undergoing new construction, major remodels or tenant improvements in 1996 that did not participate in the program.

Table 7 (continued): Data Quality and Processing Documentation for 1996 Nonresidential New Construction Program First Year Load Impact Evaluation February 1998 Study ID No. 1004

6. The final analysis database was a pooled database consisting of observations from the 1995 program evaluation as well as new observations from 1996 samples. A waiver request to use this pooled approach was approved by CADMAC on August 22, 1997. The total samples used in specific analyses are summarized below.

   Engineering Analysis: Engineering analysis was conducted for 250 sites (150 participants and 100 nonparticipants) from the 1996 sample. These results were then pooled with engineering analyses conducted for 411 sites (253 participants and 158 nonparticipants) in the evaluation of the 1995 program. Estimates were developed on an hourly basis, then aggregated to a monthly level.

   SAE Analysis: The SAE analysis made use of the pooled samples from 1995 and 1996. For The 1995 sample consisted of 204 participating and 145 nonparticipating sites with billing data matched to the surveyed site. The 1996 sample was comprised of 142 participants and 94 nonparticipants for whom billing data could be matched to the surveyed site. Thirteen monthly observations were used for each site, but one observation was lost in the course of the autocorrelation correction.

   Net-to-Gross Analysis: The net-to-gross analysis was conducted with data on 150 1996 participants and a total of 237 nonparticipants from both 1995 and 1996. The exclusion of 1995 participants is discussed in Section 6.

   Refer to Section 2 for a detailed summary of participant and nonparticipant analysis samples.

7.B Database Management

1. The evaluation of the Nonresidential New Construction Program required several types of data. The integrated database for the evaluation is comprised of five components: (1) on-site survey data for participating and nonparticipating sites, (2) DOE-2 building simulations, (3) hourly weather data by CEC weather zone, (4) daily weather data by SDG&E weather zone, (5) consumption records, and (6) telephone survey data of participating and nonparticipating builders and developers. Figure 7.1 illustrates the relationship among these data elements.
2. The RER project team collected the on-site survey data, conducted the DOE-2 simulations, and conducted the telephone survey of participating and nonparticipating builders and developers. Hourly weather data by CEC weather zone and the daily weather data were provided by SDG&E. Section 3 describes the collection of on-site data, weather data, billing data and decision-maker survey data. Section 4 describes the development of engineering estimates.

Table 7 (continued): Data Quality and Processing Documentation for 1996 Nonresidential New Construction Program First Year Load Impact Evaluation February 1998 Study ID No. 1004

3. The program database consisted of 290 sites, two of which were ultimately found to be the same, thus leaving 289 distinct sites. Of these, 150 sites were ultimately subjected to the on-site survey. However, billing data matching the surveyed sites were available for 142 of these sites, so only these sites were covered by the SAE analysis. The lack of appropriate billing data stemmed from the fact that some sites were covered by meters also covering significantly more area (e.g., campus settings with large master meters). While we attempted to screen out such sites in the course of pulling the initial sample, it was not possible to discern this situation in all cases. Decision-maker surveys were completed for132 of the participating sites (1996 only), and were available for the net-to-gross analysis.

   The nonparticipant frame for the on-site survey consisted of 870 sites for which building permits had been issued in 1995 or 1996. A total of 224 sites were contacted. Screening during the recruitment process revealed that 96 of the contacted sites were not qualified, in the sense that they had not done a major remodel, tenant improvement, or new construction at the site. This left only 128 qualified sites that were actually recruited. Of these, 100 agreed to the survey. All of these sites were covered by the engineering analysis. Billing data matching the surveyed sites were available for of these nonparticipating sites. Again, the unavailability of billing data traced to master metering. Decision-maker surveys were completed for 62 of the nonparticipant sites, thus allowing these sites to be included in the net-to-gross analysis.

4. Special emphasis was placed on the accurate identification of meters at the surveyed sites. Reconciliation of site areas and metered areas took place at five points during the project.
   - First, accounts were aggregated to customer locations in the sample-design phase.
   - Second, surveyors verified the account matching during the on-site visit. Changes in account numbers were recorded on the survey form.
   - Third, for the sites for which the surveyors had complete billing information, they computed energy intensities while at the site. Intensities that are out of the "reasonable" range were investigated with the customer contact. Potential problem sites, or ones for which intensities could not be computed, were flagged for follow-up by the RER analysis team.
   - Fourth, the billing information was reviewed by RER staff. Again, the intensities were reviewed and problems were flagged for follow-up with the SDG&E Project Manager.
   - Finally, when the simulations were performed, the results were compared with the billing data. If the simulation and billing data differed substantially, and there appeared to be no problems with the survey data, these cases were reviewed further.
5. Not applicable.

Table 7 (continued): Data Quality and Processing Documentation for 1996 Nonresidential New Construction Program First Year Load Impact Evaluation February 1998 Study ID No. 1004

7.C Sampling

1. A stratified sample design was used for the 1996 survey. Participants were stratified by ex ante energy savings and building category; nonparticipant targets were allocated across building categories in a way that matched the distribution of the combined 1995 and 1996 nonparticipant sample with the distribution of the combined 1995 and 1996 participant sample. The associated participant on-site survey response rate was 96%. The nonparticipant on-site survey response was 78%.
2. Appendix A of the report contains a copy of the on-site survey instrument. Appendix B of the report contains copies of the participant and nonparticipant decision-maker survey instruments. Response rates for these surveys are presented above in item 1. Given the high response rates, non-response bias was not considered a major problem.
3. Appendix C contains a sample inventory report for the on-site survey. Appendix D presents frequencies for the decision-maker surveys. Appendix E provides a SitePro User Guide. Appendix F provides a listing of the SitePro results. Appendix G presents descriptive statistics for the variables used in the SAE analysis. Appendix H presents descriptive statistics for the variables used in the net-to-gross analysis. Additional descriptive statistics for participants and nonparticipants are presented throughout the Report.

7.D Data Screening and Analysis

1. In this project, we did not attempt to screen out outliers per se, but large residuals were reviewed to identify data anomalies. In a few cases, consumption readings seemed to reflect partial occupancy of the site; these reading were omitted from the SAE analysis. No observations were omitted from the efficiency (net-to-gross) analysis. There were no missing data from the on-site survey. Missing data from the decision-maker survey were "plugged" with mean values associated with respondents in the same participation class and building category. Missing billing data caused some sites to be left out of the SAE analysis, as explained above under 7B.3. Weather adjustment variables were included in the SAE model. Setting these variables equal to 0 essentially weather-normalized the adjustment and the estimates of realized gross savings.
2. Not applicable.
3. See Section 7B.3.
4. Regression statistics for the SAE analysis are presented in Table 5-1 and the results of the estimated efficiency equations are presented in Tables 6-2 through 6-5.

Table 7(continued): Data Quality and Processing Documentation for 1996 Nonresidential New Construction Program First Year Load Impact Evaluation February 1998 Study ID No. 1004

5. The SAE analysis is presented in Section 5, with the rationale for the model specification detailed in Sections 5-2 and 5-3. The net-to-gross analysis is presented in Section 6. The rationale for the efficiency model specifications is presented in Section 6.4. Note the following:
   a. The SAE model contains engineering estimates developed at the individual site level. These estimates take into account the factors that affect end-use consumption levels. The efficiency models include a variety of both site characteristics and decision-making factors.
   b. The SAE model includes engineering estimates that reflect changes in consumption over time. In addition, it includes actual weather, which will also affect usage.
   c. Self-selection bias is addressed in the efficiency analysis. This problem is mitigated by the use of the Double Mills Ratio approach. See Section 6.3.
   d. No important factors were knowingly omitted from the analysis.
   e. The efficiency models presented in Section 6 are designed to estimate the net impacts of the program on efficiency levels.
6. This analysis did not address the issue of measurement error, except in the sense that the SAE analysis reconciled engineering estimates of usage to actual billed consumption.
7. Autocorrelation, which is the correlation of the error term over time for individual sites, was found to be present in the SAE analysis. This problem was mitigated with generalized least squares, a standard remedy. All SAE models presented in the study correct for the presence of autocorrelation.
8. Heteroskedasticity was also found to present in the SAE analysis. The error variance was found to be positively related to scale of the sites, as represented by square footage. Generalized least squares was used to mitigate the problem.
9. 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. Moreover, individual savings terms were aggregated in some specifications in order to mitigate collinearity across program variables

Table 7 (continued): Data Quality and Processing Documentation for 1996 Nonresidential New Construction Program First Year Load Impact Evaluation February 1998 Study ID No. 1004

10.	Influential data points were identified by plotting regressors against residuals. No observations were omitted from the SAE analysis, except as indicated above under 7D.1. No observations were omitted from the efficiency analysis on the basis of outlier analysis.
11.	In the SAE analysis, there were no missing data for regressors. For some sites, however, billing data associated with the specific surveyed area were unavailable. These cases were assigned missing consumption readings. They were thus not used to estimate SAE model coefficients. Due to the lack of decision-maker survey information for some sites, values of two variables used in the efficiency modeling were plugged on the basis of responses in the same participation class and building category. The results were not sensitive to this approach.
12.	Standard errors on estimated parameters are presented in results tables. Table 5-1 presents the t-statistics for each estimated parameter in the SAE analysis. Confidence intervals for gross savings were based on Version 1. The standard error for combined savings was developed by combing the savings terms into a single composite variable, then estimating its overall standard error. Confidence intervals for net savings are based on the standard errors developed in the same manner, as explained in Section 6. Insofar as net-to-gross ratios are estimated by end-use, relative confidence intervals were constructed for four end-use groups and then weighted to develop a single relative confidence interval for whole building net savings.
7.E	**Data Interpretation And Application**
1.	Net Program impacts are calculated from the results of the SAE analysis and the net-to-gross analysis (Option A).
2.	Sections 5 and 6 detail the rationale for the SAE model and the net-to gross analysis, respectively. More specifically, Section 5.2 summarizes the general rationale for the SAE model, and Section 5.3 discusses specific SAE model used in this study. Gross savings were defined as the estimated end-use adjustment factors times the corresponding engineering estimate of savings. This calculation was done for surveyed participants, then expanded to the total program using the appropriate case weights. Section 6.3 discusses efficiency modeling approach to obtain end use estimates of net-to-gross ratios. The overall net-to-gross ratio was defined as the ratio of total program net savings to total program gross savings.

Figure 7-1: Analysis Data Flow