Customer Energy Efficiency Program
Measurement and Evaluation Program

EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S PRE-1998 COMMERCIAL ENERGY EFFICIENCY INCENTIVES PROGRAM CARRY-OVER: LIGHTING TECHNOLOGIES

PG&E Study ID number: 404A

March 1, 2000

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PG&E Study ID number: 404A

Purpose of Study

This study was conducted in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholders Earnings from Demand-Side Management Programs" (Protocols), as adopted by California Public Utilities Commission Decision 93-05-063, revised March 1998, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079 and 98-03-063.

This study evaluated the gross and net energy savings from lighting energy efficiency technologies for which rebates were paid in 1998 by Pacific Gas & Electric Company's Commercial Energy Efficiency Incentive (CEEI) Program. These retrofits were performed under CEEI programs offered from 1994 through 1997. Although several programs were offered, the retrofits rebated in 1998 were performed under a single PG&E program, the Retrofit Express (RE) Program.

Methodology

For this evaluation, there were two types of primary data collected: telephone survey data and on-site data. An integrated sample design was implemented for the lighting and HVAC end uses, due to the number of participant crossover among these end uses. There were a total of 428 unique Indoor Lighting sites (including HVAC/Lighting participants) that received a rebate in 1998. A complete census of the population was needed to meet the goals of the telephone survey. A non-participant sample was developed based upon the business type and usage strata distribution that resulted from the participant sample allocation. The lighting end-use included 190 lighting participant and 589 nonparticipant telephone surveys, and 158 on-site audits.

An integrated evaluation approach employed engineering, billing regression and net-to-gross (NTG) analyses. Engineering and statistically adjusted engineering (SAE) estimates were used to develop per participant gross energy, demand, and therm impacts for specified time-of-use costing periods. The engineering analysis combined information from telephone surveys with detailed on-site audit data to develop unadjusted engineering impacts. A billing regression analysis was employed to model the differences in customers' energy usage between pre- and post-installation periods. The model was specified using actual customer billing data and independent variables that explain changes in customers' energy usage including engineering estimates of unadjusted savings.

Three separate models were implemented to estimate the components of the NTG ratio (free-ridership and spillover): a model based on self-reports, a net billing analysis model applying a double inverse Mills ratio (estimating free-ridership only), and a two-stage discrete choice model. The final NTG ratios applied to the ex post gross impacts were derived solely from the results of the discrete choice model. The discrete choice model results are the most conservative, and the model is the most sophisticated and preferred of the three methods. Furthermore, the overall net-to-gross ratio is reasonably well validated by the self report results.

Study Results

The results of the analyses for the lighting technologies are summarized below:

	Gross Savings	Gross Realization Rate	Net-To-Gross 1-FR	Spillover	NTG Ratio	Net Savings	Net Realization Rate
			EX ANTE				
kW	3,055	-	0.850	0.100	0.950	2,902	-
kWh	15,153,761	-	0.850	0.100	0.950	14,396,074	-
Therms	-	-	-	-		-	-
			EX POST				
kW	2,705	0.885	0.747	0.315	1.062	2,873	0.990
kWh	10,572,456	0.698	0.748	0.310	1.058	11,183,773	0.777
Therms	-4,143	-	0.743	0.363	1.106	-4,584	-

Regulatory Waivers and Filing Variances

A regulatory waiver was filed requesting that PG&E be allowed to forego the collection of additional lighting loggered data for the Pre-1998 CEEI Program Carry-Over evaluation, and instead use a mean value of previous (1994 and 1995) evaluation results. This waiver was approved by CADMAC on May 20, 1999.

The CADMAC also approved a waiver on May 20, 1999, that allows the use of self - report based algorithms to estimate free ridership and spillover effects in the event discrete choice and LIRM models fail to produce statistically reliable results.

There were no E-Table variances.

QUANTUM CONSULTING

EVALUATION OF PG&E'S PRE-1998 COMMERCIAL EEI PROGRAM CARRY-OVER LIGHTING TECHNOLOGIES

PG&E Study ID#: 404A

FINAL REPORT

March 1, 2000

Submitted to

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1. EXECUTIVE SUMMARY

This section presents a summary of the impact results for the commercial indoor lighting technologies offered under Pacific Gas & Electric Company's (PG&E's) Pre-1998 Commercial Energy Efficiency Incentive (CEEI) Program Carry-Over, referred to in this report as the Lighting Program. This evaluation covers indoor lighting technology retrofits that were rebated during 1998 under CEEI programs offered from 1994 through 1997. These retrofits were performed under a single PG&E program, the Retrofit Express (RE) Program. The results are presented in two sections: Evaluation Results Summary (covering the numerical results of the study) and Major Findings.

1.1 EVALUATION RESULTS SUMMARY

The evaluation results are summarized in terms of energy savings (kWh), demand savings (kW), therms impacts, and realization rates. Realization rates are defined as the ratio of the evaluation results (ex post) to the program design estimates (ex ante). All of these results are presented on a gross and net basis (i.e., before and after accounting for customer actions outside the program). Exhibit 1-1 presents the gross energy, demand and therm savings results (ex post and ex ante), together with each applicable gross realization rate. The net-to-gross ratio is comprised of free ridership, and participant and nonparticipant spillover effects.

Exhibit 1-1
Summary of Gross Evaluation and Program Design Results for Commercial Indoor Lighting Applications

	Gross Savings	Gross Realization Rate	Net-To-Gross 1-FR	Spillover	NTG Ratio	Net Savings	Net Realization Rate
			EX ANTE				
kW	3,055	-	0.850	0.100	0.950	2,902	-
kWh	15,153,761	-	0.850	0.100	0.950	14,396,074	-
Therms	-	-	-	-		-	-
			EX POST				
kW	2,705	0.885	0.747	0.315	1.062	2,873	0.990
kWh	10,572,456	0.698	0.748	0.310	1.058	11,183,773	0.777
Therms	-4,143	-	0.743	0.363	1.106	-4,584	-

The ex ante numbers presented above in Exhibit 1-1 were obtained from PG&E's Marketing Decision Support System (MDSS), PG&E's program participant database. The values presented are identical to those filed in Table E-3 of the Technical Appendix of the Annual Summary Report on Demand Side Management Programs.

These ex post results illustrate the following key points about the gross and net commercial lighting impacts:

Gross Energy Impacts - The ex post gross energy impacts were 31 percent smaller than the ex ante gross estimates. The unadjusted engineering estimates of gross energy impact, however, were only 9 percent smaller.

Gross Demand Impacts - The ex post gross impacts for demand were only 11 percent smaller than the ex ante gross estimates. The difference is primarily the result of the ex post components of each applicable summer on-peak operating factor—the lighting system operating schedule and the open-period operating factors (as determined by field inspections). In addition, ex post HVAC savings were also applied (cooling savings result from the replacement of existing lighting systems with more efficient lights).

Gross Therm Impacts - The heating penalty attributed to the installation of lower-wattage lighting by customers with gas heat was not included in the ex ante impact estimates, and therefore the ex-post impacts could not be compared using a realization rate.

Net Impacts - The net ex post impacts were 22 percent less than ex ante for energy and 1 percent less for demand. The net realization rate for energy and demand impacts are higher than the gross realization rates because of the higher ex post net-to-gross (NTG) ratios relative to ex ante. The ex ante NTG ratio was 0.95, while the ex post NTG ratio was 1.06 for both energy and demand. Therefore, the ex post NTG ratios contribute an additional 11 percent increase relative to ex ante for energy and demand impacts.

1.2 MAJOR FINDINGS

Relative to the 1997 program year evaluation, the gross realization rate for energy has decreased by 16 percent (the gross energy realization rate was 86% for the 1997 evaluation). This difference is attributable to the SAE analysis results, which detected approximately 16 percent less savings overall than the 1997 SAE results. The algorithms for estimating the engineering estimates for the 1998 evaluation are nearly identical to those used in the 1997 evaluation. The resulting program-level SAE coefficient, however, dropped from 92% in 1997 to 76% for this evaluation. This explains the difference between the 1997 and 1998 gross energy realization rates.

Overall, the gross demand estimates are only 11 percent lower than the ex ante values. Relative to the 1997 program year evaluation, the gross realization rate for demand has decreased by 4 percent (the gross demand realization rate was 93% for the 1997 evaluation). This difference is likely due to different distributions of measures and business types.

Relative to the 1997 program year evaluation, the net realization rate for energy has decreased by 7 percent, while the net realization rate for demand impacts has increased by 10 percent (the net energy and demand realization rates were 85 and 88 percent for the 1997 evaluation, respectively.) As we have already discussed above, the gross realization rates have decreased by 16 percent and 4 percent, for energy and demand, respectively.

The differences are explained by a number of factors. First, the ex ante net-to-gross adjustment rose from 1997 to 1998 from 86 to 95 percent, placing downward pressure on net realization rates, all other factors held constant. Second, the SAE coefficient fell from 92 to 76 percent, placing significant downward pressure on the net realization rates for energy impacts. At the same time, the ex post net to gross adjustment rose from 82 to 106 percent from 1997 to 1998, placing upward pressure on net realization rates. These forces together result in a moderately lower net realization rate for energy impacts, and a moderately higher net realization rate for demand impacts. Overall, the net realization rate results for 1998 are similar to the 1997 results.

2. INTRODUCTION

This report summarizes the impact evaluation of Pacific Gas & Electric Company's (PG&E's) Pre-1998 Commercial Energy Efficiency Incentive (CEEI) Program Carry-Over for commercial sector lighting technologies (the Lighting Evaluation). These technologies are covered by three separate program options, the Retrofit Express (RE) Program, the Customized Efficiency Options (CEO) Program and the Advanced Performance Optionst (APO) Program.

The evaluation effort includes customers who were paid rebates in 1998, but participated under the 1994-1997 CEEI programs. The RE program, which contributed 100 percent towards the total program impacts, is summarized below.

2.1 THE RETROFIT EXPRESS PROGRAM

The RE program offered fixed rebates to customers who installed specific electric energy-efficient equipment. The program covered the most common energy saving measures and spans lighting, air conditioning, refrigeration, motors, and food service. Customers were required to submit proof of purchase with these applications in order to receive rebates. The program was marketed to small- and medium-sized commercial, industrial, and agricultural customers. The maximum rebate amount, including all measure types, was $300,000 per account. No minimum amount was required to qualify for a rebate.

Lighting end-use rebates were offered in the program for the following technologies:

Technology	Action
Halogen lamps	Replace existing lamps
Compact fluorescent lamps	Replace incandescent lamps
T-12 and T-8 fluorescent lamps	Replace incandescent lamps
Compact fluorescent lamps and LEDs	Replace incandescent lamps in exit signs
Electronic ballasts	Replace magnetic ballasts
T-8 and T-10 lamps and electronic ballasts	Replace T-12 lamps and electromagnetic ballasts in various lengths and configurations
High-intensity discharge (HID) fixtures	Replace incandescent or mercury vapor fixtures
Occupancy sensors, bypass or delay timers, photocells, and time clock controls	Reduce overall lighting consumption
Removal of lamps and ballasts	Reduce output in overlit areas

2.2 *EVALUATION OVERVIEW*

The impact evaluation described in this report covers all lighting measures installed at commercial accounts, as determined by the Marketing Decision Support System (MDSS) sector code, that were included under the RE program and for which rebates were *paid* during calendar year 1998.

The impact evaluation results in both gross and net impacts, and compares these estimates to the program ex ante estimates.

2.2.1 Objectives

The research objectives are as follows:

- Determine first-year gross energy, demand, and therm impacts by business type and technology group for RE lighting technologies paid in 1998, as required by the California Public Utilities Commission (CPUC) Protocols.
- Determine first-year net energy, demand, and therm impacts by business type and technology group for RE lighting technologies paid in 1998, as required by the CPUC protocols.
- Compare evaluation results (ex post) with PG&E's (ex ante) estimates, and investigate and explain any discrepancies between the two.
- Assess free-ridership and spillover rates, and investigate and explain differences between evaluation and program design estimates.
- Create an impact sample subset of participants for future retention monitoring as required by the CPUC Protocols.
- Complete tables 6 and 7 of the Protocols.

Results are segmented by technology and building type. Technologies are defined by measures offered by the RE program. Building types for the commercial market sector, as defined by PG&E, are:

Office	Grocery	Warehouse
Retail	Restaurant	Personal Service
College and University	Health Care	Community Service
Schools	Hotel/Motel	Miscellaneous

While gross impacts account for program participant actions (and the fuel use benefits and secondary costs associated with those retrofit decisions), net impacts account for customer participation choices and the effect that the Lighting Program's infrastructure has had on the lighting retrofit market. For example, adjustments were made to the gross savings estimates to account for customers that would have installed energy-efficient measures in the absence of the program (**free-riders**). The adjustment also included participant and nonparticipant **spillover** rates, defined as energy-efficient measures installed outside the program and as a result of the presence of the program.

The evaluation investigated and, where possible, explained differences between program design estimates and evaluation results.

2.2.2 Timing

The 1998 Lighting Evaluation began in May 1999, completed the planning stage in May 1999, executed data collection between May and October 1999, and completed the analysis and reporting phase in February 2000.

2.2.3 Role of Protocols

This evaluation was conducted under the rules specified in the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols).[1] The Protocols control most aspects of the evaluation. They specify the minimum sample sizes, the required precision, data collection techniques, certain minimum analysis approaches, and formats for documenting and reporting results to the CPUC. This evaluation has endeavored to meet all Protocol requirements.

2.3 EVALUATION APPROACH – AN OVERVIEW

This overview of the integrated evaluation approach begins by presenting the data sources used for the Lighting Evaluation. An overview of how the engineering and statistically adjusted engineering (SAE) estimates are used together to derive gross energy, demand and therm impacts follows. The final section discusses how the net-to-gross estimates are used to derive net program impacts.

2.3.1 Data Sources

The Lighting Evaluation used data supplied by PG&E to develop a sample design plan. This plan was used to specify sample points from which additional evaluation data were collected.

Existing Data

All available data supplied by PG&E were used in the analysis of the Lighting program. Of particular importance were PG&E's historical billing data, program participant data (Marketing Decision Support System [MDSS]), and other program-related data. Each of the existing data sources is described briefly below.

Program Participant Tracking System - The participant tracking system data, maintained in the PG&E MDSS, contains program, project, and technical information about measure installation.

[1] California Public Utilities Commission Decision 93-05-063, Revised March 1998, Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, and 98-03-063.

It also provides expected impact estimates based upon the ex ante engineering algorithms. This information was used to create sample designs for data collection and to leverage calibrated impact estimates from the telephone sample to the entire participant population.

Program Marketing Data - PG&E program marketing data contain detailed descriptions of program marketing and application procedures, together with details on the measures offered. This data source also provides a general description of measures accepted by the program.

PG&E Billing Data - The PG&E nonresidential billing database contains monthly energy-consumption information for all commercial customers in PG&E's service territory. It also contains demographic data for all customers and the on-peak and off-peak monthly energy usage for customers who receive services on demand or time-of-use (TOU) rates. This information is used to calibrate the engineering estimates to actual pre- and post-installation energy usage.

PG&E 1997 Customer Energy Efficiency Programs Advice Filing[2] - This report documents the ex ante earnings claims, including specific information on the derivation of per-unit ex ante savings estimates and the assumptions that go into those estimates. This documentation often includes assumptions such as operating hours and operating factors, by fixture type. This document supplies the best information available on ex ante estimates and assumptions, thus facilitating knowledge-based comparisons to ex post estimates. The 1997 version was used rather than the 1998 version because the evaluation is for carry-over participants.

Industry Standards/Information - In order to establish baseline levels and new equipment performance levels, industry standards information from organizations such as the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) and American National Standards Institute (ANSI) was used, together with information from manufacturers.

1994-1995 Commercial Lighting Results. Annual hours of operation, on-peak coincident diversity factors, interactive HVAC energy adjustments, burn out rates for lamps, and time-of-use data from the 1994 and 1995 Commercial Lighting Evaluations were applied to the participant population during the course of the engineering analysis. The use of the 1994 and 1995 evaluation results was approved through a retroactive waiver filed with the CPUC (see *Attachment 1*) requesting that this year's Lighting Evaluation forego the collection of additional lighting loggered data; and rather, use a mean value of previous evaluation results.

Primary Data Collected

Based on an assessment of existing data, program evaluation requirements were established for additional data to be collected. The two primary areas of data collection were On-Site Audits and Telephone Survey data. A brief description of each follows:

On-Site Audits. A total of 158 customer sites were visited by a QC engineer to gather site-specific data, primarily to be used in support of creating the retention panels for subsequent evaluations.

[2] PG&E 1997 Customer Energy Efficiency Programs Advice Letter No. 1978-G/1608-E, filed October 1996.

Net Impact = (Operating Impact) * (Operating Factor) * (SAE Coefficient) * (Net-to-Gross)

Where,

Operating impact is defined as the load impact coincident with a specific hour, given that the equipment is operating. The engineering analysis will simulate equipment performance independent of premise size and customer behavioral factors to obtain operating impacts.

Operating factor is defined as the fraction of premises with equipment operating during the analysis period. This term reflects the equipment's operating schedule, and will be estimated at a high level of precision using the 1994 and 1995 logger data in conjunction with on-site audit and telephone survey results.

The Statistically Adjusted Engineering (SAE) Coefficient will be estimated for those cases in which an engineering model estimate is not used as the final result. This term is defined as the percentage of savings estimate that is detected, or realized, in the statistical analysis of actual changes in energy usage. The SAE coefficient is applied to an impact estimate based upon the program baseline, equipment purchased under the program, and typical weather.

The Net-to-Gross (NTG) Ratio adjusts the program baseline derived from estimates of free ridership and spillover associated with the program.

Engineering Analysis

Gross energy estimates were developed using two distinct analysis steps. First, engineering estimates were developed for each participant. Second, these estimates were adjusted using billing data-derived SAE coefficients.

Gross unadjusted engineering impacts were developed for each retrofit measure. First, hourly direct impacts were developed using the net change in fixture connected load in conjunction with operating schedules and fixture operating factors. Then, hourly impacts were estimated for the HVAC interaction contribution, resulting from reduced heat gain due to the replacement of standard-efficiency fixtures with high-efficiency fixtures. Lastly, gross engineering energy impacts were derived by aggregating hourly impacts for specified time-of-use (TOU) costing periods. The engineering methods used are described in greater detail in *Section* 3.2.

Gross demand estimates are based solely upon unadjusted hourly engineering estimates. Engineering demand estimates were developed using the same hourly impacts developed for the gross engineering energy estimates. However, instead of aggregating the hourly impacts, demand impacts were determined by averaging all impacts for a selected hour in a particular TOU costing period.

Like gross demand estimates, therm estimates are not adjusted using SAE coefficients. For each TOU costing period, therm estimates were aggregated using methods similar to energy estimates.

Billing Analysis

Statistical analysis was then used to determine the fraction of the unadjusted engineering estimates actually observed or "realized" in customer billing data. The per-unit engineering energy impacts, combined with the units installed, form the input to the billing regression analysis, or SAE analysis. In the SAE analysis, the engineering estimates are compared to billing data using regression analyses, in order to adjust for behavioral factors of occupants and other unaccounted for effects. The outputs of the analysis are SAE-adjusted estimates of gross and net program energy savings.

Net-to-Gross Analysis

The NTG analysis is designed to adjust gross program impacts for free ridership and actions taken by PG&E customers outside the Lighting Program. Self-reported data were initially used to estimate the percentage of free-riders in the program; that is, the number of participants who would have undertaken the energy efficiency action promoted by the program in the absence of the program. In addition, self-reported data are used to calculate the percent of participant and nonparticipant spillover attributable to the program. The California DSM Measurement Advisory Committee (CADMAC) has approved a waiver allowing that self-report based algorithms be used for the net-to-gross analysis in the event the discrete choice and LIRM methods do not produce statistically reliable results. This waiver is presented in Attachment 1.

A more sophisticated estimate of NTG was developed through the application of discrete choice analysis. The discrete choice model estimates the probability that a customer will purchase a particular energy efficient lighting measure, both with and without the incentive program in place. The results of the discrete choice model are estimates of free-ridership and spillover, independent of those found through the self-report method.

Application of the final NTG adjustments, by technology, yields net program impacts. *Section 3, Methodology* describes in explicit detail, each step taken to achieve the final net results, beginning with the sample design, followed by the engineering and SAE analyses, and ending with the Net-to-Gross findings.

2.4 REPORT LAYOUT

This report presents the results of the Lighting Evaluation. It is divided into four sections, plus attachments and appendices. *Sections 1 and 2* are the *Executive Summary* and the *Introduction*. *Section 3* presents the *Methodology* of the evaluation. *Section 4* presents the detailed results and a discussion of important findings. *Attachment 1* is two waivers filed with the CPUC. The first waiver requests that this year's Lighting Evaluation forego the collection of additional lighting loggered data; and rather, use a mean value of previous evaluation results. The second waiver requests that self-report based algorithms be used for the net-to-gross analysis in the event the discrete choice and LIRM methods do not produce statistically reliable results. *Attachment 2* includes key results summary tables. Specifically, it includes the results tables for the gross ex ante, net ex ante, and unadjusted engineering impacts, as well as the SAE coefficients, gross ex post, NTG adjustments, net ex post, and gross and net realization rates. *Attachment 2* also contains gross demand and energy savings by costing period for commercial indoor lighting measures. *Attachment 3* contains Protocol Tables 6 and 7 for the lighting end use. The *Survey Appendices* provide the survey and on-site data collection instruments, and the survey call dispositions, frequencies, and refusal comments.

3. METHODOLOGY

This section provides the specifics surrounding the methods used to conduct the 1998 Pacific Gas & Electric Company (PG&E) Commercial Energy Efficiency Incentive (CEEI) Program Carry-Over Evaluation for lighting technologies (the Lighting Evaluation). This section begins with a detailed discussion on the sampling plan for the Lighting Evaluation. From there, details regarding the Engineering Analysis (*Section* 3.2), the Billing Analysis (*Section* 3.3), and the Net-to-Gross Analysis (*Section 3.4)* are discussed.

3.1 SAMPLE DESIGN

This section presents the sample design for the Lighting Evaluation. Due to the limited number of available sample, a census of the population was used for the telephone survey. First, the overall sample design approach is discussed, followed by the resulting sample allocation. The section concludes with a discussion of the California Public Utilities Commission (CPUC) Evaluation and Measurement Protocols (the Protocols) requirements.

3.1.1 Existing Data Sources

The participant tracking system contains the Retrofit Express (RE) Program which is maintained as part of PG&E's Marketing Decision Support System (MDSS). Henceforth, the RE program components are referred to as simply Retrofit. The MDSS contains program application, rebate, and technical information regarding installed measures, including measure description, quantities, rebate amount, and ex ante demand, energy, and therm savings estimates. The MDSS extract used in this evaluation is consistent with data used in the PG&E Annual Earning Assessment Proceedings (AEAP) Report.

For the Retrofit program, participation was tracked at both an application and measure level. They are linked by application code and program year. Each application can cover multiple measures and accounts, and each measure is linked to a PG&E electrical or gas service location where the measures are supposed to be installed. The account location is designated by its account number, or a unique seven-digit identification number (PG&E's control number). Unlike customer accounts, control numbers are used to identify service locations and serve as stable identifiers for linking datasets.

The billing series requested in support of the Lighting Evaluation cover a period from January 1993 to September 1999. PG&E's billing data contain monthly energy-consumption as well as other customer information, such as customer name, service location, rate schedule, and Standard Industrial Classification (SIC) code.

3.1.2 Sample Design Overview

Program participants who were paid a rebate in 1998 were in most part carry-over applicants. Their lighting projects were initiated prior to 1997 but they only applied or received a rebate in 1998 when their lighting projects reached the final implementation stage. There were a total of 428 lighting sites that participated in the Retrofit Program and received a rebate from PG&E in

1998. However, the number of available sites eligible for telephone surveying was fewer due to the exclusion of sites with invalid contact information and multi-sites (multiple sites in different location that reference the same contact person). A complete census of the population was needed to meet the goals of the telephone survey.

The objectives of the sample design were to:

- Determine the optimal sample allocation for first-year gross impact analysis, based upon sample size and evaluation accuracy requirements of the Protocols and available project resources.
- Maximize available sample points to meet net-to-gross (NTG) objectives.
- Reallocate available resources, wherever feasible, to focus on measures and/or program features deemed most important by PG&E staff, while not compromising the overall accuracy of the evaluation.

3.1.3 Sample Segmentation

Evaluation of the Commercial Lighting Program at the participant segment level allows more precise, and insightful, analyses than those undertaken at the aggregate PG&E system level. The sample segmentation consists of two primary components: participant segmentation and technology segmentation. As will become apparent, a key feature of the sample design is that the sampling unit is a unique customer site. Significant effort was undertaken to aggregate billing and participation records to this level.

The first step in the participant segmentation process grouped firms by business type, as recorded in the MDSS. There are a total of 12 business types used to segment a customer. A total of eight technology groups were defined (see definition following Exhibit 3-1) to classify measures. Exhibit 3-1 presents the distribution of unique customer sites across the business type and technology group segmentation.

Annual energy consumption values were used to group customers into four usage/size strata based upon a Dalenius-Hodges[1] stratification procedure. The comparison group customers are then selected to mirror the underlying distribution of the participant target population by size and business type.

3.1.4 Technology Segmentation

Program measures are classified into technology groups through combining measures with similar energy reduction characteristics. This grouping strengthens the analysis by creating homogenous analysis segments in terms of electricity use. The three elements of the technology segmentation are as follows:

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[1] Cochran, W.G *Sampling Techniques*, Third Edition, John Wiley & Sons, 1997. pp. 127-134.

Exhibit 3-1
1998 Commercial Lighting Segmentation and Distribution of Unique Sites

Technology \ Business Type		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Indoor Lighting End Use Unique Sites		131	77	6	55	11	19	18	14	9	9	56	23	428
Indoor Lighting	Halogen	5	1	0	1	0	1	1	0	0	0	6	0	15
	Compact Fluorescent Lamps	47	17	5	25	3	10	12	11	2	1	20	1	154
	Exit Signs	32	26	3	23	0	3	5	1	2	0	5	1	101
	Efficient Ballast Changeouts	15	0	0	2	0	0	0	0	0	0	15	2	34
	T-8 Lamps and Electronic Ballasts	118	65	4	42	11	14	16	5	8	6	33	19	341
	Delamp Fluorescent Fixtures	46	14	2	22	2	0	3	0	3	1	4	4	101
	High Intensity Discharge	2	5	0	1	0	0	0	0	1	0	2	5	16
	Controls	15	1	2	19	1	2	2	0	2	3	6	4	57

Technology Groups consist of those measures that are expected to have similar energy saving characteristics. For example, all T12 to T8 retrofit measures are grouped together under a single T8 Technology Group. The projected energy savings differences will be accounted for in the engineering estimates, yielding similar per-unit estimates.

Measure Group, the second level of segmentation, groups measures by the PG&E program measure description.

Measure, the finest level of segmentation, is the actual measure offered by the PG&E program.

The technology segmentation presented in Exhibit 3-1 above shows the level of segmentation that was performed for this evaluation. (Please note that in Exhibit 3-1, sites may contain more than one technology; therefore, the total row is less than or equal to column sum.) While the engineering analysis was conducted at the finest level of segmentation (the measure level), the statistical billing analysis was conducted at a much coarser level (the technology group).

3.1.5 Sample Allocation

For this evaluation, there were two types of primary data collected: telephone survey data and on-site audit data. These data sources formed the basis for the various analyses conducted as part of this evaluation (e.g., billing analysis, free-rider analysis, and spillover analysis). The sample design for each of these primary data sources was developed to meet each of the analysis objectives. The following sections describe these objectives and sampling strategies for each of the primary data sources collected.

Participant Telephone Sample

The telephone sample was designed to be used for the engineering, billing and net-to-gross analyses. With an available sample frame of 428 unique Indoor Lighting sites (including

HVAC/Lighting participants), a census of all eligible participants was taken for the telephone survey. This is Protocol compliant.

Comparison (nonparticipant) Sample

The primary objective of the nonparticipant telephone sample is to provide a control group for the net and gross billing analyses. The final comparison group sample frame consists of 192,689 commercial customers drawn from an eligible population of over 400,000. Since comparison group surveys were conducted only for customers in the commercial sector, the first step in creating the sample frame is to limit eligibility to only those accounts having SIC codes representing commercial business activities. In addition to the aforementioned criteria, the following screening rules were also used:

Presence of a billing rate for the customer: Customers are required to have a rate schedule code for all years spanned by the billing data.

Quality of usage readings: Customers are required to have annual non-missing, non-zero usage values for 1997, 1998, and 1999. Customers with zero, or missing billing data, were removed from the sample.

In drawing the sample frame, targets are established for each business type and usage segment, so that the nonparticipant distribution, by business type and usage segment, is the same as that of the program participant population. The drawing is conducted in this manner to ensure sufficient representation of each business type/usage segment combination in the sample frame and allows for survey data collection in accordance with the sample design. The final sample design includes 48 segments classified by size according to energy usage.

Exhibit 3-2 below illustrates the 48 segments by business type and size, the available nonparticipant sample, the calculated quota (based on the participant population), and the desired sample size to draw. Gray cells indicate nonparticipant segments where the available population to quota ratio is low. The desired nonparticipant quota was 500 points, but the quota was targeted at approximately 600 points with the assumption that for certain segments, such as the "Very Large" segment, the quota would not be filled. The final sample allocation was randomly selected within each customer segment.

The canvass sample included 50,000 randomly drawn customers within PG&E's service territory. It's primary function was to support the net-to-gross analysis by identifying nonparticipants who have installed program qualifying measures outside of the rebate programs. The sample design focused on identifying only nonparticipants who were not rebated in 1998. From a sample of 50,000 customers, the sample quota was targeted for 4,000 total completes with about 500 of the 4,000 having made lighting or HVAC changes.

Exhibit 3-2
Nonparticipant Survey Quotas
Telephone Survey Sample

Small				Medium				Large				Very Large			
Business Type	Quota	Avail.	N	Business Type	Quota	Avail.	N	Business Type	Quota	Avail.	N	Business Type	Quota	Avail.	N
Office	43	20,253	860	Office	37	1,416	740	Office	45	775	900	Office	39	148	780
Retail	30	19,857	600	Retail	30	1,403	600	Retail	11	508	220	Retail	4	38	80
Col/Univ	0	449	0	Col/Univ	2	49	40	Col/Univ	2	33	40	Col/Univ	10	25	200
School	18	1,807	360	School	16	768	320	School	20	200	400	School	3	7	60
Grocery	11	6,228	225	Grocery	7	916	150	Grocery	11	506	225	Grocery	2	19	40
Restaurant	5	11,169	109	Restaurant	14	1,794	273	Restaurant	11	85	218	Restaurant	1	0	20
Health Care/Hosp	11	7,668	210	Health Care/Hosp	3	467	60	Health Care/Hosp	16	187	330	Health Care/Hosp	8	58	160
Hotel/Motel	16	1,753	320	Hotel/Motel	2	363	40	Hotel/Motel	12	125	240	Hotel/Motel	6	30	120
Warehouse	15	6,708	300	Warehouse	8	483	150	Warehouse	8	212	150	Warehouse	1	17	20
Personal Service	15	12,984	300	Personal Service	15	306	300	Personal Service	0	121	0	Personal Service	4	12	80
Community Service	38	15,092	760	Community Service	11	787	220	Community Service	7	321	140	Community Service	6	48	120
Misc. Commercial	25	11,719	500	Misc. Commercial	3	692	67	Misc. Commercial	2	380	33	Misc. Commercial	2	95	40
SUB-TOTAL	227	115,687	4,544	SUB-TOTAL	148	9,444	2,959	SUB-TOTAL	145	3,453	2,897	SUB-TOTAL	86	497	1,720
GRAND TOTAL	606	129,081	12,120												

*Gray cells indicate nonparticipant segments where the available population to quota ratio is low.

3.1.6 Final Sample Distribution

The sample design outlined above complies with the Protocols and meets the program evaluation objectives. In this evaluation, the sampling unit is a customer site, which defines a unique service address. Applications in the MDSS database may cover more than one control number.

The final sample distribution for the telephone and on-site data collection are summarized in Exhibit 3-3 by end-use element.

Exhibit 3-3
Data Collected by Program and End Use

			Data Collected		Data Used in Lighting Analysis	
Program	End Use	Available Population	Telephone Survey	On-Site Audits	Telephone Survey	On-Site Audits
Custom	Lighting	-	-	-	-	-
	HVAC	38	5	26	5	-
Retrofit	Lighting	428	190	158	190	158
	HVAC	137	76	38	76	-
Total	Lighting	428	190	158	190	158
	HVAC	175	81	64	81	-
Total Participants		547	255	220	255	158
Total Nonparticipants		396,870	589	-	589	-
Total Sites		397,417	844	220	844	158

Telephone Survey Sample – The nonparticipant sample allocation within each segment produces a stratified random telephone survey sample representing the program participants population paid in 1998. As discussed previously, the nonparticipant telephone sample is developed based upon the business type and usage strata distribution resulting from the participant sample allocation. Because of the overlap among HVAC and Lighting participants, a single instrument was used to conduct both telephone surveys.

Telephone surveys were collected for a total of 844 customers, 255 of which were participants, with the remaining 589 in the comparison group. Among the 255 participants, 190 were lighting participants. In addition, another 4,333 customers were contacted as part of the canvass survey.

On-site Audit Sample – Similarly to the telephone survey sample, the on-site sample was also structured to be approximately proportional to program-avoided costs, with a finer level of segmentation by technology. In all, a total of 158 lighting on-site surveys were conducted.

3.1.7 Relative Precision

Given a sample design, the relative precision, based upon total annual energy use, reflects the uncertainty regarding the extent to which the allocated sample sizes are large enough to control for the population variance in terms of annual energy usage. Precision for the telephone sample was calculated using the following procedure. First, the 1997 annual energy consumption was computed for all participants in the analysis dataset.

Next, four strata were constructed based on a customers' annual usage using the Delanius-Hodges procedure. Exhibit 3-4 presents the stratum-level sample size, sample weight, sample mean, and estimated standard errors for each end use evaluated.

Then, the program level mean and standard error were calculated using classic stratified sample techniques[2]. Finally, the relative precision at a 90 percent confidence level was calculated as a two-tailed test. The very large customers (with annual energy usage greater than 3,000,000 kWh) were excluded from these calculations because of the significant influence they have over the relative precision estimate, and because these customers were excluded from the SAE analysis.

By survey, the following relative precision was achieved:

- For nonparticipants, the relative precision is 5.0 percent based upon a survey sample of 534[3].
- For Indoor Lighting, the relative precision is 6.2 percent based upon a survey sample of 168[4].

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[2] Ibid. pp. 91-95

[3] The nonparticipant sample size, 534, is the total sample of 589 less 55 very large customers.

[4] The indoor lighting participant sample size, 168, is the total sample of 190 less 22 very large customers.

Exhibit 3-4
Telephone Sample Relative Precision Levels

Nonparticipants

Weight	Sample	Mean	STD	Standard Error	Relative Precision
90.5%	238	41,641	40,421	2,617	10.3%
6.9%	150	314,202	111,989	9,041	4.7%
2.5%	146	1,228,131	618,554	49,644	6.6%
TOTAL	534	90,424		2,751	5.0%
Large Customers					
Population = 710	55	6,027,677	3,454,642	429,739	11.7%

Lighting Participants

Weight	Sample	Mean	STD	Standard Error	Relative Precision
50.6%	96	60,809	45,843	2,830	7.7%
20.0%	48	330,211	106,998	7,722	3.8%
12.5%	24	1,661,726	737,540	90,330	8.9%
TOTAL	168	304,542		11,486	6.2%
Large Customers					
Population = 29	22	11,635,057	16,102,309	828,661	11.7%

3.1.8 Demonstration of Protocol Compliance

Sampling Procedures Adopted

The sample design follows the rules established by the CPUC in the March 1998 revisions to the "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings from Demand Side Management Programs."

Sample Definitions

The following definitions are provided to introduce the primary segments targeted—both a participant sample and a comparison group — to ensure experiment control:

Participants - According to Table 5, part C, paragraph 1 of the Protocols, participants are defined as "those who received utility financial assistance to install a measure or group of measures during the program year."

Comparison Group - A control group is defined as a group of customers that represents what would have happened in the absence of the program. According to Table 5, part D, paragraphs 3 & 4, the comparison groups include both "customers who installed applicable measures" and "customers who did not install applicable measures," with no preference for either group (i.e., random or stratified random sample). This sample is therefore representative of the population, excluding only program participants during the evaluation year.

Overall Sampling Procedures

The commercial customer samples are driven by a primary data collection activity; in this case, the telephone surveys serve as the primary site-specific data collection elements that contribute to the analysis dataset. The commercial telephone sample was drawn to achieve a stratified random sample and optimally distribute the allocated sample points.

Detailed Protocol Sample Requirement

The commercial participant and comparison group samples are designed to meet the Protocol requirements in terms of analysis dataset sample size, precision of the results, availability of pre- and post-billing data contributing to the analysis dataset, and in ensuring cost-effective use of measured data.

Analysis Dataset Sample for Commercial Participants: The Protocols require that a program with more than 450 participants has a randomly drawn sample sufficiently large to achieve minimum energy use precision of ±10 percent at the 90 percent confidence level, and at least 350 contributing points in the analysis dataset. However, if a program has fewer than 450 participants then a census of the participants must be taken. The analysis dataset was derived from a census of the participant population.

As illustrated in Exhibit 3-4, the sample collected for the lighting end use achieved a relative precision of at least 7 percent at a 90 percent confidence level. This is below the 10 percent required by the Protocols, Table 5, part C, paragraph 4. Each participant chosen for the telephone sample is required to have at least nine months of post-installation billing data, and 12 months of pre-installation data, as per the Protocols, Table 5, part D, paragraphs 2 and 1, respectively. This requirement is met, with a pre- and post-installation period of 1 year used in the statistical billing analysis.

Analysis Dataset Sample for Commercial Comparison Group - The Protocols require that the comparison group sample "be drawn using the same criteria for participants," as per Table 5, part C, paragraph 6. The nonparticipant sample frame was drawn using the participant population by business type and usage segment.

The analysis dataset meets the sample size requirement in Table 5, part C, paragraph 3. The calculated relative precision meets the precision requirement in Table 5, part C, paragraph 4. Exhibit 3-4 illustrates a relative precision of 5 percent at a 90 percent confidence interval, well below the 10 percent allowable.

To ensure compliance with comparison group protocols, the telephone survey sample frame is drawn to meet the billing data requirements of Table 5, part D, paragraphs 3 and 4 of the Protocols. All customers in the analysis dataset have billing data from January 1993 to

September 1999, which ensures an adequate pre- and post-installation billing period for customers who installed applicable measures between 1996 and 1999.

3.2 ENGINEERING ANALYSIS

The comprehensive engineering approach is presented in this section for the gross impact evaluation of the lighting end-use. The analysis approach implemented is dependent upon both the program under which a particular measure is installed and the measure group classification. Either a calibrated engineering model and/or a simplified model approach (and review of the ex ante algorithms) was used. Exhibit 3-5 specifies the engineering approach applied, by measure group.

3.2.1 Lighting Models

Pacific Gas and Electric Co. (PG&E) has completed over the last few years a 1994, 1995, 1996, and 1997 paid-year evaluation of its Commercial EEI Programs, including indoor lighting measures. The data collection and analysis approach employed in PG&E's lighting evaluations has incorporated three key data sources in a nested sample design: lighting logger data, on-site audit data, and telephone survey data. The application of this thorough approach in assessing lighting impacts, and the consistent results achieved in 1994 through 1997 has allowed PG&E to reduce the on-site data requirements for completing this 1998 paid-year effort.

Exhibit 3-5
Engineering Analysis Classification by Program and Measure Group

End-Use	Program	Technology Group	Percent of Avoided Cost by End-Use	Total Participant Sites	Engineering Model Classification
Indoor Lighting	Retrofit Express	Halogen	0.0%	20	Calibrated Model
		Compact Fluorescent Lamps	14.5%	236	Calibrated Model
		Exit Signs	2.0%	107	Calibrated Model
		Efficient Ballast Changeouts	0.3%	34	Calibrated Model
		T-8 Lamps and Electronic Ballasts	50.9%	508	Calibrated Model
		Delamp Fluorescent Fixtures	25.3%	132	Calibrated Model
		High Intensity Discharge	3.5%	18	Calibrated Model
		Controls	3.4%	80	Simplified Model
	Indoor Lighting End-Use Total		100.0%	1135	-

A Retroactive Waiver was submitted to the CADMAC and approved in May of 1999 (see Attachment A). This Waiver ensures Protocol compliance for the engineering CE methods that were applied and the LIRM models performed, including the use of end use load shapes developed from the 1994 and 1995 Commercial Lighting studies. This is consistent with the evaluation methodology implemented for the 1996 and 1997 Evaluation, which utilized the 1994 and 1995 evaluation results in an identical manner.

The 1994 and 1995 evaluation studies were Protocol compliant, including the collection and use of data as per Tables 5 and C-4. By using intermediate results from these studies that are based upon a Protocol compliant data collection and analysis plan, the 1998 study meets all Table C-4 analysis requirements. Additional data were collected to meet the Table 5 sample design requirements.

Next, the general CE lighting model specifications are described followed by a presentation of the 1994 and 1995 load shape results.

General Lighting Model Specifications

The engineering analyses conducted have combined information from telephone surveys with detailed on-site audit data to develop unadjusted engineering impacts (UEIs). The general lighting model used to estimate the impacts under the RE program was founded on the decomposition of lighting impacts into manageable engineering parameters (referred to as the "impact decomposition approach"). This approach was used to develop hourly impacts for each of three daytypes, Weekday, Saturday, and Sunday. The impact decomposition equation that was used to estimate UEIs is displayed below.

$$UEI_t = [(\Delta UOL * U * OF_t) * T] * [1 + HVAC]$$

Where,

ΔUOL = the technology level change in connected kW associated with a particular measure.

U = the number of measure units installed for a particular application.

OF_t = the operating factor which describes the percentage of full load used by a group of fixtures during a prescribed period of time, t.

T = the time interval for which an impact is estimated; for most measures, the OF term is the engineering parameter that changes significantly over time. Time intervals for lighting estimates were single hours, segmented by hours "on" (open operating factor) and hours "off" (closed operating factor) schedules.[5]

$HVAC$ = the component of impact associated with both the net savings due to cooling (demand or energy) and the net increase due to heating (energy or therm).

Each of the parameters listed above are developed as follows:

[5] Although there are periods of time when lights are generally considered off, many lights are either accidentally or purposely left on during these periods. The effective hours of lighting operation captured during these off periods were applied using the operating factor term (the probability that lights operate during a particular time interval).

Δ**UOL** - The change in Unit Operating Load (ΔUOL) is derived by adjusting the change in connected load (taken from the MDSS) with burned out lamp rates developed using on-site audit data.

U - The number of units (U) of each measure type installed is verified during the post-installation on-site audit.

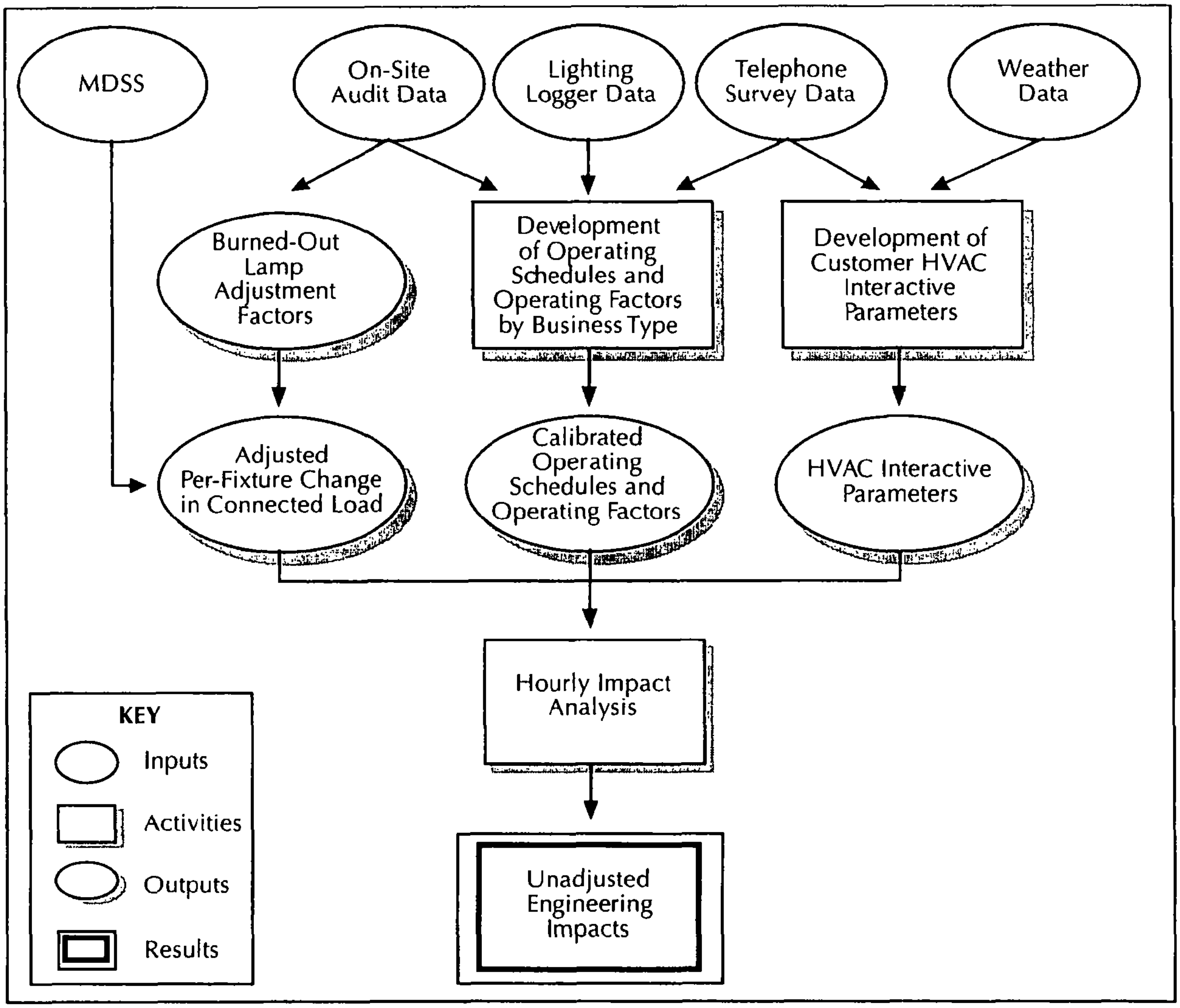
$\mathbf{OF_t}$ - The operating factor (OF_t) consists of two parameters; the probability that a given facility is open for that hour (operating schedule), and the percentage of lights operating during the period (open-period and closed-period operating factors). Operating schedules were developed for each business type using logger, on-site audit and telephone survey data. Open-period and closed-period operating factors (OOFs and COFs) were developed, by business type, using logger and on-site audit data. All logger data used were collected during the 1994 and 1995 Lighting Evaluations, as approved through a Retroactive Waiver (see Attachment 1).

HVAC - HVAC interactive effects (HVAC) were developed using weather and telephone survey data. An increase in heating loads and a decrease in cooling loads are caused by a reduction in internal heat gains when retrofit technologies are installed.

Demand estimates were developed for every hour of the year using this equation. Hourly impacts were then aggregated, yielding energy and therm impacts by costing period. Additionally, peak demand impacts were averaged for selected hours across all weekdays in a particular costing period.

Exhibit 3-6 presents a flowchart of the method used to develop hourly impacts using the decomposition approach. *Section 3.2.2* describes the methods used to develop inputs for this equation, while *Section 3.2.3* and *Section 3.2.4* describe how hourly impacts were derived, and used to develop demand and energy impacts.

Exhibit 3-6
Method Used to Develop Hourly Engineering Estimates



3.2.2 Derivation of Engineering Parameters

This section provides an overview of the methods used to develop each of the parameters used in the impact decomposition approach.

Engineering Connected Load Estimates

The change in connected load (ΔUOL) was determined for each fixture using pre- and post-retrofit information. As PG&E retains few records of the removed fixtures (hard copy application records for the CEO and APO programs only), an assumed pre-retrofit (existing) fixture was developed for each RE measure. The difference in connected load is based upon both the measure definition specified under the lighting RE program (and typical installations for each measure), and an assumed existing system that represents a typical customer configuration prior to retrofit.

These connected load values were further refined using burned-out lamp rates to adjust for potential discrepancies between ex ante estimates and observed participation. When retrofit lighting programs are implemented, often the replaced lamps are burned out, which results in an increase in energy use for the first year impacts. In addition, new fixtures sometimes fail a short time after installation, resulting in a decrease in energy use for first year energy use. For this reason, typical lamp burn-out rates were determined for specific technology groups (both for new fixtures and existing fixtures), based upon data gathered during on-site audit activities.

Final ΔUOL values were developed by applying burned-out lamp rates (where applicable) to the assumed change in connected load.

Engineering Operating Schedule and Operating Factor Estimates

For each business type and technology group, operating factors (the OF_t parameter in the impact decomposition equation) were developed for each of the three daytypes. This operating factor variable consists of two parameters: the probability that a given facility is open for that hour (operating schedule), and the percentage of lights operating during a particular period (open-period and closed-period operating factors). The following sections discuss the development of these two parameters.

Engineering Operating Schedules - Calibrated hourly operating schedules (or profiles) for each daytype were developed, by business type, using data gathered from lighting loggers (from the 1994 and 1995 evaluations), on-site audits, and participant and non-participant telephone surveys. The method used is described below and depicted in Exhibit 3-7.

Operating schedules were first developed for each "schedule group" (a group of similar fixtures that operate together) at a particular premise, and then aggregated to the premise level. Once operating schedules were developed for each premise, business type-specific schedules were developed using weighted average premise-specific schedules. The business type schedules were calibrated using the nested sample design, according to the following steps:

First, logger data were used to calibrate customer self-reported operating hours gathered during the on-site audits. Then, once calibrated, the on-site self-reported schedules were used to adjust operating schedules derived using telephone survey data. Finally, the adjusted telephone survey schedules were used to develop final business type-specific operating schedules. These schedules were used to generate final evaluation impacts for the entire MDSS sample.

By adjusting these operating profiles with two distinct calibration steps, bias adjustment for on-site self-reported schedules, and bias adjustment for telephone survey self-reported schedules; the final operating profiles are grounded in the most accurate information gathered in this research effort: lighting logger data. The final derived schedules represent, at a business type level, the probability that a particular customer will operate their lighting system for a given hour and daytype.

Engineering Open-Period and Closed-Period Operating Factors - Operating factors, the percentage of lights operating during a specified time interval, were generated by business type, technology group, and daytype, for the facility open and closed periods. The data sources contributing to these estimates were taken primarily from two sources: lamp counts performed at the time of each audit, and lighting logger data (from the 1994 and 1995 evaluations) used in conjunction with the calibrated schedule group profiles. The methods used to generate open-period operating factors (OOFs) or closed-period operating factors (COFs), for each daytype varied slightly in response to available data.

Weekday OOFs were developed using lamp counts (a visual count of lamps that were "on" and lamps that were "off") that were recorded during each on-site audit. On-site audits were conducted during normal weekday facility business hours, and so lamp counts represent highly accurate business type- and technology-specific instantaneous weekday open-period operating factors.

Since there were no supporting lamp count data for periods other than the weekday open period, Saturday and Sunday open-period operating factors were developed by using logger data in conjunction with the (lamp count-based) weekday OOFs. Logger-based open-period operating factors were developed for Saturday and Sunday, in conjunction with weekday logger derived open-period operating factors, based on the same sample points. The ratio of these two terms (weekend logger to weekday logger) was then used to adjust lamp count based weekday open-period operating factors to produce weekend operating factors.

Business type-specific closed-period operating factors were developed for the three daytypes using logger data exclusively, since there were no lamp count data available.

Operating factors were applied in the hourly impact calculation; open-period operating factors were applied to the probability that a facility is open, while closed-period operating factors were applied to one minus the probability that a given facility is open.

Engineering HVAC Interactive Estimates

In addition to the direct effects of lighting retrofits on premise energy and demand, the contribution of impact caused by cooling and heating system use is significant. Internal gains affect both the air-conditioning and heating loads in buildings, and thus HVAC equipment run-time and consumption. Lighting retrofits modify the heat gain in buildings, and thus heating system and air-conditioner usage. When high-efficiency lighting systems replace standard-efficiency systems, cooling loads are decreased while heating loads increase.

Telephone survey responses served as the primary evaluation data source used to estimate HVAC interactive impacts. Weather data were used to determine the appropriate periods to which HVAC interactive impacts were applied.

Engineering Cooling Interactive Estimates - Engineering cooling interactive estimates were developed, using an ASHRAE[6] method, for premises served by electric-powered cooling systems. Interactive cooling impacts were achieved by multiplying the heat gain fraction removed mechanically and the marginal coefficient of performance with annual fixture-level energy impacts for indoor lighting systems, on a per-premise basis. Additionally, the percentage of each facility that is conditioned is applied to each interactive cooling impact, serving as a proxy for the percent of each retrofit installed within conditioned space. The resulting cooling energy savings are used as inputs to the SAE analyses, along with both technology-level impacts and heating penalty estimates (as described below).

Engineering Heating Interactive Estimates - As described earlier, the efficient lighting technologies installed under the lighting program caused a reduction in internal heat gains in buildings, and a related increase in the energy required to heat internal spaces. A similar ASHRAE method was used to develop energy and therm impacts associated with the effects of fixture change-out on heating system use. Interactive heating penalties were achieved by multiplying the heat gain fraction and the marginal coefficient of performance with annual fixture-level energy impacts for indoor lighting systems, on a per-premise basis. Additionally, the percentage of each facility that is heated is applied to each interactive heating impact, serving as a proxy for the percent of each retrofit installed within conditioned space. To apply the ASHRAE method, the heating system fuel must be known and, if electric, whether or not the system is a heat pump.

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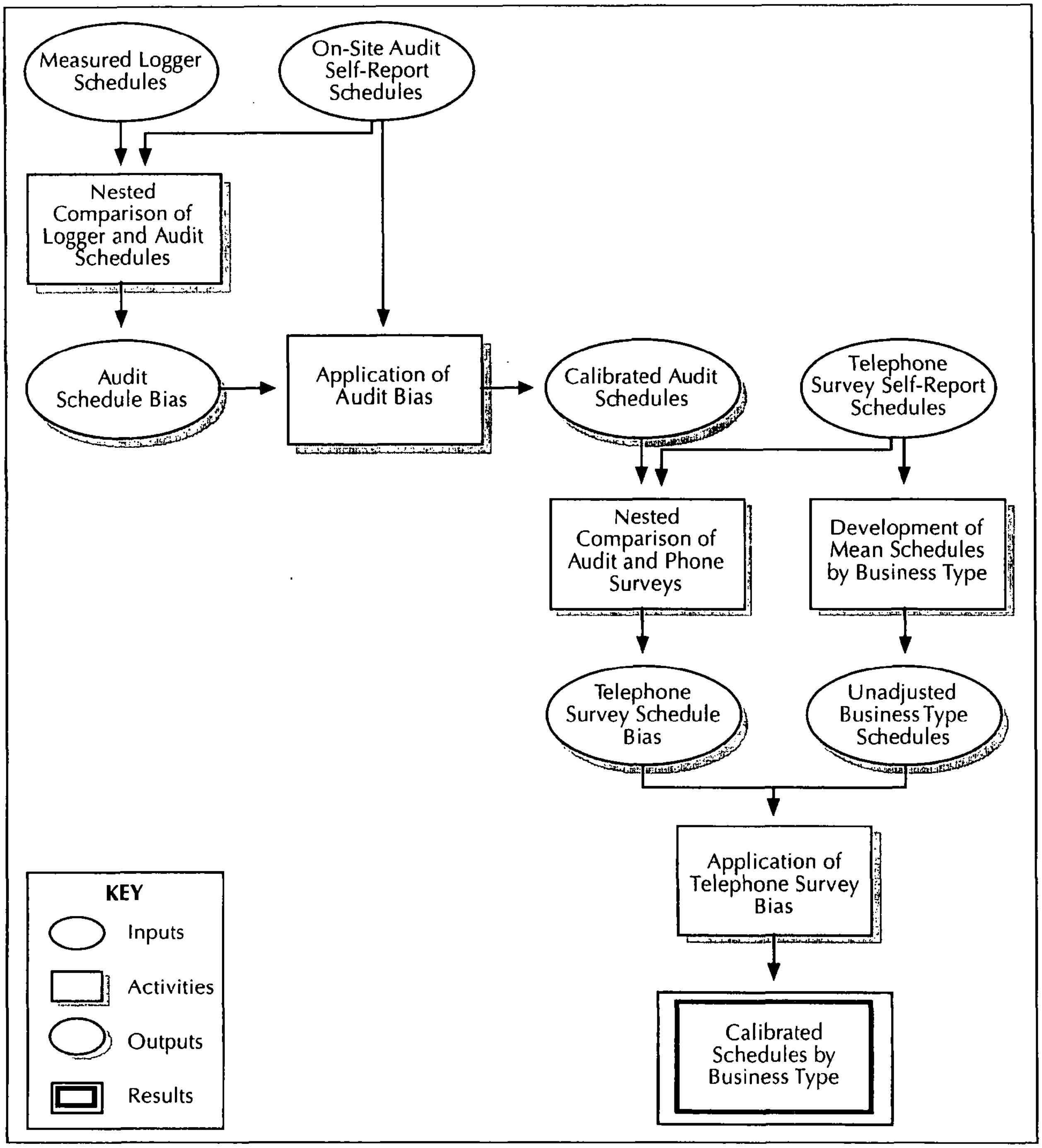
[6] Rundquist, R. *et al.* 1993. "Calculating Lighting and HVAC Interactions", ASHRAE Journal, November 1993, pages 28-37.

Exhibit 3-7
Derivation of Operating Schedules for Use in Engineering Estimates



3.2.3 Development of Engineering Hourly Energy Estimates

Using the engineering parameters discussed above, hourly engineering impact estimates were developed to satisfy the PG&E requirements for impacts by TOU costing period. To estimate hourly energy impacts, fixture noncoincident demand connected loads are used along with the applicable schedule and operating factors, according to the following equation:

$$UEI_{ijzdh} = \Delta UOL_i * U_{ij} * \left[\left(PO_{jdh} * OOF_{izd}\right) + \left(\left(1 - PO_{jdh}\right) * COF_{izd}\right)\right] * \left[1 + HVAC_{ij}\right]$$

Where,

UEI_{ijzdh} is the unadjusted engineering impact for measure i, customer j, business type z, daytype d, and hour h.

ΔUOL_i is the change in connected load for technology measure i.

U_{ij} is the number of units of technology type i installed by customer j.

PO_{jdh} is the schedule defined probability that customer j will be open on daytype d during the hour h.

OOF_{izd} is the open-period operating factor which describes the percentage of full load (during normal business hours) used by a group of fixtures of type i, in business type z, during daytype d.

COF_{izd} is the closed-period operating factor which describes the percentage of full load (during non-business hours) used by a group of fixtures of type i, in business type z, during daytype d.

$HVAC_{ij}$ is the contribution of impact caused by both heating and cooling interaction for technology measure i, installed by customer j.

Energy impacts for each measure/daytype/hour were derived and applied to the calendar year, yielding demand profiles which encompassed all 8,760 hours in a year. In addition, hourly HVAC interactive therm impacts were calculated for premises with gas heating systems.

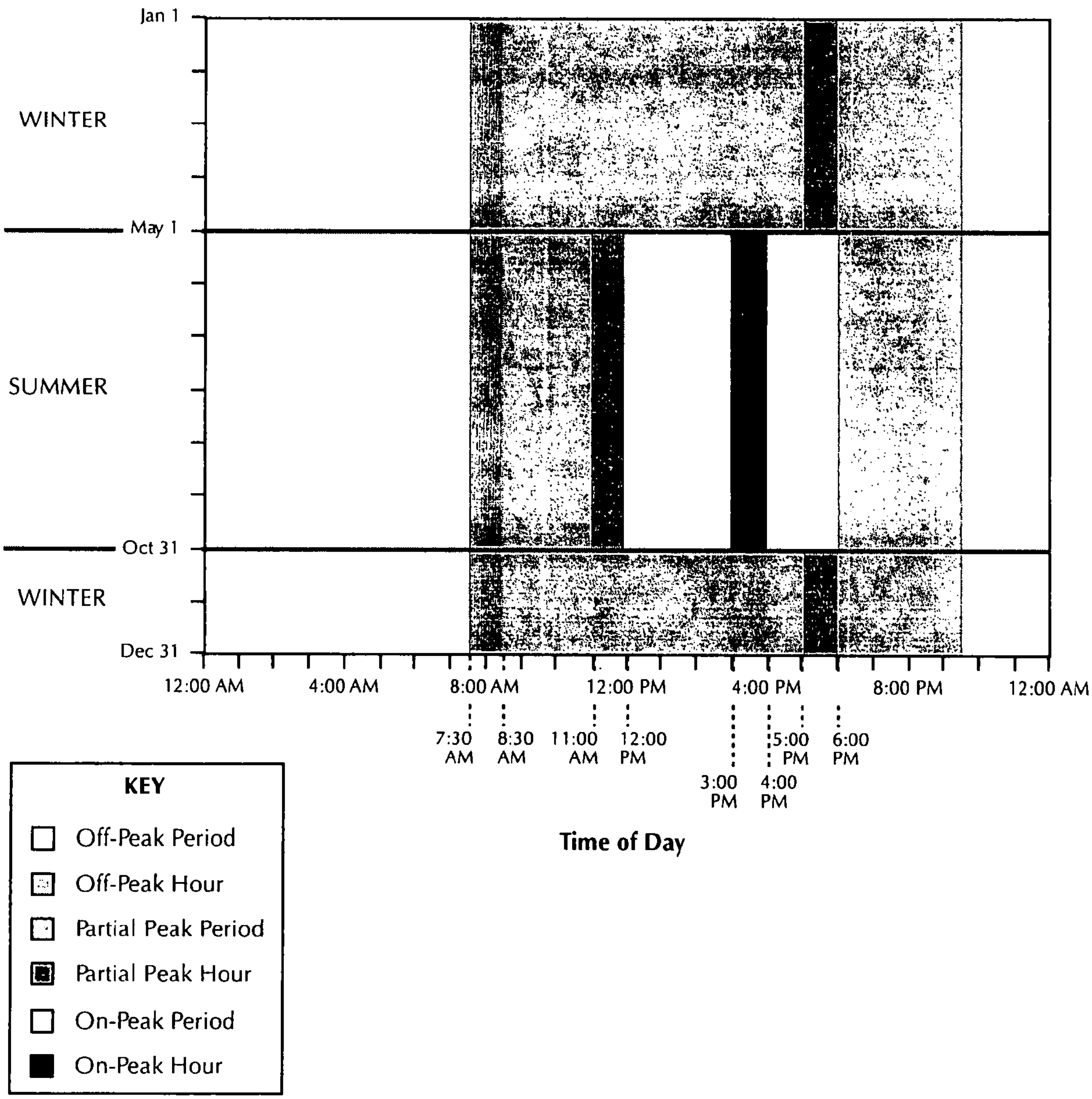
3.2.4 Aggregated Engineering Estimates by Time-of-Use Costing Period

Exhibit 3-8 illustrates the time-of-use costing periods used to derive final energy, therm and demand engineering (unadjusted) impacts.

Annual energy and therm impacts were derived by aggregating hourly impacts by TOU costing period, while demand impacts were derived by averaging all impacts for a selected hour in a particular TOU costing period.

The engineering demand and therm estimates are used as the final gross ex post impacts. Engineering energy impacts serve as inputs to the statistical billing analysis, described in detail in *Section 3.3.*

Exhibit 3-8
Weekday* Time-of-Use Costing Periods



* All weekend hours are considered part of the off-peak period.

3.2.5 *Summary of Existing Results*

Both the 1995 and 1996 Program Year CEEI impact evaluation reports clearly recommend that the evaluation results be used in support of future forecasting and evaluation efforts.

Specifically it is recommended that PG&E adopt the full load hours of operation, the coincident diversity factors (CDFs), the HVAC interactive effects, the lamp burnout rates and impact by costing period results that were developed as part of the 1994 and 1995 program year evaluation studies. It is these results in particular that will be used in support of the 1998 evaluation. In the 1998 Advice Filing, PG&E adopted the results from the 1994 and 1995 studies for the variables listed above.

Full Load Hours of Operation - Full load hours account only for lighting system operation, not total impact, which isolates the lighting technology impacts from the HVAC program impact contributions. Exhibit 3-9 presents the 1994 and 1995 M&E full load hour results for the indoor lighting end-use element. The pre-1998 program carry-over evaluation estimates are the mean adjusted full load hours (an average of 1994 and 1995 M&E results).

Exhibit 3-9
Equivalent Full Load Hours by Business Type for Commercial Lighting Technologies

	Indoor Lighting Annual Hours of Operation			
	Evaluation Estimates			Program Design Estimate
Business Type	**1994**	**1995**	**Mean**	**1998**
Office	3,900	4,100	**4,000**	**4,000**
Retail	4,200	4,700	**4,450**	**4,450**
College/Univ	3,700	4,100	**3,900**	**3,900**
School	2,000	2,300	**2,150**	**2,150**
Grocery	6,800	4,800	**5,800**	**5,800**
Restaurant	4,800	4,400	**4,600**	**4,600**
Health Care	4,900	3,900	**4,400**	**4,400**
Hotel/Motel	5,400	5,600	**5,500**	**5,500**
Warehouse	3,100	4,000	**3,550**	**3,550**
Personal Service	NA†	4,100	**4,100**	**4,500**
Community Service	NA†	2,700	**2,700**	**4,500**
Misc.	4,800	4,200	**4,500**	**4,500**

† The Personal Service and Community Service business types were not defined in the 1994 M&E study.

Although the comparison shown above depicts results by business type, mean full load hours of operation were actually applied at the business type and technology group level. These mean 1998 evaluation results are shown in Exhibit 3-10.

Exhibit 3-10
Equivalent Full Load Hours by Business Type and Technology Group for Commercial Lighting Technologies

Business Type / Technology Group	Commercial Sector Hours of Fixture Operation											
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.
Compact Fluorescent	3,800	4,150	3,550	2,050	5,400	3,850	3,600	5,150	2,800	3,700	2,000	3,900
Standard Fluorescent	4,000	4,500	4,050	2,150	5,850	4,900	4,450	6,200	3,450	4,100	2,800	4,500
High Intensity Discharge	4,050	4,350	3,300	2,350	5,950	5,550	4,750	6,500	3,650	4,100	3,100	4,700
Halogen	4,100	4,500	4,250	2,300	6,100	5,600	4,850	6,750	3,500	4,700	3,400	4,750
Exit Signs	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,450	8,700	8,700	8,450

Exhibit 3-11
Peak Hour Coincident Diversity Factors by Business Type for Commercial Lighting Technologies

	Indoor Lighting Summer On-Peak CDF			
	Evaluation Estimates			Program Design Estimate
Business Type	1994	1995	Mean	1998
Office	0.78	0.85	**0.81**	**0.81**
Retail	0.90	0.87	**0.88**	**0.88**
College/Univ	0.61	0.76	**0.68**	**0.68**
School	0.46	0.38	**0.42**	**0.42**
Grocery	0.91	0.71	**0.81**	**0.81**
Restaurant	0.70	0.66	**0.68**	**0.68**
Health Care	0.78	0.70	**0.74**	**0.74**
Hotel/Motel	0.64	0.70	**0.67**	**0.67**
Warehouse	0.78	0.90	**0.84**	**0.84**
Personal Service	NA†	0.79	**0.79**	**0.76**
Community Service	NA†	0.48	**0.48**	**0.76**
Misc.	0.71	0.81	**0.76**	**0.76**

† The Personal Service and Community Service business types were not defined in the 1994 M&E study.

Coincident Diversity Factors (CDFs) - Exhibit 3-11 presents the 1994 and 1995 M&E coincident diversity factor results for the indoor lighting end-use element. The 1998 evaluation estimates are the mean adjusted CDF (an average of 1994 and 1995 M&E results).

Although the comparison shown above depicts results by business type, mean CDF's were actually applied at the business type and technology group level. These mean 1998 evaluation results are shown in Exhibit 3-12.

Exhibit 3-12
Peak Hour Coincident Diversity Factors by Business Type and Technology Group for Commercial Lighting Technologies

Business Type / Technology Group	Commercial Sector Summer On-Peak CDF Results											
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.
Compact Fluorescent	0.77	0.78	0.59	0.39	0.72	0.54	0.57	0.63	0.65	0.68	0.32	0.63
Standard Fluorescent	0.81	0.90	0.71	0.42	0.81	0.74	0.76	0.77	0.81	0.80	0.48	0.77
High Intensity Discharge	0.84	0.86	0.58	0.48	0.83	0.83	0.83	0.79	0.87	0.78	0.55	0.78
Halogen	0.84	0.89	0.76	0.48	0.85	0.86	0.86	0.82	0.83	0.88	0.64	0.80
Exit Signs	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.99	0.99	0.97

HVAC Interactive Effects - Exhibit 3-13 presents commercial sector mean HVAC energy and summer on-peak demand adjustment factors by business type that describe the ratio of total fixture and HVAC impact to fixture-only impact. These adjustments are applied by business type to estimates of technology-only lighting impacts, yielding estimates of total impact that include the HVAC component. The 1998 evaluation estimates use the mean HVAC adjustments (an average of 1994 and 1995 M&E results).

Burned-Out Lamp Rates - Exhibit 3-14 presents commercial sector mean burned-out lamp rates by pre- vs. post-retrofit technology type for certain key technology group segments. These results were applied to the 1998 pre- and post-retrofit connected load assumptions to account for the higher probability of lamp burnout in the pre-retrofit technologies. The 1998 evaluation estimates use the mean burned-out lamp adjustments (an average of 1994 and 1995 M&E results).

Savings by Costing Period - Exhibit 3-15 presents commercial sector kW Adjustment Factors and kWh Adjustment Factors by PG&E costing period, based on the 1994 and 1995 evaluation results. These results were applied to the 1998 impacts to account for the required allocation of impacts by costing period. The 1998 evaluation estimates use the mean Adjustment Factors (an average of 1994 and 1995 M&E results).

Exhibit 3-13
Commercial Sector HVAC Adjustments by Business Type for Commercial Lighting Technologies

Business Type	Interactive HVAC Energy Adjustments (kWh)		
	1994	1995	Mean
Office	1.14	1.19	**1.17**
Retail	1.08	1.13	**1.11**
College/Univ	1.19	1.10	**1.15**
School	1.12	1.18	**1.15**
Grocery	1.12	1.14	**1.13**
Restaurant	1.13	1.16	**1.15**
Health Care	1.12	1.24	**1.18**
Hotel/Motel	1.16	1.11	**1.14**
Warehouse	1.05	1.06	**1.06**
Personal Service	NA†	1.06	**1.06**
Community Service	NA†	1.23	**1.23**
Misc.	1.10	1.06	**1.08**

Business Type	Interactive HVAC Demand Adjustments (kW)		
	1994	1995	Mean
Office	1.24	1.26	**1.25**
Retail	1.16	1.22	**1.19**
College/Univ	1.32	1.11	**1.22**
School	1.22	1.23	**1.23**
Grocery	1.23	1.26	**1.25**
Restaurant	1.26	1.26	**1.26**
Health Care	1.22	1.30	**1.26**
Hotel/Motel	1.07	1.20	**1.14**
Warehouse	1.10	1.07	**1.09**
Personal Service	NA†	1.07	**1.07**
Community Service	NA†	1.31	**1.31**
Misc.	1.16	1.09	**1.13**

Exhibit 3-13 (cont'd)
Commercial Sector HVAC Adjustments by Business Type for Commercial Lighting Technologies

Business Type	Interactive HVAC Therm Adjustments (therm/GWH)*		
	1994	1995	Mean
Office	NA†	-0.39	**-0.39**
Retail	NA†	-0.26	**-0.26**
College/Univ	NA†	-0.11	**-0.11**
School	NA†	-0.43	**-0.43**
Grocery	NA†	-0.09	**-0.09**
Restaurant	NA†	-0.46	**-0.46**
Health Care	NA†	-0.19	**-0.19**
Hotel/Motel	NA†	-0.05	**-0.05**
Warehouse	NA†	-0.06	**-0.06**
Personal Service	NA†	-0.07	**-0.07**
Community Service	NA†	-0.35	**-0.35**
Misc.	NA†	-0.08	**-0.08**

* Therm impacts represent the impact in annual therm usage per gigawatt hour of technology only impact in annual energy use (therm/GWh).

† Interactive HVAC therm adjustments were not made in 1994.

Exhibit 3-14
Commercial Sector Burned-Out Lamp Rates for Commercial Lighting Technologies

Pre- or Post-Retrofit	Technology Group	Observed Burned Out Lamp Rate		
		1994	1995	Mean
Pre-Retrofit	Incandescent	2.16%	2.10%	2.13%
	Standard Fluorescent	3.05%	1.98%	2.52%
Post-Retrofit	Compact Fluorescent	0.37%	1.39%	0.88%
	Standard Fluorescent	0.26%	0.51%	0.39%

Exhibit 3-15
Commercial Sector Impacts by Costing Period
for Commercial Lighting Technologies

PG&E Cost Period	Time-of-Use Impact Distribution					
	1994 kW Adjustment Factor	1995 kW Adjustment Factor	Mean kW Adjustment Factor	1994 kWh Adjustment Factor	1995 kWh Adjustment Factor	Mean kWh Adjustment Factor
Summer On-Peak: May 1 to Oct. 31 12:00 PM - 6:00 PM Weekdays	1.00	1.00	1.00	0.16	0.14	0.15
Summer Partial Peak: May 1 to Oct. 31 8:30 AM - 12:00 PM & 6:00 PM - 9:30 PM Weekdays	1.01	1.06	1.03	0.14	0.14	0.14
Summer Off-Peak: May to Oct. 31 9:30 PM - 8:30 AM	0.74	0.86	0.80	0.24	0.22	0.23
Winter Partial Peak: Nov. 1 to April 31 8:30 AM - 9:30 PM Weekdays	0.77	0.85	0.81	0.26	0.28	0.27
Winter Off-Peak: Nov. 1 to April 31 9:30 PM - 8:30 AM Other	0.66	0.88	0.77	0.20	0.22	0.21

3.2.6 1998 Evaluation Activities in Support of the CE Model

Noncoincident Demand Impact Calculations

All lighting estimates require the use of pre- and post-retrofit fixture connected loads or, more typically, the change in fixture connected load. This engineering parameter represents the ΔUOL term in the impact decomposition approach. This change in lighting-system connected load is referred to as the noncoincident demand impact, which is defined for each RE measure using the following formula:

$$kW_{NCP} = kW_E - kW_R$$

Where,

kW_{NCP} = Per-unit noncoincident demand impact by measure

kW_E = Per-unit existing measure demand

kW_R = Per-unit retrofit measure demand

Exhibit 3-16 provides a summary of the assumed change in connected load for the measures installed according to the 1998 Lighting RE document cited above. This difference in connected load is based upon both the measure definition specified under the Lighting RE program (and typical customer installations for each measure), and an assumed existing system that represents a typical customer configuration prior to retrofit.

Exhibit 3-16
Fixture Assumptions Used to Generate RE Commercial Lighting Evaluation Impact Estimates

Measure Group Descriptions	Application Year	Measure Code In MDSS Database	Per-Unit NC Impact (Watts)	Pre-Burn-Out Lamp Rate	Post-Burn-Out Lamp Rate	Adjusted per-unit NC Impact
Halogen		L60, L61				
< 50 watts	1995-1998	L60	30			30.000
>= 50 watts	1994-1998	L61	50			50.000
Compact Fluorescent		L64, L66, L174 - L177				
Screw In CF- Reusable ballast		L64, L174, L175				
5-13 watts	1994-1998	L64	45	0.0213	0.0088	43.854
14-26 watts	1996-1998	L174	57	0.0213	0.0088	55.561
>=27 watts	1996-1998	L175	69	0.0213	0.0088	67.143
Hard Wired CF		L66, L176, L177				
5-13 watts	1994-1998	L66	45	0.0213	0.0088	43.854
14-26 watts	1996-1998	L176	74	0.0213	0.0088	72.099
>=27 watts	1996	L177	75	0.0213	0.0088	73.090
Fluorescent Hardwire		L178, L179, L180, L181, L182, L183				
27-65 watts Incandescent to Fluorescent	1997-1998	L178	142	0.0213	0.0088	138.250
27-65 watts Mercury Vapor to Fluorescent	1997-1998	L179	67			67.000
66-156 watts Incandescent to Fluorescent	1997-1998	L180	384	0.0213	0.0088	374.371
66-156 watts Mercury Vapor to Fluorescent	1997-1998	L181	169			169.000
>=157 watts Incandescent to Fluorescent	1997-1998	L182	576	0.0213	0.0088	561.556
>=157 watts Mercury Vapor to Fluorescent	1997-1998	L183	280			280.000
Incandescent to Fluorescent Fixture		L8				
With Electronic Ballast & T8 Lamps	1993&4&5&6	L8	242	0.0213	0.0039	235.836
Exit Signs		L5, L137				
Incand. to Compact Fluorescents	1993-1998	L5	20			20.000
Incand. to LED or Electroluminescent Retrofit	1993-1998	L137	36			36.000
Efficient Ballasts Changeouts		L114, L14, L15, L16				
Electronic Ballasts		L114, L14, L15, L16				
1 Lamp Electronic Ballast	1997-1998	L114	5	0.0252	0.0039	4.587
2 Lamp Electronic Ballast	1993-1997	L14	11	0.0252	0.0039	9.338
3 Lamp Electronic Ballast	1993-1997	L15	16	0.0252	0.0039	13.595
4 Lamp Electronic Ballast	1993-1997	L16	22	0.0252	0.0039	18.346
T8 Lamps and Electronic Ballasts		L12, L69 - L75, L160				
New Fixtures		L12, L69 - L75, L160				
2'-2 U Tubes or 4 lamps	1994&5	L70	42	0.0252	0.0039	39.706
4'-1 lamp	1994&5	L72	9	0.0252	0.0039	7.973
4'-3 lamps	1994&5	L74	37	0.0252	0.0039	34.278
Fixture Modif.- Replace Lamps and Ballasts		L21 - L24, L184				
Replace Lamps & Ballasts - 2' Fixture	1993-1998	L21	21	0.0252	0.0039	9.927
Replace Lamps & Ballasts - 3' Fixture	1993-1998	L22	26	0.0252	0.0039	12.225
Replace Lamps & Ballasts - 4' Fixture	1993-1998	L23	22	0.0252	0.0039	7.973
Replace Lamps & Ballasts - 8' Fixture	1993-1998	L24	30	0.0252	0.0039	13.493
Replace Lamps & Ballasts - 8' High Output Fixture	1997-1998	L184	40	0.0252	0.0039	17.622
Delamp Fluorescent Fixtures		L17 - L20				
Fixture Modif.- Delamp and Reflector		L17 - L20				
Removal - 2' Lamps & Ballasts	1993-1998	L17	32	0.0252	0.0252	31.194
Removal - 3' Lamps	1993-1998	L18	44	0.0252	0.0252	42.891
Removal - 4' Lamps	1993-1998	L19	34	0.0252	0.0252	33.143
Removal - 8' Lamps	1993-1998	L20	82	0.0252	0.0252	79.934

Exhibit 3-16 (Continued)
Fixture Assumptions Used to Generate RE Commercial Lighting Evaluation Impact Estimates

Measure Group Descriptions	Application Year	Measure Code In MDSS Database	Per-Unit NC Impact (Watts)	Pre-Burn-Out Lamp Rate	Post-Burn-Out Lamp Rate	Adjusted per-unit NC Impact
High Intensity Discharge		L26, L27, L79 - L81, L187 - L196				
Interior Compact HPS from Incand.		L79 - L80				
36-70 watts HPS	1994&5&6	L79	112			112.000
71-100 watts HPS	1994&5&6	L80	155			155.000
Interior Compact MH from Incand.		L187, L189				
0-35 watts MH	1997-1998	L185	55			66.000
36-70 watts MH	1997-1998	L187	110			110.000
71-100 watts MH	1997-1998	L189	171			171.000
Interior Compact MH from Merc. Vapor		L188, L190				
0-35 watts MH	1997-1998	L186	29			35.000
36-70 watts MH	1997-1998	L188	35			35.000
71-100 watts MH	1997-1998	L190	71			71.000
Interior Standard MH from Merc. Vapor		L26, L27, L81				
101-175 watts MH	1993&4&5&6	L26	240			240.000
176-250 watts MH	1994&5&6	L27	528			528.000
251-400 watts MH	1994&5&6	L81	620			620.000
Interior Standard MH from Incand.		L191, L193, L195				
101-175 watts MH	1997-1998	L191	290			290.000
176-250 watts MH	1997	L193	455			455.000
>=251 watts MH	1997	L195	540			540.000
Interior Standard MH from Merc. Vapor		L192, L194, L196				
101-175 watts MH	1997-1998	L192	75			75.000
176-250 watts MH	1997	L194	159			159.000
>=251 watts MH	1997	L196	448			448.000
Controls		L31, L36, L82, L83				
Time Clocks	1993-1998	L31	380			380.000
Occupancy Sensors		L82, L83				
Wall Mounted	1994-1998	L82	228			228.000
Ceiling Mounted	1994-1998	L83	608			608.000
Photocell	1993-1998	L36	380			380.000

The RE connected load figures were carried over into the evaluation analyses of program savings, though they were modified wherever possible for lamp burn-out rates in both the new and existing systems. Typical lamp burn-out rates were determined for specific technology groups, based upon data gathered during on-site audit activities.

Design estimates are based upon an assumed existing fixture. As PG&E retains few records (hard copy application records for the CEO and APO programs only) of the removed fixtures, an assumed pre-retrofit (existing) fixture was developed for each RE measure. The difference in connected load is based upon both the measure definition specified under the lighting RE program (and typical installations for each measure), and an assumed existing system that represents a typical customer configuration prior to retrofit.

3.3 BILLING REGRESSION ANALYSIS

This section documents the detailed analytical steps undertaken in the billing regression analysis of Pacific Gas and Electric Company's (PG&E's) Pre-1998 CEEI Program Carry-Over. The section begins with a discussion of the analysis periods and data sources used in the billing regression model. Then, the results of the data censoring that was applied to the analysis sample are provided. Next, the gross billing analysis regression model specification and SAE coefficients are presented, along with the relative precision calculations. Finally, the net billing analysis regression model specification and results are presented.

3.3.1 Overview

The primary objective of the billing analysis is to determine the first-year program energy impacts. A statistical analysis is employed to model the differences of customers' energy usage between pre- and post-installation periods using actual customer billing data. The model is specified using the billing data and independent variables gathered in the telephone survey that explain changes in customers' energy usage, including the engineering estimates of energy impact due to program participation. This statistically adjusted engineering (SAE) analysis is consistent with the requirements of the Load Impact Regression Model (LIRM) defined in the California Public Utilities Commission's (CPUC's) Measurement and Evaluation Protocols (the Protocols).

The results of the billing regression analysis are estimated as ratios, termed "SAE coefficients," of realized impacts to the engineering impact estimates. These realized impacts represent the fraction of engineering estimates actually "observed" or "detected" in the statistical analysis of the billing data. The SAE coefficients estimated in the billing analysis are relative to the results of the evaluation-based engineering estimates, not the PG&E Program ex ante estimates. This distinction is important, as the SAE coefficients are then used to estimate gross ex post program impacts, which in turn are used to calculate realization rates relative to the ex ante estimates.

As discussed in detail below, the billing regression analysis was conducted on a sample of telephone surveyed participants and nonparticipants. Because many Commercial Program participants installed measures under multiple end uses, one integrated billing analysis approach was used to model both the Lighting and HVAC end uses. This section of the report presents the analysis findings for both end uses – as each was an essential input to the overall model used.

3.3.2 Data Sources for Billing Regression Analysis

The billing regression analysis for the Lighting Evaluation uses data from five primary data sources: PG&E's Marketing Decision Support System (MDSS) tracking database, the billing database, the telephone survey data, the engineering estimates of changes in usage between the pre- and post-installation periods, and weather data from PG&E's load research weather sites. A summary of the data elements used in the regression analysis are presented below.

Program Participant Tracking System

The participant tracking system for the Retrofit Express (RE) Program is maintained as part of the MDSS. It contains program applications, rebate and technical information about installed measures; including measure descriptions, quantities installed, rebated amounts, and ex ante demand, energy and therm savings estimates. The MDSS database is linked to the billing database and other program databases through PG&E's customer specific control number.

PG&E Billing Data

The PG&E billing data used in this year's evaluation study were obtained from two different data requests to PG&E's Load Data Services department. The original nonresidential billing dataset contained prorated monthly energy usage for all nonresidential accounts in PG&E's service territory, and was used in the sample design described in *Section 3.1*. The billing histories contained in this database run from January 1993 through December 1998.

A second billing dataset was later obtained from PG&E Load Data Services for use in the SAE analysis. This billing dataset contains bill readings that run from January 1999 through September 1999. The resulting combined dataset represents the billing series of PG&E pro-rated monthly usage data for each calendar month from January 1993 to September 1999.

Weather Data

The hourly dry bulb temperature collected for 25 PG&E load research weather sites was used in the billing regression analysis to calculate total monthly cooling degree days for each month in the analysis period. For each customer in the analysis dataset, the appropriate weather site was linked to that customer by using the PG&E-defined weather site to PG&E local office mapping (embedded in the account code for each customer).

Telephone Survey Data

All available telephone surveys collected as part of the evaluation for the Commercial Sector Program (except for the Canvass surveys, which do not collect detailed information regarding changes that have occurred at the premise) were used as inputs to the billing regression analysis. Two telephone survey samples totaling 844 sample points (190 of which are lighting participants and 589 are nonparticipants) were collected for the Lighting Evaluation. Because of cross-over among participants across Commercial Program end uses, one integrated billing regression model was developed to evaluate both the Commercial Lighting and HVAC Program end uses.

The data collected in the telephone survey supplies information on energy-related changes at each site for the billing period covered by the billing regression analysis. For a detailed discussion of the telephone survey and the final sample disposition, see *Survey Appendices*. A discussion of the sample design can be found in *Section 3.1*

Engineering Estimates

Engineering estimates of savings were estimated for each of the 190 lighting participants. Separate estimates of energy savings were calculated for every measure installed under the Commercial Sector Program. The engineering estimates were calculated based on expected savings from the pre-installation technology to the post-installation technology. For some technologies, such as Central A/Cs installed in the HVAC program, these savings estimates will differ from the impact estimates. This is due to the impacts being calculated relative to a baseline efficiency, compared to the savings estimates, which are based on a pre-existing unit's efficiency. In the example above, many CAC's existing efficiency had a SEER rating much lower than the program baseline estimate. Consequently, the savings estimate for energy would be much higher. The Engineering Analysis (*Section 3.2*) discusses the calculation of the savings estimates used in the billing analysis in greater detail.

3.3.3 Data Aggregation and Analysis Dataset Development

Because many measures installed under the Commercial Program affected multiple customer accounts within a unique site, the billing analysis had to be performed at the site level. Therefore, all account level data (including billing usage) had to be aggregated up to the QC defined site identifier. In PG&E's billing data, an array of variables are defined to track a customer. These include the following:

- Control number, which is the finest level of aggregation, and is usually unique to a customer's meter.

- Premise number, which is used to define a unique site, but can sometimes contain multiple buildings. The premise number may map to many control numbers, but a control number will always map to a unique premise number.

- Corporation number, which is used to define a unique corporation, which can map to many premise numbers. A premise number maps to a unique corporation number.

Of the three, the premise number serves as the best indicator of a unique site. However, there are some premise numbers that contain multiple sites. To address this issue, the customer's service address was also used to help identify a unique site. If there was more than one service address for a premise number, it was broken out into multiple sites. Therefore, a unique site was defined as all of the control numbers within a unique combination of service address,[7] premise number, and corporation number. A unique Site ID was created based on this combination of address, premise, and corporation to serve as the key variable for linking data.

The billing data was provided at the control number level. To meet the needs of the analysis team, the monthly billing data had to be aggregated to the Site ID level. One concern with aggregating to the Site ID level is that there may be control numbers associated with a different premise number, service address, or corporation number that are in the same physical site and are being affected by the installed measures. If this is the case, the billing analysis will have the effect of underestimating the impacts. This a topic that will be discussed further in the *Data Censoring* section below.

The telephone surveys were sampled at the Site ID level, and all questions were phrased to ask about all of the control numbers associated with the Site ID.

The engineering estimates of change were also aggregated to the Site ID level. However, prior to aggregating to the Site ID level, the installation dates for each individual measure were

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[7] Because of potential data entry errors in the billing system, or inconsistencies in tracking service addresses in the billing system, only the first eight characters of the service address were used. Generally, this would contain the numeric portion of the address and the first few characters of the street name. For the large majority of records in the billing system, premise number and service address were unique.

analyzed to ensure that only the impacts occurring within the billing analysis periods were being aggregated. The selection of analysis periods is discussed in the next section.

All data elements mentioned above were linked to the final analysis database by Site ID. Exhibits 3-17 and 3-18 below provide the sample frame that was available for the billing analysis for participants and nonparticipants. The sample sizes are provided by business type and technology (for participants) and by business type only for nonparticipants. The values presented are the unique number of the Site IDs within a given segment.

Exhibit 3-17
Billing Analysis Sample Frame
Pre-Censoring
Indoor Lighting End-Use Technologies

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen						1							1
	Compact Fluorescent Lamps	4	6	1	5	2	3	1	6		1	8		37
	Exit Signs	8	3	3	3			4		1		3		25
	Efficient Ballast Changeouts	5										1	1	7
	T-8 Lamps and Electronic Ballasts	30	11		4	3	6	2	3	2	2	13	8	84
	Delamp Fluorescent Fixtures	15	6	1	3					1			3	29
	High Intensity Discharge	1											3	4
	Controls										3			3
Total		63	26	5	15	5	10	7	9	4	6	25	15	**190**

Exhibit 3-18
Billing Analysis Sample Frame
Pre-Censoring
Nonparticipants

Program and Technology Group	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Nonparticipant Total	147	73	6	55	32	30	37	44	32	34	63	36	**589**

3.3.4 Analysis Periods

When the billing regression analysis is used to model the change of consumption attributable to the program measures, the first step is to isolate the pre- and post-installation periods for each customer in the analysis database so that the impact of these measures can be verified.

In accordance with the Protocols, participants are defined by the "paid date" instead of "installation date." Therefore, all customers paid in 1998 actually installed measures in 1996 or 1997 with 1997 installations accounting for most of total installations. Lighting installations in 1996 accounted for less than four percent of the total program.

Selection of Installation Date

While the billing regression analysis is used to model the change of consumption attributable to the program measures, the first step is to isolate the pre- and post-installation periods for each customer in the analysis database, so that the impact of these measures can be verified. For customers who installed these energy saving measures during the pre- or post-installation period, their energy savings must be prorated to account for energy consumption using the older technologies.

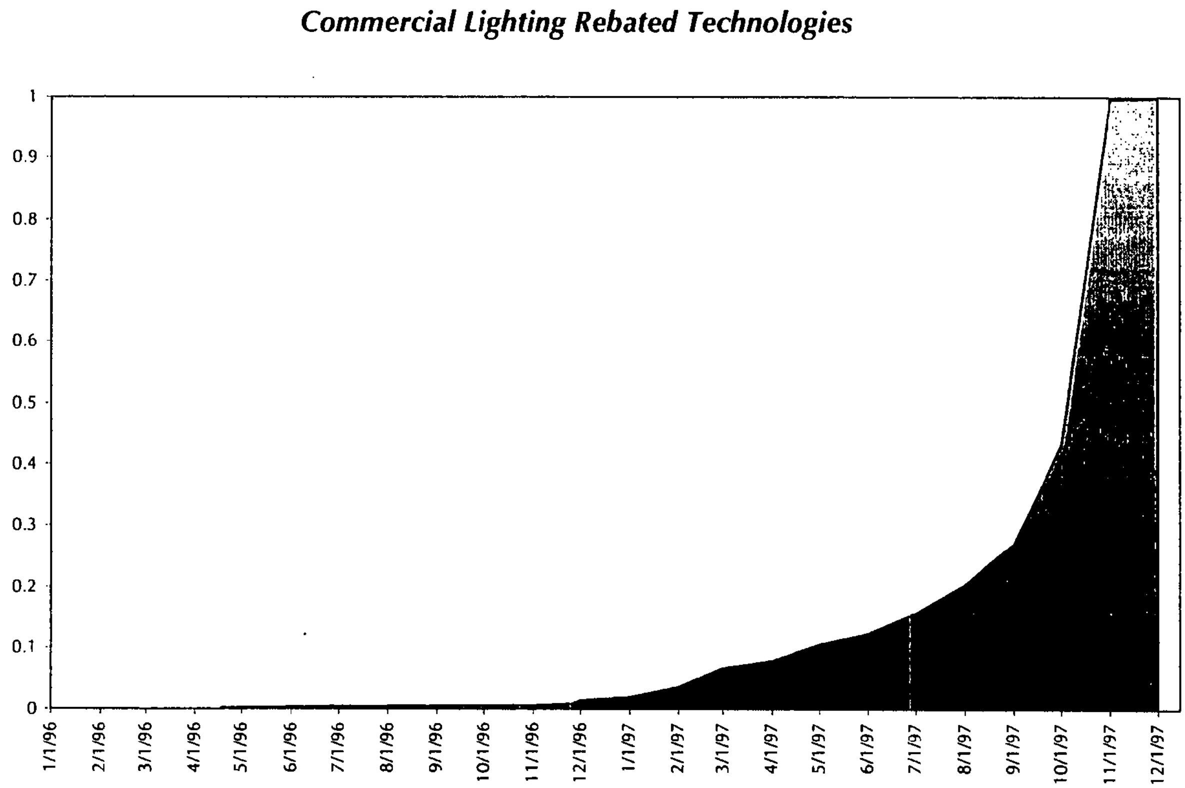
The project completion date variable in the MDSS is designated as the installation date. The project completion date is populated 99 percent of the time and falls between the pre- and post-installation inspection dates. When the project completion date is missing, the paid date and the post-installation date are used to derive an installation date. In addition to the dates recorded in the MDSS, the telephone survey asked every participant to estimate the installation date. If their self-reported installation date fell between the pre- and post-installation inspection dates (as recorded in the MDSS), the customer reported date was used.

Selection of Analysis Periods

The selection of the primary analysis period has to be defined in such a way that allows for the inclusion of the majority of the sample with high-quality data.

Billing data were available from January 1993 through September 1999. To maximize the number of post installation months in the regression model, a post period of October 1998 through September 1999 was used. As illustrated in Exhibit 3-19, this post period occurs after all of the installation dates.

Exhibit 3-19
Commercial Lighting Rebated Technologies
By Estimated Installation Date



Based on the selection of post period, the period from October 1996 through September 1997was used as the pre-period. Exhibit 3-19 suggests that almost every installation occurred between January 1997 and December 1997.

For installations that occurred prior to the pre-installation period, the engineering impact is set to zero. For installations that occurred during either the pre- or post-installation period, the engineering impact is only aggregated over the months for which there is an impact that should be realized.

Exhibit 3-19 provides the cumulative participation by month for the participants that are part of the billing analysis sample frame.

3.3.5 Data Censoring

Three types of data censoring screens were applied to the billing analysis sample frame to remove customers: those that had invalid billing data, or that may not have had their bill properly aggregated to the Site ID level, or that were extremely large users.

Invalid Usage

For customers to be included in the final billing analysis, customers had to have billing data that met the following criteria:

The pre- and post-installation annual bills had to have been comprised of at least nine non-zero monthly bills. If there were four or more monthly bills with zero energy, the customer was removed from the analysis. If there were between one and three monthly bills with zero energy, the remaining months were prorated to an annual estimate.

The pre-installation annual bill could not be more than three times or less than one third the post-installation bill. If this occurred, the customer was removed from the analysis.

Finally, customers were removed from the analysis if they had a measure installed under the program that would result in an increase in usage. These individuals were identified through customer interviews.

Exhibit 3-20 presents the number of participants and nonparticipants that were deleted for each of the above criteria. Note that only 14 nonparticipants were deleted, whereas 28 participants were deleted. This is due to the fact that the nonparticipants were pre-screened to have relatively valid billing data prior to being selected into the nonparticipant survey sample frame. The participants, however, were drawn as a census and no pre-screening was done on their billing data prior to being selected into the participant survey sample frame. Of the 28 participants, 18 were deleted due to the zero bill criteria.

Aggregation to Site ID Level

As mentioned above, one concern with aggregating to the Site ID level is that there may be control numbers associated with a different premise number, service address, or corporation number that are in the same physical site and are being affected by the installed measures. Therefore, a comparison was made between the engineering energy impact and the aggregated pre- and post-installation bills to identify any customers where this problem of bill aggregation may exist. There were 15 participants that were identified as having total Commercial Sector Program energy impacts that were greater than their pre-installation, and were dropped from the analysis. The large majority of these customers were also found to have invalid usage.

Large Customers

Customers whose annual pre-installation energy consumption exceeded three million kWh were excluded from the billing analysis. A total of 40 participants and 58 nonparticipants were dropped for this reason. This decision was made *a priori* to collecting the survey data, as is documented in the Evaluation Research Plan; and is based upon the results of the previous three Lighting Evaluations, all of which were unsuccessful in obtaining reliable results when including customers with usage above this level. This is also consistent with the recommendations made by the Verification Reports of PG&E's 1995 through 1997 Commercial Lighting Evaluations, which stated in 1995 that "program effects can be difficult to detect for large customers," and recommended censoring large customers for the final billing analyses.

Although the decision to censor these customers was made *a priori*, large participants and nonparticipants were still surveyed (as discussed above in the *Section 3.1, Sample Design*) in order to meet other evaluation objectives.

Exhibit 3-20
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria
Customers with Invalid Billing Data

Participant or Nonparticipant	Zero Monthly Bills >= 4	Usage Tripled or Cut by a Third	Measure Caused Increase in Usage	Number Removed From Analysis
NP	NO	YES	NO	2
NP	YES	NO	NO	9
NP	YES	YES	NO	3
TOTAL				14
P	NO	NO	YES	6
P	NO	YES	NO	4
P	YES	NO	NO	9
P	YES	YES	NO	9
TOTAL				28

In summary, out of the original sample frame of 589 nonparticipants, 71 were removed for bad billing data or for being an extremely large customer. This low attrition rate can be attributed to the fact that the nonparticipant sample was pre-screened for invalid billing data (though not for large usage, as they may have served as a control group for the participants). Of the original sample of 255 HVAC and lighting participants, 70 were removed because of bad billing, improper site aggregation, or because they were large customers. Of these 70 customers, 47 were lighting participants.

Exhibit 3-21 summarizes the total number of participants and nonparticipants that were removed from the billing analysis. Exhibits 3-22 and 3-23 present the final sample sizes used in the billing analysis by business type and technology for participants and by business type for nonparticipants.

Exhibit 3-21
Distribution of Customers Removed from Billing Analysis By Data Censoring Criteria

Participant or Nonparticipant	Zero Monthly Bills >= 4	Usage Tripled or Cut by a Third	Measure Caused Increase in Usage	Large Customer	Bill Not Aggregated Properly	Number Removed From Analysis
NP	NO	NO	NO	YES	NO	57
NP	NO	YES	NO	NO	NO	1
NP	NO	YES	NO	YES	NO	1
NP	YES	NO	NO	NO	NO	9
NP	YES	YES	NO	NO	NO	3
Total Nonparticipants						71
P	NO	NO	NO	NO	YES	5
P	NO	NO	NO	YES	NO	37
P	NO	NO	YES	NO	NO	6
P	NO	YES	NO	NO	NO	3
P	NO	YES	NO	NO	YES	1
P	YES	NO	NO	NO	NO	4
P	YES	NO	NO	NO	YES	3
P	YES	NO	NO	YES	NO	2
P	YES	YES	NO	NO	NO	2
P	YES	YES	NO	NO	YES	6
P	YES	YES	NO	YES	NO	1
Total Participants						70
Total Lighting Participants						47

Exhibit 3-22
Billing Analysis Sample Used Post-Censoring Indoor Lighting End-Use Technologies

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen						1							1
	Compact Fluorescent Lamps	3	4	1	5	1	3	1	3			5		26
	Exit Signs	5	3		1			3				2		14
	Efficient Ballast Changeouts	4										1	1	6
	T-8 Lamps and Electronic Ballasts	25	10		4	3	6	2	1	2	2	11	5	71
	Delamp Fluorescent Fixtures	12	6		3					1			1	23
	High Intensity Discharge												1	1
	Controls										1			1
Total		49	23	1	13	4	10	6	4	3	3	19	8	143

Exhibit 3-23
Billing Analysis Sample Used
Post-Censoring
Nonparticipants

Program and Technology Group	Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Nonparticipant Total	122	71	4	51	30	30	30	37	29	29	54	31	**518**

3.3.6 Model Specification

The billing regression analysis for the Commercial Program Evaluation used two different multivariate regression models under an integrated framework of providing unbiased and robust model estimates in the commercial sector. The key feature of the approach is that it employs a simultaneous equation approach to account for both the year-to-year and cross-sectional variation in a manner that consistently and efficiently isolates program impacts.

A baseline model is initially estimated using only the comparison (nonparticipant) group sample. This model estimates a relationship that is then used to forecast what the post-installation-year energy consumption for participants (as a function of pre-installation year usage) would have been in the absence of the program. In this way, baseline energy usage is forecasted for participants by assuming that their usage will change, on average, in the same way that usage did for the comparison group.

The resulting SAE coefficients from the first baseline model are used to adjust the engineering estimates of expected annual energy impacts for the entire participant population. These impacts are presented in *Section 4* and are used to compute program realization rates.

Baseline Model

The baseline model explains post-installation energy usage as a function of the pre-installation energy usage, weather changes, and customer self-reports of factors that could affect energy usage. In order to isolate the program impact from the energy usage changes, only the comparison group is used to fit this model. The baseline model has the following functional form:

$$kWh_{post,i} = \sum_j (\beta_j kWh_{pre,i}) + \gamma(\Delta CDD_i) * kWh_{pre,i} + \sum_k \eta_k NChg_{i,k} + \varepsilon$$

Where,

$kWh_{post,i}$ and $kWh_{pre,i}$ are nonparticipant i's annualized energy usage for the post- and pre- installation periods, respectively;

ΔCDD_i are the annual change of cooling degree days (base 62°F) between the post-installation year and pre-installation year;

$NChg_{i,k}$ are the nonparticipant self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses, and changes in number of employees and in facility square footage;

β, γ and η are the estimated slopes on their respective independent variables. Separate slopes on pre-usage are estimated by business type; and,

ε is the random error term of the model.

For each customer in the analysis dataset (participants and nonparticipants), a post-installation predicted usage value is calculated using the parameters of the baseline models estimated for the 1996 to 1999 analysis period. They both take the same functional form with different segment-level intercept series and slopes (β and γ):

$$k\hat{W}h_{post,i} = F_{pre}(kWh_{pre}, \Delta CDD) = \sum_j (\beta_j kWh_{pre,i}) + \gamma(\Delta CDD_i) * kWh_{pre,i}$$

It should be noted that the post-installation predicted usage is not a function of changes that occurred at the premise. As was discussed in *Section 3.1, Sample Design,* the control group was chosen to represent the participant sample with respect to business type and usage. It is very unlikely that the control group could be considered a representative control group for the types of changes that have occurred at the premise, simply because the participants are all installing some type of equipment and only a fraction of the nonparticipants are making changes. Furthermore, participants are installing rebated high efficiency equipment (HVAC, Lighting and other) through the program, so it is unlikely that the other HVAC and Lighting equipment changes made outside the program are similar to those made by nonparticipants. Finally, it is likely that changes made by participants outside the program will have interaction effects with the measures rebated. Therefore, the incremental effects of participant changes made outside the program on energy usage will be different than those of the nonparticipants. For these reasons, the customer self-reported change variables from the survey data ($NChg_{i,k}$), were not included in the estimate post-installation predicted usage. The SAE model discussed below did include the participant and nonparticipant self-reported change variables to control for the differences between actual and predicted post-installation usage.

This issue was a major point of contention during the verification study of the 1996 CEEI Evaluation. The recommendation made by the verification study was to include the change variables in the estimation of the post-installation predicted usage. However, the Independent Reviewers agreed with PG&E that these change variables should not be included in the post-installation predicted usage.

PG&E and Quantum Consulting, who has acted as PG&E's evaluation contractor for the past five years, met with the ORA's verification contractor, ECONorthwest, to discuss this issue in more detail. ECONorthwest agreed that applying the nonparticipant parameters for the change variables to the participants was not correct for the reasons described above. However, ECONorthwest raised an additional concern regarding the lack of inclusion of nonparticipants in the second stage SAE Model. ECONorthwest suggested the use of a switching regression[8] to address their concerns with the inclusion of the nonparticipants. PG&E and Quantum Consulting researched this approach and successfully implemented the technique in last year's Evaluation. The switching regression technique is again adopted for this year's analysis.

Exhibit 3-24 summarizes the final baseline model results that were estimated using 518 nonparticipant customers, as discussed in the *Data Censoring* section.

Exhibit 3-24
Billing Regression Analysis Final Baseline Model Outputs

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
Pre-Usage					
Office	OFFICE7	kWh	0.864184	31.75	122
Retail	RETAIL7	kWh	0.875604	25.99	71
School	SCHOOL7	kWh	0.927060	27.91	51
College	COLLEGE7	kWh	1.015876	14.36	4
Grocery	GROCERY7	kWh	0.884046	25.38	30
Restaurant	RESTRNT7	kWh	0.782524	21.42	30
Hospital	HOSP7	kWh	0.903020	25.84	30
Hotel/Motel	HOTMOT7	kWh	0.917125	30.48	37
Warehouse	WHRSE7	kWh	0.789896	20.74	29
Personal Service	PERSVC7	kWh	0.855987	11.40	29
Comm. Servcie	COMMUN7	kWh	0.858758	17.41	54
Miscellaneous	MISC7	kWh	0.978857	13.37	31
Weather Changes					
Change in CDD CliZone 1,2,3,4,5	CDD1_97	CDD*kWh	-0.000273	-4.61	232
Change in CDD CliZone 11,12,13,16	CDD11_97	CDD*kWh	-0.000097	-2.88	286
Other Site Changes					
Lighting Changes	LGT_CHG7	kWh	0.100211	5.14	60
HVAC Changes	AC__CHG7	kWh	0.008429	0.49	71
Other Equipment Changes	OTH_CHG7	kWh	-0.035692	-1.53	42
Square Footage Changes	SQFT_CH7	# Sqft*kWh	-1.012276	-1.50	20
Employee Changes	EMP_CHG7	# Emp*kWh	332.980301	3.16	413
EMS Changes	EMS_CHG7	kWh	-0.024088	-1.86	82

Exhibit 3-24 above summarizes the independent variables used in the baseline model, together with the t-statistics and the sample sizes available for each parameter estimate used to predict the post-period usage. The final functional relation is estimated as follows:

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[8] For a fuller explanation of switching regressions refer to:

Green, W., "Econometric Analysis," Macmillan Publishing Company, NY, 1990, pp. 748-750.

Maddala, G. S., "Limited-Dependent and Qualitative Variables in Econometrics," Cambridge University Press, Cambridge, 1987, pp. 283-290.

Baseline Model (1997 to 1999):

$$\begin{aligned} k\hat{W}h_{99,i} = & \ 0.86 * OFFICE7 + 0.88 * RETAIL7 + 0.93 * SCHOOL7 + 1.02 * COLLEGE7 \\ & + 0.88 * GROCERY7 + 0.78 * RESTRNT7 + 0.90 * HOSP7 + 0.92 * HOTMOT7 \\ & + 0.80 * WHRSE7 + 0.86 * PERSVC7 + 0.86 * COMMUN7 + 0.98 * MISC7 \\ & - 0.000273 * CDD1\_97_{99-97,i} * kWh_{97,i} - 0.000097 * CDD11\_97_{99-97,i} * kWh_{97,i} \end{aligned}$$

SAE Model

Using the predicted post-installation usage values estimated in the baseline model, a simultaneous equation model is specified to estimate the SAE coefficients on energy impact. The SAE simultaneous system can be described as follows:

$$\begin{aligned} kWh_{99,i} - k\hat{W}h_{99,i} &= kWh_{99,i} - F_{97}(kWh_{97}, \Delta CDD) \\ &= \sum_m \beta_m^{'} Eng_m + \sum_k \rho_k^{'} PChg_{i,k} + \sum_k \eta_k^{'} NChg_{i,k} + \mu_i \end{aligned}$$

Where,

$kWh_{99,i}$ and $kWh_{97,i}$ are customer i's annualized energy usage for the post- and pre-installation periods, respectively;

ΔCDD_i are the annual change of cooling degree days (base 62°F) between the post-installation year and pre-installation year;

$\beta_m^{'} Eng_m$ are the participant engineering impacts;

$PChg_{i,k}$ are the participant self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses, and changes in number of employees and in facility square footage;

$NChg_{i,k}$ are the nonparticipant self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses, and changes in number of employees and in facility square footage;

The difference between predicted and actual usage in 1999 was used as the dependent variable in a SAE model. Based upon the estimated participation month, the pro-rated engineering estimates and change variables were used to explain the deviation of the actual usage from the predicted usage. As discussed above, the predicted usage is estimated using only the comparison group to forecast the 1999 usage as a function of 1997 usage and change of cooling degree days from 1997 to 1999. This usage prediction presents what would have happened in the absence of any changes made at the facility, either rebated or done outside of the program.

3.3.7 *Billing Regression Analysis Results*

The coefficients of the engineering impact, termed the SAE coefficients, are then used to calculate the ex post gross energy impacts. Independent realization rates are estimated to provide PG&E with business type- and technology group-level results. Exhibit 3-25 summarizes the final SAE model results that were estimated using 703 customers (185 participants and 518 nonparticipants), as discussed in the *Data Censoring* section. The exhibit illustrates the independent variables used in the SAE model, together with the t-statistics and the sample sizes available for each parameter estimate.

Exhibit 3-25
Gross Billing Regression Analysis Final Model Outputs

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients					
Lighting End Use					
Lighting Offices	LGTOFF7	kWh	-0.824743	-3.05	50
Lighting Retails	LGTRET7	kWh	-0.891237	-1.32	23
Lighting Schools	LGTSCH7	kWh	-0.779395	-1.01	14
Lighting Miscellaneous	LGTMSC7	kWh	-0.596705	-1.34	56
HVAC End Use					
Retrofit Express Measures	RETXHVC	kWh	-1.150815	-1.38	42
Custom HVAC	CUSTHVC	kWh	-0.757689	-1.36	6
Other End Uses					
Other Impacts	OTHMEAS7	kWh	0.100398	0.05	18
Change Variables					
Part Lighting Changes	LGT_CHG7	kWh	-0.019670	-0.72	18
Part HVAC Changes	AC__CHG7	kWh	-0.064773	-2.53	28
Part Other Equipment Changes	OTH_CHG7	kWh	-0.025256	-0.38	4
Part Square Footage Changes	SQFT_CH7	# Sqft*kWh	11.647230	4.79	6
Part Employee Changes	EMP_CHG7	# Emp*kWh	611.527341	1.27	27
Part EMS Changes	EMS_CHG7	kWh	0.049254	2.64	38
Nonpart Lighting Changes	LGT_NON7	kWh	0.100211	5.94	60
Nonpart HVAC Changes	AC__NON7	kWh	0.008429	0.60	71
Nonpart Other Equipment Changes	OTH_NON7	kWh	-0.035692	-1.86	42
Nonpart Square Footage Changes	SQFT_NO7	# Sqft*kWh	-1.012276	-1.60	20
Nonpart Employee Changes	EMP_NON7	# Emp*kWh	332.980301	3.38	598
Nonpart EMS Changes	EMS_NON7	kWh	-0.024088	-2.54	82

The dependent variable is the difference between the actual and predicted 1999 usage using the 1997 baseline model.

SAE coefficients are calculated for six different combinations of business type and measure. Primarily those measures that have broad participation and relatively high expected impacts were supported by separate SAE coefficients. In addition, a separate SAE coefficient was calculated for other Commercial Program measures outside the Lighting and HVAC end uses.

Attempts were made to estimate the SAE coefficients at a finer level of segmentation, but generally either one of two problems were encountered. First, available sample sizes were too small to support a finer level of segmentation. Or second, certain parameters were correlated with each other and needed to be combined into a single parameter (a standard econometric solution to solving the problem of collinearity). For example, it was determined that there was a high incidence of compact and standard fluorescent installations at the same site in office buildings. Therefore, there was enough correlation between the compact and fluorescent engineering estimates to warrant combining the two estimates into a single office estimate in the model. Because of the high incidence of many types of lighting fixtures being installed at the same premise, the level of segmentation for the lighting population was conducted by business type. Impact estimates from the MDSS for other end uses were included in the model for customers that installed measures outside the Lighting and HVAC end uses. It is not recommended that this value be used because the sample may not be representative of the population of participants installing these measures.

In addition to the SAE Coefficients, independent variables were included to capture changes in lighting, HVAC and other equipment, made outside of the program, as well as changes made to the size (square footage) of the building and with the number of employees. Separate change variables were developed for participants and nonparticipants for the reasons discussed above.

The final SAE coefficients for the Lighting end use is provided in Exhibit 3-26. The SAE coefficient is multiplied by the evaluation estimates of gross energy impact to calculate the gross ex post energy impacts.

Exhibit 3-26
Commercial Indoor Lighting Gross Energy Impact SAE Coefficients
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs	Comm. Svcs.	Misc.
Retrofit Express	Halogen	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Compact Fluorescent Lamps	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Exit Signs	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Efficient Ballast Changeouts	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	T-8 Lamps and Electronic Ballasts	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Delamp Fluorescent Fixtures	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	High Intensity Discharge	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Controls	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Controls	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60

Relative Precision Calculation

Relative precision at 90 percent and 80 percent confidence levels for the adjusted gross energy impact estimates are calculated for each of the SAE analysis segments. There are a total of four analysis segments that were explicitly modeled, and the relative precision estimates based upon the model output are presented in Exhibit 3-27 below. In order to calculate the total program level adjusted gross impact and relative precision, the segment-level results were weighted by their unadjusted engineering energy impact estimates in the following equations.

$$\text{Total Adjusted Energy Impact} = \sum_i \beta_i Eng_i$$

Where β_i and Eng_i are the SAE coefficients and unadjusted engineering impact estimates for segment i, respectively. The program level standard error can be estimated as:[9]

$$\text{StdErr} = \sqrt{\sum_i (CV_i * \beta_i * Eng_i)^2}$$

Where,

$CV_i = \frac{std(\beta_i)}{\beta_i}$ is the coefficient of variation in segment i, estimated in the billing regression model.

Finally, the relative precision at 90 percent and 80 percent confidence levels were calculated as:

$$RP = \frac{t * StdErr}{\text{Total Adj. Energy Impact}}$$

Where,

t equals 1.645 and 1.282 for the 90 percent and 80 percent confidence levels, respectively.

Exhibit 3-27 presents the relative precision calculations.

***Exhibit* 3-27**
Relative Precision Calculation

SAE Analysis Level	Gross Engineering Energy Impact (kWh)	SAE Coefficient	t-Statistic	Relative Precision at 80%	Relative Precision at 90%
Lighting End Use					
Lighting Offices	6,630,243	-0.82	3.05	42%	54%
Lighting Retails	1,565,894	-0.89	1.32	97%	125%
Lighting Schools	1,802,245	-0.78	1.01	128%	164%
Lighting Miscellaneous	3,861,148	-0.60	1.34	96%	123%
Lighting Total	13,859,529	-0.76	3.47	37%	47%

9 This procedure assumes that the samples in different segments are independent and can be treated as strata in a stratified sampling.

3.3.8 Net Billing Analysis

In addition to conducting a billing analysis to estimate gross energy impacts, a net billing analysis was performed, with the objective of estimating SAE coefficients that could be applied to gross engineering estimates to calculate net energy impact. As with the gross billing model, the net billing model specification also incorporates both participants and nonparticipants into one model.

A disadvantage of combining both participants and nonparticipants into one model of net energy savings is that the resulting sample is not randomly determined. In particular, participants self-select into the program and therefore are unlikely to be randomly distributed. There are certain unobserved characteristics that influence the decision to participate. If these characteristics are not accounted for in the model, the net savings model could produce biased coefficient estimates.

One solution to this problem is to include an Inverse Mills Ratio in the model to correct for self-selection bias. This method was developed by Heckman (1976, 1979)[10] and is used by others (Goldberg and Train, 1996[11]) to address the problem of self-selection into energy retrofit programs. This assumes that the unobserved factors that are influencing participation are distributed normally. Including an Inverse Mills Ratio in the model as an explanatory variable controls for the influence of the characteristics that cause participants to self-select into the retrofit program. This corrects for the self-selection bias in the net savings regression as the unobserved factors affecting participation are now controlled for in the model. As a result, standard regression techniques should produce unbiased coefficient estimates.

Goldberg and Train (1996) developed the technique of including a second Inverse Mills Ratio in the savings regression to account for the possibility that participation is correlated with the size of energy savings. The second Mills Ratio is interacted with a measure of energy savings, which allows the amount of net savings to vary with participation. The rationale for the second term is that those customers who have potentially large savings are more likely to participate in the program. Consequently, the unobserved factors that are influencing participation are also affecting the amount of savings.

To calculate the Inverse Mills Ratios, a probit model of program participation is estimated separately for the Lighting and HVAC retrofit programs. Once the probit model is estimated, the parameters of the participation model are used to calculate an Inverse Mills Ratio for both participants and nonparticipants. This Mills Ratio is included in a net savings regression that combines both participants and nonparticipants into one model. If the Mills Ratio controls for those unobserved

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[10] Heckman, J. '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, Vol. 5, pp. 475-492, 1976.

Heckman, J. "Sample Selection Bias as a Specification Error." Econometrica, Vol. 47, pp. 153-161, 1979.

[11] Goldberg, Miriam and Kenneth Train. 'Net Savings Estimation: An analysis of Regression and Discrete Choice Approaches', prepared for the CADMAC Subcommittee on Base Efficiency by Xenergy, Inc. Madison, WI, March 1996.

factors that determine participation (i.e. the self-selection bias), and the other model assumptions are met, then the net savings model will produce unbiased estimates of net savings.

A description of the methods used for this application are given in the following sections. The following sections describe the data and variables used for the probit participation model and give the estimation results. A description of how the Inverse Mills Ratio is used in the Net Billing Model is also discussed, along with the estimation results from the Net Billing Model. Finally, a presentation of alternative model specifications is provided.

Probit Model of Participation

The first stage of calculating the Mills Ratio is to develop a probit model of Lighting Program participation. The probit model is a discrete choice model with a dependent variable of either zero or one indicating whether or not an event occurred. In this application, individuals receive a value of one if they received a rebate in 1998 for participating in a CEEI Lighting Program and a zero otherwise. The sample includes 190 Lighting Program participants and 4,983 Lighting nonparticipants (which includes HVAC participants that did not have lighting measures rebated), and includes information obtained from the telephone surveys, as well as billing data. All but 6 of the 5,177 survey respondents were used to estimate the participation probit for the Lighting Program[12].

Using the probit specification, the decision to participate in the Lighting Program is given by:

$$\text{PARTICIPATION} = \alpha + \beta' X + \gamma Y + \vartheta' Z + \varepsilon$$

A description of the explanatory variables is given in Exhibit 3-28. The dependent variable PARTICIPATION has a value of one if the customer received a rebate in 1998 for participating in a CEEI Lighting Program and a zero if they did not participate. The independent variables used are those characteristics that are likely to influence program participation. The first set of variables (X) used in the participation probit indicate whether a respondent was aware of the CEEI lighting program prior to 1998. There are three of these variables. The first is AWARE, which takes a value of one if a respondent indicates awareness. The second and third awareness variables will take on a value of one if the respondent is aware prior to 1998, **and** claims to have been informed of the program by their lighting contractor (LT_INFO) or their PG&E representative (PGE_INFO). Including these variables allows the model to differentiate between respondents who simply claim they were aware, and those who also state the source of their information. The latter group is likely to have more complete and accurate information about the program, and therefore will be affected in a different way by their awareness. The second group of variables (Y) reflect the building characteristics. Examples of these include ownership, recent changes at the facility, as well as total energy use. The third group of variables (Z) contain information on business type and type of lighting. Finally, the error term (ε) is assumed to be normally distributed for the probit specification.

[12] These 6 respondents were excluded due to incomplete billing data, which was necessary for constructing one of the independent variables (USE) in the probit regression model.

Exhibit 3-28
Variables Used in Lighting Probit Model

Variable Name	Units	Variable Type	Description
INTERCEPT	NA	NA	Constant
AWARE	0,1	X	Aware of program prior to 1998
ARCOOL	0,1	Y	Cooling equipment was added and removed since 1/97
B4_78	0,1	Y	Building was constructed before 1978
EMPCHG	0,1	Y	Employee change by 10% since 1/97
FLOR	0,1	Z	Fluorescent is main type of lighting
GROCERY	0,1	Z	Grocery
HEALTH	0,1	Z	Health Care Building
HID	0,1	Z	Primary lighting is HID
HOTEL	0,1	Z	Hotel
INCAN	0,1	Z	Incandescent is primary type of lighting
LT_INFO	0,1	X	Made aware of the program by lighting contractor
MISCCOM	0,1	Z	Miscellaneous commercial building
OFFICE	0,1	Z	Office building
OWN	0,1	Y	Own building
PERSONL	0,1	Z	Personal services building
PGE_INFO	0,1	X	Made aware of the program by PG&E representative
RESTR	0,1	Z	Restaurant
RETAIL	0,1	Z	Retail building
SCHOOL	0,1	Z	School
SFADD	0,1	Y	Square footage added to the facility
SHTLEASE	0,1	Y	Lease less than 1 year long
USE	KwH	Y	Energy use in 1997
TENACT	0,1	Y	Tenants active in equipment purchse decisions
WARE	0,1	Z	Warehouse

Probit Estimation Results

The estimation results for the Lighting probit are given in Exhibit 3-29. The results are partially supportive of a priori expectations. For the Lighting probit, customers who were aware of the program prior to 1998 are more likely to participate in the Lighting program. Further, those who were aware of the program prior to 1998 and received program information from their Lighting contractor or their PG&E representative were more likely to participate. Size, as indicated by energy use, has a positive effect on the probability of participation. Those who own their facility, or are active tenants are also more likely to participate. Finally, facilities with fluorescent lighting as their primary lighting technology are more likely to participate. These results all conform to expectations. However, the effects of the the two change variables do not conform to expectations. The three change variables (ARCOOL, EMPCHG, and SFADD) produced negative coefficient estimates. Six of the nine building type variables produced negative coefficients. With the exception of healthcare and warehouse (HEALTH, WARE), all of the building type variables produced statistically insignificant coefficient estimates. Our results show that awareness, size, as indicated by energy use, and ownership are very strong predictors of participation in the HVAC program, while the effect of other factors is less easily understood.

Exhibit 3-29
Lighting Probit Estimation Results

Variable Name	Units	Variable Type	Coefficient Estimate	Standard Error	Significance Level
INTERCEPT	NA	NA	-3.23	0.22	1%
AWARE	0,1	X	0.86	0.10	1%
ARCOOL	0,1	Y	-0.25	0.13	5%
B4 78	0,1	Y	0.05	0.09	60%
EMPCHG	0,1	Y	-0.07	0.13	23%
FLOR	0,1	Z	0.92	0.13	1%
GROCERY	0,1	Z	-0.29	0.26	26%
HEALTH	0,1	Z	-0.57	0.23	1%
HID	0,1	Z	0.28	0.32	39%
HOTEL	0,1	Z	0.06	0.24	79%
INCAN	0,1	Z	-0.21	0.26	41%
LT INFO	0,1	X	0.36	0.15	1%
MISCCOM	0,1	Z	-0.03	0.18	86%
OFFICE	0,1	Z	0.02	0.14	87%
OWN	0,1	Y	0.65	0.17	1%
PERSONL	0,1	Z	-0.59	0.23	1%
PGE INFO	0,1	X	0.42	0.12	1%
RESTR	0,1	Z	-0.28	0.21	2%
RETAIL	0,1	Z	0.06	0.16	71%
SCHOOL	0,1	Z	0.02	0.20	91%
SFADD	0,1	Y	-0.12	0.19	52%
SHTLEASE	0,1	Y	-0.72	0.30	2%
USE	kWh	Y	4.15E-07	2.13E-07	5%
TENACT	0,1	Y	0.71	0.18	1%
WARE	0,1	Z	-0.55	0.28	5%

Once the probit model is estimated, the coefficient estimates are used to calculate the Inverse Mills Ratio for use in the net savings regression. The product of all of the independent variables and respective coefficient estimates are used in the following calculation:

$$\text{Mills Ratio} = \phi(Q) / \Phi(Q) \text{ (for participants)}$$

$$= -\phi(Q) / \Phi(-Q) \text{ (for nonparticipants)}$$

Where,

$$Q = \alpha + \beta' X + \gamma Y + \vartheta' Z$$

The function ϕ is the standard normal probability density function and Φ is the standard normal cumulative density function. Again, this Inverse Mills Ratio is used to control for unobserved factors that may influence both program participation and the amount of energy savings achieved for measures done within the program. In the following sections, the Inverse Mills Ratio is included in the net billing regression as an additional explanatory variable to correct for the problem of self-selection into the Lighting Program.

Net Billing Model Specification

The net billing regression analysis for the Commercial Program Evaluation uses the same two-stage approach as the gross billing analysis, with two significant differences. In fact, the net billing model uses the exact same model specification as the baseline model (for the first stage). Refer to the previous section for baseline model results. The SAE models differ between the net and gross billing analyses in the following ways:

- The Mills Ratios, corresponding to each end use, are included as two separate independent variables.
- The Mills Ratios are also interacted with the engineering impact estimates for each corresponding technology. The engineering impacts alone are not used in the second stage model.

The resulting SAE coefficients on the energy impacts (that have been interacted with the Mills ratios) are then used to adjust the engineering estimates of expected annual energy impacts (the original SAE coefficients) for the entire participant population. This is one estimate of net ex post energy impacts. The net billing analysis model has the following functional form:

$$\begin{aligned} kWh_{99,i} - k\hat{W}h_{96,i} &= kWh_{99,i} - F_{97}(kWh_{97,i}, \Delta CDD_i) \\ &= \vartheta_1 Mills_{Light,i} + \vartheta_2 Mills_{HVAC,i} + \sum_m \delta_m Mills_{Light,i} * Eng_{Light,m,i} \\ &+ \sum_m \delta_m Mills_{HVAC,i} * Eng_{HVAC,m,i} + \sum_k \eta_k' NChg_{i,k} + \sum_k \rho_k' PChg_{i,k} + \varepsilon \end{aligned}$$

Where,

$kWh_{99,i}$ and $kWh_{97,i}$ are customer i's annualized energy usage for the post- and pre-installation periods, respectively;

ΔCDD_i are the annual change of cooling degree days (base 62°F) between the post-installation year and pre-installation year;

$NChg_{i,k}$ are the nonparticipant self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses, changes in number of employees and square footage;

$PChg_{i,k}$ are the participant self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses, changes in number of employees and square footage;

$Mills_{Light,i}$ is the Mills Ratio for the Lighting end use for customer i;

$Mills_{HVAC,i}$ is the Mills Ratio for the HVAC end use for customer i;

$Eng_{Light,m,i}$ are the engineering impact estimates for Lighting technology m, customer i;

$Eng_{HVAC,m,i}$ are the engineering impact estimates for HVAC technology m, customer i;

ϑ and δ are the coefficients on the individual Mills ratios, and on the Mills ratios interacted with the engineering energy impacts, respectively;

ε is the random error term of the model.

This net SAE model was run with the same set of 518 nonparticipants and 185 participants that were used in the gross billing analysis model. The results of the model are presented in Exhibit 3-30. The parameter estimates, t-statistics and sample sizes are presented for all of the net SAE coefficients and Mills ratios.

Exhibit 3-30
Net Billing Regression Analysis Final Model Outputs

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
Mills Ratios					
Lighting	LRMILLS	Unitless	7309.376033	1.19	703
HVAC	HRMILLS	Unitless	2565.422514	0.29	703
SAE Coefficients					
Lighting End Use					
Lighting Offices	LGTOFFM	Mills * kWh	-0.465558	-2.89	50
Lighting Retails	LGTRETM	Mills * kWh	-0.662977	-1.25	23
Lighting Schools	LGTSCHM	Mills * kWh	-0.600164	-0.90	14
Lighting Miscellaneous	LGTMSCM	Mills * kWh	-0.450717	-1.85	56
HVAC End Use					
Retrofit Express Measures	RETXHVM	Mills * kWh	-0.600785	-1.15	42
Custom HVAC	CUSTHVM	Mills * kWh	-0.45317	-1.25	6
Change Variables					
Part Lighting Changes	LGT_CHG7	kWh	-0.021378	-0.78	18
Part HVAC Changes	AC__CHG7	kWh	-0.067164	-2.57	28
Part Other Equipment Changes	OTH_CHG7	kWh	-0.055311	-0.88	4
Part Square Footage Changes	SQFT_CH7	# Sqft*kWh	11.673152	4.75	6
Part Employee Changes	EMP_CHG7	# Emp*kWh	567.081509	1.17	27
Part EMS Changes	EMS_CHG7	kWh	0.045470	2.42	38
Nonpart Lighting Changes	LGT_NON7	kWh	0.100325	5.93	60
Nonpart HVAC Changes	AC__NON7	kWh	0.009045	0.64	71
Nonpart Other Equipment Chan	OTH_NON7	kWh	-0.035328	-1.84	42
Nonpart Square Footage Chang	SQFT_NO7	# Sqft*kWh	-0.998534	-1.58	20
Nonpart Employee Changes	EMP_NON7	# Emp*kWh	335.619754	3.40	598
Nonpart EMS Changes	EMS_NON7	kWh	-0.023125	-2.42	82

The parameter coefficients from the net billing model represent net participation within that technology (having accounted for self-selection). From these estimates, we can now "back out" an estimate of free-ridership, by taking the product of these coefficients with their Mills ratio and dividing by the regression coefficients from the gross model. This equation has the following functional form:

$$(1 - FR)_m = \frac{Mills_m * \delta_m}{\beta_m}$$

Where,

$Mills_m$ is the mean Mills coefficient for all customers with technology m;

β_m is the SAE coefficient from the Gross Billing model for technology m; and,

δ_m is the regression coefficient from the Mills Model 1 regression for technology m.

Exhibit 3-31 illustrates the resulting estimate of net, or one minus free-ridership.

Exhibit 3-31
Net Billing Regression Analysis Estimates of (1-FR)

	Mills Model 1		Gross Model		From Probit	
Parameter Descriptions	**Variable Name**	**Parameter Estimate**	**Variable Name**	**Parameter Estimate**	**Mean Mills**	**Resulting (1-FR)**
SAE Coefficients						
Lighting End Use						
Lighting Offices	LGTOFFM	-0.466	LGTOFF7	-0.825	0.749	0.423
Lighting Retails	LGTRETM	-0.663	LGTRET7	-0.891	1.184	0.881
Lighting Schools	LGTSCHM	-0.600	LGTSCH7	-0.779	1.187	0.914
Lighting Miscellaneous	LGTMSCM	-0.451	LGTMSC7	-0.597	1.186	0.896

3.4 NET-TO-GROSS ANALYSIS

An important step in estimating total impacts from the Lighting Program is the calculation of net to gross ratios. Estimated net to gross ratios represent the proportion of net participants in the program. A net participant is defined to be a customer who engaged in retrofit activities as a direct result of the program. In order to calculate a net to gross ratio, estimates of both free ridership and spillover resulting from the program must be made.

The methods used to derive net-to-gross (NTG) results for the Lighting Evaluation are presented in this section. The NTG ratios derived using these methods are applied to the gross ex post energy, demand, and therm impacts to derive net program impacts after customer actions outside the program are accounted for. After a brief discussion of data sources, estimates of free ridership and spillover from self-reported survey data are discussed. This is followed by the more sophisticated statistical modeling techniques that were used to estimate program net effects. A third approach for estimating free ridership using a net billing model was discussed in the previous section. Finally, a comparison of the three sets of results is presented along with the final selection of NTG ratios.

3.4.1 Data Sources

The primary data sources used in the net-to-gross analysis include the 255 HVAC and lighting participants, 589 nonparticipants and 4,333 canvass telephone surveys collected in 1999. Other data used in this analysis include the MDSS and CIS databases, and information from the Advice Filings.

3.4.2 Self-report Methods

On May 20, 1999 the CADMAC approved a waiver that allows the use of self -report based algorithms to estimate free ridership and spillover effects in the event discrete choice and LIRM models fail to produce statistically reliable results. The approved waiver is presented in Attachment 5.

Self-report Method for Scoring Free Ridership

The following discussion explains the methods employed to calculate "self-report" estimates of free ridership amongst program participants (as opposed to "modeled" free ridership estimates based on the discrete choice model). Definitions used for free ridership and net participation among the participant population are presented. Specific scoring algorithms and questions used to identify free riders in the participant survey are also discussed.

<u>Overview of Methodology</u>

Participants involved in the CEEI program can be classified into four basic categories depending on the actions they would have taken in the absence of the CEEI program:

1. In the absence of the CEEI program, the participant would not have installed any new equipment
2. In the absence of the CEEI program, the participant would have installed standard efficiency equipment
3. In the absence of the CEEI program, the participant would have installed high efficiency equipment, but not as soon (more than one year later)
4. In the absence of the CEEI program, the participant would have installed high efficiency equipment at the same time (within the year)

Customers who fall into the first three categories can be considered net program participants in the calculation of first year net impacts. Customers who fall into the fourth category should be considered free riders. The self-report estimates of free ridership were based on these four categories. Data used to calculate the self-report free ridership estimates was collected as part of a telephone survey of 255 CEEI program participants. The survey collected information on the participants' likely lighting retrofit behavior, with regards to the CEEI program. Responses consistent with category 4 were counted towards free ridership. Responses consistent with categories one through three were counted towards net participation.

The questions used to classify responses directly reflect the definition of net participation and free ridership presented above. Respondents were asked what they would have done in the absence of the program. They were asked whether or not they would have adopted high efficiency equipment, and if so, when they would have installed that equipment. Generally, the answers to both of these questions allowed the responses to be classified based on the categories described above. Specific scoring algorithms and the exact text of the corresponding questions are presented below.

Raw results from the self-report free ridership estimates were weighted by the avoided cost associated with a given respondent. Results of the weighted self-report free ridership estimates were then calculated for each technology group. Results are presented at the technology group level, allowing differences in free ridership rates by technology to be examined.

Scoring Method and Scoring Algorithms

Responses were initially scored based on the following questions:

pd110	*Which of the following statements best describes actions your firm would have undertaken had the lighting program NOT existed...* 1 = We would not have changed our lighting system 2 = We would have bought high-efficiency lighting equipment 3 = We would have bought standard efficiency lighting 8 = (Refused) 9 = (Don't Know)
pd115	*Which of the following statements best describes your firm's plans to install HIGH EFFICIENCY lighting had the program NOT existed...* 1 = We would have installed high efficiency lighting at the same time we did it through the program 2 = We would have installed high efficiency lighting within the year 3 = We would have installed high efficiency lighting, but not within the year 4 = We wouldn't have installed high efficiency lighting at all 8 = (Refused) 9 = (Don't Know)

A response counted towards **net participation** (consistent with categories 1 through 3) if:

pd110 = 1 or 3

pd110 = 2 AND pd115 = 3

Under the first condition, the respondent indicated that, in the absence of the program, they would have made no equipment changes, or would have installed standard efficiency equipment. Under the second condition, the respondents indicated that, had the program not existed, they would have installed high efficiency equipment, but not within the year.

A response counted towards **free ridership** if:

pd110 = 2 AND pd115 = 1 or 2

Under this condition the respondent indicated that, in the absence of the program, they would have bought high efficiency equipment, and would have installed it at the same time, or within the year.

In the event the participant was unable to answer question pd110, or provided contradictory answers to pd110 and pd115, the data was considered inconclusive. Specifically, data was considered inconclusive if:

pd110 = 2 AND pd115=4

pd110=2 AND pd115=Refused/Don't Know

pd110 = Refused /Don't Know

Under the first condition the respondent indicated that in the absence of the program, they would have purchased high efficiency equipment. However, when the respondent was asked when they would have purchased this equipment, they stated that they would not have installed high efficiency lighting equipment at all. Under the second and third conditions, the respondent was unable to provide the information requested in questions pd115 or pd110. If any of these conditions applied, a second set of questions was examined to determine free ridership:

pd100	*Before you knew about the Lighting Program, which of the following statements best describes your company's plans to install lighting fixtures? (READ RESPONSES).* 1= You hadn't even considered purchasing new lighting equipment. 2= You were interested in installing lighting equipment, but hadn't yet decided on energy efficient lighting. (i.e. you were considering all your options.) 3= You had already decided to install high efficiency lighting, but probably not within the year. 4= You had already decided to install high efficiency lighting within the year. 8 = (Refused) 9 = (Don't Know)

A response counted toward **net participation** if:

pd100 = 1 or 3

Under this condition, the respondent indicated that, before they knew about the program, they hadn't even considered purchasing high efficiency equipment, or were planning on purchasing high efficiency equipment, but not within the year.

A response counted toward **free ridership** if:

pd100 = 4

Under this condition, the respondent indicated that, before he knew about the program, he had already decided to install high efficiency equipment within the year.

The respondent's answer to pd100 was considered inconclusive if:

pd100 = 2
pd100=Refused/Don't Know

Under the first condition the respondent indicated that they were considering both high and standard efficiency equipment before they knew about the program. Thus, the respondent has not clearly indicated what their behavior would be in the absence of the program. Under the second condition, the respondent was unable to answer question pd100. If either of these conditions held, a third survey question was used to determine free ridership:

pd050	*If you had not replaced this equipment under the program how long would you have waited to replace it?* 1 = You would have replaced the equipment at the same time 2 = You would have replaced the equipment at a year or within a year 3 = You would have replaced the equipment more than a year later 4 = You would not have replaced the equipment at all

The response counted towards **net participation** if:

pd050 = 3 or 4

Under this condition, the respondent indicated that, if they had not replaced their equipment under the program, they would have replaced it at least one year later, or not at all.

The response was not used if:

pd050 = 1 or 2

In this case, the respondent indicated that, had they not replaced the equipment under the program, they would have made the replacement at the same time, or within the year. However, it is unclear whether this question applies to new high efficiency equipment or new standard efficiency equipment. For this reason, the additional condition was not used.

The scoring routine described above classified responses in accordance with the four categories described at the beginning of this section. Respondents who indicated that, in the absence of the program, they 1) would not have done a retrofit; 2) would have bought standard efficiency equipment instead; or 3) would have installed high efficiency equipment, but more than one year later; were counted as net participants. Customers who fit the fourth classification; those who, in the absence of the program, would have installed high efficiency equipment at the same time, were counted as free riders.

If the initial combination of questions (pd110 and pd115), could not classify a response because of a "don't know" or a "refusal" response, then the response to pd100 was examined. Question pd100 made almost the same distinctions as the previous questions. The only difference is that the respondent was asked what they intended to do "before they knew about the retrofit program," as opposed to what they would have done "in the absence of the program." If the response to the initial questions (pd110 and pd115) *and* pd100 were inconclusive, question pd050 was examined. Question pd050 determined when those responding to the additional classification questions would have made the retrofit.

In the absence of a clear response to the first set of questions, the additional classification questions served as an appropriate way to assign responses to one of the four categories described at the beginning of this section. The form of the additional questions was very similar to that of the initial questions.

Data Sources

Data used in deriving the self-report estimates of free ridership included responses from 255 completed telephone surveys of CEEI program participants. The responses included 190 lighting end use adopters. The surveys were conducted between April and August of 1999 as part of a comprehensive telephone survey of CEEI program participants.

Results

Self-reported estimates of free ridership are presented in Exhibit 3-32, below, by technology group. These free ridership rates were developed within technology group by weighting each site by the avoided cost associated with the technology retrofit. Similar to the 1996 and 1997 Program estimates, the technology group with the lowest rate of free ridership was the Delamp Flourescent Fixtures category, comprised of flourescent delamping actions implemented by the respondents. The rate for this group was estimated to be 23.0 percent. The second lowest rate was found among those who installed LED or compact fluorescent exit signs. The ratio for this group was estimated to be 28.2 percent. The highest rate of free ridership was found in the

Controls category, with a rate of 80.3 percent. This unusually high rate is due to a few large customers who were free riders. The unweighted result for the Controls category is a more moderate 41.4 percent.

Exhibit 3-32
Weighted Self-report Estimates of Free Ridership for Lighting Technology Groups

Technology Group	Sample	Free Ridership
Halogen	10	45.6%
Compact Fluorescent Lamps	77	58.2%
Exit Signs	46	28.2%
Efficient Ballast Changeouts	7	49.4%
T-8 Lamps and Electronic Ballasts	157	32.8%
Delamp Fluorescent Fixtures	46	23.0%
High Intensity Discharge	7	42.9%
Controls	29	80.3%
Total - Weighted by Avoided Cost	379	35.9%

Self-report Method for Scoring Spillover

In determining the total net-to-gross ratio for the CEEI program, spillover impacts resulting from the program must be estimated for both program participants and nonparticipants. The overall impact of spillover represents an additional social benefit from the CEEI program, contributing towards total market transformation. The following discussion explains the methods employed to calculate "self-report" estimates of spillover amongst program participants and nonparticipants (as opposed to "modeled" spillover estimates based on the discrete choice model). Definitions used for spillover and net participation among the participant and nonparticipant population are presented. Specific scoring algorithms, and questions used to identify spillover in the surveys are also discussed. The final calculation of spillover impacts is also described.

Overview of Methodology

The self-report methodology is composed of three steps:

- Identification of the spillover rate
- Calculation of the impact per instance of spillover
- Estimation of the spillover contribution to the net-to-gross ratio

The spillover rate is the rate at which the participant or nonparticipant population is adopting non-rebated high-efficiency lighting equipment as a result of being influenced by the CEEI. The spillover rate is estimated using self-reported information from the surveys, as described below. Multiplying the participant or nonparticipant population by the respective spillover rate provides an estimate of the total number of non-rebated high-efficiency adoptions occurring in the participant or nonparticipant population as a result of CEEI program influence.

To estimate the contribution towards the net-to-gross ratio represented by these participants and nonparticipants, a per participant or nonparticipant estimate of impact is required. The estimate of impact per spillover adoption is based on the equipment installed as reported in the surveys. The contribution of spillover to the net-to-gross ratio can then be estimated as:

Participant Spillover:

NTGpart_spill = SP_RATEpart * POPpart*IMPACTpart_spill/IMPACTpop

Where,

NTGpart_spill = the participant contribution of spillover to the net-to-gross ratio

SP_RATEpart = the participant spillover rate

POPpart = the participant population, in number of sites

IMPACTpart_spill = the per participant site impact associated with spillover

IMPACTpop = the total CEEI Program impact

Nonparticipant Spillover:

NTGnp_spill = SP_RATEnp * POPnp*IMPACTnp_spill/IMPACTpop

Where,

NTGnp_spill = the nonparticipant contribution of spillover to the net-to-gross ratio

SP_RATEnp = the nonparticipant spillover rate

POPnp = the nonparticipant population, in number of sites

IMPACTnp_spill = the per nonparticipant site impact associated with spillover

IMPACTpop = the total CEEI Program impact

Identification of the Spillover Rate

The participant and nonparticipant spillover rates were estimated as the ratio of the number of spillover adoptions to the total surveyed population. Thus, the spillover rate reflects the rate at which the participant or nonparticipant population is making non-rebated, high-efficiency lighting equipment adoptions as a result of CEEI program influence.

A spillover adoption was defined as a lighting action taken outside of the program which increases energy efficiency, and occurred as a direct result of the program's influence. In counting the total number of adoptions contributing towards spillover, the following four conditions, which reflect this definition of spillover, were used:

1. the adoption involved the installation of **high efficiency lighting equipment**, as recognized by the CEEI program

2. the respondent was **aware** of the program **before** making the decision to purchase new lighting equipment

3. the adoption was **not rebated** as part of the program

4. the respondent stated that this adoption occurred as a result of the **CEEI program's influence**

In other words, the respondent's knowledge of, awareness of, or participation in the CEEI program encouraged them to install high efficiency equipment outside the program.

After identifying all the equipment adoptions that meet the spillover criteria, the spillover rate was calculated by dividing the total number of spillover adoptions by the total population surveyed. This was done for both participants and nonparticipants.

Identifying Participant Spillover Actions

The three spillover conditions were evaluated in the participant survey by using the following questions:

For Condition 1:

Questions br020 and br099 were used to determine whether or not additional, program qualifying, high efficiency lighting equipment was installed. If a lighting response qualified as a spillover, then the corresponding answer to question br199 was reviewed. This was done to ensure that the spillover measures included all removals associated with a specific spillover installation. The text for these questions were as follows:

br020	*Since January 1997, have you made any changes in indoor lighting at your facility other than routine replacement of burned out bulbs?*
br099	*What types of lighting equipment were added?*
br199	*What types of lighting equipment were removed?*

For Condition 2:

Question br050 and sp060 were used to verify that the out-of-program lighting adoption occurred after the respondent became aware of the Retrofit Program. The question text is as follows:

br050	*Were these changes made after you participated in the Retrofit Program?*
sp060	*Did you become aware of the Retrofit Program before or after you made the decision to purchase your new lighting equipment?*

For Condition 3:

Question br060 was used to determine whether or not additional participant lighting installations were rebated. The question text for br060 was as follows:

br060	*Was your firm paid a rebate by PG&E for these changes in your lighting equipment?*

For Condition 4:

The fourth condition, whether or not the program influenced the respondent's equipment selection, was tested with question sp010. Only those participants who made a non-rebated lighting adoption after they had become aware of the program were asked the final spillover question. Respondents who answered this question but installed standard efficiency equipment types were not counted as spillover. Because of this design, spillover could be calculated based on the response to question sp010, together with data on the efficiency of the installed lighting equipment. The question text for sp010 was as follows:

sp010	*How influential was the Retrofit Express Program in your selection of the additional equipment?* *1 = Not at all influential* *2 = Slightly influential* *3 = Moderately influential* *4 = Very influential*

<u>Participant Spillover Scoring Algorithm</u>

The final scoring algorithm for participant spillover was based on question sp010, in conjunction with data on the efficiency of the installed lighting equipment. This question was used because, as explained above, it was only asked of respondents who made a non-rebated lighting installation after becoming aware of the program. The scoring algorithm is as follows:

If sp010 = 2, 3 or 4
AND equipment is high efficiency
then spillover = 1
else spillover = 0

If a respondent scores a 1 for spillover, they have met all four spillover conditions set forth above. As described above, the total number of spillover adoptions counted using this algorithm was divided by the total number of participant's surveyed to obtain the participant spillover rate.

Participant Self-report Spillover Results

Of the 255 participants surveyed, there were 17 adoptions that met all of the spillover criteria excluding efficiency. Sixteen of these 17 adoptions were of high efficiency equipment, and the remaining one installed standard efficiency equipment. Thus, a total of 16 participants were identified as contributing to lighting spillover. This results in a participant spillover rate of 6.3%. Because there were a total of 566 pre-1998 CEEI participants who received rebates in 1998 yearthis represents a total of 36 participant spillover lighting actions in the population.

Identifying Nonparticipant Spillover Actions

For Condition 1:

As with the participant spillover, questions br020, br099, and br199 were used to determine whether or not additional program qualifying, high efficiency lighting equipment was installed. If a lighting response qualified as a spillover, then the corresponding answer to question br199 was reviewed. This was done to ensure that the spillover measures included all removals associated with a specific spillover installation. The text for these questions and their response values were identical to the ones used in calculating the participant spillover. The text can be found in the explanation of the participant spillover methodology given in the preceding section.

For Condition 2:

Questions is005 and sp060 were used to verify that the respondent was aware of the program before the lighting technology was adopted. The text for these questions was as follows:

is005	*Have you heard of PG&E's Retrofit Express programs?*
sp060	*Did you become aware of the Retrofit Express program before or after you made the decision to purchase your new lighting equipment?*

For Condition 3:

Question br060 was used to determine whether or not additional nonparticipant lighting installations were rebated. The text for this question was identical to the one used in calculating the participant spillover. The text can be found in the explanation of the participant spillover methodology given in the preceding section.

For Condition 4:

The fourth condition, whether or not the program influenced the respondent's equipment selection, was tested with question sp080. Only those respondents who were aware of the program before they made the decision to purchase new lighting equipment, and were not rebated for this purchase were asked the final spillover question. Respondents who answered this question but installed standard efficiency equipment types were not counted as spillover. Because of this design, spillover could be calculated based on the response to question sp080, together with data on the efficiency of the installed lighting equipment. The question text for sp080 was as follows:

sp080	*Did your knowledge of the Retrofit Express program at all influence your lighting equipment selection?* *1 = Not at all influential* *2 = Slightly influential* *3 = Moderately influential* *4 = Very influential*

<u>Nonparticipant Spillover Scoring Algorithm</u>

The final scoring algorithm for nonparticipant spillover was based on question sp080, in conjunction with data on the efficiency of the installed lighting equipment. Again, only respondents who stated that they were aware of the program before making the decision to purchase new lighting equipment, and were not rebated for this purchase, were asked sp080. Thus, the final spillover scoring algorithm was as follows:

If sp080 = 2, 3 or 4

AND equipment is high efficiency

then spillover = 1

else spillover = 0

If a respondent scores a 1 for spillover, they have met all four spillover conditions set forth above. Again, the number of spillover adoptions identified with this algorithm was divided by the number of nonparticipants surveyed to obtain the spillover rate.

Nonparticipant Self-report Spillover Results

Of the 4,923 nonparticipants surveyed, there were 33 adoptions that met all of the spillover criteria excluding efficiency. Of these 33 adoptions, 5 installed standard efficiency equipment, and 24 installed high efficiency equipment. The remaining 4 adoptions had inconclusive data regarding efficiency. These 4 were divided between standard and high efficiency categories based on the distribution of adoptions that met all spillover criteria and had conclusive efficiency information. Thus 24/33 of the 4 remaining adoptions were categorized as spillover actions. Finally, a total of 27.3 adoptions were identified as contributing to lighting spillover.

Nonparticipants' reported lighting adoptions spanning approximately a 30-month period (from January 1997 through approximately June 1999). In order to calculate the 1998 spillover rate, a constant adoption rate over the period was assumed. Thus, the portion of total adoptions captured in the survey assumed to occur in 1998 was calculated by dividing the 12 months in 1998 by the 30 months spanning the entire period, resulting in 40 percent.

The approach to distributing the spillover across the 30-month analysis period is conservative relative to alternative allocation methods. In the 1997 evaluation, we used a different method. Specifically, in 1997 we used the portion of all reported high efficiency lighting adoptions occurring during program year 1997. If we were to use this method in the 1998 evaluation the resulting percent would be slightly higher, 41.7 versus 40.0 percent. A second alternative estimation method would be to mimic the distribution of all non-rebated lighting adoptions, both standard and high efficiency. This method would result in a measurably higher portion allocated to this year's evaluation, 46.9 versus 40 percent. As a third alternative, the portion of all lighting adoptions, including rebated and non-rebated, high-efficiency and standard efficiency adoptions, occurring in 1998 could be used as an estimator. This portion is 47.0 percent and would also yield a higher spillover rate.

There were 416,496 unique sites identified within PG&E's 1998 CIS. After subtracting the 566 participants, this represents a total of 415,930 nonparticipant sites after subtracting the 566 participants. Therefore, given there were a total of 415,930 nonparticipants, the spillover rate represents a total of 963 nonparticipant spillover lighting actions.

Calculation of Impacts Associated With Spillover

Self-reported installation information and the MDSS database were used to calculate the impacts associated with spillover. The reported equipment type and number of units installed from the telephone surveys were used to estimate an impact for each lighting equipment adoption occurring outside of the program. From these estimates, the average impact associated with a spillover adoption could be calculated.

Participant Spillover Impact Calculation

Sixteen adoptions were identified as contributing to spillover. Rather than using only these 16 installations to calculate an average spillover impact, the entire survey sample of out-of-program, high efficiency installations was used.

Participant respondents made 23 rebated high-efficiency lighting equipment adoptions. These 23 installations were used to estimate the average participant impact associated with spillover. To calculate the impacts associated with spillover, avoided cost was used as a proxy for impact.

The first step was to calculate average avoided cost per adoption for each equipment type. This was determined by multiplying the average avoided cost per fixture by the average number of fixtures installed for each equipment type. The MDSS was used to determine what the average avoided cost per lamp installed was, by equipment type. Survey data regarding out-of-program, high efficiency installations were used to determine the average number of fixtures per installation for each equipment type.

The 23 high efficiency installations were then used to determine the distribution of installations across equipment types. Applying this distribution, to our estimate of savings by equipment type resulted in an estimate of average avoided cost per participant installation. Exhibit 3-33 below, presents the average avoided cost per installation by fixture type, along with the distribution of installations across fixture type. This method yielded an estimate of the average avoided cost per participant spillover adoption of $15,617.

Exhibit 3-33
Participant Adoption Distribution

Fixture Type	*# Fixtures*	*#Lamps Per Fixture*	*Per Lamp Av Cost*	*Total Av Cost*	*Distribution of Installs*
4 Foot T8 Fixtures	214	2.5	23	$12,301	43%
Incandescent to Flourescent	87	1	344	$29,971	9%
HID fixtures-Standard	100	1	942	$94,247	4%
Compact Flourescents-Screw In Modular	92	1	82	$7,496	17%
Compact Flourescents-Hardwire	30	1	328	$9,842	4%
Electronic Ballasts	372	1	14	$5,151	17%
Occ Sensor	85	1	254	$21,568	4%
Weighted Average *by Distribution of Installs*	190		123	$15,617	

Nonparticipant Spillover Impact Calculation

Approximately 27 nonparticipant adoptions were identified as contributing to spillover. Rather than using only these 27 installations to calculate an average spillover impact, the whole survey sample of out-of-program high efficiency lighting installations was used.

There were 264 non-rebated high efficiency lighting equipment adoptions made by nonparticipant respondents. These installations were used to estimate the average nonparticipant impact associated with spillover. To calculate the impacts associated with spillover, avoided cost was used as a proxy for impact.

The first step was to calculate average avoided cost per adoption for each equipment type. This was done by multiplying the average avoided cost per fixture by the average number of fixtures installed, for each equipment type. The MDSS was used to determine the average avoided cost per fixture, and survey data was used to identify the average number of fixtures per installation.

The 264 high efficiency installations were then used to determine the distribution of installations across equipment type. Applying this distribution to our estimates of savings by equipment type resulted in the overall average avoided cost per nonparticipant installation. Exhibit 3-34 below, presents the average avoided cost per nonparticipant installation by fixture type, along with the distribution of installations across fixture type. Exhibit 3-34 below, presents the average avoided cost per installation by fixture type, along with the distribution of installations across fixture type. Based on the distribution of the 264 high efficiency nonparticipant installations, the average avoided cost per nonparticipant was estimated to be $4,889.

It should be noted that the average avoided cost associated with a nonparticipant installation contributing towards spillover was just 31% of the average avoided cost associated with a participant installation contributing towards spillover.

Exhibit 3-34
Nonparticipant Adoption Distribution

Fixture Type	# Fixtures	#Lamps Per Fixture	Per Lamp Av Cost	Total Av Cost	Distribution of Installs
2 Foot T8 Fixtures	26	2	30	$1,545	8.76%
4 Foot T8 Fixtures	63	2.5	23	$3,610	35.59%
8 Foot T8 Fixtures	17	2	42	$1,473	5.93%
Incandescent to Flourescent	59	1	344	$20,187	6.92%
HID fixtures-Standard	11	1	942	$10,132	7.95%
HID fixtures-Compact	37	1	334	$12,341	1.89%
Compact Flourescents-Screw In Modular	13	1	82	$1,084	7.20%
Compact Flourescents-Hardwire	25	1	328	$8,061	3.79%
Exit Signs-CF	23	1	93	$2,149	1.14%
Exit Signs-LED	114	1	168	$19,089	1.51%
Halogens	25	1	8	$195	7.20%
Install Reflecters	4	2	89	$710	0.76%
Electronic Ballasts	169	1	14	$2,344	9.47%
Time Clock	2	1	101	$203	0.76%
Occ Sensor	3	1	254	$634	0.76%
Photocell	2	1	20	$40	0.38%
Weighted Average *by Distribution of Installs*	53		146	$4,889	

Calculating the Contribution of Spillover to the Total Net to Gross Ratio

As discussed above, the contribution of spillover to the total net-to-gross ratio can be estimated as follows:

Participant Spillover:

NTGpart_spill = SP_RATEpart * POPpart*AV_COSTpart_spill/AV_COSTpop

Where,

NTGpart_spill = the participant contribution of spillover to the net-to-gross ratio

SP_RATEpart = the participant spillover rate

POPpart = the participant population, in number of sites

AV_COSTpart = the per participant site avoided cost associated with spillover

AV_COSTpop = the total avoided cost for the CEEI Program

Nonparticipant Spillover:

NTGnp_spill = SP_RATEnp * POPnp*AV_COSTnp_spill/ AV_COSTpop

Where,

NTGnp_spill = the nonparticipant contribution of spillover to the net-to-gross ratio

SP_RATEnp = the nonparticipant spillover rate

POPnp = the nonparticipant population, in number of sites

AV_COSTnp = the per nonparticipant site avoided cost associated with spillover

AV_COSTpop = the total avoided cost for the CEEI Program

These equations are identical to those presented earlier, with the exception of using avoided cost as a proxy for impact. Each of the components required for calculating the contribution to participant and nonparticipant spillover have been identified and are discussed above, except for the total avoided cost. The total avoided cost as reported in the MDSS is $8,133,760 for Lighting. Because the 1998 program year was a carry-over program only, the total avoided cost is significantly lower than in previous years; in 1997 the total avoided cost was $59,140,572, over 7 times the 1998 total value.

Participant Spillover NTG Calculation

Exhibit 3-35 presents the participant spillover contribution to the net-to-gross ratio applying the equation above and using all of the previously described results. The total resulting contribution to the net-to-gross ratio made by participants is 6.82%.

Exhibit 3-35
Participant Spillover Estimate

Avoided Cost Per Participant	$15,617
Spillover Rate	6.27%
Number of Participants	566
Number Contributing to Spillover	36
Spillover Avoided Cost	$554,629
Lighting Avoided Cost	$8,133,760
NTG Contribution from Participant Spillover	**6.82%**

Nonparticipant Spillover NTG Calculation

Exhibit 3-36 presents the nonparticipant spillover contribution to the net-to-gross ratio applying the equation above and using all of the previously described results. The total resulting contribution to the net-to-gross ratio made by nonparticipants is 55.48%. This final result appears significantly different than previous years' results. However, all of the values shown in the table below are similar to previous years' results, with the exception of the lighting avoided cost and the final result. For example, the impact of nonparticipant spillover adoptions, expressed in avoided cost, was $4,137,013 in 1997, and the 1998 carry-over program value is similar, at $4,512,847. The final result is significantly different because the total program avoided cost for 1998 is a fraction what it was in previous years. The lighting program total avoided cost for 1998 was $8,133,760, less than 15% of the 1997 value. If the 1998 program year avoided cost were identical to 1997, the nonparticipant spillover rate would be a much more moderate 7.63%.

Exhibit 3-36
Nonparticipant Spillover Estimate

Avoided Cost Per Nonparticipant	$4,889
Spillover Rate	0.222%
Number of Nonparticipants	415,930
Number Contributing to Spillover	923
Spillover Avoided Cost	$4,512,847
Lighting Avoided Cost	$8,133,760
NTG Contribution from Nonparticipant Spillover	**55.48%**

3.4.3 Discrete Choice Model

A two-stage discrete choice model is used to simulate the decision to purchase commercial lighting equipment. The results of this model are used to estimate both a net-to-gross ratio and the free ridership rate associated with the CEEI program. This section contains a detailed description of the two-stage model used in the discrete choice analysis.

The probability of purchasing any given equipment option A can be expressed as the product of two separate probabilities: the probability that a purchase is made multiplied by the probability that equipment option A is chosen given that a purchase has been made. This can be written as:

*Prob (Purchase & Equipment A) = Prob(Purchase) * Prob(Equipment A | Purchase)*

The two-stage model adopted for this analysis estimates both of the right hand side probabilities separately. The first stage of the model estimates the probability that a customer makes a lighting equipment purchase and is referred to as the **purchase probability**. The second stage of the model estimates the type of lighting equipment chosen given that the decision to purchase has already been made and is referred to as the **equipment choice probability**. The product of the purchase probability and the equipment choice probability is the **total probability** and reflects the probability that any one lighting equipment option is purchased. Once estimated, the model is used to determine the probability of purchasing high-efficiency equipment in the absence of the Lighting Program. This is simulated by setting the rebate and program awareness variables to zero in both stages of model.

The net-to-gross ratio is calculated using the total probability of purchasing high-efficiency lighting equipment both with and without the existence of the retrofit program. The expected impact with the program is the total probability of choosing high-efficiency equipment multiplied by the energy impact of the equipment. Similarly, the expected energy impact in the absence of the Lighting Program is the total probability of purchasing high-efficiency equipment without the program multiplied by the energy impact of the equipment. The net-to-gross ratio is the net savings due to the program divided by the expected energy impact that results from having the program. As discussed below, this method is also used to determine free ridership rates and spillover.

Data Sources for the Net-to-Gross Analysis

The data used for the net-to-gross analysis are a combination of telephone survey information and program information contained in the MDSS dataset. The sample is divided into purchase and nonpurchase groups. Those that purchased lighting equipment either in or outside the program are in the purchase group while those that made no purchases are in the nonpurchase group.

The sample used to estimate the purchase model contains information on 3,227 customers, who made 1,065 lighting purchases. Of these, 2,751 are nonparticipants that did not make any lighting equipment purchases either in or outside the program. There were 476 customers who purchased lighting equipment between January of 1997 and July of 1999. Of those that did make lighting equipment purchases, 197 customers did so within the lighting program. Two hundred and forty customers purchased high efficiency equipment outside the program. Finally, 57 customers reported purchasing standard lighting equipment. Some customers made more than one type of purchase.

Stage 1 -- Purchase Model Specification

The purchase decision is specified as a logit model with a dependent variable having a value of either zero or one. In this application, customers are given a value of one if they made a lighting equipment purchase either in or outside the program and a zero if they did not purchase any lighting equipment. The purchase decision model specification is defined as:

$$PURCHASE = \alpha + \beta'X + \gamma'Y + \vartheta'Z + \varepsilon$$

Variable definitions are given in Exhibit 3-37. The explanatory variables X contain information on rebate and program awareness that capture the effect of the Lighting Program. Building characteristics such as square footage and changes to the facility are contained in Y. Variable group Z contains variables indicating building type and type of lighting. The error term ε is assumed to be distributed logistic, consistent with the logit model specification.

There are four variables specified to capture the effect of the Lighting Program on the decision to make a purchase, AWARE, LT_INFO, PGE_INFO and CINDEX. For AWARE, customers are given a value of one if they indicated that they were aware of the retrofit program before they made the decision to purchase new lighting equipment. If they became aware of the program after or at the same time they selected the equipment, they are given a value of zero for AWARE. This definition of awareness is used to take into account that the process of shopping for lighting equipment may result in some customers becoming aware of the Lighting Program. When awareness is set to zero to simulate the absence of the program, only those who started shopping after they became aware of the program will be affected since it is assumed that the program influenced them to shop for new lighting equipment. This definition of program awareness avoids the problem of having program awareness affect those customers who were already looking for lighting equipment when they became aware of the program.

Similar to the 1997 Lighting Program Evaluation, the variables LT_INFO and PGE_INFO are included to enhance the model's ability to identify the effects of program awareness. These two variables can take the value of either zero or one. LT_INFO takes on a value of one if:

1) the respondent was aware of the program prior to making the decision to purchase new lighting equipment, and

2) the respondent indicated they were informed of the program by their lighting contractor

PGE_INFO is defined similarly, but indicates that the respondent was informed of the program through their PG&E representative. Respondents who state they were aware of the program **and** are also able to state their source of information are likely to be more accurately and completely informed about the program. Perhaps more importantly, the addition of these two variables reduces the concern evaluators commonly have with customers falsely claiming they are aware of the program. Allowing the impact of awareness to vary over these types of respondents improves the model's ability to interpret the impact of awareness. We expect that those who state they were aware of the program, and cite one or both of these two sources of information, will be more affected by their awareness.

Seventy-six percent of program participants were aware of the Lighting Program prior to making the decision to purchase their lighting equipment (compared to 82% in 1997). Among those that did not make any lighting purchases, 18 percent were aware of the lighting program. For the entire sample, 22 percent of the customers were coded as being aware of the Lighting Program.

Of those participants who were aware of the program, 23 percent claimed to have been made aware of the program by their lighting contractor. Those who stated that their PG&E representative told them about the program comprised 56 percent of the participants who were aware. Among nonparticipants who were aware, 12 percent received program information from their lighting contractor; 25 percent from their PG&E representative. Overall, 14 percent of those who were aware received information from their lighting contractor, and 32 percent from their PG&E representative.

The variable CINDEX gives the fraction of the cost of the lighting equipment that is paid by the customer and is defined by the cost of the equipment minus any rebate divided by the cost of the equipment:

$$CINDEX = (Cost - Rebate) / Cost$$

For those that did not purchase lighting equipment or were unaware of the program when the lighting equipment was selected, the expected rebate is zero. This results in a CINDEX value of one since the anticipated cost of the measure is paid entirely by the customer. Similarly, for those that made a purchase and were aware of the program, the expected rebate is nonzero and CINDEX takes on a value less than one.

Exhibit 3-37
Purchase Model Variable Definitions

Variable Name	Units	Variable Type	Description
AWARE	0,1	X	Aware of program prior to purchase
ARCOOL	0,1	Y	Cooling equipment was added and removed since 1/97
B4_78	0,1	Y	Building was constructed before 1978
CINDEX	ratio	X	(Cost-Rebate)/Cost
EMPCHG	0,1	Y	Employee change by 10% since 1/97
FLOR	0,1	Z	Fluorescent is main type of lighting
GROCERY	0,1	Z	Grocery
HEALTH	0,1	Z	Health Care Building
HID	0,1	Z	Primary lighting is HID
HOTEL	0,1	Z	Hotel
INCAN	0,1	Z	Incandescent is primary type of lighting
LT_INFO	0,1	X	Made aware by lighting contractor prior to purchase
MISCCOM	0,1	Z	Miscellaneous commercial building
OFFICE	0,1	Z	Office building
OWN	0,1	Y	Own building
PERSONL	0,1	Z	Personal services building
PGE_INFO	0,1	X	Made aware by PG&E representative prior to purchase
RESTR	0,1	Z	Restaurant
RETAIL	0,1	Z	Retail building
SCHOOL	0,1	Z	School
SFADD	0,1	Y	Square footage added to the facility
SHTLEASE	0,1	Y	Lease less than 1 year long
SQFEET	Square ft.	Y	Square footage of facility
TENACT	0,1	Y	Tenants active in equipment purchse decisions
WARE	0,1	Z	Warehouse

Purchase Model Estimation Results

The estimation results from the purchase model are given in Exhibit 3-38. A likelihood ratio test yields a test statistic of over 2313 with 25 degrees of freedom, which is well above the critical value at any of the conventional levels of significance. In addition, Exhibit 3-39 shows that the estimated probability of making a purchase is relatively high for those customers who made purchases both in and outside the program, which conforms to *a priori* expectations. These factors suggest that the purchase model does have significant explanatory power.

The coefficient estimates from the purchase model are shown in Exhibit 3-38. As expected, program awareness has a notable positive effect on the decision to purchase lighting equipment. Further, this effect is greater if either their lighting contractor or PG&E representative informed the respondent of the program.

Exhibit 3-38
Purchase Model Estimation Results

Variable Name	Variable Type	Coefficient Estimate	Standard Error	Significance Level
AWARE	X	0.88	0.12	1%
ARCOOL	Y	0.23	0.13	8%
B4_78	Y	0.61	0.11	1%
CINDEX	X	-4.83	0.25	1%
EMPCHG	Y	0.31	0.14	3%
FLOR	Z	1.57	0.14	1%
GROCERY	Z	-0.14	0.29	63%
HEALTH	Z	0.31	0.21	15%
HID	Z	0.80	0.37	3%
HOTEL	Z	-0.18	0.34	60%
INCAN	Z	0.45	0.21	3%
LT_INFO	X	0.77	0.20	1%
MISCCOM	Z	-0.07	0.22	77%
OFFICE	Z	0.44	0.17	1%
OWN	Y	1.21	0.18	1%
PERSONL	Z	0.08	0.22	72%
PGE_INFO	X	0.48	0.17	1%
RESTR	Z	0.27	0.23	24%
RETAIL	Z	0.28	0.19	15%
SCHOOL	Z	0.09	0.25	70%
SFADD	Y	0.81	0.20	1%
SHTLEASE	Y	-0.81	0.27	1%
SQFEET	Y	1.12E-06	3.11E-07	1%
TENACT	Y	1.27	0.19	1%
WARE	Z	-0.51	0.30	9%

The coefficient estimate for CINDEX is negative. This suggests that the greater the percentage of costs that are paid by the customer, the less attractive it is to make a purchase. The variables reflecting building ownership (OWN) and the role tenants play in equipment decisions (TENACT) also have a positive and significant effect on the likelihood of a lighting purchase. The facility size variable (SQFEET) is also positive, indicating that larger facilities are more likely to make lighting purchases. Not surprisingly, changes to the facility (ARCOOL, SFADD, EMPCHG) are also likely to lead to a lighting equipment purchase.

The variable B4_78 is a dummy variable indicating whether a building was constructed before 1978. The coefficient estimate for B4_78 is positive, confirming our expectation that older buildings would be more likely to be in need of new lighting equipment. The variable SHTLEASE is a dummy variable indicating whether a tenant has a lease less than one year long. The coefficient estimate for this variable is negative, confirming our expectation that tenants with shorter leases would be less likely to purchase new lighting equipment.

The estimated model parameters are used to calculate the probability of making a lighting equipment purchase. With the logit model, the probability of purchasing is given by:

$$PURCHASE = exp\,(Q) \,/\, 1 + exp\,(Q)$$

where $Q = \alpha + \beta' X + \gamma' Y + \vartheta' Z$

The estimated probabilities for different customer groups are given in Exhibit 3-39. As expected, Lighting Program participants have a high probability of making an equipment purchase with an estimated purchase probability of 0.63. Conversely, those that did not make any purchases have a low estimated probability of purchasing new lighting equipment at 0.14.

Exhibit 3-39
Estimated Purchase Probabilities

Customer Group	With Program	Without Program
No Purchase	0.14	0.11
Participants	0.63	0.23
Purchase HE Outside Program	0.37	0.21
Purchase Std Efficiency	0.21	0.17

The probability of making a lighting equipment purchase in the absence of the program is calculated by removing the effect of the Lighting Program from the purchase decision model. This is done by setting AWARE, LT_INFO and PGE_INFO equal to zero and setting CINDEX equal to one to reflect the absence of a rebate. The probability of making a lighting purchase is then recalculated using the logistic density function given above. All other variable values remain the same, as they are not expected to change in absence of the program.

The new probabilities of a lighting purchase in the absence of the Lighting Program are also given in Exhibit 3-39. In the absence of the Lighting Program, the probability of purchasing lighting equipment among participants drops from 0.63 to 0.23. This indicates that many of those who purchased lighting equipment would not have done so without the Lighting Program. The Lighting Program also decreases the probability that those outside the program will purchase new lighting equipment. For those purchasing high-efficiency equipment outside the program, removing the program decreases the probability of a purchase from 0.37 to 0.21.

Stage 2 -- Equipment Choice Model Specification

The second stage of the model is devoted to estimating the probability that a specific lighting equipment option is chosen given that the decision to purchase lighting equipment has already been made. This second stage of the model is specified as a conditional logit and is described below.

A conditional logit specification is used to model the equipment choice decision given that the decision has already been made to purchase lighting equipment. The choice set for the equipment choice model contains nine different options: compact fluorescents, controls, exit signs, halogen, reflectors, T-8's, interior HID's, standard fluorescents (T-10's or T-12's), and incandescent fixtures. In the logit model, customers are given a value of 1 for the dependent variable for the option they actually chose and a zero for the remaining eight nonchosen alternatives.

The conditional logit model specification for equipment choice is:

$$\text{EQUIPMENT CHOICE} = \beta'\text{AWARE} + \beta'\text{LT\_INFO} + \beta'\text{PGE\_INFO} + \beta'\text{PREDISP} + \beta'\text{SQFEET} + \beta'\text{CINDEX} + \beta'\text{SAVINGS} + \Sigma\, \beta'\text{BLDTYPE} + \varepsilon$$

Where AWARE = Awareness of the retrofit program at the time of purchase

LT_INFO = Respondent was made aware by lighting contractor prior to purchase

PGE_INFO = Respondent was made aware by a PG&E representative prior to purchase

PREDISP = Predisposition towards high efficiency equipment

SQFEET = Square footage of the facility

CINDEX = (cost – rebate) / cost

SAVINGS = Annual dollar amount of electricity savings expected from equipment

BLDTYPE = Vector of dummy variables indicating building type

ε = Random error term assumed logistically distributed.

The explanatory variables used in the equipment choice model are described in Exhibit 3-40. In this stage of the model, a customer is considered aware of the program (AWARE = 1) if he became aware of the program before or at the same time he selected the lighting equipment. This is slightly different from the definition of awareness used in the purchase model, where a customer is coded as aware only if they became aware before they began shopping for new lighting equipment. Awareness is redefined in the equipment choice model since, although program awareness does not encourage all customers to make a purchase, it will tend to influence more people to purchase high efficiency if they are aware of the program at the time they make the purchase. This modified definition of aware is applied to the other awareness variables: LT_INFO and PGE_INFO. That is, LT_INFO was given a value of one if the respondent was aware of the program at the time new lighting equipment was purchased **and** received program information from their lighting contractor. PGE_INFO takes a value of one if the respondent was similarly aware, **and** was informed of the program by their PG&E representative.

Exhibit 3-40
Equipment Choice Model Variable Definitions

Variable Name	Units	Description
AWARE	0,1	Aware of program at time of purchase
CINDEX	ratio	(Cost-Rebate)/Cost
GROCERY	0,1	Grocery
HEALTH	0,1	Health Care Building
HOTEL	0,1	Hotel
LT_INFO	0,1	Made aware of the program by lighting contractor
MISCCOM	0,1	Miscellaneous commercial building
OFFICE	0,1	Office building
PERSONL	0,1	Personal services building
PGE_INFO	0,1	Made aware of the program by PG&E representative
PREDISP	0,1	Predisposition to buying high efficiency
RESTR	0,1	Restaurant
RETAIL	0,1	Retail building
SCHOOL	0,1	School
SAVINGS	dollars	Expected dollar amount of electricity savings
SQFEET	Square ft.	Square footage of facility
WARE	0,1	Warehouse

A characteristic of the conditional logit specification is that variables that do not vary over choices will drop out of the model.[13] For instance, firmographic variables such as size do not vary across the equipment options and therefore cannot be included in the model. One way to avoid this problem is to interact firmographic variables with choice specific dummy variables. This method is used in this application to allow for firm specific variables such as size, building type, and program awareness to influence equipment choice. All of the variables except CINDEX and SAVINGS are interacted with a dummy variable for the high efficiency equipment options. As a result, these variables have positive values for seven of the nine choices and values of zero for the two standard efficiency choices.

For those that purchased high efficiency lighting within the retrofit program or were aware of the lighting program, survey information was available that helped identify those customers that might be predisposed to purchasing high efficiency equipment even if the program did not exist. For those that indicated that they would have installed high efficiency lighting even if the program had not existed, the variable PREDISP has a value of one, otherwise PREDISP has a value of zero.

[13] For a fuller explanation of the conditional logit model and its properties, see Greene (1990) pp. 699-703.

As in the purchase model, cost and rebate information is combined into one variable called CINDEX. As before, CINDEX is determined by calculating the fraction of the cost that the customer must pay for equipment installation after any rebate has been paid. For those that are unaware of the retrofit program and for standard equipment options not covered by the program, CINDEX has a value of one.

Estimation of Cost, Savings, and Rebates

A requirement of the conditional logit specification is that information must be included in the model for all of the choices in the choice set and not just for the option that is actually selected. As a result, data on equipment characteristics is needed for the nonchosen equipment alternatives as well as for the equipment option actually chosen. How this information is calculated for nonchosen equipment alternatives is described below.

For those customers that installed high-efficiency equipment within the Lighting Program, the reported cost, savings, and rebate data are used in the model. For those customers who installed high-efficiency equipment outside of the Lighting Program, the costs are determined from vendor prices of equipment and the Advice Filings. These per unit costs are multiplied by the number of reported fixtures installed to determine the total cost of the lighting retrofit. Energy savings are calculated by multiplying the noncoincident demand savings for a given technology by the electricity rate, number of fixtures installed, and the operating hours for that customer.

For the nonchosen equipment options, cost, savings, and rebate information is assigned based on available data in the MDSS and customer surveys. For each of the lighting equipment options, the cost per square foot is determined from those who reported installing the technology. Based on these customers, the median cost per square foot is calculated for each technology. Finally, an installation cost for a nonadopted technology is estimated by multiplying the square footage of the site by the median cost per square foot for that technology. The estimated savings for nonadopted technologies are estimated in a similar manner using the median savings per square foot based on those who reported installing the technology.

To calibrate these estimates, the costs for the equipment actually chosen by the customer is estimated using the method described above. The estimated costs are then compared with the reported cost information. The ratio of estimated costs to reported costs is used as an adjustment factor for the estimated costs and savings for all nonchosen equipment alternatives.

Expected rebate amounts are determined using a similar method. The average ratio of rebate to installation cost is calculated for program participants for each technology. To get an estimated rebate for those that did not choose the technology, the rebate-to-cost ratio for the technology is multiplied by the estimated cost of installation to get the expected rebate associated with the installation. If a person was unaware of the program, the expected rebate amount is automatically set to zero for all equipment options. The costs, savings, and rebate calculations are summarized below.

Actual Equipment Option Chosen – In Program: Uses the reported cost, savings, and rebate information from the MDSS.

Actual Equipment Option Chosen – Outside Program: Costs and savings are calculated using the reported number of units installed and equipment cost information contained in the Advice Filing.

Non Chosen Equipment Alternatives: Costs are estimated by multiplying the square footage of the facility by the median cost per square foot from the MDSS associated with that technology. Savings are assigned using the same method. Rebate amount is determined by multiplying the expected cost of the technology by the rebate-to-cost ratio for that technology. For those unaware of the retrofit program, rebate is set to zero for all program qualifying equipment options.

Equipment Choice Model Estimation Results

The estimation results for the equipment choice model are given in Exhibit 3-41. In general, the estimation results conform to expectations. The coefficient estimate on CINDEX is negative, indicating that the greater portion of the installation cost a customer must pay himself, the less attractive the equipment option. The estimate for SAVINGS is positive and significant, indicating the higher the savings associated with a particular equipment option, the more attractive that option is.

The remaining variables are all interacted with a dummy variable indicating a high efficiency equipment option. The coefficient estimate on AWARE is positive and significant, indicating that those that are aware of the retrofit program are more likely to purchase high efficiency equipment. Further, both LT_INFO and PGE_INFO are strongly positive, indicating the effect of awareness is greater for those who were made aware of the program through either their lighting contractor or their PG&E representative.

Also as was expected, the coefficient estimate on PREDISP is positive, indicating that those identified as predisposed to purchasing high efficiency do in fact tend to choose high efficiency equipment. SQFEET is the square footage of the facility interacted with a dummy variable for the high efficiency equipment options. The coefficient estimate on SQFEET is positive, indicating a tendency for larger firms to purchase high efficiency equipment. The remaining variables indicate business type. Of these, only RESTR (restaurant) and WARE (warehouse) have positive coefficient estimates. Of all the business types, only HEALTH (healthcare) and HOTEL are statistically significant at the 90 percent confidence level.

Exhibit 3-41
Equipment Choice Model Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
AWARE	1.82	0.38	1%
CINDEX	-0.27	0.32	40%
GROCERY	-0.63	0.69	36%
HEALTH	-0.70	0.40	8%
HOTEL	-0.71	0.85	4%
LT_INFO	1.96	1.04	6%
MISCOM	-0.40	0.52	44%
OFFICE	-0.35	0.29	22%
PERSONL	-0.49	0.40	22%
PREDISP	0.39	0.45	39%
PGE_INFO	1.28	0.65	5%
RETAIL	-0.05	0.40	89%
RESTR	0.68	0.44	12%
SAVINGS	5.90E-05	1.22E-05	1%
SCHOOL	-0.77	0.61	21%
SQFEET	1.17E-06	8.60E-07	17%
WARE	0.20	0.78	80%

Using the coefficient estimates from the purchase model, the probability of choosing any particular equipment option is calculated. Using the conditional logit density function, the probability of selecting equipment option j is given by:

$$P_j = \exp(\beta' X_j) / \Sigma \exp(\beta' X)$$

where $\beta' X_j$ is the product of the variables and coefficient estimates used in the equipment choice model for equipment option j and the denominator is the sum of $\beta' X$ across all nine equipment options in the choice set.

As is done with the purchase probability, the equipment choice probability is calculated both with and in the absence of the program. To simulate the absence of the program, AWARE, LT_INFO and PGE_INFO are set to zero and CINDEX is set to one for all of the lighting equipment options.

Net-to-Gross Calculation

Once both the purchase probability and the equipment choice probability are estimated, the two probabilities are multiplied together to determine the total probability that a purchase is made and that an individual equipment option is selected. This total probability is calculated twice. First, the total probability is calculated using the original values for the program variables AWARE, LT_INFO, PGE_INFO and CINDEX. This gives the total probability with the existence of the program. Next, the total probability is calculated in absence of the program. This is done by setting the awareness variables equal to zero and CINDEX equal to one to reflect the absence of rebates. While the awareness variables are set to zero, PREDISP retains its original value since this variable captures the effect of those that are predisposed to high efficiency equipment who would likely purchase the equipment even if the Lighting Program did not exist.

The estimated impacts are weighted up to the population based on participation. Participants are weighted to reflect the Lighting Program participation population in the MDSS. Nonparticipants are assigned weights based on the nonparticipant population represented in the sample. For those that reported making a lighting purchase since January of 1997, the weight was scaled down to reflect the portion of those adoptions that would have occurred during the pre-1998 program year carry-over. To estimate this portion a constant adoption rate over the 2 and ½ year period was assumed. That is, the 12 months of 1998 were divided by the 30 months spanning the period over which reported adoptions took place, which results in 40 percent. This percentage is used to adjust the nonparticipant weight. Finally, those that reported purchasing lighting outside the program since 1997 and receiving a rebate from PG&E were given a weight of zero since these impacts were already counted toward a program other than the Pre-1998 Lighting Program Carry-Over.

To calculate expected impacts, the total probability of making a purchase with the program is multiplied by the gross impact associated with the technology. The expected impact is then summed across the seven high efficiency equipment options to get a total expected impact for each customer. The calculation is given by:

$$\text{EXPECTED IMPACT}^{W} = \Sigma\, P^{W}_{j} * \text{IMPACT}_{j}$$

Where P^{W}_{j} = Total probability of choosing equipment option j with the program

IMPACT_{j} = One year impact associated with equipment option j.

The expected impact without the program is calculated in the same manner using the total probability in absence of the program:

$$\text{EXPECTED IMPACT}^{WO} = \Sigma\, P^{WO}_{j} * \text{IMPACT}_{j}$$

Where P^{WO}_{j} = Total probability of choosing equipment option j without the program.

The net impact associated with program is simply the difference in expected impacts with and without the program:

$$\text{NET IMPACT} = \text{EXPECTED IMPACT}^{W} - \text{EXPECTED IMPACT}^{WO}_{j}$$

The net-to-gross ratio is then the net impact divided by the expected impact with the program:

$$\text{NTG} = \text{NET IMPACT} / \text{EXPECTED IMPACT}$$

The contributions to net made by participants (less free ridership), and through participant and nonparticipant spillover, can all be calculated separately using the two stage model.

For rebated participant actions, net impacts are calculated using the same method shown above:

$$\text{NET IMPACT}_{P} = \text{EXPECTED IMPACT}^{W}_{P} - \text{EXPECTED IMPACT}^{WO}_{P}$$

For actions done outside the program, net impacts are calculated as:

$$\text{NET IMPACT}_{P\_SP} = \text{EXPECTED IMPACT}^{W}_{P\_SP} - \text{EXPECTED IMPACT}^{WO}_{P\_SP}$$

$$\text{NET IMPACT}_{NP\_SP} = \text{EXPECTED IMPACT}^{W}_{NP\_SP} - \text{EXPECTED IMPACT}^{WO}_{NP\_SP}$$

Spillover is broken out into participant spillover (P_SP), which reflects actions done by current program participants outside the program, and nonparticipant spillover (NP_SP). The net impact for actions done outside the program is then incorporated into the net-to-gross calculations:

$$\text{NTG} = (\text{NET IMPACT}_{P} + \text{NET IMPACT}_{P\_SP} + \text{NET IMPACT}_{NP\_SP}) / \text{EXPECTED IMPACT}^{W}_{P}$$

The expected impacts by building type are shown below in Exhibit 3-42. The net-to-gross ratios are generally higher than in previous years and range from 4.67 for restaurants to 0.71 for community service. As discussed previously, the high level of net-to-gross values are a result of unusually low program gross impacts, which raises the proportional impact of nonparticipant spillover. If nonparticipant spillover were expressed as a percent of the discrete choice results for gross impacts from the 1997 Evaluation, the nonparticipant spillover rate would be about 5 percent, which is consistent with previous years' evaluation results. The smaller gross program impacts for the 1998 Evaluation raise the nonparticipant spillover rate to 32 percent.

The strong variability in the net-to-gross ratios across the building types is explained by characteristics of the nonparticipant population that are exaggerated by the relatively small gross program impacts. For example, restaurants make up about 5 percent of the lighting participant sample, but 9 percent of the nonparticipant sample. Also, the nonparticipant restaurants made more than their share of spillover-qualifying lighting adoptions, at nearly 26 percent. The same is true of the personal service building type. The lighting participant sample is about 3 percent personal service, while the nonparticipant sample is nearly 10 percent personal service. Similar to the case for restaurants, personal service nonparticipants made more than their share of spillover-qualifying lighting adoptions, nearly 18 percent. In the case of the grocery building type, the unusually high nonparticipant spillover is explained by the small program gross impacts; the absolute level of nonparticipant spillover is comparable to previous years. For example, the 1998 grocery nonparticipant spillover is $169 thousand, which is actually somewhat lower than the 1997 level of $232 thousand.

The overall free ridership rate is 0.26. The total spillover rate for participants is 0.02, and nonparticipant spillover is 0.32. Again, nonparticipant spillover is unusually large because of relatively small gross program impacts. These results produce a final overall net-to-gross ratio of 1.08 for the entire Pre-1998 Lighting Program Carry-Over.

Exhibit 3-42
Estimated NTG Ratios by Building Type

Building Type	NTG
Office	1.07
Retail	0.82
College/univ	0.62
School	1.03
Grocery	1.82
Restaurant	4.67
Healthcare	0.87
Hotel	0.88
Warehouse	0.80
Personal Service	1.49
Community Service	0.71
Misc. Com.	1.61

3.4.4 Final Net-to-Gross Ratios

As discussed above, three separate models were implemented to estimate the components of the net-to-gross ratio (free ridership and spillover). The first approach relied on a net billing analysis model and applied the double inverse Mills ratio methodology, which resulted in estimates of free ridership only. The second methodology utilized self-reported estimates of free ridership, participant spillover and nonparticipant spillover to estimate the net-to-gross ratios. The final approach employed a two-stage discrete choice model to estimate free ridership, participant spillover and nonparticipant spillover.

The most sophisticated, and preferred, of the three approaches is the two-stage discrete choice model. The Mills ratios lack the estimate of spillover, and are also run on a reduced set of data due to the censoring of customers billing data. The self-report values rely on customers to give accurate and unbiased responses to their hypothetical actions in the absence of the program.

Exhibit 3-43 presents the results of each model, by business type and for the total program. Results, both within business type and overall, are weighted by the ex-post gross energy impacts. Results are presented for the total net-to-gross ratio, as well as the two primary components, free ridership and spillover. For the Mills ratio methodology, only free ridership is estimated, as discussed above.

Exhibit 3-43
Comparison of Net-to-Gross Ratios

Business Type	Discrete Choice Model NTG	Discrete Choice Model 1-FR	Discrete Choice Model Spill	Self Report NTG	Self Report 1-FR	Self Report Spill	Mills 1-FR
Office	1.07	0.74	0.33	1.29	0.67	0.62	0.75
Retail	0.82	0.77	0.05	1.30	0.68	0.62	1.18
College/Univ	0.62	0.56	0.06	1.20	0.57	0.62	1.19
School	1.03	0.72	0.31	1.28	0.66	0.62	1.19
Grocery	1.82	0.77	1.05	1.26	0.64	0.62	1.19
Restaurant	4.67	0.83	3.84	1.15	0.53	0.62	1.19
Health Care	0.87	0.77	0.10	1.16	0.54	0.62	1.19
Hotel/Motel	0.88	0.88	0.00	1.06	0.44	0.62	1.19
Warehouse	0.80	0.80	0.00	1.31	0.69	0.62	1.19
Personal Svcs.	1.49	0.87	0.62	0.91	0.28	0.62	1.19
Comm. Svcs.	0.71	0.69	0.01	1.23	0.61	0.62	1.19
Misc.	1.61	0.78	0.83	1.24	0.62	0.62	1.19
Total	**1.06**	**0.75**	**0.31**	**1.25**	**0.63**	**0.62**	**0.96**

A comparison of the three models shows that the discrete choice model is reasonably well validated by the self-report results. The free ridership results are reasonably close for the two methods, although both the free ridership and spillover results are somewhat lower for the discrete choice method than for the self-report method. The most notable difference between the two results is for spillover, which is significantly higher for the self-report method.

Even at the business type level, the free ridership results for discrete choice are reasonably close to the self report results. The results are within 20% for all but 4 business types. The spillover results are more disparate, partially due to the inability to conduct this analysis at the business type level.

The Mills ratio method produced a significantly lower estimate of free ridership than either of the other two methods. However, the result for the office business type is well validated by both the discrete choice and self-report results.

The discrete choice method produced the most conservative results, and is the most sophisticated and preferred of the three methods. Furthermore, the overall net-to-gross result is reasonably well validated by the self report results. For these reasons, we choose the discrete choice result for our final net-to-gross ratios.

The final net-to-gross ratios applied to the gross ex-post impacts are based solely on the discrete choice model. As discussed above, these model results are considered to be the most accurate and are reasonably well validated by the self-report results. In addition, the selection of the discrete choice model provides the most conservative estimates of the three approaches. Exhibit 3-44 provides the final net-to-gross ratios by business type. Overall program net-to-gross ratios are also presented, weighted across business type by ex-post gross energy, demand and therm savings, respectively. Please note that although there were no ex ante therm estimates for lighting, there were ex-post estimates based on the HVAC interaction effects.

Exhibit 3-44
Final Net-to-Gross Ratios

Business Type	*NTG*	*1-FR*	*Spill*
Office	1.07	0.74	0.33
Retail	0.82	0.77	0.05
College/Univ	0.62	0.56	0.06
School	1.03	0.72	0.31
Grocery	1.82	0.77	1.05
Restaurant	4.67	0.83	3.84
Health Care	0.87	0.77	0.10
Hotel/Motel	0.88	0.88	0.00
Warehouse	0.80	0.80	0.00
Personal Svcs.	1.49	0.87	0.62
Comm. Svcs.	0.71	0.69	0.01
Misc.	1.61	0.78	0.83
Totals Weighted by:			
Energy	**1.06**	**0.75**	**0.31**
Demand	**1.06**	**0.75**	**0.31**
Therm	**1.11**	**0.74**	**0.36**

4. EVALUATION RESULTS

This section contains the results of the Lighting Evaluation, beginning with ex post gross impacts, then presenting the net-to-gross (NTG) adjustments, and concluding with the program realization rates (ratio of ex post evaluation findings to the ex ante program design estimates), for both gross and net impacts. Explanations of the differences between the ex ante and ex post estimates are discussed in the presentation of program realization rates.

Where segment analysis could be supported, results are presented by technology group and business type. As stated previously, the Pre-1998 Program Carry-Over for lighting technologies had only Retrofit Express participants. Thus, only Retrofit Express data is presented. All results are aggregated to the total commercial sector.

4.1 EX POST GROSS IMPACT RESULTS

Ex post gross energy and demand impacts for the Pre-1998 Program Carry-Over for indoor lighting applications, are presented in Exhibits 4-1 and 4-2, respectively. The ex post gross energy and demand impacts by PG&E costing period are provided in *Attachment* 2. *Attachment* 2 also provides all of the results tables in this section (as well as the ex ante impacts, which are not included in the main body of this report), in a larger, more readable format.

The results in Exhibits 4-1 and 4-2 illustrate the following gross impact findings:

Exhibit 4-1
Ex Post Gross Energy Impacts
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	17,210	3,339	-	825	-	6,341	12,840	-	-	-	8,484	-	49,038
	Compact Fluorescent Lamps	685,757	23,728	182,214	120,695	16,582	70,280	142,386	463,643	5,969	1,539	30,174	220	1,743,187
	Exit Signs	125,471	14,813	28,447	27,266	-	1,276	36,174	3,104	3,998	-	18,364	871	259,784
	Efficient Ballast Changeouts	11,331	-	-	5,304	-	-	-	-	-	-	5,317	1,543	23,494
	T-8 Lamps and Electronic Ballasts	2,515,775	1,054,709	207,531	413,798	103,640	54,795	211,258	32,861	43,136	39,625	168,770	100,349	4,946,250
	Delamp Fluorescent Fixtures	1,973,158	205,677	77,268	275,765	6,029	-	36,169	-	72,710	8,423	32,012	43,992	2,731,204
	High Intensity Discharge	77,817	93,107	-	16,985	-	-	-	-	33,475	-	8,691	132,083	362,159
	Controls	61,728	210	28,908	19,656	1,278	979	74,611	-	434	230,253	25,910	13,373	457,339
Total		5,468,246	1,395,583	524,368	880,293	127,530	133,670	513,439	499,608	159,724	279,841	297,723	292,432	10,572,456

Exhibit 4-2
Ex Post Gross Demand Impacts
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	5	1	-	0.2	-	2	4	-	-	-	3	-	14
	Compact Fluorescent Lamps	180	5	41	32	4	18	40	95	2	0.5	9	0.1	427
	Exit Signs	19	2	4	4	-	0	7	1	1	-	4	0.2	42
	Efficient Ballast Changeouts	3	-	-	1	-	-	-	-	-	-	2	0.5	6
	T-8 Lamps and Electronic Ballasts	660	254	50	111	27	15	65	7	17	13	52	30	1,300
	Delamp Fluorescent Fixtures	518	49	18	74	2	-	11	-	29	3	10	13	727
	High Intensity Discharge	21	22	-	5	-	-	-	-	14	-	3	38	103
	Controls	9	0.0	4	3	0.3	0.2	15	-	0	44	5	3	85
Total		1,414	334	118	230	33	36	143	102	64	61	86	85	2,705

High Participation Business Types – The office and retail business types represent over 60 percent of the energy and demand impacts. The office business type is the largest single segment, accounting for over 50 percent of demand and energy impacts. These business types have historically comprised a large share of lighting program impacts. This is a result of the large number of lighting retrofits performed within these business types.

High Participation Technologies – The three technologies that made the largest contributions to impacts were the replacement of standard-efficiency fluorescent lamps and ballasts with T-8 lamps and electronic ballasts; the installation of optical reflectors in combination with delamping of fluorescent fixtures; the installation of compact fluorescent fixtures to replace incandescent lighting. These three technologies represent approximately 90 percent of the RE program energy and demand savings. T-8 lamps and electronic ballasts alone account for over 45 percent of the gross energy and demand savings. The large impacts attributable to these technologies are driven by the equally large participation within those particular measure categories.

Low Participation Business Types – The lowest energy impacts were contributed by the grocery and restaurant business types, primarily because of fewer and smaller installations made within these segments.

Low Participation Technologies – The lowest energy impacts were contributed by the efficient ballast changeouts, due to the low participation in this segment.

HVAC Interactive Effects – Because of the heating penalty (associated with reduced gas heating usage) during the heating season, the Lighting Program also has therm impacts. These impacts, which are by definition negative, are presented next in Exhibit 4-3.

Exhibit 4-3
Ex Post Gross Therm Impacts
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-8	-1	-	0	-	-5	-4	-	-	-	-5	-	-24
	Compact Fluorescent Lamps	-324	-7	-26	-67	-3	-54	-45	-39	-1	0	-18	0	-583
	Exit Signs	-59	-4	-4	-15	-	-1	-12	0	0	-	-11	0	-107
	Efficient Ballast Changeouts	-5	-	-	-3	-	-	-	-	-	-	-3	0	-12
	T-8 Lamps and Electronic Ballasts	-1,190	-308	-29	-228	-16	-42	-67	-3	-4	-5	-99	-13	-2,004
	Delamp Fluorescent Fixtures	-933	-60	-11	-152	-1	-	-12	-	-7	-1	-19	-6	-1,202
	High Intensity Discharge	-37	-27	-	-9	-	-	-	-	-3	-	-5	-18	-100
	Controls	-29	0	-4	-11	0	-1	-24	-	0	-27	-15	-2	-113
Total		-2,586	-407	-74	-486	-19	-103	-163	-42	-16	-33	-175	-39	-4,143

4.2 *NET-TO-GROSS ADJUSTMENTS*

The NTG results are designed to account for all of the market spillover effects (free-ridership, participant spillover, and nonparticipant spillover) by measure. Exhibit 4-4 presents the NTG values by business type, separating out the effects of free ridership and spillover (note that due to rounding, values may not sum properly). For this Lighting Evaluation, the results from the discrete choice analysis were used.

Exhibit 4-4
NTG Adjustments by Business Type

Business Type	NTG	1-FR	Spill
Office	1.07	0.74	0.33
Retail	0.82	0.77	0.05
College/Univ	0.62	0.56	0.06
School	1.03	0.72	0.31
Grocery	1.82	0.77	1.05
Restaurant	4.67	0.83	3.84
Health Care	0.87	0.77	0.10
Hotel/Motel	0.88	0.88	0.00
Warehouse	0.80	0.80	0.00
Personal Svcs.	1.49	0.87	0.62
Comm. Svcs.	0.71	0.69	0.01
Misc.	1.61	0.78	0.83
Totals Weighted by:			
Energy	**1.06**	**0.75**	**0.31**
Demand	**1.06**	**0.75**	**0.31**
Therm	**1.11**	**0.74**	**0.36**

The overall NTG ratio is 1.06 based on both energy and demand savings, and 1.11 based on therm savings. For energy and demand impacts, free ridership and spillover were approximately 25 and 31 percent, respectively. For therm impacts, free ridership and spillover were 26 and 36 percent, respectively. The variation between energy, demand and therm results is due to the distribution of ex-post energy, demand and therm savings across business types.

4.3 EX POST NET IMPACTS

Exhibits 4-5 and 4-6 present the ex post net energy and demand indoor lighting impacts, for the Pre-1998 Lighting Program Carry-Over.

These exhibits show increases of 6 percent in ex post program energy impacts and demand impacts (when compared to Exhibits 4-1 and 4-2, gross impacts). The increases are a result of the application of the NTG adjustments presented in Exhibit 4-4. T-8/electronic ballast, optical reflectors with delamp, and compact fluorescents still dominate the savings, representing nearly 90 percent of the energy and demand impacts. Among the various business segments, office and retail still dominate the impacts, yielding more than sixty percent of the total program savings.

Exhibit 4-5
Ex Post Net Energy Impacts
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	18,358	2,744	-	850	-	29,634	11,206	-	-	-	5,989	-	68,781
	Compact Fluorescent Lamps	731,504	19,502	113,637	124,406	30,239	328,462	124,265	406,575	4,795	2,291	21,301	355	1,907,332
	Exit Signs	133,841	12,175	17,741	28,104	-	5,962	31,571	2,722	3,211	-	12,964	1,403	249,693
	Efficient Ballast Changeouts	12,087	-	-	5,467	-	-	-	-	-	-	3,753	2,484	23,791
	T-8 Lamps and Electronic Ballasts	2,683,604	866,887	129,426	426,521	189,000	256,092	184,371	28,816	34,648	58,983	119,141	161,555	5,139,044
	Delamp Fluorescent Fixtures	2,104,788	169,050	48,188	284,244	10,995	-	31,566	-	58,402	12,538	22,598	70,824	2,813,193
	High Intensity Discharge	83,008	76,527	-	17,508	-	-	-	-	26,888	-	6,136	212,644	422,710
	Controls	65,846	172	18,028	20,260	2,331	4,573	65,115	-	349	342,734	18,291	21,530	559,229
Total		5,833,036	1,147,058	327,020	907,360	232,564	624,723	448,094	438,114	128,292	416,545	210,173	470,795	11,183,773

Exhibit 4-6
Ex Post Net Demand Impacts
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	5	1	-	0.2	-	8	4	-	-	-	2	-	20
	Compact Fluorescent Lamps	192	4	26	32	7	85	35	83	2	0.7	6	0.1	474
	Exit Signs	20	2	3	4	-	1.3	6	1	1	-	3	0.3	41
	Efficient Ballast Changeouts	3	-	-	1	-	-	-	-	-	-	1	0.7	7
	T-8 Lamps and Electronic Ballasts	704	209	31	114	49	71	56	6	14	19	36	48	1,358
	Delamp Fluorescent Fixtures	552	41	11	76	3	-	10	-	24	4	7	21	749
	High Intensity Discharge	22	18	-	5	-	-	-	-	11	-	2	62	120
	Controls	10	0.0	3	3	0.5	1.0	13	-	0.1	66	4	4	105
Total		1,508	274	74	237	59	166	125	90	51	91	61	137	2,873

Exhibit 4-7
Ex Post Net Therm Impacts
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-9	-1	-	0	-	-23	-4	-	-	-	-4	-	-40
	Compact Fluorescent Lamps	-346	-6	-16	-69	-5	-253	-40	-34	0	0	-12	0	-781
	Exit Signs	-63	-4	-3	-16	-	-5	-10	0	0	-	-8	0	-108
	Efficient Ballast Changeouts	-6	-	-	-3	-	-	-	-	-	-	-2	0	-11
	T-8 Lamps and Electronic Ballasts	-1,269	-253	-18	-235	-29	-197	-59	-2	-3	-7	-70	-22	-2,164
	Delamp Fluorescent Fixtures	-995	-49	-7	-157	-2	-	-10	-	-6	-1	-13	-9	-1,250
	High Intensity Discharge	-39	-22	-	-10	-	-	-	-	-3	-	-4	-29	-106
	Controls	-31	0	-3	-11	0	-4	-21	-	0	-40	-11	-3	-123
Total		-2,758	-335	-46	-501	-35	-482	-143	-37	-13	-49	-123	-63	-4,584

4.4 REALIZATION RATES

Exhibits 4-8 through 4-11 present the gross and net realization rates for energy and demand impacts for the Pre-1998 CEEI Program Carry-Over for lighting technologies. Exhibit 4-12, at the end of this section, summarizes the gross and net ex ante impacts, ex post impacts, and realization rates. Because there were no ex ante estimates for therm impacts, no therm realization rates could be calculated.

4.4.1 Gross Realization Rates for Energy Impacts

The gross energy realization rates are presented in Exhibit 4-8. These values represent, by segment, the ratio of the ex post gross impact evaluation findings to the gross ex ante program design estimates. These realization rates illustrate how well the ex ante estimates predicted energy savings, before taking into account customer behavior effects, both inside and outside the rebate programs. These results vary considerably across business type and technology; from 0.29 to 1.35. The overall result, 0.70 is reasonably close to one.

Exhibit 4-8
Gross Energy Impact Realization Rates
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.17	1.35	-	0.83	-	1.12	1.11	-	-	-	0.82	-	1.07
	Compact Fluorescent Lamps	0.76	0.81	0.69	0.72	0.54	0.49	0.48	0.54	0.46	0.57	0.29	0.46	0.62
	Exit Signs	0.85	0.87	0.79	0.79	-	0.61	0.62	0.60	0.56	-	0.67	0.57	0.77
	Efficient Ballast Changeouts	0.63	-	-	0.60	-	-	-	-	-	-	0.32	0.46	0.50
	T-8 Lamps and Electronic Ballasts	0.73	0.80	0.72	0.69	0.53	0.56	0.54	0.60	0.51	0.47	0.38	0.52	0.69
	Delamp Fluorescent Fixtures	0.80	0.88	0.79	0.76	0.59	-	0.59	-	0.57	0.52	0.41	0.58	0.78
	High Intensity Discharge	0.89	0.94	-	0.97	-	-	-	-	0.61	-	0.44	0.58	0.72
	Controls	0.89	0.99	0.82	0.84	0.63	0.67	0.65	-	0.63	0.58	0.68	0.59	0.65
Total		0.77	0.82	0.73	0.73	0.54	0.53	0.55	0.55	0.55	0.56	0.40	0.56	0.70

Relative to the 1997 program year evaluation, the gross realization rate for energy has decreased by 16 percent (the gross energy realization rate was 86% for the 1997 evaluation). This difference is attributable to the SAE analysis results, which detected approximately 16 percent less savings overall than the 1997 SAE results. The algorithms for estimating the engineering estimates for the 1998 evaluation are nearly identical to those used in the 1997 evaluation. The resulting program-level SAE coefficient, however, dropped from 92% in 1997 to 76% for this evaluation. This explains the difference between the 1997 and 1998 gross energy realization rates.

The only technology group with a gross realization rate greater than one was Halogens at 1.07. The technology group with the smallest realization rate was Efficient Ballasts, at 0.50. Results across business types are fairly consistent. These results are discussed below using information from the review of the ex ante estimates in conjunction with the billing analysis results.

Halogen - The relatively high realization rates for halogen technologies are due to ex ante lamp life assumptions for this technology, where the lamp is replaced with a conventional light at the end of the original lamp life. Lamp life ranges from 0.3 years up to 1.5 years, depending on the wattage of the halogen and the business type in which it is installed. During field inspections, no evidence of this short measure life was uncovered, nor was it detected in the billing regression analysis. The high realization rates for halogen lamps, however, have only a small effect on the overall lighting end-use realization rate because the energy impact of this technology accounts for less than 1 percent of the lighting program's total.

Efficient Ballast Changeouts – Overall, ex post energy impacts differ from ex ante energy impact by about 50 percent. The difference can be explained by two factors. First, the average SAE coefficient applied to this segment was 73%, which explains over half of this difference. The other half was attributable to the differences in the ex ante and ex post engineering estimates. This is due to differences in the operating hours, HVAC interactive effects, and burn-out rates applied to the measure. The difference was marked for this technology due to a relatively large portion of the Community Service business type within this technology. As explained below, the ex ante and ex post engineering estimate algorithms differ notably for community service. It should be noted that efficient ballast changeouts account for less than 1 percent of total program gross energy impacts.

Office, Retail, Colleges and Schools – The SAE coefficient generated for these segments combined was 0.83, exerting a significant influence on the realization rate results within each of those segments, and for the program as a whole. This SAE coefficient explains why the gross energy realization rates for these business types are all between 73 and 82 percent. The difference between the ex ante and ex post engineering estimates for these segments as a whole is only 7 percent.

Grocery Restaurant, Health Care, Hotel/Motel, Warehouse, Personal Service, Community Service and Miscellaneous – These business types received the lowest SAE coefficient, 60 percent. This SAE coefficient explains why the gross energy realization rates for these business types are generally near 50 percent. The difference between the ex ante and ex post engineering estimates for these segments as a whole is only 12 percent.

Community Service stands out as the lowest of these business types, due to a marked different in the annual operating hours assumed in ex ante and ex post engineering estimate algorithms.

The ex ante estimate assumed 4,800 annual operating hours, versus 2,700 for the ex post engineering estimate.

4.4.2 Gross Realization Rates for Demand Impacts

Gross demand realization rates are presented in Exhibit 4-9. These values represent, by segment, the ratio of the ex post gross impact evaluation findings to the gross ex ante program design estimates. These realization rates illustrate how well the ex ante estimates predicted demand savings, before taking into account customers' actions within the lighting market. Refer to Exhibit 4-12 for an individual presentation of both the ex ante and ex post impacts.

Overall, the gross demand estimates are only 11 percent lower than the ex ante values, as illustrated above. Relative to the 1997 program year evaluation, the gross realization rate for demand has decreased by 4 percent (the gross demand realization rate was 93% for the 1997 evaluation). This difference is likely due to different distributions of measures and business types.

Exhibit 4-9
Gross Demand Impact Realization Rates
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.43	1.51	-	1.14	-	1.95	1.96	-	-	-	1.55	-	1.63
	Compact Fluorescent Lamps	0.93	0.86	0.84	0.90	0.87	0.77	0.75	0.92	0.75	1.06	0.48	0.72	0.87
	Exit Signs	1.01	0.96	0.99	0.99	-	1.02	1.02	0.92	0.88	-	1.08	0.91	1.01
	Efficient Ballast Changeouts	0.76	-	-	0.76	-	-	-	-	-	-	0.55	0.77	0.70
	T-8 Lamps and Electronic Ballasts	0.89	0.91	0.92	0.90	0.89	0.97	0.91	1.02	0.86	0.89	0.65	0.88	0.88
	Delamp Fluorescent Fixtures	0.98	1.00	1.02	0.97	0.98	-	1.00	-	0.94	0.97	0.71	0.99	0.97
	High Intensity Discharge	1.09	0.95	-	1.07	-	-	-	-	1.04	-	0.84	1.03	1.02
	Controls	0.54	-	0.47	0.66	0.64	1.66	0.54	-	-	0.41	0.55	0.46	0.46
Total		0.92	0.93	0.88	0.92	0.89	0.88	0.82	0.92	0.93	0.48	0.65	0.93	0.89

The only technologies that differed from ex ante by more than 20 percent were halogens, efficient ballast changeouts, and controls. The only business type results that differ by more than 20 percent were personal services and community services. Specific comments and justifications for these results are as follows:

Halogen - As previously discussed, the high realization rate for halogen technologies results from ex ante estimates for this technology, which are based on an assumed average lamp life of less than one year (depending on business type full load operating hours). Ex ante estimates assume the replacement of each lamp with a standard technology at the end of the original lamp life. Because this assumption was not observed during on-site evaluation activities, the ex post estimates are substantially larger than the ex ante values.

Controls - The estimated impacts for controls are low because the ex ante assumptions regarding the relationship between energy and coincident demand impacts were not confirmed.

As a result, energy impacts were more evenly distributed throughout the year, leading to a relatively lower peak demand impact than that contained in the MDSS.

Efficient Ballast Changeouts – Overall, ex post energy impacts differ from ex ante demand impacts by about 30 percent. The difference can be explained by the differences in the ex ante and ex post demand impact engineering estimates. These differences include HVAC interactive effects, and burn-out rates applied to the measure. The difference was marked for this technology due to a relatively large portion of the Community Service business type within this technology. As explained above, the ex ante and ex post engineering estimate algorithms differ notably. Finally, it should be noted that efficient ballast changeouts account for less than one-half of one percent of total program gross demand impacts.

Community Services – Similar to the differences in operating hours for the energy estimates, the community services business type had a significant difference in the CDF assumptions between the ex ante and ex post engineering algorithms. For all other business types, the CDFs for the ex ante and ex post engineering algorithms were within 12 percent of each other. For the community services business type, however, the ex post estimate for the CDF was only 68% of the ex ante estimate.

Personal Services - The difference between ex ante and ex post demand impact estimates within the personal service business type are quite notable. The difference is explained quite readily by the large portion of control technologies within this business type. Controls comprise 73 percent of demand impacts within the personal services business type. As explained earlier, the estimated impacts for controls are low because the ex ante assumptions regarding the relationship between energy and coincident demand impacts were not confirmed.

4.4.3 Net Realization Rates

The difference between the gross and net realization rates is due to the differences between the ex ante and the ex post NTG adjustments, in combination with the differences already exhibited between the ex ante gross impacts and their corresponding ex post values.

The net energy realization rates by segment are presented in Exhibit 4-10, with the net demand realization rates illustrated in Exhibit 4-11. These values represent, by segment, the ratio of net impact evaluation findings to the net ex ante program design estimates. The realization rates illustrate how well the ex ante estimates predict savings, after taking into account customers' actions within the lighting market.

Many of the results presented in Exhibits 4-10 and 4-11 can be explained using information from the review of the ex ante estimates and the evaluation engineering and billing analyses, as discussed under the review of the gross realization rates. Most of the comments mentioned previously also apply to the calculation of the net realization rates. Since the same NTG ratio was applied to the energy and demand impacts, the comments and justifications for the net realization rates discussed below apply to both Exhibits.

Relative to the 1997 program year evaluation, the net realization rate for energy has decreased by 7 percent, while the net realization rate for demand impacts has increased by 10 percent (the net energy and demand realization rates were 85 and 88 percent for the 1997 evaluation, respectively.) As we have already discussed above, the gross realization rates have decreased by 16 percent and 4 percent, for energy and demand, respectively.

The differences are explained by a number of factors. First, the ex ante net-to-gross adjustment rose from 1997 to 1998 from 86 to 95 percent, placing downward pressure on net realization rates, all other factors held constant. Second, the SAE coefficient fell from 92 to 76 percent, placing significant downward pressure on the net realization rates for energy impacts. At the same time, the ex post net to gross adjustment rose from 82 to 106 percent from 1997 to 1998, placing upward pressure on net realization rates. These forces together result in a moderately lower net realization rate for energy impacts, and a moderately higher net realization rate for demand impacts. Overall, the results for 1998 are similar to the 1997 results.

Exhibit 4-10
Net Energy Impact Realization Rates
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc	Total
Retrofit Express	Halogen	1.31	1.16	-	0.90	-	5.50	1.02	-	-	-	0.61	-	1.58
	Compact Fluorescent Lamps	0.86	0.70	0.45	0.79	1.04	2.39	0.44	0.50	0.39	0.89	0.22	0.78	0.72
	Exit Signs	0.96	0.76	0.52	0.86	-	2.99	0.57	0.56	0.47	-	0.50	0.97	0.78
	Efficient Ballast Changeouts	0.71	-	-	0.65	-	-	-	-	-	-	0.24	0.77	0.54
	T-8 Lamps and Electronic Ballasts	0.82	0.69	0.47	0.75	1.02	2.77	0.49	0.55	0.43	0.74	0.28	0.88	0.75
	Delamp Fluorescent Fixtures	0.90	0.76	0.52	0.82	1.13	-	0.54	-	0.48	0.81	0.31	0.99	0.84
	High Intensity Discharge	1.00	0.81	-	1.05	-	-	-	-	0.52	-	0.33	0.98	0.88
	Controls	1.00	0.85	0.54	0.91	1.21	3.27	0.60	-	0.53	0.91	0.50	1.00	0.83
Total		0.86	0.71	0.48	0.79	1.03	2.62	0.50	0.51	0.47	0.88	0.30	0.94	0.78

Exhibit 4-11
Net Demand Impact Realization Rates
By Business Type and Technology Group
For Commercial Indoor Lighting Applications

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.61	1.30	-	1.24	-	9.58	1.80	-	-	-	1.15	-	2.37
	Compact Fluorescent Lamps	1.04	0.75	0.55	0.98	1.66	3.81	0.69	0.85	0.64	1.67	0.35	1.22	1.02
	Exit Signs	1.13	0.83	0.65	1.08	-	5.01	0.94	0.85	0.74	-	0.80	1.55	1.01
	Efficient Ballast Changeouts	0.85	-	-	0.83	-	-	-	-	-	-	0.41	1.30	0.74
	T-8 Lamps and Electronic Ballasts	1.00	0.79	0.61	0.97	1.70	4.75	0.84	0.94	0.73	1.39	0.48	1.49	0.97
	Delamp Fluorescent Fixtures	1.10	0.86	0.67	1.06	1.87	-	0.92	-	0.80	1.52	0.53	1.67	1.05
	High Intensity Discharge	1.23	0.82	-	1.16	-	-	-	-	0.88	-	0.63	1.75	1.26
	Controls	0.60	-	0.31	0.72	1.22	8.19	0.50	-	-	0.64	0.41	0.77	0.60
Total		1.04	0.80	0.58	1.00	1.70	4.33	0.76	0.85	0.78	0.75	0.49	1.58	0.99

4.5 *OVERVIEW OF REALIZATION RATES*

The net ex post energy impacts are lower than predicted by the ex ante impact estimates. The net ex post energy impacts are 22 percent lower than the net ex ante design estimates. This difference is explained primarily by the fact that the billing analysis detected less savings. The unadjusted gross ex post engineering estimates are only 9 percent lower than the ex ante estimates. This difference combined with a program-level SAE coefficient of 76 percent resulted in a gross realization rate of 70 percent. A higher ex post net-to-gross adjustment relative to ex ante brought the net realization rate closer to one, at 78 percent.

The net ex post realization rate for demand impacts is very close to 1, at 99 percent. The ex post gross demand impacts are 89 percent of ex ante gross demand impacts. Again, the higher ex post net-to-gross adjustment relative to ex ante resulted in a higher net realization rate relative to gross, at 99 percent.

Exhibit 4-12 summarizes all of the gross and net energy, demand, and therm impacts discussed above. Results are also presented for the net-to-gross adjustments and the realization rates.

Exhibit 4-12
Commercial Indoor Lighting Impact Summary
By Technology Group

Program and Technology Group		Gross Program Impact			NTG Adjustment*		Net Program Impact		
		kWh	kW	Therm	(1-FR)	Spillover	kWh	kW	Therm
		EX ANTE							
Retrofit	Halogen	45,878	9	-	0.85	0.10	43,584	8	-
Express	Compact Fluorescent Lamps	2,802,312	491	-	0.85	0.10	2,662,196	467	-
	Exit Signs	335,763	42	-	0.85	0.10	318,975	40	-
	Efficient Ballast Changeouts	46,704	9	-	0.85	0.10	44,369	9	-
	T-8 Lamps and Electronic Ballasts	7,192,217	1,470	-	0.85	0.10	6,832,606	1,397	-
	Delamp Fluorescent Fixtures	3,519,223	748	-	0.85	0.10	3,343,262	711	-
	High Intensity Discharge	506,455	101	-	0.85	0.10	481,133	96	-
	Controls	705,209	184	-	0.85	0.10	669,949	175	-
	Total	15,153,761	3,055	-	0.85	0.10	14,396,074	2,902	-
		EX POST							
Retrofit	Halogen	49,038	14	-24	0.75	0.65	68,781	20	-40
Express	Compact Fluorescent Lamps	1,743,187	427	-583	0.76	0.33	1,907,332	474	-781
	Exit Signs	259,784	42	-107	0.73	0.24	249,693	41	-108
	Efficient Ballast Changeouts	23,494	6	-12	0.73	0.28	23,791	7	-11
	T-8 Lamps and Electronic Ballasts	4,946,250	1,300	-2,004	0.74	0.30	5,139,044	1,358	-2,164
	Delamp Fluorescent Fixtures	2,731,204	727	-1,202	0.74	0.29	2,813,193	749	-1,250
	High Intensity Discharge	362,159	103	-100	0.76	0.40	422,710	120	-106
	Controls	457,339	85	-113	0.80	0.43	559,229	105	-123
	Total	10,572,456	2,705	-4,143	0.75	0.31	11,183,773	2,873	-4,584
		REALIZATION RATES							
Retrofit	Halogen	1.07	1.63	-	-	-	1.58	2.37	-
Express	Compact Fluorescent Lamps	0.62	0.87	-	-	-	0.72	1.02	-
	Exit Signs	0.77	1.01	-	-	-	0.78	1.01	-
	Efficient Ballast Changeouts	0.50	0.70	-	-	-	0.54	0.74	-
	T-8 Lamps and Electronic Ballasts	0.69	0.88	-	-	-	0.75	0.97	-
	Delamp Fluorescent Fixtures	0.78	0.97	-	-	-	0.84	1.05	-
	High Intensity Discharge	0.72	1.02	-	-	-	0.88	1.26	-
	Controls	0.65	0.46	-	-	-	0.83	0.60	-
	Total	0.70	0.89	-	-	-	0.78	0.99	-

* Weighted by ex-post Gross Energy impact

Attachments

Attachment 1

Waivers

PACIFIC GAS & ELECTRIC COMPANY
REQUEST FOR RETROACTIVE WAIVER FOR
Pre-1998 CEEI PROGRAM CARRY-OVER: LIGHTING END USE
Study ID # 404a
Date Approved: 5/20/99

Program Background

Pacific Gas & Electric Company's (PG&E's) pre-1998 Commercial sector carry-over lighting end-use DSM programs were designed to promote the installation of energy efficient lighting system retrofits. These programs offered a wide variety of energy efficient prescriptive lighting measures ranging from compact fluorescent lamps to custom non-prescriptive lighting.

The pre-1998 program carry-overs are being evaluated by PG&E, with one of the objectives being to assess the actual load impacts resulting from the lighting measures committed under the pre-1998 programs but rebated during 1998.

Pre-1998 Program Carry-Over Summary: Indoor Lighting End Use

Technology	Unique Sites	Avoided Cost	Percentage of Avoided Cost
Compact Fluorescent Lamps	164	1,224,634	13.8%
Controls	65	348,665	3.9%
Customized Lighting	3	16,694	0.2%
Delamp Fluorescent Fixtures	106	2,083,451	23.6%
Efficient Ballast Changeouts	35	26,744	0.3%
Exit Signs	108	201,030	2.3%
Halogen	15	2,447	0.0%
High Intensity Discharge	19	325,393	3.7%
T-8 Lamps and Electronic Ballasts	371	4,615,941	52.2%
TOTAL (Unique Sites)	474	8,844,997	100.0%

Proposed Waiver

The purpose of this waiver is to state PG&E's interpretation of the Protocols[1] for use in conducting the 1998 Commercial Sector EEI Evaluation of the pre-1998 Program Lighting End Uses rebated in 1998 (Commercial Lighting Program Carry-Over). PG&E seeks the California DSM Measurement Advisory Committee's (CADMAC's) approval to use the following methods for impact measurement for the pre-1998 Commercial Lighting Program Carry-Over first year study:

1. For the estimation of first year electric energy impacts, a load impact regression model (LIRM) will be performed. In addition, the LIRM will include calibrated engineering estimates of energy savings, based on interim results from the 1994 and 1995 Commercial Lighting Programs to

[1] Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs, as adopted by California Public Utilities Commission Decision 93-05-063, revised March 1998.

estimate the following parameters: full load hours of operation, coincident diversity factors, HVAC interactive effects, and burned-out lamp rates.

2. For the estimation of first year electric capacity load (kW) impacts, a calibrated engineering (CE) model will be used, based on interim results from the 1994 and 1995 Commercial Lighting Programs to estimate the following parameters: coincident diversity factors, HVAC interactive effects, and burned-out lamp rates.

Parameters and Protocol Requirements

The Protocols Table C-4, Item 2 for Commercial end uses states that the end use consumption and load impact model may be a LIRM or CE model. In addition, the Protocols Table C-4, Item 6 for Commercial end uses states that electric capacity load impacts must be based on premise-specific end-use monitored data, or end-use load shapes from other sources.

Rationale

This exact waiver was approved by the CADMAC on June 17, 1998 and on November 21, 1997 for the 1997 and 1996 Commercial Sector EEI Evaluations of the Lighting End Use, respectively. The rationale is consistent with that presented in the approved waivers and is repeated below:

The following reasons are provided to explain why PG&E feels their recommended approach described above is justified under the Protocols:

1. For the estimation of first year electric energy impacts, a load impact regression model (LIRM) will be performed. As stated in Protocols Table C-4, Item 2 for Commercial end uses, the end use consumption and load impact model will be either a LIRM or CE. The LIRM model that we propose to use will be a statistically adjusted engineering (SAE) model, which will incorporate the results of the CE model.

2. For the estimation of first year electric capacity load (kW) impacts, a calibrated engineering (CE) model will be used, based on interim results from the 1994 and 1995 Commercial Lighting Programs to estimate the following parameters: full load hours of operation, coincident diversity factors, HVAC interactive effects, and burned-out lamp rates. Protocols Table C-4, Item 6 for Commercial end uses states that electric capacity load impacts must be based on premise-specific end-use monitored data, or end use load shapes from other sources. We are using end-use load shapes developed from the 1994 and 1995 Commercial Lighting Study.

We believe that there are a number of advantages to using the 1994 and 1995 Commercial Lighting Program Evaluation results of full load hours of operation, coincident diversity factors, HVAC interactive effects, and burned-out lamp rates:

- Extensive premise specific end-use metering, on-site audit and telephone survey data were collected in support of PG&E's 1994 and 1995 Commercial sector evaluations, and used to derive independent engineering-based results at the business type and/or technology group level. It is anticipated that additional data collection and detailed engineering analysis would not yield more or less reliable results (by business type and/or technology group) than those derived in 1994 and 1995. In fact, PG&E expects that transferring a mean result for the above list of derived parameters will yield a more accurate overall program result than could be achieved using a single year of data collection and analysis.

- PG&E has worked diligently to improve its load forecasting parameters during these two years of evaluation activities. With regards to generating a mean estimate from these two years, PG&E does not believe that adding results from a third year would significantly improve the current load forecasting results.
- The 1998 engineering-based evaluation analysis activities will include the use of 1998 paid year on-site customer records. In particular, analyses will be conducted to assess the accuracy of PG&E Management Decision Support System (MDSS) records surrounding the number of items installed. That is, the engineering evaluation will incorporate premise specific data from on-site audits, but not for determining lighting system operating schedules and operating factors (and thus annual operating hours and coincident diversity factors).
- Analyses will also incorporate a comparison between self-report operating schedules for 1994 and 1995 vs. 1998 carry-over participants, in an effort to assess differences in these schedules. If significant differences are observed, then adjustments will be made to the mean annual operating hours and coincident diversity factors.
- These mean forecasting results will be used as priors to an SAE energy impact analysis, which will yield an SAE realization rate, serving to calibrate those results. That is, the analysis approach will still incorporate premise specific information used in deriving lighting program impacts.

Proposed Schedule of Operating Hours
(Participant/Nonparticipant Metered Data)

Business Type	1994 Result	1995 Result	Mean
Office	3,900	4,100	4,000
Retail	4,200	4,700	4,450
College/University	3,700	4,100	3,900
College/University	3,700	4,100	3,900
School	2,000	2,300	2,150
Grocery	6,800	4,800	5,800
Restaurant	4,800	4,400	4,600
Health Care	4,900	3,900	4,400
Hotel/Motel	5,400	5,600	5,500
Warehouse	3,100	4,000	3,550
Personal Service	NA	4,100	4,100
Community Service	NA	2,700	2,700
Miscellaneous	4,800	4,200	4,500

Conclusion

PG&E is seeking a retroactive waiver to clearly define, in advance, acceptable methods for performing the pre-1998 Commercial Lighting Carry-Over Program evaluation. Recommendations in this waiver are designed to maximize the quality and value of evaluation results. The waiver allowing the use of previous year's evaluation results will allow for the most cost-effective and reliable set of first year load impact estimates.

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PACIFIC GAS & ELECTRIC COMPANY

RETROACTIVE WAIVER FOR
Pre-1998 CEEI PROGRAM CARRY-OVER: LIGHTING AND HVAC END USES

Net-to-Gross Analysis
STUDY IDs: 404a & 404b
Date Approved: 5/20/99

Program Background

Pacific Gas & Electric Company (PG&E) fielded DSM programs to the Commercial sector (among others) prior to 1998. The primary purpose of the Pre-1998 Commercial Energy Efficiency Incentives Program (Program) was to promote the installation of energy efficient equipment retrofits. The Program offered a wide variety of energy efficient prescriptive lighting and HVAC measures ranging from compact fluorescent lamps to custom non-prescriptive lighting and HVAC measures. The impact evaluation associated with this waiver is designed to assess the actual load impacts resulting from the lighting and HVAC measures committed under the pre-1998 Programs but rebated during 1998 (Carry-Over).

Pre-1998 Program Carry-Over Summary: Indoor Lighting End Use

Technology	Unique Sites	Avoided Cost	Percentage of Avoided Cost
Compact Fluorescent Lamps	164	1,224,634	13.8%
Controls	65	348,665	3.9%
Customized Lighting	3	16,694	0.2%
Delamp Fluorescent Fixtures	106	2,083,451	23.6%
Efficient Ballast Changeouts	35	26,744	0.3%
Exit Signs	108	201,030	2.3%
Halogen	15	2,447	0.0%
High Intensity Discharge	19	325,393	3.7%
T-8 Lamps and Electronic Ballasts	371	4,615,941	52.2%
TOTAL (Unique Sites)	474	8,844,997	100.0%

Pre-1998 Program Carry-Over Summary: HVAC End Use

Technology	Unique Sites	Avoided Cost	Percentage of Avoided Cost
Adjustable Speed Drives	20	456,485	4.7%
Central A/C	63	251,301	2.6%
Convert To VAV	2	222,348	2.3%
Cooling Towers	4	167,833	1.7%
Customized Controls	5	304,060	3.1%
Customized EMS	13	1,012,859	10.4%
High Efficiency Gas Boilers	1	8,066	0.1%
Other Customized Equip	6	2,252,416	23.2%
Other HVAC Technologies	3	657,368	6.8%
Package Terminal A/C	12	41,720	0.4%
Reflective Window Film	24	62,266	0.6%
Set-Back Thermostat	20	49,780	0.5%

Water Chillers	17	4,223,765	43.5%
TOTAL (Unique Sites)	164	9,710,268	100.0%

Proposed Waiver

This waiver requests deviations from the Protocols[2] by PG&E for the pre-1998 Commercial Sector Carry-Over Evaluation, lighting and HVAC end uses. PG&E seeks CADMAC approval to allow the use of self-report based algorithms to estimate free ridership and spillover effects for certain technologies should the discrete choice and LIRM models fail to produce statistically reliable results of net-to-gross estimates. Therefore, the self-report methodology would only apply to those technologies (not the entire end-use) for which the discrete choice and LIRM models fail to produce statistically reliable results. This waiver is very similar to one submitted and approved by the CADMAC on January 20, 1999.

Rationale

It is our expectation that the discrete choice model will provide statistically reliable results for all lighting technologies, as was the case in the 1996 and 1997 evaluations. However, because this is a carry-over year, participation in the HVAC end use was very low. Therefore, we do not expect to have sufficient sample sizes to implement a discrete choice model for HVAC measures. Furthermore, for custom types of HVAC installations and lower penetrated HVAC technologies, sample sizes of nonrebated installations are also too small to implement a discrete choice model. In addition, low levels of participation for HVAC technologies also reduce the likelihood of obtaining statistically reliable results from a LIRM model.

If, after following procedures that are generally accepted as best practices for developing statistical models (see Table 7 of the Protocols) we are unable to build a reliable discrete choice model or LIRM for certain technologies, we propose relying on the self-report estimates of free-ridership and spillover. Methods used for the self-report analysis will follow the Quality Assurance Guidelines, and are documented in previous PG&E Evaluation Research Plans and Final Reports, which have been submitted to the ORA.

The primary reason why the discrete choice model may not be used for some technologies is an insufficient number participants, as well as an insufficient number of nonparticipant adoptions identified in the nonparticipant and canvass survey. For example, we do not expect to find a sufficient number of cooling tower adoptions to warrant its inclusion in the discrete choice model. Examples of conditions that could lead to the rejection of the net LIRM approach might include the following: (1) a small number of observations control the model results; (2) intractable collinearity; or (3) intractable nonsignificant t statistics. Based on our experience (particularly with the HVAC end use), we believe these problems (and possibly others) are very likely to materialize. The prevailing criterion for assessing this decision would be that a verification study or peer review would lead to a similar conclusion. Results from all three models will be presented in the final Study, as they were for the 1996 and 1997 evaluations.

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[2] Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs, as adopted by California Public Utilities Commission Decision 93-05-063, revised March 1998.

Attachment 2

Results Tables

Attachment 2-1
Commercial Indoor Lighting Ex Ante Gross Energy Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	14,742	2,482	-	989	-	5,674	11,591	-	-	-	10,400	-	45,878
	Compact Fluorescent Lamps	897,966	29,301	263,777	166,787	30,634	144,391	299,285	851,447	13,012	2,700	102,531	481	2,802,312
	Exit Signs	147,032	16,931	35,889	34,398	-	2,102	58,094	5,160	7,147	-	27,480	1,529	335,763
	Efficient Ballast Changeouts	17,971	-	-	8,904	-	-	-	-	-	-	16,446	3,383	46,704
	T-8 Lamps and Electronic Ballasts	3,439,632	1,314,836	288,739	597,783	194,299	97,262	393,354	54,731	83,952	83,777	449,880	193,972	7,192,217
	Delamp Fluorescent Fixtures	2,454,314	234,112	97,934	362,989	10,277	-	61,484	-	128,626	16,194	77,663	75,631	3,519,223
	High Intensity Discharge	87,326	99,057	-	17,586	-	-	-	-	54,564	-	19,769	228,154	506,455
	Controls	69,428	213	35,175	23,419	2,025	1,470	114,959	-	687	396,995	38,226	22,612	705,209
Total		7,128,411	1,696,932	721,515	1,212,856	237,234	250,898	938,767	911,338	287,988	499,665	742,397	525,761	**15,153,761**

Attachment 2-2
Commercial Indoor Lighting Ex Ante Net Energy Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	14,005	2,358	-	940	-	5,390	11,012	-	-	-	9,880	-	43,584
	Compact Fluorescent Lamps	853,067	27,836	250,588	158,448	29,102	137,171	284,321	808,875	12,362	2,565	97,405	457	2,662,196
	Exit Signs	139,681	16,085	34,094	32,678	-	1,997	55,190	4,902	6,790	-	26,106	1,452	318,975
	Efficient Ballast Changeouts	17,073	-	-	8,459	-	-	-	-	-	-	15,624	3,213	44,369
	T-8 Lamps and Electronic Ballasts	3,267,650	1,249,094	274,302	567,894	184,584	92,399	373,686	51,994	79,755	79,588	427,386	184,274	6,832,606
	Delamp Fluorescent Fixtures	2,331,598	222,406	93,038	344,840	9,763	-	58,410	-	122,195	15,384	73,780	71,850	3,343,262
	High Intensity Discharge	82,960	94,104	-	16,707	-	-	-	-	51,835	-	18,780	216,746	481,133
	Controls	65,957	202	33,417	22,248	1,924	1,397	109,211	-	653	377,145	36,315	21,481	669,949
Total		6,771,990	1,612,086	685,439	1,152,213	225,372	238,354	891,829	865,771	273,589	474,682	705,277	499,473	**14,396,074**

Attachment 2-3
Commercial Indoor Lighting Unadjusted Engineering Energy Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	20,867	3,746	-	1,058	-	10,626	21,518	-	-	-	14,219	-	72,034
	Compact Fluorescent Lamps	831,479	26,623	233,789	154,857	27,789	117,780	238,621	777,006	10,004	2,580	50,568	369	2,471,465
	Exit Signs	152,133	16,620	36,499	34,983	-	2,138	60,624	5,202	6,700	-	30,776	1,460	347,135
	Efficient Ballast Changeouts	13,739	-	-	6,805	-	-	-	-	-	-	8,910	2,586	32,040
	T-8 Lamps and Electronic Ballasts	3,050,375	1,183,422	266,273	530,922	173,688	91,830	354,041	55,071	72,291	66,407	282,837	168,172	6,295,327
	Delamp Fluorescent Fixtures	2,392,452	230,777	99,138	353,819	10,104	-	60,615	-	121,853	14,116	53,648	73,725	3,410,248
	High Intensity Discharge	94,353	104,469	-	21,793	-	-	-	-	56,101	-	14,566	221,354	512,636
	Controls	74,845	235	37,090	25,220	2,142	1,640	125,038	-	727	385,874	43,421	22,412	718,644
Total		6,630,243	1,565,894	672,788	1,129,457	213,723	224,013	860,457	837,279	267,676	468,976	498,944	490,079	**13,859,529**

Attachment 2-4
Commercial Indoor Lighting Gross Energy SAE Coefficients
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	[illegible]
	Compact Fluorescent Lamps	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	[illegible]
	Exit Signs	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	[illegible]
	Efficient Ballast Changeouts	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	[illegible]
	T-8 Lamps and Electronic Ballasts	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	[illegible]
	Delamp Fluorescent Fixtures	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	[illegible]
	High Intensity Discharge	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	[illegible]
	Controls	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	[illegible]
	Controls	0.82	0.89	0.78	0.78	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	[illegible]
Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.76

Attachment 2-5
Commercial Indoor Lighting Ex Post Gross Energy Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	17,210	3,339	-	825	-	6,341	12,840	-	-	-	8,484	-	49,038
	Compact Fluorescent Lamps	685,757	23,728	182,214	120,695	16,582	70,280	142,386	463,643	5,969	1,539	30,174	220	1,743,187
	Exit Signs	125,471	14,813	28,447	27,266	-	1,276	36,174	3,104	3,998	-	18,364	871	259,784
	Efficient Ballast Changeouts	11,331	-	-	5,304	-	-	-	-	-	-	5,317	1,543	23,494
	T-8 Lamps and Electronic Ballasts	2,515,775	1,054,709	207,531	413,798	103,640	54,795	211,258	32,861	43,136	39,625	168,770	100,349	4,946,250
	Delamp Fluorescent Fixtures	1,973,158	205,677	77,268	275,765	6,029	-	36,169	-	72,710	8,423	32,012	43,992	2,731,204
	High Intensity Discharge	77,817	93,107	-	16,985	-	-	-	-	33,475	-	8,691	132,083	362,159
	Controls	61,728	210	28,908	19,656	1,278	979	74,611	-	434	230,253	25,910	13,373	457,339
Total		5,468,246	1,395,583	524,368	880,293	127,530	133,670	513,439	499,608	159,724	279,841	297,723	292,432	**10,572,456**

Attachment 2-6
Commercial Indoor Lighting Gross Energy Impact Realization Rates
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.17	1.35	-	0.83	-	1.12	1.11	-	-	-	0.82	-	1.07
	Compact Fluorescent Lamps	0.76	0.81	0.69	0.72	0.54	0.49	0.48	0.54	0.46	0.57	0.29	0.46	0.62
	Exit Signs	0.85	0.87	0.79	0.79	-	0.61	0.62	0.60	0.56	-	0.67	0.57	0.77
	Efficient Ballast Changeouts	0.63	-	-	0.60	-	-	-	-	-	-	0.32	0.46	0.50
	T-8 Lamps and Electronic Ballasts	0.73	0.80	0.72	0.69	0.53	0.56	0.54	0.60	0.51	0.47	0.38	0.52	0.69
	Delamp Fluorescent Fixtures	0.80	0.88	0.79	0.76	0.59	-	0.59	-	0.57	0.52	0.41	0.58	0.78
	High Intensity Discharge	0.89	0.94	-	0.97	-	-	-	-	0.61	-	0.44	0.58	0.72
	Controls	0.89	0.99	0.82	0.84	0.63	0.67	0.65	-	0.63	0.58	0.68	0.59	0.65
Total		0.77	0.82	0.73	0.73	0.54	0.53	0.55	0.55	0.55	0.56	0.40	0.56	**0.70**

Attachment 2-7
Commercial Indoor Lighting Net-to-Gross Adjustments
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.40
	Compact Fluorescent Lamps	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.09
	Exit Signs	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	0.96
	Efficient Ballast Changeouts	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.01
	T-8 Lamps and Electronic Ballasts	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.04
	Delamp Fluorescent Fixtures	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.03
	High Intensity Discharge	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.17
	Controls	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.22
Total		1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.06

Attachment 2-8
Commercial Indoor Lighting Ex Post Net Energy Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	18,358	2,744	-	850	-	29,634	11,206	-	-	-	5,989	-	68,781
	Compact Fluorescent Lamps	731,504	19,502	113,637	124,406	30,239	328,462	124,265	406,575	4,795	2,291	21,301	355	1,907,332
	Exit Signs	133,841	12,175	17,741	28,104	-	5,962	31,571	2,722	3,211	-	12,964	1,403	249,693
	Efficient Ballast Changeouts	12,087	-	-	5,467	-	-	-	-	-	-	3,753	2,484	23,791
	T-8 Lamps and Electronic Ballasts	2,683,604	866,887	129,426	426,521	189,000	256,092	184,371	28,816	34,648	58,983	119,141	161,555	5,139,044
	Delamp Fluorescent Fixtures	2,104,788	169,050	48,188	284,244	10,995	-	31,566	-	58,402	12,538	22,598	70,824	2,813,193
	High Intensity Discharge	83,008	76,527	-	17,508	-	-	-	-	26,888	-	6,136	212,644	422,710
	Controls	65,846	172	18,028	20,260	2,331	4,573	65,115	-	349	342,734	18,291	21,530	559,229
Total		5,833,036	1,147,058	327,020	907,360	232,564	624,723	448,094	438,114	128,292	416,545	210,173	470,795	**11,183,773**

Attachment 2-9
Commercial Indoor Lighting Net Energy Impact Realization Rates
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.31	1.16	-	0.90	-	5.50	1.02	-	-	-	0.61	-	1.58
	Compact Fluorescent Lamps	0.86	0.70	0.45	0.79	1.04	2.39	0.44	0.50	0.39	0.89	0.22	0.78	0.72
	Exit Signs	0.96	0.76	0.52	0.86	-	2.99	0.57	0.56	0.47	-	0.50	0.97	0.78
	Efficient Ballast Changeouts	0.71	-	-	0.65	-	-	-	-	-	-	0.24	0.77	0.54
	T-8 Lamps and Electronic Ballasts	0.82	0.69	0.47	0.75	1.02	2.77	0.49	0.55	0.43	0.74	0.28	0.88	0.75
	Delamp Fluorescent Fixtures	0.90	0.76	0.52	0.82	1.13	-	0.54	-	0.48	0.81	0.31	0.99	0.84
	High Intensity Discharge	1.00	0.81	-	1.05	-	-	-	-	0.52	-	0.33	0.98	0.88
	Controls	1.00	0.85	0.54	0.91	1.21	3.27	0.60	-	0.53	0.91	0.50	1.00	0.83
Total		0.86	0.71	0.48	0.79	1.03	2.62	0.50	0.51	0.47	0.88	0.30	0.94	**0.78**

Attachment 2-10
Commercial Indoor Lighting Ex Ante Gross Demand Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	3	1	-	0.2	-	1	2	-	-	-	2	-	9
	Compact Fluorescent Lamps	194	6	49	35	5	23	54	104	3	0.5	18	0.1	491
	Exit Signs	18	2	5	4	-	0.3	7	1	1	-	3	0.2	42
	Efficient Ballast Changeouts	4	-	-	2	-	-	-	-	-	-	3	1	9
	T-8 Lamps and Electronic Ballasts	743	278	54	124	30	16	71	7	20	15	79	34	1,470
	Delamp Fluorescent Fixtures	531	50	18	76	2	-	11	-	31	3	14	13	748
	High Intensity Discharge	19	23	-	4	-	-	-	-	13	-	3	37	101
	Controls	17	-	10	5	0.4	0.1	28	-	-	109	10	6	184
Total		1,530	360	135	250	37	40	173	111	69	127	132	92	**3,055**

Attachment 2-11
Commercial Indoor Lighting Ex Ante Net Demand Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	3	1	-	0.2	-	1	2	-	-	-	2	-	8
	Compact Fluorescent Lamps	185	6	46	33	4	22	51	98	3	0.4	17	0.1	467
	Exit Signs	18	2	4	4	-	0	7	1	1	-	3	0.2	40
	Efficient Ballast Changeouts	4	-	-	2	-	-	-	-	-	-	3	1	9
	T-8 Lamps and Electronic Ballasts	706	264	51	117	28	15	67	6	19	14	75	33	1,397
	Delamp Fluorescent Fixtures	504	47	17	72	2	-	10	-	30	3	13	13	711
	High Intensity Discharge	18	22	-	4	-	-	-	-	13	-	3	35	96
	Controls	16	-	9	4	0.4	0.1	27	-	-	104	9	6	175
Total		1,453	342	128	237	35	38	164	105	65	121	126	87	**2,902**

Attachment 2-12
Commercial Indoor Lighting Unadjusted Engineering Demand Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	5	1	-	0	-	2	4	-	-	-	3	-	14
	Compact Fluorescent Lamps	180	5	41	32	4	18	40	95	2	0.5	9	0.1	427
	Exit Signs	19	2	4	4	-	0	7	1	1	-	4	0.2	42
	Efficient Ballast Changeouts	3	-	-	1	-	-	-	-	-	-	2	0.5	6
	T-8 Lamps and Electronic Ballasts	660	254	50	111	27	15	65	7	17	13	52	30	1,300
	Delamp Fluorescent Fixtures	518	49	18	74	2	-	11	-	29	3	10	13	727
	High Intensity Discharge	21	22	-	5	-	-	-	-	14	-	3	38	103
	Controls	9	0.0	4	3	0.3	0.2	15	-	0	44	5	3	85
Total		1,414	334	118	230	33	36	143	102	64	61	86	85	**2,705**

Attachment 2-13
Commercial Indoor Lighting Ex Post Gross Demand Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	5	1	-	0.2	-	2	4	-	-	-	3	-	14
	Compact Fluorescent Lamps	180	5	41	32	4	18	40	95	2	0.5	9	0.1	427
	Exit Signs	19	2	4	4	-	0	7	1	1	-	4	0.2	42
	Efficient Ballast Changeouts	3	-	-	1	-	-	-	-	-	-	2	0.5	6
	T-8 Lamps and Electronic Ballasts	660	254	50	111	27	15	65	7	17	13	52	30	1,300
	Delamp Fluorescent Fixtures	518	49	18	74	2	-	11	-	29	3	10	13	727
	High Intensity Discharge	21	22	-	5	-	-	-	-	14	-	3	38	103
	Controls	9	0.0	4	3	0.3	0.2	15	-	0	44	5	3	85
Total		1,414	334	118	230	33	36	143	102	64	61	86	85	**2,705**

Attachment 2-14
Commercial Indoor Lighting Gross Demand Impact Realization Rates
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.43	1.51	-	1.14	-	1.95	1.96	-	-	-	1.55	-	1.63
	Compact Fluorescent Lamps	0.93	0.86	0.84	0.90	0.87	0.77	0.75	0.92	0.75	1.06	0.48	0.72	0.87
	Exit Signs	1.01	0.96	0.99	0.99	-	1.02	1.02	0.92	0.88	-	1.08	0.91	1.01
	Efficient Ballast Changeouts	0.76	-	-	0.76	-	-	-	-	-	-	0.55	0.77	0.70
	T-8 Lamps and Electronic Ballasts	0.89	0.91	0.92	0.90	0.89	0.97	0.91	1.02	0.86	0.89	0.65	0.88	0.88
	Delamp Fluorescent Fixtures	0.98	1.00	1.02	0.97	0.98	-	1.00	-	0.94	0.97	0.71	0.99	0.97
	High Intensity Discharge	1.09	0.95	-	1.07	-	-	-	-	1.04	-	0.84	1.03	1.02
	Controls	0.54	-	0.47	0.66	0.64	1.66	0.54	-	-	0.41	0.55	0.46	0.46
Total		0.92	0.93	0.88	0.92	0.89	0.88	0.82	0.92	0.93	0.48	0.65	0.93	**0.89**

Attachment 2-15
Commercial Indoor Lighting Net-to-Gross Adjustments for Demand Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.38
	Compact Fluorescent Lamps	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.11
	Exit Signs	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	0.96
	Efficient Ballast Changeouts	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.01
	T-8 Lamps and Electronic Ballasts	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.04
	Delamp Fluorescent Fixtures	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.03
	High Intensity Discharge	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.17
	Controls	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.23
Total		1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.06

Attachment 2-16
Commercial Indoor Lighting Ex Post Net Demand Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	5	1	-	0.2	-	8	4	-	-	-	2	-	20
	Compact Fluorescent Lamps	192	4	26	32	7	85	35	83	2	0.7	6	0.1	474
	Exit Signs	20	2	3	4	-	1.3	6	1	1	-	3	0.3	41
	Efficient Ballast Changeouts	3	-	-	1	-	-	-	-	-	-	1	0.7	7
	T-8 Lamps and Electronic Ballasts	704	209	31	114	49	71	56	6	14	19	36	48	1,358
	Delamp Fluorescent Fixtures	552	41	11	76	3	-	10	-	24	4	7	21	749
	High Intensity Discharge	22	18	-	5	-	-	-	-	11	-	2	62	120
	Controls	10	0.0	3	3	0.5	1.0	13	-	0.1	66	4	4	105
Total		1,508	274	74	237	59	166	125	90	51	91	61	137	**2,873**

Attachment 2-17
Commercial Indoor Lighting Net Demand Impact Realization Rates
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.61	1.30	-	1.24	-	9.58	1.80	-	-	-	1.15	-	2.37
	Compact Fluorescent Lamps	1.04	0.75	0.55	0.98	1.66	3.81	0.69	0.85	0.64	1.67	0.35	1.22	1.02
	Exit Signs	1.13	0.83	0.65	1.08	-	5.01	0.94	0.85	0.74	-	0.80	1.55	1.01
	Efficient Ballast Changeouts	0.85	-	-	0.83	-	-	-	-	-	-	0.41	1.30	0.74
	T-8 Lamps and Electronic Ballasts	1.00	0.79	0.61	0.97	1.70	4.75	0.84	0.94	0.73	1.39	0.48	1.49	0.97
	Delamp Fluorescent Fixtures	1.10	0.86	0.67	1.06	1.87	-	0.92	-	0.80	1.52	0.53	1.67	1.05
	High Intensity Discharge	1.23	0.82	-	1.16	-	-	-	-	0.88	-	0.63	1.75	1.26
	Controls	0.60	-	0.31	0.72	1.22	8.19	0.50	-	-	0.64	0.41	0.77	0.60
Total		1.04	0.80	0.58	1.00	1.70	4.33	0.76	0.85	0.78	0.75	0.49	1.58	**0.99**

Attachment 2-18
Commercial Indoor Lighting Ex Ante Gross Therm Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-	-	-	-	-	-	-	-	-	-	-	-	-
	Compact Fluorescent Lamps	-	-	-	-	-	-	-	-	-	-	-	-	-
	Exit Signs	-	-	-	-	-	-	-	-	-	-	-	-	-
	Efficient Ballast Changeouts	-	-	-	-	-	-	-	-	-	-	-	-	-
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-	-	-
	Delamp Fluorescent Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	-
	High Intensity Discharge	-	-	-	-	-	-	-	-	-	-	-	-	-
	Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
	Controls	.	.	.	.	.	.	.	.	.	.	.	.	-
Total		-	-	-	-	-	-	-	-	-	-	-	-	-

Attachment 2-19
Commercial Indoor Lighting Ex Ante Net Therm Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-	-	-	-	-	-	-	-	-	-	-	-	-
	Compact Fluorescent Lamps	-	-	-	-	-	-	-	-	-	-	-	-	-
	Exit Signs	-	-	-	-	-	-	-	-	-	-	-	-	-
	Efficient Ballast Changeouts	-	-	-	-	-	-	-	-	-	-	-	-	-
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-	-	-
	Delamp Fluorescent Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	-
	High Intensity Discharge	-	-	-	-	-	-	-	-	-	-	-	-	-
	Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
	Controls	.	.	.	.	.	.	.	.	.	.	.	.	-
Total		-	-	-	-	-	-	-	-	-	-	-	-	-

Attachment 2-20
Commercial Indoor Lighting Unadjusted Engineering Therm Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-8	-1	-	0	-	-5	-4	-	-	-	-5	-	-24
	Compact Fluorescent Lamps	-324	-7	-26	-67	-3	-54	-45	-39	-1	0	-18	0	-583
	Exit Signs	-59	-4	-4	-15	-	-1	-12	0	0	-	-11	0	-107
	Efficient Ballast Changeouts	-5	-	-	-3	-	-	-	-	-	-	-3	0	-12
	T-8 Lamps and Electronic Ballasts	-1,190	-308	-29	-228	-16	-42	-67	-3	-4	-5	-99	-13	-2,004
	Delamp Fluorescent Fixtures	-933	-60	-11	-152	-1	-	-12	-	-7	-1	-19	-6	-1,202
	High Intensity Discharge	-37	-27	-	-9	-	-	-	-	-3	-	-5	-18	-100
	Controls	-29	0	-4	-11	0	-1	-24	-	0	-27	-15	-2	-113
Total		-2,586	-407	-74	-486	-19	-103	-163	-42	-16	-33	-175	-39	**-4,143**

Attachment 2-21
Commercial Indoor Lighting Ex Post Gross Therm Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-8	-1	-	0	-	-5	-4	-	-	-	-5	-	-24
	Compact Fluorescent Lamps	-324	-7	-26	-67	-3	-54	-45	-39	-1	0	-18	0	-583
	Exit Signs	-59	-4	-4	-15	-	-1	-12	0	0	-	-11	0	-107
	Efficient Ballast Changeouts	-5	-	-	-3	-	-	-	-	-	-	-3	0	-12
	T-8 Lamps and Electronic Ballasts	-1,190	-308	-29	-228	-16	-42	-67	-3	-4	-5	-99	-13	-2,004
	Delamp Fluorescent Fixtures	-933	-60	-11	-152	-1	-	-12	-	-7	-1	-19	-6	-1,202
	High Intensity Discharge	-37	-27	-	-9	-	-	-	-	-3	-	-5	-18	-100
	Controls	-29	0	-4	-11	0	-1	-24	-	0	-27	-15	-2	-113
Total		-2,586	-407	-74	-486	-19	-103	-163	-42	-16	-33	-175	-39	**-4,143**

Attachment 2-22
Commercial Indoor Lighting Gross Therm Impact Realization Rates
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-	-	-	-	-	-	-	-	-	-	-	-	-
	Compact Fluorescent Lamps	-	-	-	-	-	-	-	-	-	-	-	-	-
	Exit Signs	-	-	-	-	-	-	-	-	-	-	-	-	-
	Efficient Ballast Changeouts	-	-	-	-	-	-	-	-	-	-	-	-	-
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-	-	-
	Delamp Fluorescent Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	-
	High Intensity Discharge	-	-	-	-	-	-	-	-	-	-	-	-	-
	Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		-	-	-	-	-	-	-	-	-	-	-	-	-

Attachment 2-23
Commercial Indoor Lighting Net-to-Gross Adjustments for Therm Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.70
	Compact Fluorescent Lamps	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.34
	Exit Signs	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.01
	Efficient Ballast Changeouts	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	0.97
	T-8 Lamps and Electronic Ballasts	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.08
	Delamp Fluorescent Fixtures	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.04
	High Intensity Discharge	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.07
	Controls	1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.09
Total		1.07	0.82	0.62	1.03	1.82	4.67	0.87	0.88	0.80	1.49	0.71	1.61	1.11

Attachment 2-24
Commercial Indoor Lighting Ex Post Net Therm Impacts
By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-9	-1	-	0	-	-23	-4	-	-	-	-4	-	-40
	Compact Fluorescent Lamps	-346	-6	-16	-69	-5	-253	-40	-34	0	0	-12	0	-781
	Exit Signs	-63	-4	-3	-16	-	-5	-10	0	0	-	-8	0	-108
	Efficient Ballast Changeouts	-6	-	-	-3	-	-	-	-	-	-	-2	0	-11
	T-8 Lamps and Electronic Ballasts	-1,269	-253	-18	-235	-29	-197	-59	-2	-3	-7	-70	-22	-2,164
	Delamp Fluorescent Fixtures	-995	-49	-7	-157	-2	-	-10	-	-6	-1	-13	-9	-1,250
	High Intensity Discharge	-39	-22	-	-10	-	-	-	-	-3	-	-4	-29	-106
	Controls	-31	0	-3	-11	0	-4	-21	-	0	-40	-11	-3	-123
Total		-2,758	-335	-46	-501	-35	-482	-143	-37	-13	-49	-123	-63	**-4,584**

Attachment 2-25

Commercial Indoor Lighting Net Therm Impact Realization Rates

By Business Type and Technology Group

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-	-	-	-	-	-	-	-	-	-	-	-	-
	Compact Fluorescent Lamps	-	-	-	-	-	-	-	-	-	-	-	-	-
	Exit Signs	-	-	-	-	-	-	-	-	-	-	-	-	-
	Efficient Ballast Changeouts	-	-	-	-	-	-	-	-	-	-	-	-	-
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-	-	-
	Delamp Fluorescent Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	-
	High Intensity Discharge	-	-	-	-	-	-	-	-	-	-	-	-	-
	Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		-	-	-	-	-	-	-	-	-	-	-	-	-

Attachment 2-26
Commercial Indoor Lighting
Mapping of Technology to PG&E's Measure Code

Business Type / Program and Technology Group	PG&E Measure Classification Measure Code
Retrofit Express Program	
Compact Fluorescent	L64, L66, L174-L183
Incandescent to Fluorescent	L8
Efficient Ballast	L14, L15, L16, L114
T8 Lamps and Electronic Ballasts	L21-L24, L70-L75, L184
Delamp Fluorescent Fixtures	L17, L18, L19, L20
High Intensity Discharge	L26, L27, L79, L80, L81, L187-L202
Halogen	L60, L61
Exit Signs	L5, L137
Controls	L31, L36, L82, L83
Customized Efficiency Options Program	
Halogen	*
Compact Fluorescent Lamps	*
Efficient Ballast Changeouts	*
T-8 Lamps and Electronic Ballasts	*
Delamp Fluorescent Fixtures	*
Controls	*
Advanced Performance Options Program	
Halogen	*
T-8 Lamps and Electronic Ballasts	*

* The MDSS does not track CEO and APO measures by the results classification shown.

Attachment 2-27
Time-of-Use Impact Distribution by Costing Period

PG&E Cost Period	Time-of-Use Impact Distribution	
	kW Adjustment Factor	kWh Adjustment Factor
Summer On-Peak: **May 1 to Oct. 31** **12:00 PM - 6:00 PM Weekdays**	1.0000	0.1508
Summer Partial Peak: **May 1 to Oct. 31** **8:30 AM - 12:00 PM &** **6:00 PM - 9:30 PM Weekdays**	1.0336	0.1392
Summer Off-Peak: **May to Oct. 31** **9:30 PM - 8:30 AM**	0.7977	0.2318
Winter Partial Peak: **Nov. 1 to April 31** **8:30 AM - 9:30 PM Weekdays**	0.8110	0.2684
Winter Off-Peak: **Nov. 1 to April 31** **9:30 PM - 8:30 AM Other**	0.7679	0.2098

Attachment 3

Protocol Tables 6 and 7

PROTOCOL TABLES 6 AND 7

PRE-1998 COMMERCIAL EEI PROGRAM CARRY-OVER EVALUATION OF LIGHTING TECHNOLOGIES

PG&E STUDY ID #404A

This Attachment presents Tables 6 and 7 for the above referenced study as required under the "Protocols and Procedures for the Verification of Cost, Benefits, and Shareholder Earnings from Demand Side Management Programs" (the Protocols), as adopted by the California Public Utility Commission (CPUC) Decision 93-05-063, Revised March 1998 Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, 96-12-079, and 98-03-063.

Table 6 Assumptions

In some instances, interpretation of the Protocols allows for a variety of results to be presented. For lighting technologies, the interpretation of these terms are:

- Items 1.A, 1.B, 2.C, 3.C: The change model of estimates did not require an evaluation of base usage for these technologies.
- Item 2.B: The per-unit gross and net impacts required by the Protocols specify two terms in the denominator, square footage and hour of fixture operation. The interpretation of these terms are:
  - Square footage estimates of the lighted area were derived using survey responses for total area affected by the retrofit.
  - Hours of fixture operation were defined using survey self-report values of weekday, Saturday, and Sunday hours of operation.
- Items 6 and 7: The number of measures reported are the purchased number in the MDSS. As such, they reflect a variety of units of measure, including lamps, fixtures, ballasts, time clocks, photocells, sensors, etc.

The Table 7 synopsis of analytical methods applied follows Items 1 through 7 of Protocol Table 6.

Protocol Table 6
Items 1-5
PG&E Lighting Study ID #404A

Table Item			Relative Precision	
Item Number	Description	Estimate	90% Confidence	80% Confidence
1.A†	Pre-installation usage, Base usage, and Base usage per designated unit of measurement.	N/A	N/A	N/A
1.B†	Impact Year usage, Impact year usage per designated unit of measurement.	N/A	N/A	N/A
2.A	Gross Peak kW (Demand) Impacts	2,705	52%	41%
	Gross kWh (Energy) Impacts	10,572,456	47%	37%
	Gross thm (Therm) Impacts	-4,143	52%	41%
	Net Peak kW (Demand) Impacts	2,873	52%	41%
	Net kWh (Energy) Impacts	11,183,773	48%	37%
	Net thm (Therm) Impacts	-4,584	52%	41%
2.B	Per designated unit* Gross Demand (kW) Impacts	0.00007	77%	53%
	Per designated unit* Gross Energy (kWh) Impacts	0.27433	73%	50%
	Per designated unit Gross Therm Impacts	-0.00011	77%	53%
	Per designated unit* Net Demand (kW) Impacts	0.00007	77%	53%
	Per designated unit* Net Energy (kWh) Impacts	0.29019	74%	51%
	Per designated unit Net Therm Impacts	-0.00012	77%	53%
2.C†	Percent change in usage (relative to base usage) of the participant group and comparison group.	N/A	N/A	N/A
2.D	Gross Demand Realization Rate	0.885	52%	41%
	Gross Energy Realization Rate	0.698	47%	37%
	Gross Therm Realization Rate §	N/A	N/A	N/A
	Net Demand Realization Rate	0.990	52%	41%
	Net Energy Realization Rate	0.777	48%	37%
	Net Therm Realization Rate §	N/A	N/A	N/A
3.A	Net-to-Gross ratio based on Avg. Load Impacts	1.058	7%	5%
3.B	Net-to-Gross ratio based on Avg. Load Impacts per designated unit* of measurement.	1.058	7%	5%
3.C†	Net-to-Gross ratio based on Avg. Load Impacts as a percent change from base usage	N/A	N/A	N/A
4.A	Pre-installation Avg. (mean) Sq. Foot (participant group)	71,265	27.3%	21.3%
	Pre-installation Avg. (mean) Sq. Foot (comparison group)	66,642	16.2%	12.6%
	Pre-installation Avg. Hours of Operation¥ (participant group)	4,068	3.2%	2.5%
	Pre-installation Avg. Hours of Operation¥ (comparison group)			
4.B	Post-installation Avg. (mean) Sq. Foot (participant group)	73,250	28.6%	22.3%
	Post-installation Avg. (mean) Sq. Foot (comparison group)	67,031	16.2%	12.6%
	Post-installation Avg. Hours of Operation¥ (participant group)	4,068	3.2%	2.5%
	Post-installation Avg. Hours of Operation¥ (comparison group)			

† The change model estimates of impact did not require an evaluation of base usage.
* The per designated unit used Sq. Ft. 1000 hours of operation.
¥ Hours of operation are based purely upon survey self-report. It is assumed that pre- and post-retrofit operation schedules are the same.
§ There were no Ex Ante therm calculations for this end use.

Protocol Table 6
Item 6: Lighting Measure Count Data
PG&E Study ID #404A

	Number of Measures Paid in 1998		
Program and Technology Group Description	**All Participants (Item 6.B)**	**Participant Sample (Item 6.A)**	**Comparison Group (Item 6.C)**
Retrofit Express Program			
Compact Fluorescent	7,325	4,403	429
Efficient Ballast	1,920	658	10,189
T8 Lamps and Electronic Ballasts	174,641	101,451	15,516
Delamp Fluorescent Fixture	23,162	13,640	4
High Intensity Discharge	313	158	1,391
Halogen	319	249	501
Exit Signs	1,273	844	291
Controls	1,171	1,057	19
TOTAL:	**210,124**	**122,460**	**28,340**

Protocol Table 6
Item 7.A: Lighting Market Segment Data by Business Type
PG&E Study ID # 404A

Business Type	Indoor Lighting	
	# of Part.	% of Part.
Office	132	31%
Retail	77	18%
Col/Univ	6	1%
School	55	13%
Grocery	11	3%
Restaurant	19	4%
Health Care/Hospital	18	4%
Hotel/Motel	14	3%
Warehouse	8	2%
Personal Service	9	2%
Community Service	56	13%
Misc. Commercial	23	5%
TOTAL:	**428**	**100%**

Protocol Table 6
Item 7.B: Lighting Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 404A

	Lighting	
Industry (3-Digit SIC Code)	# of Part.	% of Part.
821	55	12.9%
652	54	12.6%
553	20	4.7%
581	19	4.4%
602	18	4.2%
866	17	4.0%
701	13	3.0%
832	12	2.8%
922	11	2.6%
533	10	2.3%
573	10	2.3%
650	10	2.3%
753	10	2.3%
823	9	2.1%
541	8	1.9%
551	8	1.9%
603	8	1.9%
822	6	1.4%
919	6	1.4%
531	5	1.2%
737	5	1.2%
799	5	1.2%
801	5	1.2%
431	4	0.9%
514	4	0.9%
594	4	0.9%
805	4	0.9%
806	4	0.9%
835	4	0.9%
913	4	0.9%
422	3	0.7%
561	3	0.7%
784	3	0.7%
809	3	0.7%
864	3	0.7%
921	3	0.7%
384	2	0.5%
525	2	0.5%
565	2	0.5%

Protocol Table 6
Item 7.B: Lighting Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 404A

Industry (3-Digit SIC Code)	Lighting # of Part.	Lighting % of Part.
571	2	0.5%
592	2	0.5%
593	2	0.5%
631	2	0.5%
653	2	0.5%
791	2	0.5%
802	2	0.5%
839	2	0.5%
869	2	0.5%
72	1	0.2%
74	1	0.2%
161	1	0.2%
356	1	0.2%
366	1	0.2%
413	1	0.2%
421	1	0.2%
449	1	0.2%
495	1	0.2%
504	1	0.2%
507	1	0.2%
519	1	0.2%
521	1	0.2%
539	1	0.2%
544	1	0.2%
550	1	0.2%
552	1	0.2%
569	1	0.2%
591	1	0.2%
615	1	0.2%
632	1	0.2%
636	1	0.2%
702	1	0.2%
703	1	0.2%
721	1	0.2%
723	1	0.2%
734	1	0.2%
754	1	0.2%
792	1	0.2%
863	1	0.2%

Protocol Table 6
Item 7.B: Lighting Market Segment Data
by 3-Digit SIC Code
PG&E Study ID # 404A

	Lighting	
Industry (3-Digit SIC Code)	# of Part.	% of Part.
871	1	0.2%
931	1	0.2%
944	1	0.2%
971	1	0.2%
TOTAL	**428**	**100.0%**

PROTOCOL TABLE 7

PRE-1998 *COMMERCIAL EEI PROGRAM CARRY-OVER EVALUATION OF LIGHTING TECHNOLOGIES PG&E STUDY ID 404A*

The purpose of this section is to provide the documentation for data quality and processing as required in Table 7 of the California Public Utility Commission (CPUC) Evaluation and Measurement Protocols (the Protocols). Although other important considerations are addressed throughout this section, major topics are organized and presented in the same order as they are listed in Table 7 for ease of reference and review. When responses to the items are discussed in detail elsewhere in the report, only a brief summary will be given in this section to avoid redundancy.

A. OVERVIEW INFORMATION

1. Study Title and Study ID Number

Study Title: Evaluation of PG&E's Pre-1998 Commercial EEI Program Carry-Over for Lighting Technologies.

Study ID Number: 404A

2. Program, Program Year and Program Description

Program: Pre-1998 PG&E Commercial EEI Program.

Program Year: Rebates Received in the 1998 Calendar Year.

Program Description:

The Commercial Energy Efficiency Incentives Program for lighting technologies offered by PG&E has three components: the Retrofit Express (RE) Program, the Customized Efficiency Options (CEO) Program, and the Advanced Performance Options (APO) Program.

Rebates paid in 1998 only occurred in the RE Program. The RE Program offers fixed rebates to PG&E's customers that install specific gas or electric energy-efficient equipment in their facilities. The RE Program covers most common energy-saving measures: lighting, air conditioning, refrigeration/food service, and motors. To receive a rebate, the customer is required to submit proof of purchase along with the application. This Program is primarily marketed to small and medium commercial, industrial, and agricultural customers. The maximum total rebate amount allowable for the RE Program is $300,000 per account. This includes participation in any combination of the lighting, air conditioning, refrigeration/food service, and motor program options.

3. *End Uses and/or Measures Covered*

End Use Covered: Indoor Lighting Technologies.

Measures Covered: For the list of Program measures covered in this evaluation, see Attachment 2, Exhibit 2-26.

4. *Methods and Models Used*

The PG&E Commercial Lighting Technologies consisted of three key analysis components: engineering analysis, billing data regression analysis, and net-to-gross analysis. This integrated approach reduces a complicated problem to manageable components, while incorporating the comparative advantages of each analysis method. This approach describes per-unit net impacts as follows:

Net Impact = (Gross Impact) x (SAE Realization Rate) x (Net-to-Gross)

or

= {[(Operating Impact) x (Operating Factor)] x [1+HVAC]} x (SAE Realization Rate) x (Net-to-Gross)

or

= $\{[(\Delta UOL \times U) \times (OF_t \times T)] \times [1+HVAC]\} \times$ (SAE Realization Rate) x (Net-to-Gross)

Operating impact -- The technology level change in connected kW associated with a particular measure, which is defined as the load impact coincident with a specific hour, given that the equipment is operating. This approach relies on the engineering analysis to simulate operating equipment performance independent of premise size and customer behavioral factors. This term captures the per-unit difference in connected load between program installed (retrofit) high efficiency lighting measures and the existing equipment (ΔUOL), the number of units installed (U), and includes an adjustment for the probability of lamp burnout for both the retrofit and existing fixture. A detailed discussion of the operating impact calculation can be found in the *Section 3.2.2,* (under the subheading *Engineering Connected Load Estimates*).

Operating factor -- The percentage of full load (OF_t) used by a group of fixtures during a prescribed time period (T). This term reflects both the equipment's operating schedule and the percentage of lights operating (which is dependent upon whether the schedule reflects an open- or closed-period). The schedule was estimated at a high level of precision using lighting logger data in conjunction with on-site audits and telephone surveys. The open- and closed-period probability of fixture operation was estimated using both on-site audit lamp counts and lighting logger data. A detailed discussion of the operating factor approach can be found in *Section 3.2.2,* (under the subheading *Engineering Operating Schedule and Operating Factor Estimates*).

HVAC Interaction -- The component of lighting impact associated with an interaction between the HVAC system and reduced internal gains. A detailed discussion of the HVAC interaction approach can be found in *Section 3.2.2,* (under the subheading *Engineering HVAC Interactive Estimates*).

SAE Realization Rates -- The SAE Realization Rates were estimated based on a Statistically Adjusted Engineering (SAE) analysis using cross-sectional time series data and incorporating prior engineering estimates. As a result, the SAE realization rates could be defined as the percentage of a savings estimate that is detected or realized in the statistical analysis of actual changes in energy usage. The SAE realization rates were then applied to an impact estimate based upon the program baseline, equipment purchased under the program, and typical weather. A detailed discussion of the final SAE model specification can be found in *Section 3.3.*

Net-to-Gross -- The net-to-gross (NTG) ratio adjusts the program baseline derived from estimates of free-ridership and spillover associated with the program. Two approaches were used to capture the NTG effect: (1) a discrete choice model used to estimate free ridership and spillover effects and (2) the NTG ratio calculation based on survey self report using a representative nonparticipant sample to account for naturally occurring conservation. The NTG analysis approach is presented in detail in *Section 3.4.* A third approach using the net billing model was used to verify the results of the first two approaches, and is described in detail in *Section 3.3.9.*

5. *Participant and Comparison Group Definition*

Participant

Participants are defined as those PG&E commercial customers who received PG&E rebates in the 1998 calendar year for installing at least one lighting measure under the Commercial EEI Program.

Comparison Group

The comparison group for this study is defined as a group of PG&E commercial customers who did not receive any lighting end-use rebates in the 1998 calendar year under the Commercial EEI Program, and who share as many characteristics as possible with the commercial sector participant group in terms of annual usage and business type distribution. Customers who participated in previous years or those who simply participated by installing a non-lighting end-use measure, are eligible for the comparison group.

6. *Analysis Sample Size*

The final analysis dataset has 703 observations based upon 703 telephone survey completes. The distribution of the sample by business type and technology is presented in *Section 3.1.*

B. DATABASE MANAGEMENT

1. *Data Description and Flow Chart*

All data elements mentioned above were linked to the final analysis database through the unique customer identifier -- the evaluation 'site_id' variable. For this evaluation, the analysis database served as a centralized tracking system for each customers' billing history, program participation, and sampling status, which helped to reduce data problems such as account mismatch, double counting, or repeated customer contacts. Exhibit A below illustrates how each key data element was used to create the final analysis database for the Evaluation.

2. *Key Data Elements and Sources*

A complete list of data elements and their sources can be found in *Section 3.1.1*. The key analysis data elements and their sources are listed below:

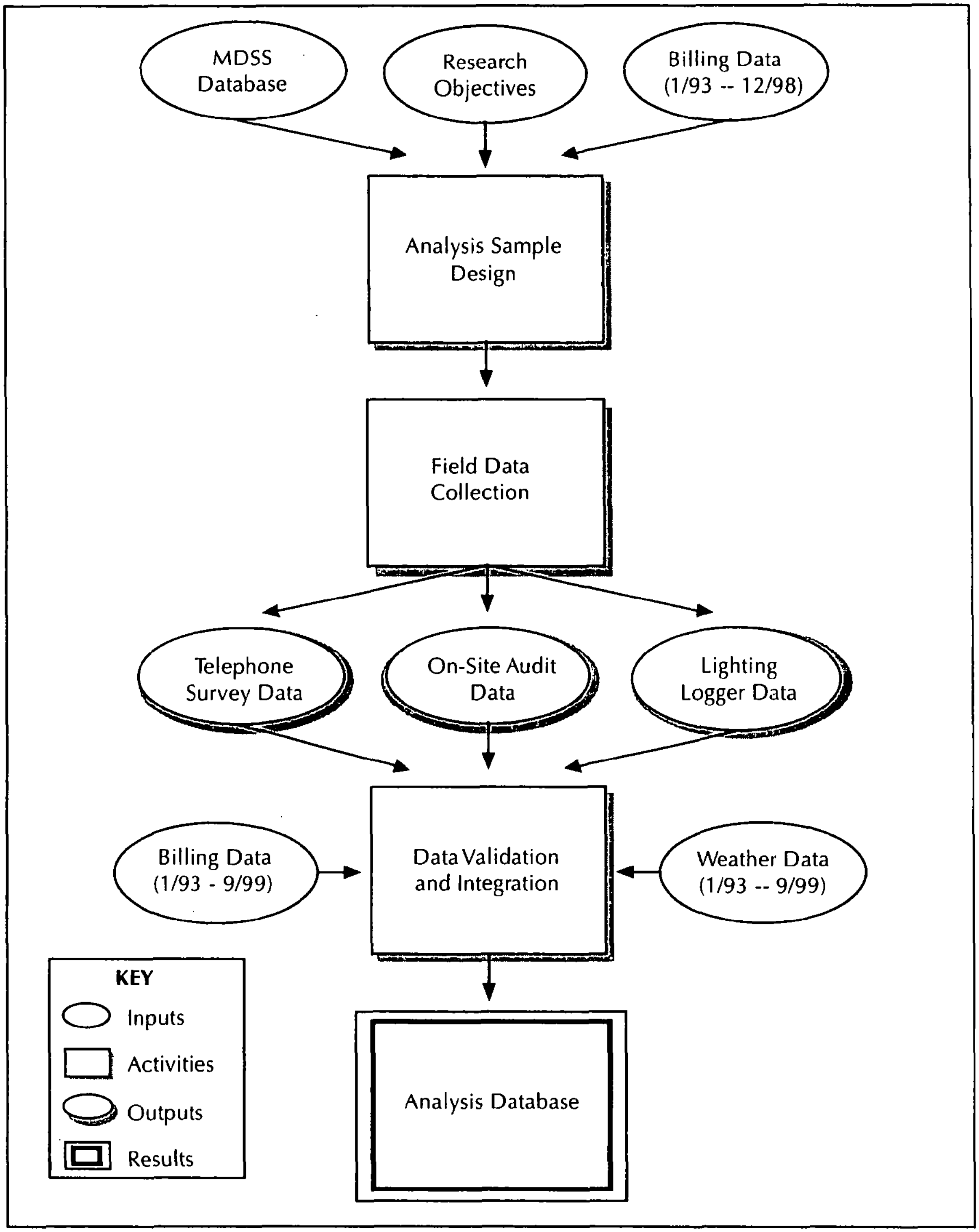
Program Participant Tracking System. The participant tracking system for the program was maintained as part of the PG&E MDSS. It contains program application, rebate, and technical information about installed measures, including measure description, quantity, rebate amount, and ex ante demand, energy, and therm saving estimates.

PG&E Billing Data. The PG&E billing data were obtained from two separate data requests. The original nonresidential billing dataset contains monthly energy usage for all nonresidential accounts in PG&E's service territory, and was used in the sample design as described in *Section 3.1*. The billing histories contained in this database run for 1993 through 1998.

The second billing dataset, was later obtained from PG&E's Load Data Services.[1] This billing dataset contains bill readings that run for January 1999 through September 1999, and was therefore used in the billing regression analysis. In addition, the billing series from this database is the PG&E pro-rated monthly usage data, a series calculated by PG&E for each calendar month.

[1] A preliminary analysis has concluded that the monthly usage and bill read date information in these two datasets is consistent.

Exhibit A
Analysis Database Development



Telephone Survey Data. Two telephone survey samples (255 participants and 589 comparison group customers) were collected as part of this evaluation. They were designed to be representative of the population by each business type. The telephone survey supplies information on customer decision-making, equipment operating characteristics, equipment stocks, and energy-related changes at each site for the billing period covered by the statistical billing analysis.

On-Site Audit Data. On-site audit data were collected as part of this evaluation for the participant group, but only to support future retention analyses. A retroactive waiver was submitted to the CADMAC and approved in May 1999. The waiver ensures Protocol compliance for the engineering models that were applied, based on evaluation results from the 1994 and 1995 Commercial Lighting Evaluations. On-site audit data from these evaluations were used in support of this year's engineering results.

Lighting Logger Data. No lighting logger data was collected as part of the 1998 Commercial Lighting Evaluation. Lighting logger data from the 1994 and 1995 Commercial Lighting Evaluations were applied to current evaluation-year engineering results.

Weather Data. The hourly dry bulb temperature collected for 25 PG&E load research weather sites is used in the billing regression analysis to calculate total monthly cooling and heating degree days for each month in the analysis period. For each customer in the analysis dataset, the appropriate weather site is linked to that customer by using the PG&E-defined weather site to PG&E's local office mapping.

Other data elements include PG&E program marketing data, PG&E internal SIC code mapping/segmentation scheme, program procedural manuals and other industry standard data sources.

3. Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. Records with out-of-range or questionable data were either deleted or flagged to ensure that only those records with sufficient data, both in terms of data quality and representativeness, were used in the analysis. The key data attrition decisions are summarized in *Section 3.3.5*.

4. Internal Data Quality Procedures

The Evaluation contractor of this project, Quantum Consulting Inc. (QC), has performed extensive data quality control on all categories of program data, including utility billing data, program tracking data, telephone survey data, and on-site audit data. QC's data quality procedures are consistent with PG&E's internal database guidelines and the guidelines established in the Protocols.

Throughout the course of sample design and creation, survey data collection, and data analysis, several data quality assurance procedures were in place to insure that all energy usage data used in analysis and all telephone survey data collected was of high quality and would prove useful in later analysis. The stages of data validation undertaken and the methods employed are detailed below.

Pre-Survey Usage and Account Characteristic Data Validation. The goal of this stage of data validation was to screen out customers who had unreasonable or unreliable usage data, or who had changes in key elements of their billing data over the 1996 to 1998 period. Accounts for which changes were observed in account numbers, service addresses, SIC codes, electric rate schedules, electric meter numbers, or corporation and premise identification variables, were excluded from sample eligibility. Usage data reliability screening first eliminated from the sample, all accounts which experienced service interruptions, exhibited inconsistent read dates, or for which bills were estimated. Additionally, based on comparisons of account usage between years, and between different months in the same year, customers with unusual usage patterns such as unusually high variation in monthly or yearly usage were given special attention and, in some cases, excluded from the sample frame. A more detailed discussion of the steps undertaken in the pre-survey usage and account characteristics data validation, is provided in the discussion of survey sample creation in *Section 3.1*.

Real Time Survey Data Validation. Survey data collection was performed using QC's 24 station Computer Aided Telephone Interviewing (CATI) center. Data entry applications, programmed using a third-party software package, employed logical branching routines and real-time data validation procedures to ensure that survey questions were appropriate for each customer's situation and that recorded responses were reasonable and logical. Data entry applications also performed real time range checks and field protection for out of range values during the data collection process thereby affording an additional means of ongoing data validation. Finally, because the software package used to program the data collection software could output the survey data in the form of a SAS dataset, the survey data was on-line continuously throughout the course of data collection. This allowed for the generation of frequency distributions and cross-tabs on data at regular stages throughout the survey fielding to facilitate QC's internal early detection and correction of data entry errors.

Final Survey Data Validation. Following the completion of survey data collection, all data was subjected to a final stage of validation and cleaning during which illogical responses were identified and corrected or flagged, and corrections were made to any mis-coding of data not detected in earlier stages of cleaning and validation. All activities undertaken in the course of survey were documented in accordance with QC's Enumerated Quality Assurance Logs and Standards (EQUALS) survey data collection documentation Protocols.

5. *Unused Data Elements*

Without exception, all data collected specifically for the Evaluation were utilized in the analysis.

C. *SAMPLING*

1. *Sampling Procedures and Protocols*

Program participants who were paid a rebate in 1998 were in most part carryover applicants. Their lighting projects were initiated prior to 1997 but they only applied or received a rebate in 1998 when their lighting projects reached the final implementation stage. There were a total of

428 lighting sites that participated in the Retrofit Program and received a rebate from PG&E in 1998. However, the number of available sites eligible for telephone surveying was fewer due to the exclusion of sites with invalid contact information and multi-sites (multiple sites in different location that reference the same contact person). A complete census of the population was needed to meet the goals of the telephone survey.

The primary objective of the nonparticipant telephone sample is to provide a control group for the net and gross billing analyses. The final comparison group sample frame consists of 192,689 commercial customers drawn from an eligible population of over 400,000. Since comparison group surveys were conducted only for customers in the commercial sector, the first step in creating the sample frame is to limit eligibility to only those accounts having SIC codes representing commercial business activities. In addition to the aforementioned criteria, the following screening rules were also used:

Presence of a billing rate for the customer: Customers are required to have a rate schedule code for all years spanned by the billing data.

Quality of usage readings: Customers are required to have annual non-missing, non-zero usage values for 1997, 1998, and 1999. Customers with zero, or missing billing data, were removed from the sample.

In drawing the sample frame, targets are established for each business type and usage segment, so that the nonparticipant distribution, by business type and usage segment, is the same as that of the program participant population. The drawing is conducted in this manner to ensure sufficient representation of each business type/usage segment combination in the sample frame and allows for survey data collection in accordance with the sample design. The final sample design includes 48 segments classified by size according to energy usage.

The desired nonparticipant quota was 500 points, but the quota was targeted at approximately 600 points with the assumption that for certain segments with small available sample frames, such as the "Very Large" segment, the quota would not be filled. The final sample allocation was randomly selected within each customer segment.

The canvass sample included 50,000 randomly drawn customers within PG&E's service territory. It's primary function was to support the net-to-gross analysis by identifying nonparticipants who have installed program qualifying measures outside of the rebate programs. The sample design focused on identifying only nonparticipants who were not rebated in 1998. From a sample of 50,000 customers, the sample quota was targeted for 4,000 total completes with about 500 of the 4,000 having made lighting or HVAC changes.

Finally, the achieved samples and their distributions can be found in *Section 3.1*. Based on the total energy usage, the sample relative precision's were estimated to be well under 10 percent at the 90 percent level. The procedures used in the relative precision calculation and a summary of how the Evaluation sample design meets the Protocols' requirement in terms of sample size and relative precision are presented in *Section 3.1*.

2. *Survey Information*

Telephone survey instruments are presented in the *Survey Appendices, Appendix A* (for participants) and *Appendix B* (for comparison group customers). Participant and comparison group customer's survey response frequencies are presented in *Appendices E* and *F*, respectively. Finally, reasons for refusals are presented in *Appendices K* and *L*.

On-site audit instruments are presented in the *Survey Appendices, Appendix D*.

3. *Statistical Descriptions*

As mentioned above, a complete set of participant and comparison group customer's responses frequencies are presented in *Survey Appendices E* and *F*. In addition, statistics on usage and engineering impact variables that were used in the billing data regression models are also presented in *Section 3.3*.

D. *DATA SCREENING AND ANALYSIS*

A detailed discussion of the billing data regression data analysis is presented in *Section 3.3*. The statistical billing model described in this section incorporates analysis for two distinct end uses: lighting and HVAC (for Study ID's 404A and 404B, respectively). Specific procedures and modeling issues are discussed below.

1. *Outliers, Missing Data and Weather Adjustment*

Three types of data censoring screens were applied to the billing analysis sample frame to remove customers: those that had invalid billing data, or that may not have had their bill properly aggregated to the Site ID level, or that were extremely large users.

Invalid Usage

For customers to be included in the final billing analysis, customers had to have billing data that met the following criteria:

The pre- and post-installation annual bills had to have been comprised of at least nine non-zero monthly bills. If there were four or more monthly bills with zero energy, the customer was removed from the analysis. If there were between one and three monthly bills with zero energy, the remaining months were prorated to an annual estimate.

The pre-installation annual bill could not be more than three times or less than one third the post-installation bill. If this occurred, the customer was removed from the analysis.

Finally, customers were removed from the analysis if they had a measure installed under the program that would result in an increase in usage. These individuals were identified through customer interviews.

Note that only 14 nonparticipants were deleted, whereas 28 participants were deleted. This is due to the fact that the nonparticipants were pre-screened to have relatively valid billing data prior to being selected into the nonparticipant survey sample frame. The participants, however, were drawn as a census and no pre-screening was done on their billing data prior to being selected into the participant survey sample frame. Of the 28 participants, 18 were deleted due to the zero bill criteria.

Aggregation to Site ID Level

As mentioned above, one concern with aggregating to the Site ID level is that there may be control numbers associated with a different premise number, service address, or corporation number that are in the same physical site and are being affected by the installed measures. Therefore, a comparison was made between the engineering energy impact and the aggregated pre- and post-installation bills to identify any customers where this problem of bill aggregation may exist. There were 15 participants that were identified as having total Commercial Sector Program energy impacts that were greater than their pre-installation, and were dropped from the analysis. The large majority of these customers were also found to have invalid usage.

Large Customers

Customers whose annual pre-installation energy consumption exceeded three million kWh were excluded from the billing analysis. A total of 40 participants and 58 nonparticipants were dropped for this reason. This decision was made *a priori* to collecting the survey data, as is documented in the Evaluation Research Plan; and is based upon the results of the previous three Lighting Evaluations, all of which were unsuccessful in obtaining reliable results when including customers with usage above this level. This is also consistent with the recommendations made by the Verification Reports of PG&E's 1995 through 1997 Commercial Lighting Evaluations, which stated in 1995 that "program effects can be difficult to detect for large customers," and recommended censoring large customers for the final billing analyses.

Although the decision to censor these customers was made *a priori*, large participants and nonparticipants were still surveyed (as discussed above in the *Section 3.1, Sample Design*) in order to meet other evaluation objectives.

In summary, out of the original sample frame of 589 nonparticipants, 71 were removed for bad billing data or for being an extremely large customer. This low attrition rate can be attributed to the fact that the nonparticipant sample was pre-screened for invalid billing data (though not for large usage, as they may have served as a control group for the participants). Of the original sample of 255 HVAC and lighting participants, 70 were removed because of bad billing, improper site aggregation, or because they were large customers. Of these 70 customers, 47 were lighting participants.

Section 3.3 presents the number of participants that were removed from the analysis for each of the above criteria.

2. *Background Variables*

Background variables, such as interest rates, unemployment rates and other economic factors, were not explicitly controlled for in the final model. However, the effect of these factors was explicitly accounted for when a cross-sectional time series model was used with a comparison group. This is based on the assumption that the comparison group was equally impacted by the same set of background variables.

3. *Data Screen Process*

As explained in *Section 3.3*, the final model was fitted in two steps. The first step is to estimate a baseline model to develop the relationship between the pre-installation year usage and the post-installation year usage, followed by an SAE model to estimate the SAE realization rates based on the engineering estimates of program impacts. Section 1 above describes in detail all of the data screening criteria. *Section 3.3* also details the number of customers that were screened for each criteria.

4. *Regression Statistics*

The billing regression analysis for the lighting program uses two different multivariate regression models under an integrated framework of providing unbiased and robust model estimates in the commercial sector. The key feature of our approach is that it employs a simultaneous equation method to account for both the year-to-year and cross-sectional variations in a manner that consistently and efficiently isolates program impacts.

A baseline model is initially estimated using only the comparison group sample. This model estimates a relationship that is then used to forecast the post-installation-year energy consumption for both participants and the comparison group, as a function of pre-installation-year usage. In this way, baseline energy usage is forecasted for participants by assuming that their usage will change, on average, in the same way that usage did for the comparison group. The outputs of the baseline model are presented in *Section 3.3*.

The estimated SAE realization rates are used to adjust the engineering estimates of expected annual energy impacts for the entire participant population. The regression statistics for the final SAE model are presented in the following exhibit, and a more detailed discussion can be found in *Section 3.3.*

The dependent variable is the difference between the actual and predicted 1999 usage using the 1997 baseline model.

SAE coefficients are calculated for six different combinations of business type and measure. Primarily those measures that have broad participation and relatively high expected impacts were supported by separate SAE coefficients. In addition, a separate SAE coefficient was calculated for other Commercial Program measures outside the Lighting and HVAC end uses.

Attempts were made to estimate the SAE coefficients at a finer level of segmentation, but generally either one of two problems were encountered. First, available sample sizes were too small to support a finer level of segmentation. Or second, certain parameters were correlated with each other and needed to be combined into a single parameter (a standard econometric solution to solving the problem of collinearity). For example, it was determined that there was a high incidence of compact and standard fluorescent installations at the same site in office buildings. Therefore, there was enough correlation between the compact and fluorescent engineering estimates to warrant combining the two estimates into a single office estimate in the model. Because of the high incidence of many types of lighting fixtures being installed at the same premise, the level of segmentation for the lighting population was conducted by business type.

Impact estimates from the MDSS for other end uses were included in the model for customers that installed measures outside the Lighting and HVAC end uses. It is not recommended that this value be used because the sample may not be representative of the population of participants installing these measures.

In addition to the SAE Coefficients, independent variables were included to capture changes in lighting, HVAC and other equipment, made outside of the program, as well as changes made to the size (square footage) of the building and with the number of employees. Separate change variables were developed for participants and nonparticipants.

Exhibit B
Final SAE Model Output

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients					
Lighting End Use					
Lighting Offices	LGTOFF7	kWh	-0.824743	-3.05	50
Lighting Retails	LGTRET7	kWh	-0.891237	-1.32	23
Lighting Schools	LGTSCH7	kWh	-0.779395	-1.01	14
Lighting Miscellaneous	LGTMSC7	kWh	-0.596705	-1.34	56
HVAC End Use					
Retrofit Express Measures	RETXHVC	kWh	-1.150815	-1.38	42
Custom HVAC	CUSTHVC	kWh	-0.757689	-1.36	6
Other End Uses					
Other Impacts	OTHMEAS7	kWh	0.100398	0.05	18
Change Variables					
Part Lighting Changes	LGT_CHG7	kWh	-0.019670	-0.72	18
Part HVAC Changes	AC__CHG7	kWh	-0.064773	-2.53	28
Part Other Equipment Changes	OTH_CHG7	kWh	-0.025256	-0.38	4
Part Square Footage Changes	SQFT_CH7	# Sqft*kWh	11.647230	4.79	6
Part Employee Changes	EMP_CHG7	# Emp*kWh	611.527341	1.27	27
Part EMS Changes	EMS_CHG7	kWh	0.049254	2.64	38
Nonpart Lighting Changes	LGT_NON7	kWh	0.100211	5.94	60
Nonpart HVAC Changes	AC__NON7	kWh	0.008429	0.60	71
Nonpart Other Equipment Changes	OTH_NON7	kWh	-0.035692	-1.86	42
Nonpart Square Footage Changes	SQFT_NO7	# Sqft*kWh	-1.012276	-1.60	20
Nonpart Employee Changes	EMP_NON7	# Emp*kWh	332.980301	3.38	598
Nonpart EMS Changes	EMS_NON7	kWh	-0.024088	-2.54	82

5. *Model Specification*

The model specifications are presented in *Section 3.3*. Specific model specification issues are further explored below:

Cross-sectional Variation. The final model specification recognizes the potential heterogeneity problem in the model and uses the following procedures to eliminate the impacts of the cross-sectional variation: (1) observations with highest usage values were removed in the model to reduce the overall variance of the sample in terms of usage and size; and (2) independent variables were all interacted with pre-installation usage to ensure that change of independent variable will be proportional to the usage value.

Time Series Variation. The key factors to control for the time series variation in the final model are: (1) use of the comparison group to define the relationship of the energy consumption between two different time periods; and (2) elimination of the multiple time period interactions by only one yearly pre-installation period and one yearly post-installation period for each stage.

Self-selection. One solution to the problem of self-selection in the gross billing model is to include an Inverse Mills Ratio in the model to correct for self-selection bias. This method was addressed by Heckman (1976, 1979[2]) and is used by others (Goldberg and Train, 1996[3]). Goldberg and Train develop the technique of including a second Inverse Mills Ratio in the savings regression to account for the possibility that participation is correlated with the size of energy savings. The second Mills Ratio is interacted with a measure of energy savings, which allows the amount of net savings to vary with participation. A complete description of the methods used to calculate the Inverse Mills Ratios, and the results of the net billing model, are described in detail in *Section 3.3.9.*

Collinearity. Various statistical tests (such as COLLIN and VIF options in SAS) were used to check multiple collinearity problem among independent variables in the model to ensure that the final parameter estimates are robust.

Net Impact. As mentioned in the Self-selection section above, a net billing model was implemented using the double inverse Mills ratio approach. The net billing model's estimates of the term (1-FR) were used to verify the results of the self-report and discrete choice models. The net billing model's estimates of (1-FR) were the highest of all three models tested. To be both conservative and consistent, the net impacts were derived from the gross billing analysis model and adjusted by a net-to-gross ratio using the discrete choice method. For a detailed discussion on the selection of the NTG ratios, refer to *Section 3.4.4.*

6. Measurement Errors

For the billing data regression analysis, the main source of measurement errors is the telephone survey. Our approach has been to proactively stop the problem before it happens so that statistical corrections are kept to a minimum.

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[2] Heckman, J. '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, Vol. 5, pp. 475-492, 1976.

Heckman, J. "Sample Selection Bias as a Specification Error." Econometrica, Vol. 47, pp. 153-161, 1979.

[3] Goldberg, Miriam and Kenneth Train. 'Net Savings Estimation: An analysis of Regression and Discrete Choice Approaches', prepared for the CADMAC Subcommittee on Base Efficiency by Xenergy, Inc. Madison, WI, March 1996.

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias, which includes, but is not limited to, ill-formed or misleading questions and mis-coded study variables. In this project, we have implemented several controls to reduce systematic bias in the data. These steps included: (1) thorough auditor/coder training; (2) instrument pretest; and (3) cross-validation between on-site audit data and telephone survey responses.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased. For the measures that were modeled in the billing regression analysis, the impact of random unbiased measurement errors was accounted for as part of the overall standard variance in the parameter estimate.

7. *Autocorrelation*

The autocorrelation problem exists if the residuals in one time period are correlated with the residuals in the previous time period. Since the final model is based on a yearly pre- and post-installation period comparison with only one year in each period, the autocorrelation problem was unlikely to occur under this scenario, as was confirmed by examining the Durbin-Watson statistic for these models.

8. *Heteroskdasticity*

See discussion above.

9. *Collinearity*

See discussion above.

10. *Influential Data Points*

See discussion above.

11. *Missing Data*

See discussion above.

12. *Precision*

The precision calculation for the gross SAE realization rates are presented in *Section 3.3*. Relative precision's for net estimates were calculated using the following procedure:

- First, NTG ratios, N_i, were computed for all technology groups that were represented in the telephone survey.

- Then, the program level NTG and program level standard error for the NTG were calculated using the classic stratified sample techniques. The program level NTG was a weighted average of technology level NTG values with adjusted gross impacts per technology group providing the weights.[4] The functional relation can be best described in the following equations:

$$\overline{N} = \sum_i w_i * \overline{N_i} \text{ with } w_i = MWh_i$$

$$StdErr_{NTG} = \sqrt{\sum_i \left[(w_i)^2 * StdErr_i^2\right]}$$

Where,

NTG = Net-to-Gross Value;

i = Technology Group i; and,

w_i = Weight of technology group i.

- Then, the relative precision[5] for the program NTG value for energy was calculated and combined with the relative precision of the gross energy impact to yield an overall relative precision for the net energy impacts:

$$RP_{NTG\_Energy} = \frac{t_{\alpha=10} * StdErr}{NetMWh}$$

$$RP_{NetEnergy} = \sqrt{RP^2_{NTG\_Energy} + RP^2_{GrossEnergy}}$$

- Finally, the relative precision net demand impacts were calculated using a scaled version of the relative precision for the net energy impact. The sample sizes of the on-site audits and telephone surveys served as the scalars:

$$RP_{NetDemand} = RP_{NetEnergy} * \sqrt{\frac{N_{OnSite}}{N_{Telephone}}}$$

- Per-unit NTG relative precision data appearing in Table 6 (Items 1-5) were calculated in a similar fashion.

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[4] Technology groups with no standard errors were excluded from this calculation.

[5] The example shown is for the 90 percent confidence level. Relative precision was also calculated at the 80 percent confidence level.

E. *DATA INTERPRETATION AND APPLICATION*

The program net-to-gross analysis was conducted based on a discrete choice analysis. For a detailed NTG analysis discussion, see *Section 3.4*.

Discrete Choice Method

A discrete choice logit model is used to estimate both a net-to-gross ratio and the free ridership rate associated with PG&E's Commercial Lighting Retrofit Program (the Lighting Program). The decision to purchase high-efficiency equipment is explained in the logit model by the cost and savings of the equipment, any rebate offered by the Lighting Program, awareness of the Lighting Program, and other customer characteristics. Once estimated, the model can be used to determine the probability of purchasing high-efficiency equipment in the absence of the Lighting program. This is simulated by setting both the rebate and program awareness variables to zero and re-calculating the probability of purchasing high efficiency lighting equipment.

The net-to-gross ratio is calculated using the probability of purchasing high-efficiency equipment both with and without the existence of the retrofit program. The expected impact with the program is the probability of choosing high-efficiency equipment multiplied by the energy impact of the equipment. Similarly, the expected energy impact in absence of the Lighting program is the probability of purchasing high-efficiency equipment without the program multiplied by the energy impact of the equipment. The net-to-gross ratio is the net savings due to the program divided by the expected energy that results from having the program. As discussed in *Section 3.4*, this method is also used to determine free ridership rates and nonparticipant spillover.