Customer Energy Efficiency Program
Measurement and Evaluation Program

IMPACT EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1996 COMMERCIAL ENERGY EFFICIENCY INCENTIVES PROGRAM: LIGHTING TECHNOLOGIES

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1. EXECUTIVE SUMMARY

This section presents a summary of the impact results for the commercial indoor lighting technologies offered under the Pacific Gas & Electric Company's (PG&E's) 1996 Commercial Energy Efficiency Incentive (CEEI) Program, referred to in this report as the Lighting Program. This evaluation covers indoor lighting technology retrofits that were performed at PG&E customer facilities, for all rebates paid in 1996. These retrofits were performed under three different PG&E programs: the Retrofit Express (RE), Customized Incentives, and Customized Efficiency Options (CEO) Programs. The results are presented in three sections: evaluation results summary (covering the numerical results of the study), major findings, and major recommendations.

1.1 EVALUATION RESULTS SUMMARY

The evaluation results are summarized in terms of energy savings (kWh), demand savings (kW), therms impacts, and realization rates, the ratio of the evaluation results (ex post) to the program design estimates (ex ante). 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	Net-To-Gross Spillover	Net-To-Gross NTG Ratio	Net Savings	Net Realization Rate
EX ANTE							
kW	22,073	-	0.67	0.10	0.77	16,988	-
kWh	127,919,770	-	0.67	0.10	0.77	98,422,264	-
Therms	-	-	-	-		-	-
EX POST							
kW	27,575	1.25	0.70	0.14	0.84	23,073	1.36
kWh	138,339,806	1.08	0.71	0.10	0.82	112,831,780	1.15
Therms	-35,752,874	-	0.69	0.18	0.87	-30,983,279	-

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 commercial lighting impacts:

Lighting Retrofit Programs - Overall, the vast majority of the savings are from lighting technologies installed through the RE program. More than 95 percent of the energy and demand impacts can be attributed to the RE program.

Gross Energy Impacts - The ex post gross energy impacts were just eight percent larger than the ex ante gross estimates. The unadjusted engineering estimates of gross energy impact, however, were 13 percent larger.

Gross Demand Impacts - The ex post gross impacts for demand, exceeded the ex ante estimates by 20 percent. This 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 exceed the net ex ante estimates by 15 percent for energy and 36 percent for demand. To a certain extent, these results reflect the high gross realization rates, but they are also driven by the ex ante and ex post net-to-gross (NTG) ratios. The ex ante NTG ratio was just 0.77 for both demand and energy, while the ex post NTG ratio was 82 percent for energy and 84 percent for demand. Therefore, the ex post NTG ratios contribute a 6 percent and 9 percent increase of ex ante for energy and demand, respectively.

The larger overall savings estimates reflect not only the larger NTG ratios, but the conservative ex ante estimates. The higher operating factors that the evaluation identified in the commercial sector, and the inclusion of HVAC savings in the ex post evaluation impacts, also contributed to the larger net demand savings.

1.2 MAJOR FINDINGS

The key findings are summarized as follows:

- Overall, PG&E's ex ante estimates for the commercial lighting technologies paid under the 1996 programs were conservative, resulting in net realization rates exceeding one.
- For many of the business types and technologies, hours of operation and operating factors exceeded the ex ante values by a significant margin. This was the main factor contributing to many high gross realization rates.
- High NTG ratios, combined with low program ex ante NTG estimates, also increased the net realized savings.
- The high participation technologies of T-8/electronic ballast, optical reflectors with delamping, and HID replacement of less efficient technologies yielded large realized savings.

1.3 MAJOR RECOMMENDATIONS

Trade on Established Information in Future Evaluations - This evaluation utilized extensive observed and measured operating factor and operating hours information on the highest participation segments from previous evaluations. QC recommends that PG&E continue to use this existing information in subsequent evaluations, thus minimizing the need to replicate operating hours and operating factor data for sectors where this information is unlikely to change. There is no reason to believe that the operating factor and operating hours information utilized in this evaluation will change significantly from year to year. This will allow PG&E and the CPUC to maximize return on money invested in future evaluations, resulting in better estimates for sectors that have yet to be definitively documented.

Other detailed recommendations concerning measures offered and the CPUC Protocols are covered in detail in *Section 5*.

2. INTRODUCTION

This report summarizes the impact evaluation of Pacific Gas & Electric Company's (PG&E's) Commercial Energy Efficiency Incentive (CEEI) Program for commercial sector lighting technologies (the Lighting Evaluation). These technologies are covered by three separate program options, the Retrofit Express (RE) Program, the Customized Incentives Program, and the Customized Efficiency Options (CEO) Program. The evaluation effort includes customers who were paid rebates in 1996. These programs are 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 THE CUSTOMIZED INCENTIVES PROGRAM

The Customized Incentives Program offered financial incentives to CIA customers who undertook large or complex projects that save gas or electricity. These customers were required to submit calculations for projected first-year energy impacts with their applications prior to installation of the project. The maximum incentive amount for the Customized Incentives Program was $500,000 per account, and the minimum qualifying incentive was $2,500 per project. The total incentive payment for kW, kWh, and therm savings was limited to 50 percent of direct project cost for retrofit of existing systems. Since the program also applied to expansion projects, the new systems incentive was limited to 100 percent of the incremental cost to make new processes or added systems energy efficient. Customers were paid 4¢ per kWh and 20¢ per therm for first-year annual energy impacts. A $200 per peak kW incentive for peak demand impacts required that savings be achieved during the hours PG&E experiences high power demand.

There was no Customized Incentives Program in 1995 or 1996. Due to the significant documentation and analysis involved in Customized Incentives Program measures, however, rebates for a number of 1992, 1993, and 1994 measures were delayed for payment until 1996. All equipment applied for under the program must have been installed and in operation by November 30, 1995. This evaluation covers those measures where rebates were paid in 1996. A total of 35 Customized Incentives Lighting Program participants were paid rebates in 1996.

As a result of program design, many of the measures installed were similar to or the same as those for the RE program, but were installed in larger and more complex projects.

2.3 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, Customized Incentives, and CEO programs and for which rebates were *paid* during calendar year 1996.

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

2.3.1 Objectives

These research objectives are as follows:

- Determine first-year gross energy, demand, and therm impacts by business type and technology group for RE, Customized Incentives, and CEO lighting technologies paid in 1996, and overall impacts for the commercial sector 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, Customized Incentives, and CEO lighting technologies paid in 1996, and overall impacts for the commercial sector 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, Customized Incentives, and CEO programs. 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 programs' 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, explains differences between program design estimates and evaluation results.

2.3.2 Timing

The 1996 Lighting Evaluation began in June 1997, completed the planning stage in July 1997, executed data collection between mid-July and early November 1997, and completed the analysis and reporting phase in February 1998.

2.3.3 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.

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[1] California Public Utilities Commission Decision 93-05-063, Revised January 1996 Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, and 95-12-054.

2.4 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.

2.4.1 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]), paper copies of RE, Customized Incentives, and CEO applications, 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. 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 1996 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.

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[2] ["1996 Lighting Retrofit Express Program"; Advice Filing 1921-G/1540-E, October 1995.]

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.

Copies of RE, Customized Incentives, and CEO Paper Application Files **-** QC requested and received complete copies of application files for a random 50 RE participants and all Customized Incentives participants. The RE files were used to verify the entries in the MDSS electronic files and to identify additional information that could be extracted from the file to improve the analysis. The Customized Incentives files were used to classify these participants into categories similar to the RE program, where possible, thus allowing maximum use of the statistical billing regression analysis.

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 (and verified using 1996 self-report data) 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 On-Site Audits and Telephone Survey data. A brief description of each follows:

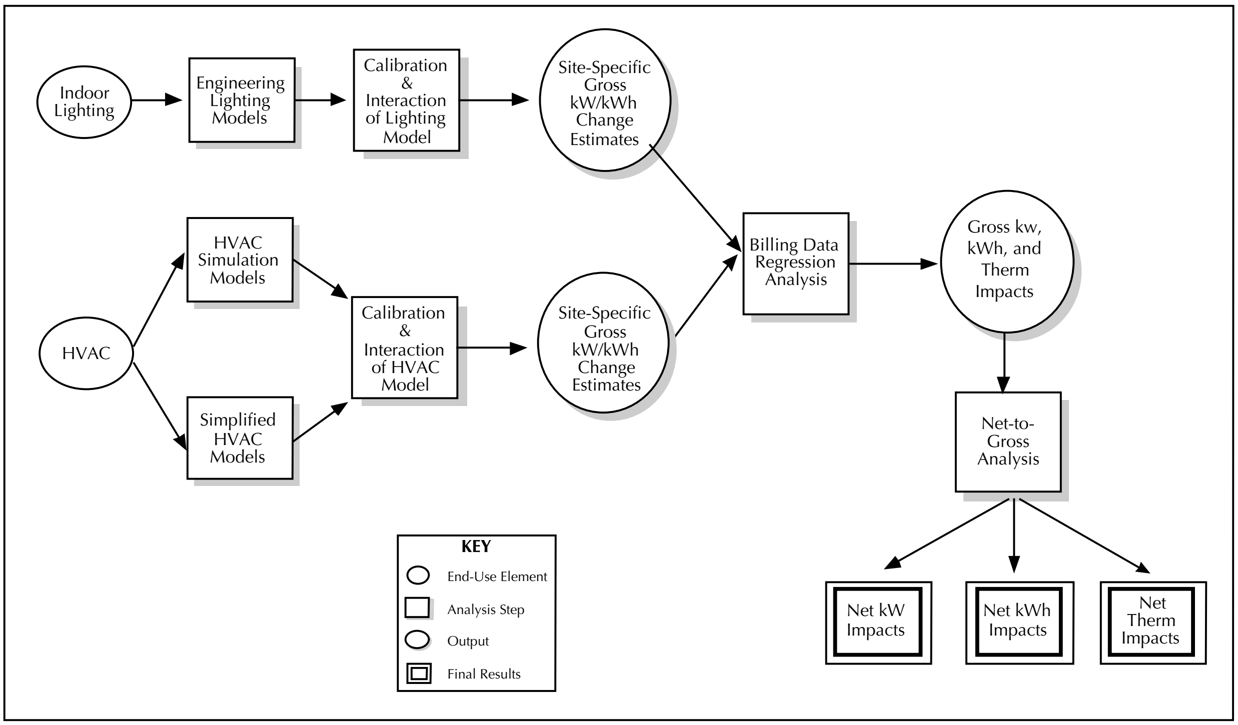
On-Site Audits. A total of 162 customer sites were visited by a QC engineer to gather site-specific data used in support of the engineering and survival analyses, as well as to create the retention panels to be used in subsequent evaluations. The on-site visit included a customer interview and an equipment/facilities audit. Only data required for this PG&E study was collected. This sample contributes equipment details that are site-specific, and better estimates of operating hours, operating factors, equipment efficiency, lamp burn-out rates, missed opportunities, and other technical factors that are difficult to collect over the telephone. The on-site sample itself is not designed to be statistically representative, but rather to support the estimate of detailed engineering parameters collected within the segments with the highest projected impact

Telephone Survey Data. A significantly larger telephone survey sample was collected. A total of 496 Lighting participant, 462 nonparticipant, and 3,796 canvass surveys were completed to gather customer profiles used in all of the analyses. The nonparticipant survey was similar to the participant survey, and served as a control group in the SAE analysis. The canvass survey was used in support of the net-to-gross analysis.

2.4.2 Analysis Elements

This sub-section describes the general approach used to estimate both the gross and net demand and energy impacts for the Lighting Evaluation. The application and program design data are used to create a data collection plan, which in turn guides the evaluation data collection efforts. The sample design, engineering analysis, billing analysis, and net-to-gross analysis are all described in greater detail in *Section 3, Methodology*.

Exhibit 2-1
Overall Impact Analysis Approach



The analysis approach illustrated in Exhibit 2-1 consists of three primary analysis components: the **engineering analysis**, the **billing analysis**, and the **net-to-gross analysis**. This integrated approach reduces a complicated problem into manageable components, while incorporating the comparative advantages of each method. This approach describes per-unit net impacts as:

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. Engineering estimates were first developed for each participant. These estimates were then 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 output 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 the 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 attributed to the program.

A more sophisticated estimate of NTG for selected high-participation measures was developed through the application of discrete choice analysis. The discrete choice probit 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 also 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.

2.5 REPORT LAYOUT

This report presents the results of the above evaluation. It is divided into five sections, plus 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. This section also includes the impacts by Time-of-Use costing periods. *Section 5* presents recommendations for improving the evaluation, the program measures, the program tracking system, and the CPUC Protocols. *Attachment 1* is a waiver filed with the CPUC 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. *Attachment 2* are 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. The attachment also contains gross demand and energy savings by costing period for commercial indoor lighting measures. *Attachment 3* contains Protocol Tables 6 and 7. 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 1996 Pacific Gas & Electric Company (PG&E) Commercial Energy Efficiency Incentive (CEEI) 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 (*Section3.4)* are discussed.

3.1 SAMPLE DESIGN

This section presents the sample design for the Lighting Evaluation. An integrated sample design was implemented for the Lighting and HVAC end uses, due to the high number of participant crossover amongst the various end uses. 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 for the Retrofit Express (RE), Customized Incentives (CI), and Customized Efficiency Options (CEO) Programs are maintained as part of PG&E's Marketing Decision Support System (MDSS). Henceforth, the RE program components are referred to as simply Retrofit, with the remaining program components referred to as Custom. 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 and Custom programs, 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 1997. 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

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.

- Allocate sufficient 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 ten 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.

Exhibit 3-1
1996 Commercial Lighting Segmentation and Distribution of Unique Sites

Technology	Business Type	Commercial												
		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Serv.	Comm. Serv.	Misc.	Total
Indoor Lighting	Halogen	62	32	8	7	8	15	19	9	2	4	19	0	184
	Compact Fluorescent Lamps	288	92	36	141	61	66	58	85	22	27	94	43	1,010
	Incandescent to Fluorescent Fixture	20	6	7	43	7	3	9	9	3	3	19	7	136
	Exit Signs	137	170	16	75	31	41	34	12	10	16	51	20	613
	Efficient Ballast Changeouts	17	34	3	25	5	0	8	2	1	6	16	6	123
	T-8 Lamps and Electronic Ballasts	672	554	49	235	407	144	118	32	85	77	206	121	2,688
	Delamp Fluorescent Fixtures	225	102	14	58	49	23	36	3	28	22	41	34	631
	High Intensity Discharge	28	29	8	32	9	4	2	1	66	6	28	44	257
	Controls	82	55	13	39	19	9	21	9	12	10	29	15	313
	Customized Lighting Measures	0	0	0	0	33	1	0	1	0	0	0	1	36
Indoor Lighting End Use Total		796	687	52	287	451	178	141	117	141	105	280	163	3,383

Annual energy consumption values were used to group customers into five usage/size strata based upon a Dalenius-Hodges[3] 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:

Technology Groups consist of those measures that comprise, in the case of the Indoor Lighting end use, those specific 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. 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 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. For each of these analyses, it was necessary for a representative sample of participants to be collected. To allow for more accurate results, a total of 425 Lighting participants was planned, which far exceeded the Protocol requirement of 350. Because there were HVAC participants that also participated in the Lighting end use, it was expected that more than 425 Lighting surveys would be completed, as some HVAC surveys would include Lighting participants. The sample plan therefore concentrated on the set of Lighting

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

participants that did not participate in HVAC, with the assumption that the sample would be supplemented with additional HVAC/Lighting participants.

With an available sample frame of 3,261 unique Indoor Lighting sites (exclusive of HVAC/Lighting participants), it was possible to develop a sample plan, as opposed to simply conducting a census. Participants were segmented by technology and business types where participation was concentrated. These segments were then ranked by their contribution to total program avoided costs. A corresponding percentage of the total anticipated quota of 425 points was then assigned to that segment. The quotas calculated based on avoided cost were then rounded up to the nearest 5. It should be noted that some of the available segment sample frames were low relative to the anticipated quota. The final sample distribution was expected to differ from the planned sample design for these segments.

Exhibit 3-2 below illustrates the make-up of the Lighting segment, sorted by descending avoided costs.

Exhibit 3-2
Final Participant Lighting Quotas
Telephone Survey Sample

			Sites					
Strata Name	Avoided Costs	% of Av. $	Total in Technology	Unique	Calculated Quota	Pop'ln to Quota Ratio	Actual Quota	Actual Ratio
Office T-8	$ 5,798,565.39	12%	652	428	47	9.18	50	8.56
Retail T-8	$ 6,038,024.37	12%	546	451	49	9.29	50	9.02
Grocery T-8	$ 3,745,954.69	8%	402	352	30	11.69	30	11.73
Office Delamp	$ 4,600,735.96	9%	218	185	37	5.00	40	4.63
Office Other	$ 1,780,405.00	4%	437	150	14	10.48	15	10.00
Retail Other	$ 2,714,190.19	5%	419	225	22	10.31	25	9.00
College/Univ	$ 3,952,587.30	8%	47	46	32	1.45	25	1.84
Schools	$ 3,968,065.58	8%	263	263	32	8.24	35	7.51
Grocery Other	$ 2,761,817.51	6%	334	87	22	3.92	25	3.48
Restaurants	$ 466,102.83	1%	175	174	4	46.43	10	17.40
Warehouse HIDs	$ 1,831,424.07	4%	78	68	15	4.62	15	4.53
Warehouse Other	$ 1,671,218.93	3%	83	67	13	4.99	15	4.47
Health Care	$ 3,554,402.22	7%	139	139	29	4.86	30	4.63
Hotel/Motel	$ 1,698,280.50	3%	105	105	14	7.69	15	7.00
Miscellaneous Services	$ 5,162,744.32	10%	526	521	42	12.55	45	11.58
TOTALS	$ 49,744,518.86	100%	4,424	3,261	400		425	

Comparison (nonparticipant) Sample

The primary objective of the nonparticipant telephone sample was to provide a control group for the net and gross billing analyses. The final comparison group sample frame consists of 82,400 commercial customers drawn from an eligible population of over 400,000 commercial controls. 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 non-missing, non-zero usage values for at least 7 month of every billing year spanned by the billing data. Customers with mean zero, or missing billing data, were removed from the sample.

Reasonable usage and miscellaneous data across years: Accounts are screened to ensure that the mean usage on the account for 1995 and 1996 is no more than twice (or less than half) the mean usage on the account for 1994 and 1995, respectively. Accounts are also screened to ensure that they have reasonable phone numbers, meter numbers, and division codes. Any accounts with invalid data are rejected from the sample frame.

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. Exhibit 3-3 below illustrates the business type/usage segments, the available nonparticipant sample, the calculated quota (based on the participant population), and the desired sample size to draw. Gray cells indicated nonparticipant segments where the available population to quota ratio is low. The final sample allocation was randomly selected within each customer segment.

Exhibit 3-3
Nonparticipant Survey Quotas
Telephone Survey Sample

SAMPLE DESIGN															
Small				Medium				Large				Very Large			
Business Type	Avail.	Quota	N	Business Type	Avail.	Quota	N	Business Type	Avail.	Quota	N	Business Type	Avail.	Quota	N
Office	12,644	52	1,031	Office	1,383	54	1,079	Office	61	7	146	Office	33	8	158
Retail	13,402	42	849	Retail	1,684	26	522	Retail	52	1	24	Retail	12	1	12
Col/Univ	211	2	49	Col/Univ	42	0	0	Col/Univ	5	0	0	Col/Univ	10	3	61
School	619	10	194	School	545	26	522	School	23	2	36	School	5	0	0
Grocery	3,004	7	133	Grocery	1,370	12	230	Grocery	90	3	61	Grocery	1	0	0
Restaurant	5,906	12	230	Restaurant	1,273	13	255	Restaurant	5	0	0	Restaurant	0	0	0
Health Care/Hosp	5,537	13	267	Health Care/Hosp	287	8	158	Health Care/Hosp	22	2	36	Health Care/Hosp	21	7	133
Hotel/Motel	1,001	7	146	Hotel/Motel	158	9	182	Hotel/Motel	15	5	109	Hotel/Motel	6	1	24
Warehouse	4,139	15	303	Warehouse	505	18	364	Warehouse	28	1	24	Warehouse	9	1	12
Personal Service	9,405	21	412	Personal Service	258	7	146	Personal Service	10	1	12	Personal Service	4	0	0
Community Servic	9,306	38	764	Community Servic	791	18	352	Community Servic	61	2	49	Community Servic	24	2	49
Misc. Commercial	7,629	18	364	Misc. Commercial	658	8	158	Misc. Commercial	95	4	73	Misc. Commercial	51	4	73
SUB-TOTAL:		237	4,742	SUB-TOTAL:		198	3,966	SUB-TOTAL:		29	570	SUB-TOTAL:		26	522
GRAND TOTAL:		490	9,800												

Due to the lack of "very large" commercial customers available in the nonparticipant population, a final quota of 490 sample points was set, with the expectation that only 450 surveys would be completed. Ultimately, 462 points were collected from a draw of 9,214 customers.

Finally, the canvass survey sample draw of 50,000 customers was randomly drawn from a frame of 147,762 customers who met the criteria outlined above. Although this number is well in excess of the number needed for 4,000 completes, it ensured that additional sample draws would not be necessary for the canvass telephone survey. A total of 3,796 canvass surveys were conducted to support the net-to-gross analysis.

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 3-4 by end-use element.

Telephone Survey Sample – For each segment, the retrofit program sample design allocated the sample in proportion to the program-avoided cost by the segments in Exhibit 3-2. This sample design concentrates sample points to segments that represent the highest impact, in order to obtain the best estimate of impact for the largest portion of the population. This sample allocation, combined with the random sampling techniques within each segment, produces a stratified random telephone survey sample representing the program participants population paid in 1996. A discussed previously, the nonparticipant telephone sample is developed based upon the business type and usage strata distribution resulting from the participant sample allocation. It should also be noted that only one customized incentive participant completed a telephone survey. This is in part due to the fact that the sample frame consisted of only 36. All 36 were attempted to be contacted for the telephone survey.

Exhibit 3-4
Data Collected by Program and End Use

Program	End Use	Available Population	Data Collected		Data Used in Lighitng Analysis	
			Telephone Surveys	On-Site Audits	Telephone Surveys	On-Site Audits
Custom	Lighting	36	1	-	1	-
	HVAC	90	21	50	21	0
Retrofit	Lighting	3,359	495	162	495	162
	HVAC	1,025	329	178	329	0
Total	Lighting	3,383	496	162	496	162
	HVAC	1,112	350	228	350	0
Total Participants		4,367	808	351	808	162
Total Nonparticipants		408,668	462	-	462	-
Total Sites		413,035	1,270	351	1,270	162

Telephone surveys were collected for a total of 1,270 customers, 808 of which were participants, with the remaining 462 in the comparison group. Among the 808 participant, 496 were lighting participants.

On-site Audit Sample – Similarly to the telephone survey sample, this 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 162 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 is calculated using the following procedure. First, the 1994 annual energy consumption is computed for all participants in the analysis dataset.

Next, five strata are constructed based on a customers' annual usage using the Delanius-Hodges procedure. Exhibit 3-5 presents the stratum-level sample size, sample weight, sample mean, and estimated standard errors for each end use evaluated.

Exhibit 3-5
Telephone Sample Relative Precision Levels

Nonparticipants

Weight	Sample	Mean	STD	Standard Error	Relative Precision
96.1%	385	53,784	52,739	2,681	8.2%
3.0%	42	318,960	166,942	25,513	13.2%
0.8%	18	1,169,320	404,165	93,876	13.2%
0.1%	6	2,237,123	434,312	171,228	12.6%
TOTAL	451	73,630		2,805	6.3%
Large Customers					
Population = 281	11	6,072,193	5,247,728	1,519,643	41.2%

Lighting Participants

Weight	Sample	Mean	STD	Standard Error	Relative Precision
58.3%	339	68,293	69,203	3,083	7.4%
29.7%	75	419,527	477,869	50,869	19.9%
9.5%	42	1,220,591	596,417	79,398	10.7%
2.5%	14	2,706,409	443,498	98,043	6.0%
TOTAL	470	347,834		17,149	8.1%
Large Customers					
Population = 142	26	14,943,801	31,549,424	5,054,456	55.6%

Then, the program level mean and standard error are calculated using classic stratified sample techniques[4]. Finally, the relative precision at a 90 percent confidence level is 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.

By survey, the following relative precision was achieved:

- For nonparticipants, the relative precision is 6.3 percent based upon a survey sample of 451.
- For Indoor Lighting, the relative precision is 8.1 percent based upon a survey sample of 470.

3.1.8 Demonstration of Protocol Compliance

Sampling Procedures Adopted

The sample design follows the rules established by the CPUC in the January 1996 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

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[4] Ibid. pp. 91-95

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. This requirement was either met or exceeded.

As illustrated in Exhibit 3-5, the sample collected for the lighting end use achieved a relative precision of at least 8 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 3-5 illustrates a relative precision of 6.3 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 1997, which ensures an adequate pre- and post-installation billing period for customers who installed applicable measures between 1994 and 1997.

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.

Each measure approach is also segmented according to the general analysis strategy; analyses are either standardized (standard) or require individual analysis and data collection (custom). Exhibit 3-6 specifies the engineering approach applied, using these analysis segment classifications by program, and measure group.

Exhibit 3-6
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	Analysis Segment
Indoor Lighting	Retrofit Express	Halogen	0.1%	184	Calibrated Model	Standard
		Compact Fluorescent Lamps	4.9%	1,010	Calibrated Model	Standard
		Incandescent to Fluorescent Fixture	2.8%	136	Calibrated Model	Standard
		Exit Signs	2.3%	613	Calibrated Model	Standard
		Efficient Ballast Changeouts	0.5%	123	Calibrated Model	Standard
		T-8 Lamps and Electronic Ballasts	51.0%	2,688	Calibrated Model	Standard
		Delamp Fluorescent Fixtures	23.7%	631	Calibrated Model	Standard
		High Intensity Discharge	10.3%	257	Calibrated Model	Standard
		Controls	1.8%	313	Simplified Model	Standard
	Customized Ince	Customized Lighting Measures	2.8%	36	Calibrated/Simplified	Standard
	Indoor Lighting End Use Total		100.0%	3,383	-	-

3.2.1 Lighting Models

Pacific Gas and Electric Co. (PG&E) has recently completed both a 1994 and 1995 paid-year evaluation of its Commercial sector Retrofit 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 and 1995, has allowed PG&E to reduce the on-site data requirements for completing this 1996 paid-year effort.

A Retroactive Waiver was submitted to the CADMAC and approved on November 21, 1997 (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.

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 1996 study meets all Table C-4 analysis requirements. Additional data were collected to meet the Table 5 sample design requirements; in fact, analyses were carried out to compare and contrast the self-report lighting schedule information from the 1994, 1995 and 1996 paid-year evaluation efforts. Results have shown that there are not significant differences in the operating schedules for the contributing key business types. For this reason, adjustments to the 1994 and 1995 CE model load shape results were not required.

The 1996 program CE lighting models incorporate previous evaluation results including full load hours of operation, coincident diversity factors, HVAC interactive effects, and burnout rates. However, 1996 evaluation activities include: an assessment of fixture change in connected load for measures installed under both the RE and Customized programs, and a comparison of self-reported lighting system operating schedules. A discussion of these activities is reserved for the end of this engineering section.

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 most of the impacts under the RE and Customized Incentives programs 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:

ΔUOL - 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.

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[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).

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

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 from during the 1994 and 1995 Lighting Evaluations, as approved through a Retroactive Waiver (see *Attachment A*).

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 3-7 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.

3.2.2 Derivation of Engineering Parameters

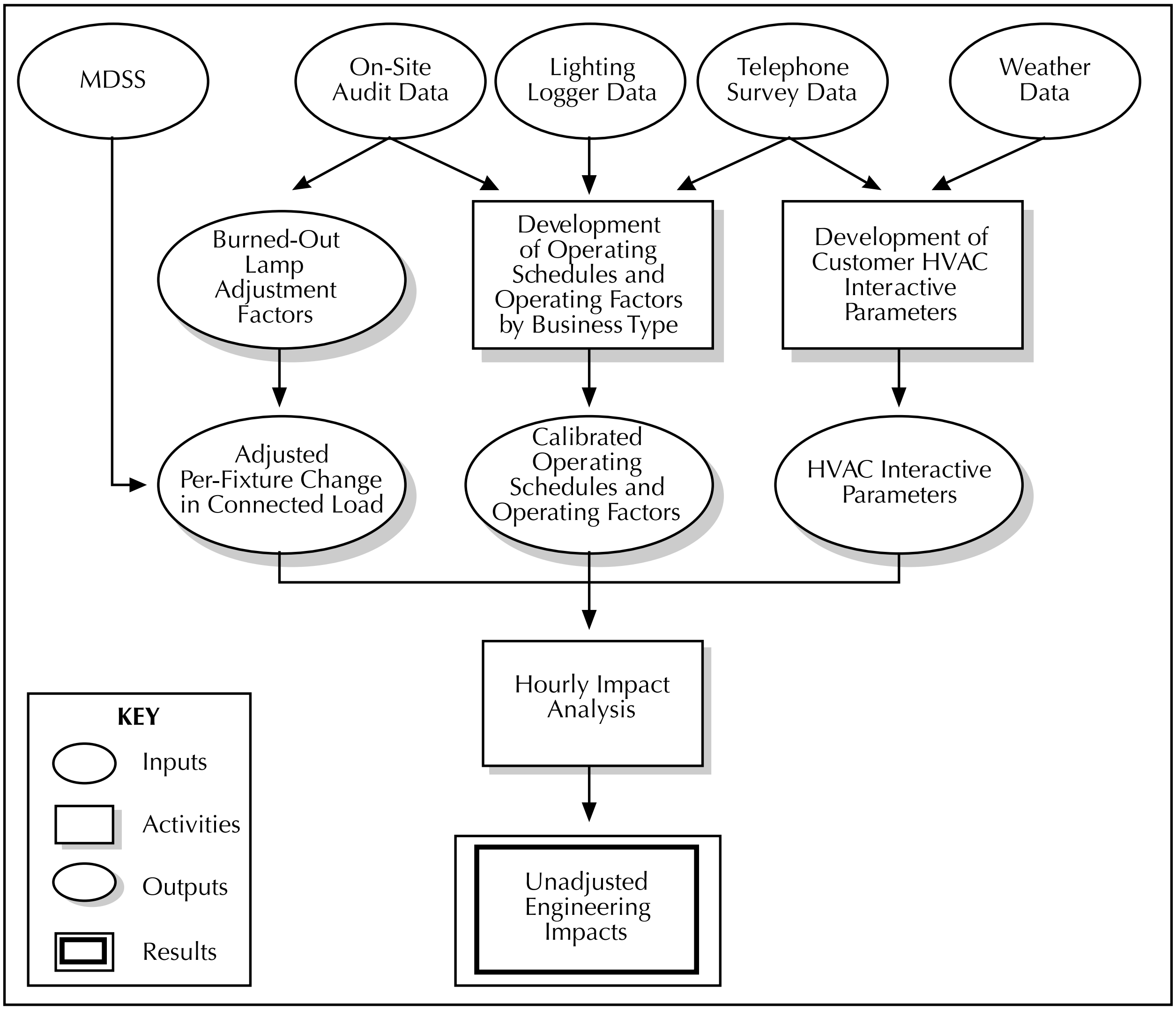
This section provides an overview of the methods used to develop each of the parameters used in the impact decomposition approach.

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 (hard copy application records for the Customized Incentives Program 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.

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.

Exhibit 3-7
Method Used to Develop Hourly Engineering Estimates



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 3-8.

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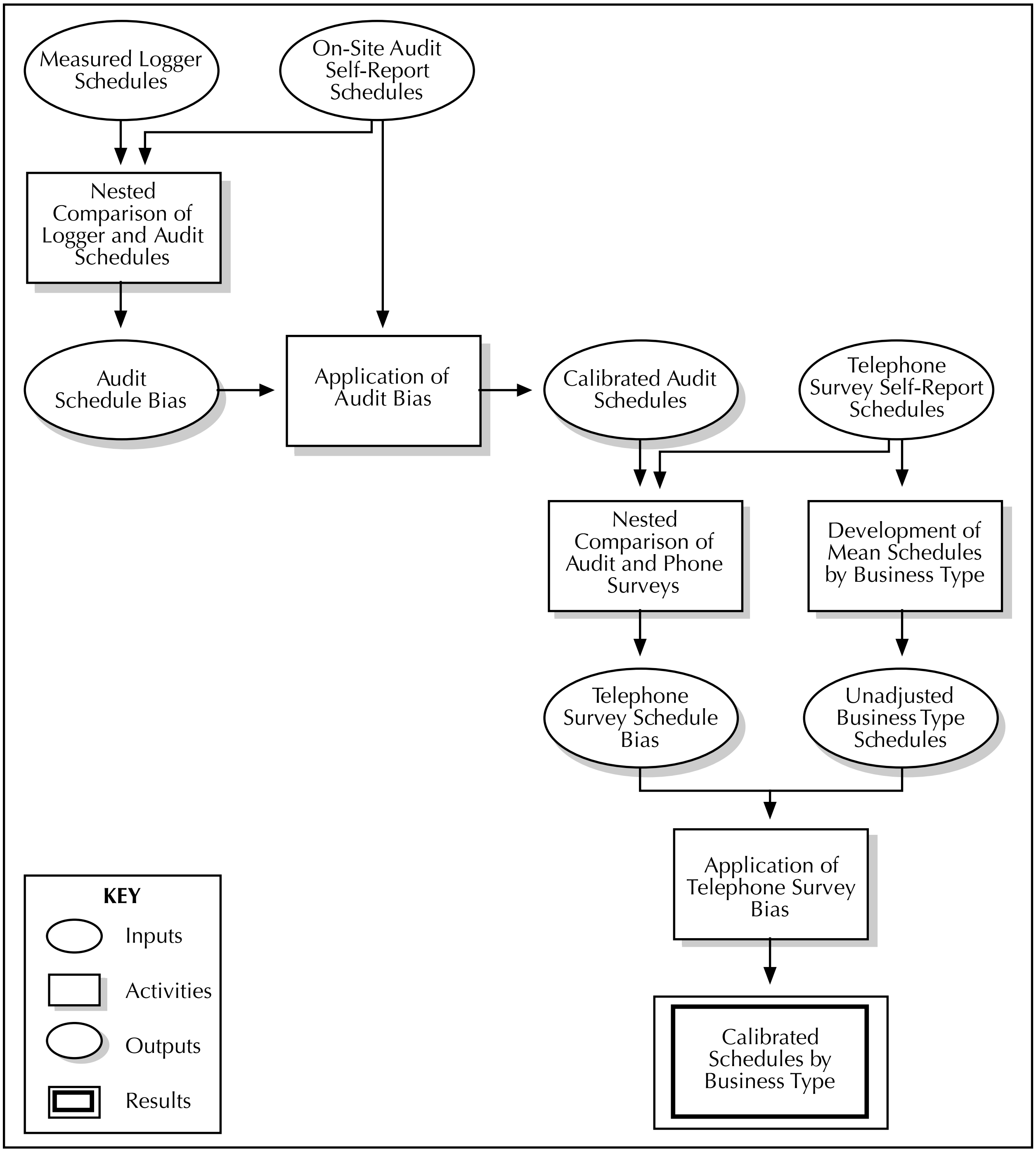
[6] Rundquist, R. *et al*. 1993. "Calculating Lighting and HVAC Interactions", ASHRAE Journal, November 1993, pages 28-37.

Exhibit 3-8
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.

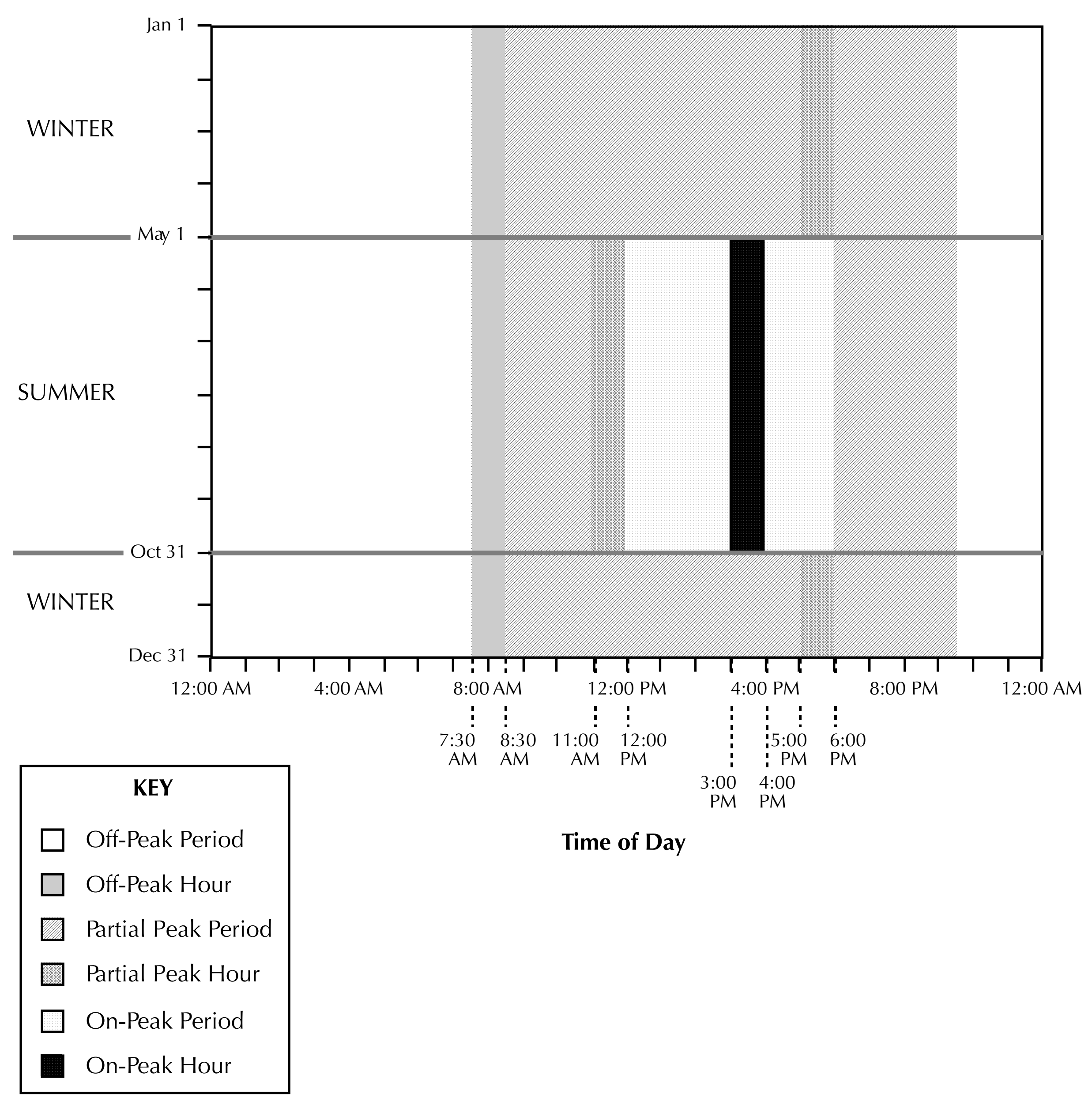
3.2.4 Aggregated Engineering Estimates by Time-of-Use Costing Period

Exhibit 3-9 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 3-9
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 February 1996 and March 1997 final Commercial sector 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 were used in support of the 1996 program evaluation.

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 3-10 presents the 1994 and 1995 M&E full load hour results for the indoor lighting end-use element. The 1996 evaluation estimates are the mean adjusted full load hours (an average of 1994 and 1995 M&E results).

Exhibit 3-10
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	1995
Office	3,900	4,100	**4,000**	**3,400**
Retail	4,200	4,700	**4,450**	**4,700**
College/Univ	3,700	4,100	**3,900**	**3,500**
School	2,000	2,300	**2,150**	**2,100**
Grocery	6,800	4,800	**5,800**	**7,000**
Restaurant	4,800	4,400	**4,600**	**4,800**
Health Care	4,900	3,900	**4,400**	**4,000**
Hotel/Motel	5,400	5,600	**5,500**	**4,000**
Warehouse	3,100	4,000	**3,550**	**4,000**
Personal Service	NA†	4,100	**4,100**	**4,000**
Community Service	NA†	2,700	**2,700**	**4,000**
Misc.	4,800	4,200	**4,500**	**4,000**

† 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 1996 evaluation results are shown in Exhibit 3-11.

Exhibit 3-11
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	4,000	5,200	3,900	2,300	5,700	3,400	3,200	5,400	3,300	3,700	2,000	3,900
Standard Fluorescent	4,100	4,700	4,300	2,300	4,800	4,600	4,000	5,900	3,900	4,100	2,800	4,200
High Intensity Discharge	3,900	4,700	2,700	2,300	5,400	5,500	4,400	6,200	4,100	4,100	3,100	4,300
Halogen	4,000	5,100	4,600	2,300	5,700	5,700	4,600	6,600	3,900	4,700	3,400	4,500
Exit Signs	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700	8,700

Exhibit 3-12
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**	**1995**
Office	0.78	0.85	**0.81**	**0.67**
Retail	0.90	0.87	**0.88**	**0.67**
College/Univ	0.61	0.76	**0.68**	**0.67**
School	0.46	0.38	**0.42**	**0.67**
Grocery	0.91	0.71	**0.81**	**0.67**
Restaurant	0.70	0.66	**0.68**	**0.67**
Health Care	0.78	0.70	**0.74**	**0.67**
Hotel/Motel	0.64	0.70	**0.67**	**0.67**
Warehouse	0.78	0.90	**0.84**	**0.67**
Personal Service	NA†	0.79	**0.79**	**0.67**
Community Service	NA†	0.48	**0.48**	**0.67**
Misc.	0.71	0.81	**0.76**	**0.67**

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

Coincident Diversity Factors (CDFs) - Exhibit 3-12 presents the 1994 and 1995 M&E coincident diversity factor results for the indoor lighting end-use element. The 1996 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 1996 evaluation results are shown in Exhibit 3-13.

Exhibit 3-13
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 3-14 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 1996 evaluation estimates use the mean HVAC adjustments (an average of 1994 and 1995 M&E results).

Burned-Out Lamp Rates - Exhibit 3-15 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 1996 pre- and post-retrofit connected load assumptions to account for the higher probability of lamp burnout in the pre-retrofit technologies. The 1996 evaluation estimates use the mean burned-out lamp adjustments (an average of 1994 and 1995 M&E results).

Savings by Costing Period - Exhibit 3-16 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 1996 impacts to account for the required allocation of impacts by costing period. The 1996 evaluation estimates use the mean Adjustment Factors (an average of 1994 and 1995 M&E results).

Exhibit 3-14
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 3-14 (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).

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

Exhibit 3-15
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 3-16
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 1996 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 3-17 provides a summary of the assumed change in connected load for the measures installed according to the 1996 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.

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 Customized Incentives Program 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.

Customized Lighting Evaluation

For the Customized Incentives program, NC impacts were derived through a careful review of each 1996 hard copy application (including the one CEO application). Wherever possible, application measures were re-classified as an RE measure, and the same load shape parameters and noncoincident savings estimates (including the full load hours of operation, coincident diversity factors, and HVAC interactive factors) applied to determine UEIs. For the remaining measures, savings estimates were independently calculated and verified against the hard copy application form.

Validation of Previous Operating Schedule Results

Additional data collection and analysis in support of engineering-based operating schedules were gathered during the telephone interviews. To validate the 1994 and 1995 schedules (and to show that they are applicable to the 1996 program participants), comparisons were drawn between the schedules gathered for the 1996 evaluation and those gathered previously for the 1994 and 1995 evaluations.

Self-reported lighting operating hours for 1996 were compared to 1995 operating hours to identify trends between years. If differences were found, the current self-reported hours would be adjusted for the Unadjusted Engineering Impacts analysis. Analyses were performed for each of the twelve business types separating operating hours by day type into weekdays, Saturdays, and Sundays because operations are distinct between weekdays and weekends.

Comparison analysis was conducted with the 1996 participant and nonparticipant survey samples to 1995 samples. The same methodology that built the 1995 operating hours database was applied to the 1996 data to develop self reported operating schedules (of participants and nonparticipants). The operating schedule is calculated with the start and end hours of operation of a day. Operating schedules of all sites that fall into a particular business type are aggregated to a mean operating schedule. Thirty-six mean operating schedules are calculated for the twelve business types and three day types.

Exhibit 3-17
Fixture Assumptions Used to Generate RE Commercial Lighting Evaluation Impact Estimates

Measure Group Descriptions	Application Year	MDSS Measure Code	Per-unit NC Impact (Watts)	Pre-Burn-Out Lamp Rate	Post-Burn-Out Lamp Rate	Adjusted per-unit NC Impact (Watts)
Halogen						
< 50 watts	1995&6	L60	30.0			30.0
> 50 watts	1994&5&6	L61	50.0			50.0
Screw In CF- Reusable ballast						
5-13 watts	1994&5&6	L64	45.0	0.0213	0.0088	43.9
14-25 watts	1996	L174	54.0	0.0213	0.0088	52.6
=26 watts	1996	L175	75.0	0.0213	0.0088	73.1
Hard Wired CF						
5-13 watts	1994&5&6	L66	45.0	0.0213	0.0088	43.9
14-25 watts	1996	L176	54.0	0.0213	0.0088	52.6
=26 watts	1996	L177	75.0	0.0213	0.0088	73.1
Incandescent to Fluorescent Fixture						
With Electronic Ballast & T8 Lamps	1993&4&5&6	L8	242.0	0.0213	0.0039	235.8
Exit Signs						
Incand. to Compact Fluorescents	1993&4&5&6	L5	29.0			29.0
Incand. to LED or Electroluminescent Retrofit	1993&4&5&6	L6	36.0			36.0
Efficient Ballasts Changeouts						
Electronic Ballasts						
2 Lamp Electronic Ballast	1993&4&5&6	L14	19.0	0.0252	0.0039	17.1
3 Lamp Electronic Ballast	1993&4&5&6	L15	29.0	0.0252	0.0039	26.0
4 Lamp Electronic Ballast	1993&4&5&6	L16	38.0	0.0252	0.0039	34.1
T8 Lamps and Electronic Ballasts						
New Fixtures						
Four-Lamp Fixture	1993	L12	45.0			45.0
2′-1 U Tube or 2 lamps	1994&5	L69	21.0	0.0252	0.0039	19.9
2′-2 U Tubes or 4 lamps	1994&5	L70	42.0	0.0252	0.0039	39.7
2′-3 U Tubes or 6 lamps	1994&5	L71	63.0	0.0252	0.0039	59.6
4′-1 lamp	1994&5	L72	11.8	0.0252	0.0039	10.9
4′-2 lamps	1994&5	L73	22.0	0.0252	0.0039	20.2
4′-3 lamps	1994&5	L74	37.0	0.0252	0.0039	34.3
4′-2 lamps or 8′-1 lamps	1995	L160	22.0	0.0252	0.0039	20.2
4′-4 lamps or 8′-2 lamps	1994&5	L75	45.0	0.0252	0.0039	41.6
Fixture Modif.- Replace Lamps and Ballasts						
Replace Lamps & Ballasts - 2′ Fixture	1993&4&5&6	L21	10.5	0.0252	0.0039	9.9
Replace Lamps & Ballasts - 3′ Fixture	1993&4&5&6	L22	13.0	0.0252	0.0039	12.2
Replace Lamps & Ballasts - 4′ Fixture	1993&4&5&6	L23	11.8	0.0252	0.0039	10.9
Replace Lamps & Ballasts - 8′ Fixture	1993&4&5&6	L24	22.5	0.0252	0.0039	20.8
Delamp Fluorescent Fixtures						
Fixture Modif.- Delamp and Reflector						
Removal - 2′ Lamps & Ballasts	1993&4&5&6	L17	32.0	0.0252	0.0252	31.2
Removal - 3′ Lamps	1993&4&5&6	L18	43.0	0.0252	0.0252	41.9
Removal - 4′ Lamps	1993&4&5&6	L19	46.0	0.0252	0.0252	44.8
Removal - 8′ Lamps	1993&4&5&6	L20	96.0	0.0252	0.0252	93.6
High Intensity Discharge						
Interior Compact HPS from Incand.						
36-70 watts HPS	1994&5&6	L79	112			112
71-100 watts HPS	1994&5&6	L80	155			155
Interior Standard MH from Merc. Vapor						
101-175 watts MH	1993&4&5&6	L26	240			240
176-250 watts MH	1994&5&6	L27	528			528
251-400 watts MH	1994&5&6	L81	620.0			620.0
Controls						
Time Clocks	1993&4&5&6	L31	352			352
Occupancy Sensors						
Wall Mounted	1994&5&6	L82	264			264
Ceiling Mounted	1994&5&6	L83	704			704
Photocell	1993&4&5&6	L36	352			352

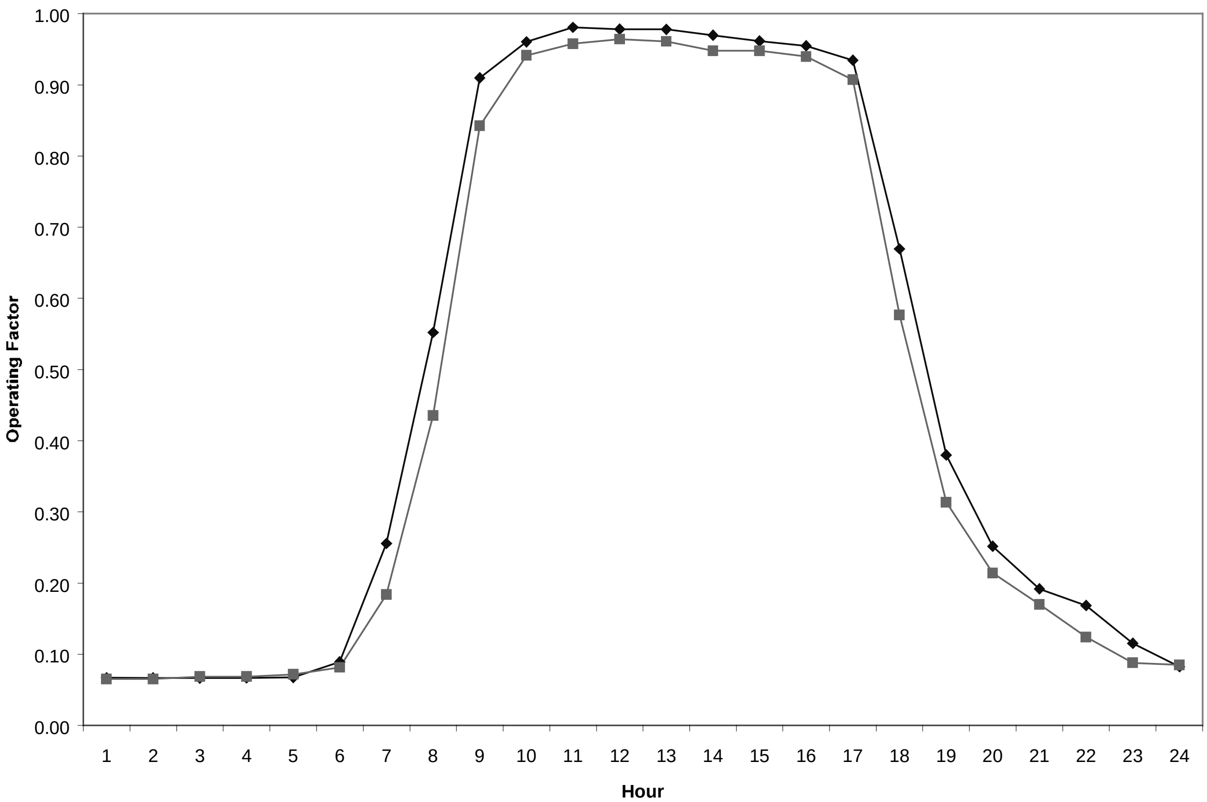
Exhibit 3-18 compares operating hours within the segment with the highest concentration of participants (offices). It is an hourly comparison of the probability that office lighting is in operation for that day. For example, more than 90 percent of all offices in the 1995 and 1996 survey samples operate between the hours of 10AM-5PM on weekdays. Comparatively, less than 50 percent are operating on Saturday and less than 25 percent on Sunday between the same hours. Exhibit 3-19 is a line graph depicting a comparison of 1995 and 1995 self-report office weekday operating hours.

Exhibit 3-18
Comparison of 1995 and 1996 Office Lighting
Self Reported Operating Factors*

	Weekday		***Saturday***		***Sunday***	
Hour	***1995***	***1996***	***1995***	***1996***	***1995***	***1996***
1	0.07	0.07	0.08	0.06	0.08	0.06
2	0.07	0.07	0.08	0.06	0.08	0.06
3	0.07	0.07	0.09	0.07	0.08	0.06
4	0.07	0.07	0.09	0.07	0.08	0.06
5	0.07	0.07	0.09	0.07	0.08	0.06
6	0.09	0.08	0.09	0.07	0.08	0.06
7	0.26	0.18	0.15	0.10	0.11	0.07
8	0.55	0.44	0.20	0.16	0.13	0.09
9	0.91	0.84	0.34	0.28	0.16	0.12
10	0.96	0.94	0.40	0.35	0.19	0.15
11	0.98	0.96	0.46	0.43	0.22	0.18
12	0.98	0.96	0.46	0.44	0.22	0.19
13	0.98	0.96	0.43	0.38	0.21	0.19
14	0.97	0.95	0.38	0.34	0.21	0.18
15	0.96	0.95	0.35	0.30	0.20	0.17
16	0.95	0.94	0.31	0.27	0.19	0.16
17	0.93	0.91	0.27	0.21	0.17	0.15
18	0.67	0.58	0.19	0.14	0.13	0.11
19	0.38	0.31	0.14	0.12	0.11	0.10
20	0.25	0.21	0.12	0.10	0.10	0.09
21	0.19	0.17	0.12	0.10	0.10	0.08
22	0.17	0.12	0.11	0.09	0.09	0.08
23	0.12	0.09	0.09	0.07	0.09	0.07
24	0.08	0.08	0.08	0.07	0.08	0.07

*The use of the 1994 and 1995 evaluation results were approved through a Retroactive Waiver, presented in *Attachment A*.

Exhibit 3-19
Comparison of 1995 and 1996 Office Lighting Operating Profiles



The change in likelihood of operation over time is consistent with the 1995 results. Daytype average OF comparisons were conducted for the other eleven business types with similar results. Based on this analysis, no adjustments were necessary when applying mean 1994 and 1995 load shapes.

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) 1996 CEEI Programs. 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 key 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), Customized Incentives (CI), and Customized Efficiency Options (CEO) Programs are 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 1995 through April 1997.

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 1993 through December 1994, and then from January 1997 to September 1997. 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 1997.

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 (except for the Canvass surveys, which do not collect detailed information regarding changes that have occurred at the premise) collected as part of the evaluation for the Commercial Sector Program were used as inputs to the billing regression analysis. Two telephone survey samples totaling 1,270 sample points (496 of which are lighting participants) 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 496 lighting participants. Separate estimates of energy savings were calculated for every measure installed under a 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

[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 3-20 and 3-21 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 3-20
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	5	9			2	5	2	1	1		5		30
	Compact Fluorescent Lamps	32	12	1	24	8	9	11	21	7	6	24	9	164
	Incandescent to Fluorescent Fixtures	3			7	1	1	3	2	1	2	5	1	26
	Exit Signs	18	6	1	13	3	2	8	2	4	3	17	4	81
	Efficient Ballast Changeouts				1	1		3	1	1	3	2	1	13
	T-8 Lamps and Electronic Ballasts	87	75	4	38	28	8	24	9	25	22	40	31	391
	Delamp Fluorescent Fixtures	37	20		13	14		6		9	9	6	4	118
	High Intensity Discharge	6	5	1	1	1	1	1		20		7	10	53
	Controls	14	5		7	4	3	5	1	3		10	5	57
Retrofit Express Program Total		105	81	4	40	30	14	28	27	42	27	57	41	496
Customized Incentives	T-8 Lamps and Electronic Ballasts													
	High Intensity Discharge													
	Controls													
	Other													
Customized Incentives Program Total														
Customized Efficiency Options Program Total													1	1
Total													1	**496**

Exhibit 3-21
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	117	69	2	30	22	25	24	17	35	28	59	34	**462**

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 1996 actually installed measures in 1992, 1993, 1994, 1995, or 1996 with 1996 installations accounting for approximately one half of total installations. Lighting installations prior to 1995 accounted for only 3 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.

Although installation date is a field in the MDSS, it is rarely populated (only 2 percent of the time). And because the "paid date" (another field in the MDSS) can vary from the installation date by as much as 4 years, another approach had to be developed to estimate an installation date. For 66 percent of the MDSS records, a pre- and post-installation inspection date was collected. In every case where the installation date was populated, it's value fell between the pre- and post-installation inspection dates. Therefore, we can derive from these two variables a time interval containing the installation date. Another date field in the MDSS that is populated 100 percent of the time is the date the application was received by PG&E. This date always occurs after the pre-installation inspection date (when populated) and rarely exceeds the post-installation inspection date (when populated) by more than a month (only 9 percent of the time). Consequently, the application received date served as an excellent proxy to the installation date, when the installation date was not populated.

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 over the application received date.

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.

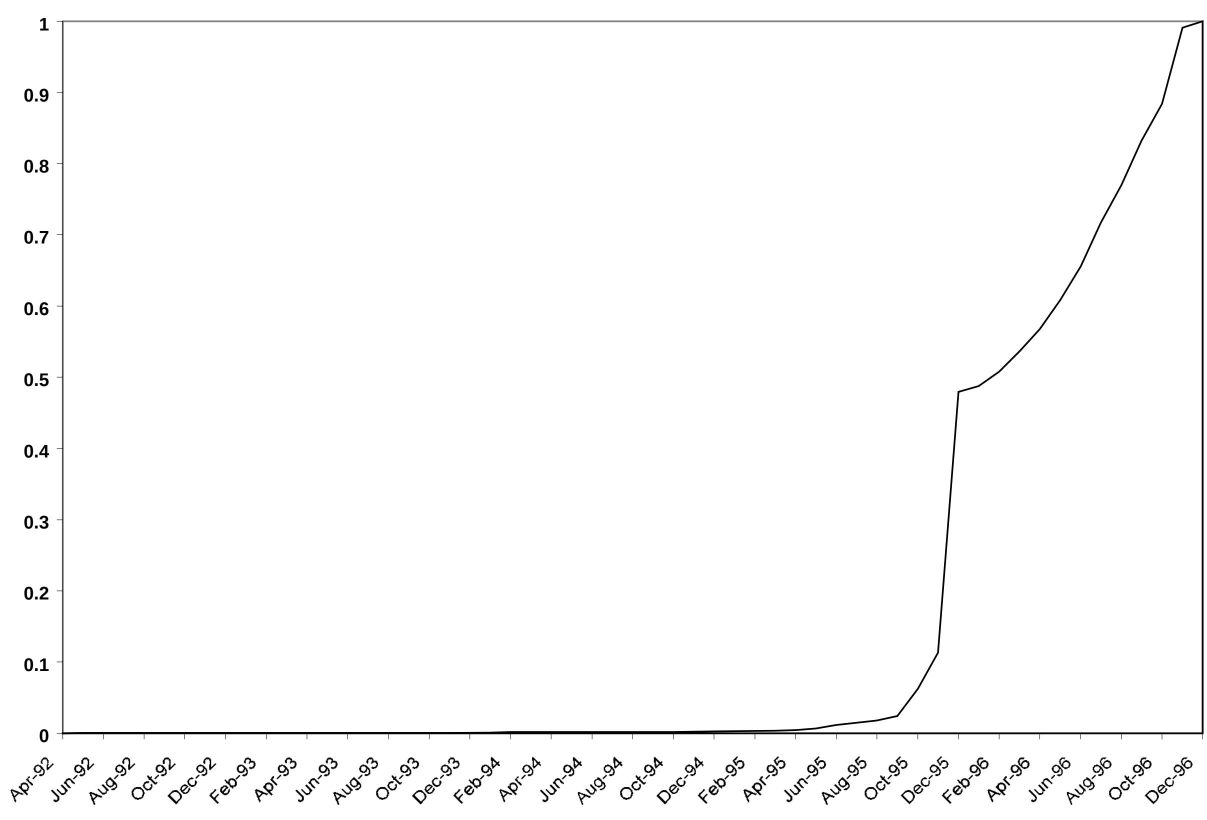
Billing data were available from January 1993 through September 1997. To maximize the number of post installation months in the regression model, a post period of October 1996 through September 1997 was used. As illustrated in Exhibit 3-22, this post period occurs after 85 percent of the installation dates.

Based on the selection of post period, there are only two feasible pre-periods that could have been used: October 1993 through September 1994 (a 1994 pre-period), and October 1994 through September 1995 (a 1995 pre-period). Exhibit 3-22 suggests that over 95 percent of the installations occurred between January 1995 and December 1996. In order to minimize the number of installation periods for which the engineering estimate would have to be pro-rated, it was decided to use the 1994 pre-period.

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 3-22 provides the cumulative participation by month for the participants that are part of the billing analysis sample frame.

Exhibit 3-22
Commercial Lighting Rebated Technologies
By Estimated Installation Date



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 two criteria:

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

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

Exhibit 3-23 presents the number of participants and nonparticipants that were deleted for each of the above criteria. Note that only 24 nonparticipants were deleted, whereas 123 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 often a census and no pre-screening was done on their billing data prior to being selected into the participant survey sample frame. Of the 123 participants, 59 were deleted due to the zero bill criteria.

Large Customers

Customers whose annual pre-installation energy consumption that exceeded three million kWh were excluded from the billing analysis. A total of 41 participants and 10 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 two Lighting Evaluations, both 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 Report of PG&E's 1995 Commercial Lighting Evaluation, which states "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. Because data were available, and *after* the billing analysis models were finalized, the large customers were included back into the model to test the hypothesis that reliable results could not be obtained. When included, seven of the nine SAE Coefficients became insignificant, with six of the coefficients having t-statistics of less than 0.5. Furthermore, the most significant result was lighting offices with a parameter estimate with the wrong sign of 7.39 (indicating that this would cause an *increase* of usage of over 700% of the expected impact) and a t-statistic of 9.8. Clearly, the censoring of the large customers was valid.

Exhibit 3-23
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria
Customers with Invalid Billing Data

Participant or Nonparticipant	Zero Monthly Bills > 6	Usage Doubled or Cut In Half	Usage Tripled	Number Removed From Analysis
NP	No	No	Yes	5
NP	No	Yes	No	4
NP	Yes	No	No	4
NP	Yes	No	Yes	8
NP	Yes	Yes	No	3
TOTAL				24
P	No	No	Yes	29
P	No	Yes	No	35
P	Yes	No	No	6
P	Yes	No	Yes	51
P	Yes	Yes	No	2
TOTAL				123

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. In addition, both a ratio of energy to square feet (from the MDSS and the survey), and energy to employee was calculated for each participant to further aid in the identification of poorly aggregated sites.

There were 278 lighting and/or HVAC participants that were identified as having total Commercial Sector Program energy impacts that were either more than 50 percent of their pre-installation usage or whose energy to square foot or energy to employee ratio was in the bottom 10^{th} percentile of the participant population. These 278 participants were further analyzed to determine whether the impact was large relative to usage because of a problem in aggregating the bill, or if the engineering estimates were just over-estimated. In the latter case, the customer would **not** be removed from the billing analysis.

Three criteria were used to determine if there was a problem with aggregating the bill for these 278 participants. If a participant failed any of these criteria, the customer was removed from the analysis on the basis that their billing data were not properly aggregated to the Site ID level, and the entire impact would not be detected in an analysis of the customer's billing data.

- If the customer's energy impacts were greater than 100 percent of their pre-installation usage and any one of their annual kWh per square foot or annual kWh per employee was in the bottom tenth percentile of all participants, the customer was removed.

- If the customer's energy impacts were greater than 50 percent of their pre-installation usage and either their annual kWh per square foot or annual kWh per employee was in the bottom tenth percentile of all participants, the customer was removed.

- If all three of the annual kWh per square foot and annual kWh per employee ratios were in the bottom tenth percentile of all participants, the customer was removed.

As a result of these three criteria, 94 of the 278 premises were removed. Of the 94 removed customers, 39 also failed the invalid usage data screening checks. Therefore, only an additional 55 premises were removed based solely upon the data screening criteria described above.

Exhibit 3-24 presents the number of participants that were removed from the analysis for each of the above criteria,

Exhibit 3-24
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria
Customers with Billing Aggregation Problems

Low Usage per Sqft (MDSS)	Low Usage per Sqft (Survey)	Low Usage Per Employee	Estimated Savings Greater Than Usage	Low Usage Relative to Estimated Savings	Number of Participants Removed
No	No	No	Yes	No	3
No	No	Yes	No	Yes	5
No	No	Yes	Yes	No	1
No	Yes	No	No	Yes	5
No	Yes	Yes	No	Yes	2
No	Yes	Yes	Yes	No	4
Yes	No	No	No	Yes	5
Yes	No	No	Yes	No	2
Yes	No	Yes	No	Yes	2
Yes	No	Yes	Yes	No	7
Yes	Yes	No	No	Yes	13
Yes	Yes	No	Yes	No	7
Yes	Yes	Yes	No	No	9
Yes	Yes	Yes	No	Yes	6
Yes	Yes	Yes	Yes	No	23
Total					94

In summary, out of the original sample frame of 462 nonparticipants, 34 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 808 participants, 217 were removed because of bad billing, improper site aggregation, or because they were large customers. Of these 217 customers, 139 were lighting participants.

Exhibit 3-25 summarizes the total number of participants and nonparticipants that were removed from the billing analysis. Exhibits 3-26 and 3-27 present the final sample sizes used in the billing analysis by business type and technology for participants and by business type for nonparticipants.

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.

Exhibit 3-25
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria

Participant or Nonparticipant	Zero Monthly Bills > 6	Usage Doubled or Cut in Half?	Usage Tripled or Cut in Third?	Large Customer?	Bill Not Aggregated Properly?	Number of Sites Removed
NP	No	No	No	Yes	No	10
NP	No	No	Yes	No	No	5
NP	No	Yes	No	No	No	4
NP	Yes	No	No	No	No	4
NP	Yes	No	Yes	No	No	8
NP	Yes	Yes	No	No	No	3
TOTAL						34
P	No	No	No	No	Yes	55
P	No	No	No	Yes	No	39
P	No	No	Yes	No	No	18
P	No	No	Yes	No	Yes	11
P	No	Yes	No	No	No	22
P	No	Yes	No	No	Yes	11
P	No	Yes	No	Yes	No	2
P	Yes	No	No	No	No	3
P	Yes	No	No	No	Yes	3
P	Yes	No	Yes	No	No	39
P	Yes	No	Yes	No	Yes	12
P	Yes	Yes	No	No	Yes	2
TOTAL						217

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.

Exhibit 3-26
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	3	6			2	4		1	1		3		20
	Compact Fluorescent Lamps	24	5		16	7	9	5	17	3	3	15	5	109
	Incandescent to Fluorescent Fixtures	1			4		1	2	2	2	1			13
	Exit Signs	14	5		10	3	2	4	2	3	3	14	1	61
	Efficient Ballast Changeouts				1	1			1		2	2	1	8
	T-8 Lamps and Electronic Ballasts	69	52	1	30	24	7	12	9	16	19	31	20	290
	Delamp Fluorescent Fixtures	31	13		9	12		2		5	6	4	2	84
	High Intensity Discharge	4	3	1	1			1		7		7	4	28
	Controls	10	4		5	3	2	2	1	2		7		36
Retrofit Express Program Total		80	56	1	31	26	12	16	23	23	21	44	24	357
Customized Incentives	T-8 Lamps and Electronic Ballasts													
	High Intensity Discharge													
	Controls													
	Other													
Customized Incentives Program Total														
Customized Efficiency Options Program Total														
Total		80	56	1	31	26	12	16	23	23	21	44	24	**357**

Exhibit 3-27
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	105	68	2	28	21	23	23	15	34	25	54	30	**428**

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:

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

Where,

$kWh_{post,i}$ and $kWh_{pre,i}$ 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;

$Chg_{i,k}$ are the customer 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;

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, a post-installation predicted usage value is calculated using the parameters of the baseline models estimated for the 1994 to 1997 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 ($Chg_{i,k}$), were not included in the estimate post-installation predicted usage. The SAE model discussed below, did include the customer self-reported change variables to control for the differences between actual and predicted post-installation usage.

Exhibit 3-28 summarizes the final baseline model results that were estimated using 428 nonparticipant customers, as discussed in the *Data Censoring* section. Exhibit 3-28 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:

Baseline Model (1994 to 1997):

$$
\begin{aligned}
k\hat{W}h_{97,i} =\ & 1.04 * SM\_OFF4 + 1.06 * OTH\_OFF4 + 1.11 * SM\_RET4 + 1.00 * OTH\_RET4 \\
& + 1.23 * SCHOOL4 + 1.18 * SM\_GRC4 + 1.17 * OTH\_GRC4 + 0.98 * RESTRNT4 \\
& + 1.18 * HOSP4 + 1.13 * HOTMOT4 + 1.28 * WHRSE4 + 1.30 * PERSVC4 \\
& + 1.10 * SM\_COM4 + 1.13 * OTH\_COM4 + 1.36 * MISC4 \\
& - 0.002535 * CDD1_{97-94,i} * kWh_{94,i} - 0.000150 * CDD2_{97-94,i} * kWh_{94,i} \\
& - 0.000006165 * CDD3_{97-94,i} * kWh_{94,i} - 0.000307 * CDD4_{97-94,i} * kWh_{94,i} \\
& - 0.000389 * CDD5_{97-94,i} * kWh_{94,i} - 0.000298 * CDD11_{97-94,i} * kWh_{94,i} \\
& - 0.000041334 * CDD12_{97-94,i} * kWh_{94,i} + 0.000494 * CDD13_{97-94,i} * kWh_{94,i} \\
& - 0.000363 * CDD16_{97-94,i} * kWh_{94,i}
\end{aligned}
$$

Participant 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:

$$kWh_{97,i} - k\hat{W}h_{97,i} = kWh_{97,i} - F_{94}(kWh_{94}, \Delta CDD) = \sum_m \beta_m^{'} Eng_m + \sum_k \eta_k^{'} Chg_{i,k} + \mu_i$$

The difference between predicted and actual usage in 1997 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 1997 usage as a function of 1994 usage and change of cooling degree days from 1994 to 1997. 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 3-29 summarizes the final SAE model results that were estimated using 591 participants, 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.

The dependent variable is the difference between the actual and predicted 1997 usage using the 1994 baseline model.

Exhibit 3-28
Billing Regression Analysis Final Baseline Model Outputs

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
Pre-Usage					
Small Office	SM_OFF4	kWh	1.044147	3.535	49
Large Office	OTH_OFF4	kWh	1.060393	69.987	56
Small Retail	SM_RET4	kWh	1.107020	2.543	41
Large Retail	OTH_RET4	kWh	1.001194	20.511	27
Schools	SCHOOL4	kWh	1.235795	17.186	30
Small Grocery	SM_GRC4	kWh	1.176976	3.098	6
Large Grocery	OTH_GRC4	kWh	1.172005	35.380	15
Restaurant	RESTRNT4	kWh	0.979361	11.391	23
Hospital	HOSP4	kWh	1.175914	41.709	23
Hotel/Motel	HOTMOT4	kWh	1.126563	13.675	25
Warehouse	WHRSE4	kWh	1.278263	24.786	34
Personal Service	PERSVC4	kWh	1.302686	22.802	25
Small Comm. Service	SM_COM4	kWh	1.104953	2.529	34
Large Comm. Servcie	OTH_COM4	kWh	1.133564	25.238	20
Miscellaneous	MISC4	kWh	1.364311	53.663	20
Weather Changes					
Change in CDD CliZone 1	CDD1_74	CDD*kWh	-0.002535	-1.335	9
Change in CDD CliZone 2	CDD2_74	CDD*kWh	-0.000150	-2.388	51
Change in CDD CliZone 3	CDD3_74	CDD*kWh	-0.000006165	-0.063	116
Change in CDD CliZone 4	CDD4_74	CDD*kWh	-0.000307	-5.314	38
Change in CDD CliZone 5	CDD5_74	CDD*kWh	-0.000389	-4.079	26
Change in CDD CliZone 11	CDD11_74	CDD*kWh	-0.000298	-0.644	51
Change in CDD CliZone 12	CDD12_74	CDD*kWh	-0.000041334	-0.469	74
Change in CDD CliZone 13	CDD13_74	CDD*kWh	0.000494	1.927	59
Change in CDD CliZone 16	CDD16_74	CDD*kWh	-0.000363	-0.066	4
Other Site Changes					
Lighting Changes	LIT_CHG4	kWh	0.073123	2.357	41
HVAC Changes	HVC_CHG4	kWh	-0.237771	-10.514	53
Other Equipment Changes	OTHR4	kWh	0.128064	1.326	19
Employee Changes	EMP_CHG4	# Emp*kWh	346.394623	3.473	70

Exhibit 3-29
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	LGTOFF4	kWh	-0.796704	-5.494	154
Lighting Schools	LGTSCH4	kWh	-0.886600	-2.339	32
Lighting Hotel/Motel	LGTHOT4	kWh	-0.694864	-5.458	23
Lighting Warehouse	LGTWAR4	kWh	-1.284596	-1.745	18
Lighting Miscellaneous	LGTMSC4	kWh	-1.461133	-3.928	113
HIDs	HID4	kWh	-0.484505	-6.131	28
HVAC End Use					
Retrofit Express Measures	RETX4	kWh	-1.553054	-2.993	248
ASDs	ASD4	kWh	-3.240228	-5.452	4
Custom HVAC	CSTHVC4	kWh	-2.237938	-1.927	8
Other End Uses					
Other Impacts	OTHMEAS4	kWh	-1.693618	-0.937	47
Change Variables					
Lighting Changes	LIT_CHG4	kWh	0.132770	5.463	78
HVAC Changes	HVC_CHG4	kWh	-0.035071	-1.524	87
Other Equipment Changes	OTHR4	kWh	0.073020	0.786	28
Employee Changes	EMP_CHG4	# Emp*kWh	589.214738	2.791	90

SAE coefficients are calculated for 10 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. This was true for all but one technology type, HIDs, which were estimated separately. This was done because HIDs usually have different applications that the other types of lighting measures, and are not found to be installed along with other fixtures at a high rate of incidence.

All but one of the lighting SAE coefficients are significant at the 95 percent confidence level (t-statistics greater than 1.96), with that one being significant at the 92 percent level. All of the coefficients are within the commonly accepted 90 percent confidence boundary. In addition, all of the SAE coefficients were the correct sign.

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. Of these, only the lighting parameter estimate is significant at the 90 percent confidence level. Another independent variable was included to capture the effects of the number of employees changing at the facility, which was statistically significant.

The final SAE coefficients for the Lighting end use is provided in Exhibit 3-30. The SAE coefficient is multiplied by the evaluation estimates of gross energy impact to calculate the gross ex post energy impacts.

Exhibit 3-30
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	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
	Compact Fluorescent Lamps	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
	Incandescent to Fluorescent Fixtures	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
	Exit Signs	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
	Efficient Ballast Changeouts	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
	T-8 Lamps and Electronic Ballasts	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
	Delamp Fluorescent Fixtures	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
	High Intensity Discharge	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
	Controls	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
Retrofit Express Program Total													
Customized Incentives	T-8 Lamps and Electronic Ballasts	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
	High Intensity Discharge	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
	Controls	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
	Other	0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
Customized Incentives Program Total													
Customized Efficiency Options Program Total		0.80	1.46	0.89	0.89	1.46	1.46	0.80	0.69	1.28	1.46	0.80	0.80
Total													

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. As mentioned above, there are a total of sixteen analysis segments that were explicitly modeled, and the relative precision estimates based upon the model output are presented in Exhibit 3-31 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:[8]

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

Where,

$CV_i = \dfrac{std(\beta_i)}{\beta_i}$ 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 3-31 presents the relative precision calculations.

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. The net billing analysis model specification differs from the gross billing analysis model, in that the SAE Model incorporates both participants and nonparticipants into one model.

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

Exhibit 3-31
Relative Precision Calculation

SAE Analysis Level	Gross Engineering Energy Impact (MWh)	SAE Coefficient	t-Statistic	Relative Precision at 80%	Relative Precision at 90%
Lighting End Use					
Lighting Offices	60,149	-0.80	-5.49	-23%	-30%
Lighting Schools	18,947	-0.89	-2.34	-55%	-70%
Lighting Hotel/Motel	9,898	-0.69	-5.46	-23%	-30%
Lighting Warehouse	3,574	-1.28	-1.75	-73%	-94%
Lighting Miscellaneous	37,837	-1.46	-3.93	-33%	-42%
HIDs	14,172	-0.48	-6.13	-21%	-27%
Lighting Total	144,577	-0.93	-7.38	-17%	-22%

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. As a result, 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[9]) and is used by others (Goldberg and Train, 1996[10]) to address the problem of self-selection into energy retrofit programs. This assumes that the unobserved factors that are influencing participation are distributed normally. The influence of these unobserved factors on participation can be approximated by including an Inverse Mills Ratio in the model as an explanatory variable. 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) 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. The rationale for the second

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[9] 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.

[10] 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.

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 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. Finally, a description of how the Inverse Mills Ratio is used in the Net Billing Model is discussed, concluding with the estimation results from the Net Billing Model.

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 participated in the Lighting Program and a zero otherwise. The sample includes 496 Lighting Program participants and 774 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 of the 1,270 survey respondents were used to estimate the participation probit for the Lighting Program. For those customers with missing information for any of the explanatory variables, an average value is assigned based on both building type and program participation.

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 3-32. The dependent variable PARTICIPATION has a value of one if the customer participated in the 1996 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 describe the customer's business activity. These consist of indicator variables for various building types. The second group of variables (Y) reflect the building characteristics. These include customer size and energy use as well as recent changes in high energy equipment. The third group of variables (Z) contain information on participation in other PG&E programs. Finally, the error term (ε) is assumed to be normally distributed for the probit specification.

Probit Estimation Results

The estimation results for the lighting probit are given in Exhibit 3-33. In general, the estimation results conform to expectations. For the lighting probit, customer size as reflected by energy use has a positive impact on program participation. In addition, those customers who own their building or changed their cooling equipment are also likely to participate. Those that recently changed their lighting equipment or participated in the 1996 HVAC program are less likely to participate. All of the building type variables except GROCERY have negative coefficient estimates. Of these, only RESTAURANT, HEALTH, SCHOOL, and MISCCOM are statistically different from zero.

Exhibit 3-32
Variables Used in Lighting Probit Model

Variable Name	Units	Variable Type	Description
AVGUSE	Kwh	Y	Average monthly electricity use over 1993-1995
ARCOOL	0,1	Y	Cooling equipment was added and removed since 1/95
CCHGPGE	0,1	Z	Cooling change was part of a PG&E program
COLLEGE	0,1	X	College
COMMSERV	0,1	X	Community service building
EMPCHG	0,1	Y	Employee change by 10 % since 1/95
GROCERY	0,1	X	Grocery
HEALTH	0,1	X	Health Care Building
HID	0,1	Y	Primary lighting is HID
HOTEL	0,1	X	Hotel
HVPART	0,1	Y	Participant in 1996 HVAC program
INCAN	0,1	Y	Primary lighting is incandescent
LGOFF	0,1	X	Large Office building
LIGHT95	0,1	Y	Lighting change done in 1995 or later
MISCCOM	0,1	X	Miscellanious commercial building
OFFICE	0,1	X	Office building
OWN	0,1	Y	Own building
PERSONAL	0,1	X	Personal services building
RESTRNT	0,1	X	Restaurant
RETAIL	0,1	X	Retail Building
SCHOOL	0,1	X	School
WAREHSE	0,1	X	Warehouse

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,

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

Exhibit 3-33
Lighting Probit Estimation Results

Variable Name	Units	Variable Type	Coefficient Estimate	Standard Error	Significance Level
AVGUSE	Kwh	Y	0.00	0.00	1%
ARCOOL	0,1	Y	0.26	0.15	9%
CCHGPGE	0,1	Z	-0.18	0.37	62%
COLLEGE	0,1	X	-0.17	0.47	72%
COMMSERV	0,1	X	-0.21	0.16	20%
EMPCHG	0,1	Y	0.11	0.09	24%
GROCERY	0,1	X	0.02	0.18	92%
HEALTH	0,1	X	-0.44	0.18	2%
HID	0,1	Y	0.18	0.23	43%
HOTEL	0,1	X	-0.03	0.21	89%
HVPART	0,1	Y	-1.32	0.11	0%
INCAN	0,1	Y	-0.42	0.19	3%
LGOFF	0,1	X	-0.30	0.22	17%
LIGHT95	0,1	Y	-0.25	0.13	5%
MISCCOM	0,1	X	-0.28	0.16	7%
OFFICE	0,1	X	-0.48	0.10	1%
OWN	0,1	Y	0.44	0.09	1%
PERSONAL	0,1	X	-0.25	0.16	12%
RESTRNT	0,1	X	-0.60	0.20	1%
RETAIL	0,1	X	-0.12	0.11	24%
SCHOOL	0,1	X	-0.39	0.13	1%
WAREHSE	0,1	X	-0.15	0.15	33%

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 three 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:

- Both participants and nonparticipants are used in the net SAE model.
- 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:

$$
\begin{aligned}
kWh_{97,i} - k\hat{W}h_{97,i} &= kWh_{97,i} - F_{94}(kWh_{94,i}, \Delta CDD_i) \\
&= \vartheta_1 Mills_{Light,i} + \vartheta_2 Mills_{HVAC,i} + \sum_m \delta_m Mills_{Light,i} * Eng_{Light,m,i} \\
&\quad + \sum_m \delta_m Mills_{HVAC,i} * Eng_{HVAC,m,i} + \sum_k \eta_k^{'} Chg_{i,k} + \varepsilon
\end{aligned}
$$

Where

$kWh_{97,i}$ and $kWh_{94,i}$ 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;

$Chg_{i,k}$ are the customer 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 428 nonparticipants and 591 participants that were used in the gross billing analysis model. The results of the model are presented below. The parameter estimates, t-statistics and sample sizes are presented for all of the net SAE coefficients and Mills ratios.

Exhibit 3-34
Net Billing Regression Analysis Final Model Outputs

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
Mills Ratios					
Lighting	LRMILLS	Unitless	-6852.243796	-0.774	154
HVAC	HRMILLS	Unitless	613.304572	0.079	32
SAE Coefficients					
Lighting End Use					
Lighting Offices	LGTOFFM	Mills * kWh	-0.729372	-4.289	154
Lighting Schools	LGTSCHM	Mills * kWh	-0.955361	-3.154	32
Lighting Hotel/Motel	LGTHOTM	Mills * kWh	-1.501011	-6.006	23
Lighting Warehouse	LGTWARM	Mills * kWh	-1.516367	-1.563	18
Lighting Miscellaneous	LGTMSCM	Mills * kWh	-1.757547	-3.083	113
HIDs	HIDM	Mills * kWh	-1.048963	-6.227	28
HVAC End Use					
Retrofit Express Measures	RETXM	Mills * kWh	-1.121011	-1.989	248
ASDs	ASDM	Mills * kWh	-2.543545	-5.289	4
Custom HVAC	CSTHVCM	Mills * kWh	-1.817877	-1.926	47
Change Variables					
Lighting Changes / Additions	LIT_CHG4	kWh	0.131659	5.470	78
HVAC Changes / Additions	HVC_CHG4	kWh	-0.043436	-1.896	87
Other Equipment Changes	OTHR4	kWh	0.076376	0.816	28
Employee Changes	EMP_CHG4	# Emp*kWh	574.591239	2.700	90

It was found that the net billing model results were significant at the 95 percent level in all cases but one, lighting warehouses. 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 3-35 illustrates the resulting estimate of net, or one minus free-ridership.

Exhibit 3-35
Net Billing Regression Analysis Estimates of (1-FR)

Parameter Descriptions	Mills Model 1		Gross Model		From Probit	Resulting (1-FR)
	Variable Name	Parameter Estimate	Variable Name	Parameter Estimate	Mean Mills	
Lighting End Use						
Lighting Offices	LGTOFFM	-0.729372	LGTOFF4	-0.796704	0.89213	0.81673
Lighting Schools	LGTSCHM	-0.955361	LGTSCH4	-0.886600	0.87015	0.93764
Lighting Hotel/Motel	LGTHOTM	-1.501011	LGTHOT4	-0.694864	0.64965	1.40334
Lighting Warehouse	LGTWARM	-1.516367	LGTWAR4	-1.284596	0.71697	0.84633
Lighting Miscellaneous	LGTMSCM	-1.757547	LGTMSC4	-1.461133	0.84422	1.01548
HIDs	HIDM	-1.048963	HID4	-0.484505	0.82079	1.77703

Because the net billing model produced statistically significant coefficients at the 95 percent confidence level for all but one estimate (Lighting Warehouse), the estimates of (1-FR) were incorporated into the final net ex post energy impact estimates. Although the values from the net billing model were not actually applied in the net-to-gross adjustments; they were used to verify similar results found in the self-report and nested logit analyses discussed next, in *Section 3-4.*

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 ante 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 participant self-reports are discussed, 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 808 participant, 462 nonparticipant and 3,796 canvass telephone surveys collected in 1997. Other data used in this analysis include the MDSS, CIS, and information from the Advice Filings.

3.4.2 Self-report Methods

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 nested logit 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. 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 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 definitions 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 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 = 4

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 and third conditions, the respondents first indicated that, had the program not existed, they would have bought high efficiency equipment. Under the third condition, they subsequently indicated that they would not have installed high efficiency equipment had the program not existed. Under the fourth condition, they subsequently 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.

If the participant answered "don't know" or refused to give a response to question, their responses were reclassified according to a second set of questions:

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.

If the answer to pd100 was also a "don't know" or "refused," a third set of questions was used:

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

In other words, the respondent indicated that, if they had not replaced their equipment under the program, they would have replaced it at least a 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 will not be 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 at a later time; 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 responses to the additional questions were used. The pd100 questions 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." The pd050 questions 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 808 completed telephone surveys of CEEI program participants. The responses included 496 Lighting end use adopters. The surveys were conducted between July and September of 1997 as part of a comprehensive telephone survey of CEEI program participants.

Results

Self-reported estimates of free ridership are presented below by technology group. 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 13.4%. The second lowest rate was found in the Exit Signs technology group. The ratio for this group was estimated to be 18.1%. The highest rate of free ridership was found in the Incandescent to Flourescent Fixture group, with a rate of 68.5%. These free ridership rates were developed within technology group by weighting by each site's avoided cost associated with the technology retrofit.

Exhibit 3-36
Weighted Self-report Estimates of Free Ridership
for Lighting Technology Groups in the 1996 CEEI Program

Technology Group	*Sample*	*Free Ridership*
Halogen	30	45.0%
Compact Flourescent Lamps	164	37.2%
Incandescent to Flourescent Fixtures	26	68.5%
Exit Signs	81	18.1%
Efficient Ballast Changeouts	13	24.7%
T-8 Lamps and Electronic Ballasts	391	24.1%
Delamp Flourescent Fixtures	118	13.4%
High Intensity Discharge	53	19.8%
Controls	57	57.2%

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 participant and nonparticipant surveys are also discussed. The final calculation of these 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 unit of spillover
- Estimation of the spillover contribution to the net-to-gross ratio

The spillover rate is simply the percentage of the participant or nonparticipant population that is identified as being influenced by the CEEI program to install non-rebated high-efficiency equipment. The spillover rate is estimated using self-reported survey results, as described below. Multiplying the participant or nonparticipant population by the respective spillover rate provides an estimate of the total number of participants or nonparticipants influenced by the CEEI program to install non-rebated high-efficiency equipment.

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 per unit impact estimate is based on the equipment installed as reported in the surveys, as described below. 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 percentage of participants or nonparticipants surveyed that indicated that they were influenced by the CEEI program to install non-rebated high-efficiency equipment.

In general, a spillover action was defined as any 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 surveyed participants and nonparticipants contributing towards spillover, the following three conditions, which reflect this definition of spillover, were used:

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

2. the action was **not rebated** as part of the program

3. the respondent stated that this action was taken 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 which meet the spillover criteria, the spillover rate was calculated by dividing the total number of spillover adoptions for each end use against 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 1995, have you made any changes in indoor lighting at your facility other than routine replacement of burned out bulbs?*
br099	*What type of fixtures were added?*

br199	*What types of lighting equipment were removed?*

For Condition 2:

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 3:

The third condition, whether or not the program influenced the respondents equipment selection, was tested with question sp010. Only those respondents who met the first two criteria were asked the final spillover question.[11] Because of this design, spillover could be calculated based solely on the response to question sp010 for lighting adoptions. The question text for sp010 was as follows:

sp010	*Did your participation in the Retrofit Express and Customized Incentives program at all influence your additional lighting equipment selection?*

<u>Participant Spillover Scoring Algorithm</u>

The final scoring algorithm for participant spillover was based on question sp010. This question was used because, as explained above, it was only asked of respondents who had already met the first two spillover criteria. The scoring algorithm is as follows:

If sp010 = 1 then spillover = 1

else spillover = 0

[11] Respondents who answered this question, but installed standard efficiency equipment types were not counted as spillover. Again, no one who was rebated was allowed to respond to this question.

If a respondent scores a 1 for spillover, they have met all three spillover conditions set forth above. As described above, the total number of spillovers 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 808 participants surveyed, a total of 26 participants were identified as contributing to lighting spillover. This results in a participant spillover rate of 3.2%. Because there were a total of 5,230 participants, this is equivalent to a total of 168 participant spillover Lighting actions.

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:

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 3:

The third condition, whether or not the program influenced the respondents equipment selection, was tested with question sp080. Only those respondents who met the first two criteria were asked the final spillover question. Because of this design, spillover could be calculated based solely on the response to question sp080. This question was used to evaluate the third spillover criterion, as follows:

sp080	*Did your knowledge of the Retrofit program at all influence your additional lighting equipment selection?*

Nonparticipant Spillover Scoring Algorithm

The final scoring algorithm for nonparticipant spillover was based on question sp080. This question was used because, as explained above, it was only asked of respondents who had already met the first two spillover criteria. The scoring algorithm is as follows:

If sp080 = 1 then spillover = 1

else spillover = 0

If a respondent scores a 1 for spillover, they have met all three spillover conditions set forth above.

As described above, the total number of spillovers counted using this algorithm was divided by the total number of nonparticipant's surveyed to obtain the nonparticipant spillover rate.

Nonparticipant Self-report Spillover Results

Of the 4,258 nonparticipants surveyed, a total of 10 nonparticipants were identified as contributing to lighting spillover. Because nonparticipants reported installations that spanned approximately a 3 year period (since 1995), the spillover rate was divided by 3 to correspond only to 1996. This results in a nonparticipant spillover rate of 0.08%.

From PG&E's 1996 CIS, there were 413,898 unique sites identified, resulting in a total of 408,668 nonparticipant sites less the 5,230 participants. Therefore, because there were a total of 408,668 nonparticipants, the spillover rate is equivalent to a total of 320 nonparticipant spillover Lighting actions.

Calculation of Impacts Associated With Spillover

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

Participant Spillover Impact Calculation

A total of 26 participants were identified as contributing to spillover. Of these 26, 20 provided valid equipment type information and the number of units installed. To calculate the impacts associated with spillover, avoided cost was used as a proxy for impact. The MDSS was used to determine what the average avoided cost per lamp installed was, by equipment type. By multiplying the average avoided cost per lamp by the number of lamps installed, an estimate of avoided cost could be calculated for each of the 20 participant installations.

Exhibit 3-37 below, presents the 26 participant installations identified as contributing to spillover, along with the estimate of avoided cost for the 20 installations that provided valid information. As discussed above, the average avoided cost per lamp was estimated using the MDSS. Based on these 20 participant installations, the average avoided cost per participant was estimated at $15,586.

Nonparticipant Spillover Impact Calculation

Only a total of ten nonparticipants were identified as contributing to spillover. Of these ten, only eight provided valid equipment type information and the number of units installed. Instead of using only the eight responses, it was assumed that a high-efficiency installation that was influenced by the program was the same as one that was not influenced by the program. There were a total of 135 high-efficiency installations, for which valid responses were obtained for equipment type and number of units installed. Therefore, these 135 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 MDSS was used to determine what the average avoided cost per lamp installed was, by equipment type. The 135 nonparticipant installations were used to determine the average number of fixtures installed by fixture type. Multiplying the average number of fixtures by the number of lamps per fixture, gives the total number of lamps installed by fixture type. Multiplying this by the average avoided cost per lamp from the MDSS gives an estimate of the average avoided cost per nonparticipant installation by equipment type. The 135 nonparticipant installations were then used to determine the distribution of installations across equipment type. Using this distribution, the overall average avoided cost per nonparticipant installation could be estimated.

Exhibit 3-37
Participant Spillover Adoptions

Fixture Type	# Fixtures	#Lamps Per Fixture	Per Lamp Av Cost	Total Av Cost
4ft T8 Fixtures	-	2.5	$19	$0
4ft T8 Fixtures	120	2.5	$19	$5,739
4ft T8 Fixtures	30	2.5	$19	$1,435
4ft T8 Fixtures	-	2.5	$19	$0
4ft T8 Fixtures	30	2.5	$19	$1,435
4ft T8 Fixtures	15	2.5	$19	$717
4ft T8 Fixtures	100	2.5	$19	$4,783
4ft T8 Fixtures	2500	2.5	$19	$119,572
4ft T8 Fixtures	12	2.5	$19	$574
4ft T8 Fixtures	-	2.5	$19	$0
4ft T8 Fixtures	750	2.5	$19	$35,872
8ft T8 Fixtures	15	2	$51	$1,533
8ft T8 Fixtures	6	2	$51	$613
Compact Flourescent	6	1	$54	$322
Electronic Ballast	40	1	$34	$1,357
HID Standard	6	1	$926	$5,553
HID Standard	16	1	$926	$14,808
HID Standard	48	1	$926	$44,425
Incandescent to Flourescent	100	1	$372	$37,232
Incandescent to Flourescent	16	1	$372	$5,957
Incandescent to Flourescent	12	1	$372	$4,468
Incandescent to Flourescent	20	1	$372	$7,446
Incandescent to Flourescent	48	1	$372	$17,871
Other	400	1	-	$0
Other	10	1	-	$0
Other	30	1	-	$0

Exhibit 3-38 below, presents the average avoided cost per nonparticipant install by fixture type, along with the distribution of installations across fixture type. As discussed above, the average avoided cost by fixture is based on the average number of fixtures installed from the 135 nonparticipant adopters and the average avoided cost per lamp from the MDSS. Based on distribution of the 135 nonparticipant installations, the average avoided cost per nonparticipant was estimated at $8,473. It should be noted that the average avoided cost associated with a nonparticipant installation contributing towards spillover was just 54% of the average avoided cost associated with a participant installation contributing towards spillover.

Exhibit 3-38
Nonparticipant Adoption Distribution

Fixture Type	# Fixtures	#Lamps Per Fixture	Per Lamp Av Cost	Total Av Cost	Distribution of Installs
2 Foot T8 Fixtures	29	2	$22	$1,294	8%
4 Foot T8 Fixtures	19	2.5	$19	$891	27%
8 Foot T8 Fixtures	17	2	$51	$1,691	8%
Incandescent to Flourescent	68	1	$372	$25,359	7%
HID fixtures	34	1	$926	$31,711	15%
Compact Flourescents	242	1	$54	$12,956	10%
Exit Signs	1	1	$112	$112	1%
Halogens	12	1	$5	$60	17%
Delamp Flourescent	60	2	$78	$9,307	1%
Electronic Ballasts	65	1	$34	$2,205	4%
Controls	7	1	$130	$911	1%

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 to 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 $51,077,333 for Lighting.

Participant Spillover NTG Calculation

Exhibit 3-39 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 5.14%.

Exhibit 3-39
Participant Spillover Estimate

Avoided Cost Per Participant	$15,586
Spillover Rate	3%
Number of Participants	5,230
Number Contributing to Spillover	168
Spillover Avoided Cost	$2,622,950
Lighting Avoided Cost	$51,077,333
NTG Contribution from Participant Spillover	**5.14%**

Exhibit 3-40
Nonparticipant Spillover Estimate

Avoided Cost Per Nonparticipant	$8,473
Spillover Rate	0.08%
Number of Nonparticipants	408,668
Number Contributing to Spillover	320
Spillover Avoided Cost	$2,710,747
Lighting Avoided Cost	$51,077,333
NTG Contribution from Nonparticipant Spillover	**5.31%**

Nonparticipant Spillover NTG Calculation

Exhibit 3-40 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 5.31%.

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 both 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 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 that results from having the program. As discussed below, this method is also used to determine free ridership rates and nonparticipant 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 the program information contained in the MDSS dataset. The sample is divided into a purchase and nonpurchase group. 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 3,033 customers. Of these, 2,375 are nonparticipants that did not make any lighting equipment purchases either in or outside the program. Of those that did make lighting equipment purchases, 466 customers did so within the lighting program. An additional 138 customers purchased high efficiency lighting equipment outside the program. Finally, 54 customers reported purchasing standard lighting equipment.

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 3-41. 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.

The variables AWARE and CINDEX are specified to capture the effect of the Lighting Program on the decision to make a purchase. For AWARE, customers are given a value of one if they indicated that they were aware of the retrofit program before they selected their 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 will 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.

Using this restricted definition of awareness, 79 percent of program participants were aware of the Lighting Program at the time that they selected their lighting equipment. For those that did not make any lighting purchases, 16 percent were aware of the program. For the entire sample, 27 percent of the customers were coded as being aware of the Lighting Program.

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 entire cost of the measure is paid by the customer. Similarly, for those that made a purchase and are aware of the program, the expected rebate is nonzero and CINDEX takes on a value less than one.

Exhibit 3-41
Purchase Model Variable Definitions

Variable Name	Units	Variable Type	Description
AWARE	0,1	Z	Aware of program prior to time of purchase
ARCOOL	0,1	Y	Cooling equipment was added and removed since 1/95
CINDEX	ratio	Z	(Cost - Rebate) / Cost
EMPCHG	0,1	Y	Employee change by 10 % since 1/95
FLUOR	0,1	Y	Fluorescent main type of lighting
HEALTH	0,1	X	Health Care Building
HID	0,1	Y	Primary lighting is HID
INCAN	0,1	Y	Primary lighting is incandescent
MISCCOM	0,1	X	Miscellanious commercial building
OFFICE	0,1	X	Office building
OWN	0,1	Y	Own building
PERSONAL	0,1	X	Personal services building
RESTRNT	0,1	X	Restaurant
RETAIL	0,1	X	Retail Building
SCHOOL	0,1	X	School
SFADD	0,1	Y	Square footage added to facility
SQFEET	Square ft.	Y	Square footage of facility
TENACT	0,1	Y	Tenants active in equipment purchase decisions

Purchase Model Estimation Results

The estimation results from the purchase model are given in Exhibit 3-42. A likelihood ratio test yields a test statistic of over 2212 with 18 degrees of freedom, which is well above the critical value at any of the conventional levels of significance. In addition, Exhibit 3-43 shows that the estimated probability of making a purchase is 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 3-42. As expected, program awareness has a strong positive effect on the decision to purchase lighting equipment. 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. Based on the building type coefficient estimates, offices and schools are the only building types that were likely to make a lighting purchase. Buildings categorized as health, personal , miscellaneous commercial were all less likely to make lighting purchases. 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 a purchase. Not surprisingly, changes to the facility (ARCOOL, SFADD, EMPCHG) are also likely to lead to a lighting equipment purchase.

Exhibit 3-42
Purchase Model Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
AWARE	2.03	0.09	1%
ARCOOL	0.44	0.19	2%
CINDEX	-3.53	0.18	1%
EMPCHG	0.61	0.11	1%
FLUOR	0.51	0.12	1%
HEALTH	-0.34	0.20	9%
HID	0.54	0.30	7%
INCAN	0.11	0.23	63%
MISCCOM	-0.46	0.18	1%
OFFICE	0.23	0.14	10%
OWN	1.48	0.13	1%
PERSONAL	-0.35	0.19	6%
RESTRNT	-0.04	0.23	3%
RETAIL	0.10	0.14	47%
SCHOOL	0.39	0.16	2%
SFADD	0.71	0.17	1%
SQFEET	0.00	0.00	1%
TENACT	1.15	0.14	1%

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 3-43. As expected, Lighting Program participants have a high probability of making an equipment purchase with an estimated purchase probability of 0.70. Conversely, those that did not make any purchases have a low estimated probability of purchasing high-efficiency equipment at 0.20.

Exhibit 3-43
Estimated Purchase Probabilities

Customer Group	With Program	Without Program
No Purchase	0.20	0.14
Participants	0.70	0.41
Purchase HE Outside Program	0.45	0.23
Purchase Std Efficiency	0.28	0.20

The probability of making a lighting equipment purchase in absence of the program is calculated by removing the effect of the Lighting Program from the purchased decision model. This is done by setting AWARE 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 high-efficiency purchase in absence of the Lighting Program are also given in Exhibit 3-46. In the absence of the Lighting Program, the probability of purchasing lighting equipment drops from 0.70 to 0.41. This indicates that many of those who purchased lighting equipment would not have done so without the Lighting Program. This is similar to the result found in the self-report analysis where 37 percent of the participants would not have made any equipment purchase without the program. The Lighting Program also decreases the probability that those outside the program will purchase lighting equipment. For those purchasing high-efficiency outside the program, removing the program decreases the probability of a purchase from 0.45 to 0.23.

Stage 2 -- Equipment Choice Model Specification

The second stage of the model is to 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 eleven different options: compact fluorescents, controls, exit signs, halogen, reflectors, T-8's, external and internal HID's, T-10's, 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 ten nonchosen alternatives.

A conditional logit model is used to estimate the equipment choice decision. The equipment choice model specification is:

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

Where AWARE = Awareness of the retrofit program

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 3-44. 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 they 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 start shopping for 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.

Exhibit 3-44
Equipment Choice Model Variable Definitions

Variable Name	Units	Description
AWARE	0,1	Aware of program at time of purchase
CINDEX	ratio	(Cost - Rebate) / Cost
HEALTH	0,1	Health Care Building
MISCCOM	0,1	Miscellanious commercial building
OFFICE	0,1	Office building
PERSONAL	0,1	Personal services building
PREDISP	0,1	Predispostion to buying high efficiency
RETAIL	0,1	Retail building
RESTRNT	0,1	Restaurant
SAVINGS	0,1	Expected dollar amount of electricity savings
SCHOOL	0,1	School
SQFEET	0,1	Square footage of facility

A characteristic of the conditional logit specification is that variables that do not vary over choices will drop out of the model.[12] For instance, firmographic variables such as size does 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. The variables AWARE, PREDISP, SQFEET, OFFICE, RETAIL RESTAURANT, HEALTH PERSONAL, MISC, and SCHOOL are all variables interacted with a dummy variable for the high efficiency equipment options. As a result, these variables have positive values for eight of the eleven choices and values of zero for the three standard efficiency choices.

For those that purchased high efficiency lighting within the retrofit 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 program participants 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.

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.

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

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 filings.

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 3-45. In general, the estimation results conform to expectations. The coefficient estimate on CINDEX is negative and significant, 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 negative, but small in magnitude.

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. Similarly, 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. The coefficient on PREDISP, however, is lower in magnitude than the estimate for AWARE and is not statistically significant. 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 negative and small in magnitude, indicating a slight tendency for larger firms to purchase standard efficiency equipment. The remaining variables indicate business type. Of these, only OFFICE has a positive coefficient estimate while SCHOOL is the only one that is statistically significant.

Exhibit 3-45
Equipment Choice Model Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
AWARE	3.29	0.38	1%
CINDEX	-3.42	0.24	1%
HEALTH	-0.15	0.67	83%
MISCCOM	-0.11	0.44	80%
OFFICE	0.35	0.43	41%
PERSONAL	-0.48	0.47	31%
PREDISP	0.11	0.79	88%
RETAIL	-0.07	0.39	87%
RESTRNT	-0.97	0.61	11%
SAVINGS	0.00	0.00	1%
SCHOOL	-0.62	0.35	8%
SQFEET	0.00	0.00	26%

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 eleven equipment options in the choice set.

As is done with the purchase probability, the equipment choice probability is calculated both with and in absence of the program. To simulate the absence of the program, AWARE is set to zero and CINDEX is set to one for all of the lighting equipment options. For program participants, the probability of choosing high efficiency equipment is the sum of the individual probabilities for the eight high efficiency options. The probability of choosing a standard equipment is the sum of the three remaining probabilities. For participants, the probability of purchasing high efficiency equipment is 0.70 with the program and falls over 60 percent to 0.27 without the program. Again, this result is very similar to that found in the self-report analysis, where 30 percent of participants would have purchased high efficiency equipment without the program.

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 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 AWARE equal to zero and CINDEX equal to one to reflect the absence of rebates. While AWARE is 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 in the survey of making a lighting purchase within the last three years, the weight is divided by three to adjust for the fact that only a third of these actions were likely to have been done during the 1996 program year. Finally, those that reported purchasing lighting outside the program since 1995 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 1996 Lighting Program.

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 eight 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 associate 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:

$$EXPECTED\ IMPACT^{WO} = \Sigma\ P^{WO}_j * IMPACT_j$$

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:

$$NET\ IMPACT = EXPECTED\ IMPACT^{W} - EXPECTED\ IMPACT^{WO}_j$$

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

NTG = NET IMPACT / EXPECTED IMPACT

Both participant and nonparticipant spillover are also calculated using the two stage model. For actions done outside the program, net impacts are calculated using the same method shown above:

$$NET\ IMPACT_{P\_SP} = EXPECTED\ IMPACT^{W}_{P\_SP} – EXPECTED\ IMPACT^{WO}_{P\_SP}$$

$$NET\ IMPACT_{NP\_SP} = EXPECTED\ IMPACT^{W}_{NP\_SP} – EXPECTED\ IMPACT^{WO}_{NP\_SP}$$

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:

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

The expected impacts by building type are shown below in Exhibit 3-46. The net-to-gross ratios range from 0.64 for community service buildings to 0.81 for restaurants. The overall net-to-gross ratio for all business types is 0.71 which results in a free ridership rate of 0.29. The total spillover rate for participants and nonparticipants is 0.10. This results in a final net-to-gross ratio estimate including spillover of 0.81 for the entire Lighting Program.

Exhibit 3-46
Estimated NTG Ratios by Building Type

Building Type	NTG
Office	1.01
Retail	0.74
College	0.69
School	0.77
Grocery	0.76
Restaurant	0.81
Health	0.72
Hotel	0.70
Warehouse	0.78
Personal	1.04
Comm. Services	0.66
Misc. Comm.	0.98

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 methodology relied on self-reported estimates of free ridership, participant spillover and nonparticipant spillover to estimate the net-to-gross ratios. The second 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 final approach relied on 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 the data due to the censoring of customers billing data. The self-report values rely on customers to give unbiased responses to their hypothetical actions in the absence of the program.

Exhibit 3-47 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 3-47
Comparison of Net-to-Gross Ratios

	Discrete Choice Model			Self Report			Mills
Business Type	**NTG**	**1-FR**	**Spill**	**NTG**	**1-FR**	**Spill**	**1-FR**
Office	1.01	0.65	0.36	0.88	0.78	-	0.84
Retail	0.74	0.73	0.01	0.86	0.75	-	1.03
College/Univ	0.69	0.68	0.01	0.84	0.74	-	0.96
School	0.77	0.75	0.02	0.84	0.74	-	0.97
Grocery	0.76	0.76	0.00	0.85	0.74	-	1.06
Restaurant	0.81	0.81	0.00	0.84	0.73	-	1.05
Health Care	0.72	0.72	0.00	0.84	0.73	-	0.82
Hotel/Motel	0.70	0.68	0.01	0.68	0.58	-	1.41
Warehouse	0.78	0.74	0.04	0.92	0.81	-	1.14
Personal Svcs.	1.04	0.79	0.26	0.85	0.75	-	1.05
Comm. Svcs.	0.66	0.64	0.02	0.85	0.74	-	0.92
Misc.	0.98	0.73	0.25	0.88	0.78	-	1.08
Total	**0.82**	**0.71**	**0.10**	**0.85**	**0.75**	**0.10**	**0.99**

Upon comparison of the three models, it is clear that the discrete choice model is well validated by the self-report results. The total net-to-gross ratio is within five percent of the self-reported results, with spillover estimates differing by less than one percent. Even at the business type level, the self-report results are within 20% of the discrete choice model results for all but two business types. Much of this variation can be attributed to the fact that the spillover estimates for the self-report approach were not estimated at the business type level. Rather, a single estimate of spillover was estimated.

Analyzing the free ridership estimates among the discrete choice and self-report models at the business type level provides even stronger validation for the two sets of results. The self-reported results are within 10% of the discrete choice model results for all but three business types.

The free ridership estimates generated using the Mills approach appears to provide significantly higher estimates of net participation. This is in part due to the large net estimates for HID technologies, and Hotel/Motels[13]. By focusing in on the primary business types and technologies, however, the Mills results for free ridership are more in line with those estimated using the other two approaches. For example, comparing the free ridership estimates for all non-HID technologies within office buildings, the Mills approach provides an estimate of 18% free ridership, whereas the self-report estimate is 22% (not shown in Exhibit 3-47 above).

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[13] It should be noted that values greater than one for the (1-FR) term from the Mills approach should not be considered invalid (i.e., negative free ridership). Recall that these values are estimated as a ratio of the Mills SAE Coefficients and the Gross SAE Coefficients. Therefore, there is a considerable amount of error surrounding these estimates, since the variance incorporates the error from both the Mills and the Gross SAE Coefficients. Furthermore, the instances where the Mills (1-FR) term were significantly greater than one also corresponded to technologies which had the lowest Gross SAE Coefficients.

The 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 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 3-48 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 3-48
Final Net-to-Gross Ratios

Business Type	*NTG*	*1-FR*	*Spill*
Office	1.01	0.65	0.36
Retail	0.74	0.73	0.01
College/Univ	0.69	0.68	0.01
School	0.77	0.75	0.02
Grocery	0.76	0.76	0.00
Restaurant	0.81	0.81	0.00
Health Care	0.72	0.72	0.00
Hotel/Motel	0.70	0.68	0.01
Warehouse	0.78	0.74	0.04
Personal Svcs.	1.04	0.79	0.26
Comm. Svcs.	0.66	0.64	0.02
Misc.	0.98	0.73	0.25
Totals Weighted by:			
Energy	**0.82**	**0.71**	**0.10**
Demand	**0.84**	**0.70**	**0.14**
Therm	**0.87**	**0.69**	**0.18**

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. Explanation for 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. All results are segmented by program, the Retrofit Express (RE), Customized Incentives, and the one Customized Efficiency Options (CEO) application. All results are aggregated to the total commercial sector.

ex post gross impact results

Ex post gross energy and demand impacts for the RE, Customized Incentives, and CEO programs 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 these results tables in this section (as well as the ex ante impacts, not included in the main body of this report), in a larger, more readable format.

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	328,406	881,715	123,888	11,374	49,250	159,588	266,824	331,192	9,293	66,970	166,657	-	2,395,158
	Compact Fluorescent Lamps	1,331,571	820,091	851,310	616,038	587,988	386,824	667,845	4,132,853	25,151	401,628	280,135	77,990	10,179,423
	Incandescent to Fluorescent Fixtures	315,681	433,747	299,945	430,645	66,059	27,185	484,430	1,436,245	21,050	23,961	126,184	63,008	3,728,139
	Exit Signs	763,449	356,774	380,350	256,864	51,635	46,259	437,766	137,929	31,688	113,523	269,876	38,433	2,884,546
	Efficient Ballast Changeouts	69,951	60,547	25,066	59,321	53,197	-	32,315	1,217	4,005	14,055	157,326	6,404	483,405
	T-8 Lamps and Electronic Ballasts	15,078,232	21,728,298	4,422,491	4,786,423	12,497,226	830,511	4,563,628	725,641	1,746,728	1,249,381	2,192,315	1,235,127	71,056,000
	Delamp Fluorescent Fixtures	13,116,932	5,955,498	1,978,715	1,756,791	2,379,784	410,658	1,979,356	32,153	2,717,470	548,229	827,029	513,938	32,216,554
	High Intensity Discharge	768,827	526,536	198,156	336,666	805,714	100,823	33,011	1,723	2,100,741	131,578	525,646	914,144	6,443,566
	Controls	1,543,036	965,583	429,258	369,524	22,311	17,495	304,806	25,521	35,725	86,841	224,162	13,557	4,037,819
Retrofit Express Program Total		33,316,084	31,728,789	8,709,180	8,623,645	16,513,165	1,979,343	8,769,982	6,824,474	6,691,852	2,636,167	4,769,330	2,862,601	133,424,611
Customized Incentives	T-8 Lamps and Electronic Ballasts	-	-	-	-	1,985,274	28,982	-	55,007	-	-	-	-	2,069,262
	High Intensity Discharge	-	-	-	-	363,708	-	-	59,274	-	-	-	-	422,982
	Controls	-	-	-	-	1,590,296	-	-	-	-	-	-	-	1,590,296
	Other	-	-	-	-	387,808	-	-	-	-	-	-	-	387,808
Customized Incentives Program Total		0	0	0	0	4,327,085	28,982	0	114,280	0	0	0	0	4,470,348
Customized Efficiency Options Program Total		0	0	0	0	0	0	0	0	0	0	0	444,848	444,848
Total		33,316,084	31,728,789	8,709,180	8,623,645	20,840,250	2,008,325	8,769,982	6,938,754	6,691,852	2,636,167	4,769,330	3,307,449	**138,339,806**

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	90.2	127.9	26.5	2.9	5.2	18.4	63.4	57.9	1.8	8.7	41.9	-	444.8
	Compact Fluorescent Lamps	361.8	113.1	169.3	141.4	59.4	40.7	141.7	727.6	4.7	51.0	59.9	16.5	1,887.1
	Incandescent to Fluorescent Fixtures	85.7	63.7	62.9	101.5	6.9	3.1	110.9	256.7	4.0	3.2	28.9	14.2	741.6
	Exit Signs	117.5	30.0	52.2	35.6	4.5	4.0	67.4	22.8	2.9	8.9	41.1	5.8	392.7
	Efficient Ballast Changeouts	19.0	8.9	5.3	14.0	5.6	-	7.4	0.2	0.8	1.9	36.1	1.4	100.4
	T-8 Lamps and Electronic Ballasts	4,094.5	3,188.5	927.7	1,128.0	1,310.0	94.1	1,044.6	129.7	328.3	168.4	502.4	277.6	13,193.8
	Delamp Fluorescent Fixtures	3,561.9	873.9	415.1	414.0	249.5	46.5	453.1	5.7	510.7	73.9	189.5	115.5	6,909.4
	High Intensity Discharge	351.6	230.3	76.3	151.8	256.6	34.1	12.7	0.4	1,062.7	52.2	205.0	327.6	2,761.4
	Controls	236.2	80.9	58.6	50.9	1.9	1.5	46.6	4.2	3.3	6.8	34.2	2.0	527.2
Retrofit Express Program Total		8,918.6	4,717.3	1,793.9	2,040.0	1,899.6	242.3	1,947.8	1,205.3	1,919.1	375.0	1,139.0	760.6	26,958.4
Customized Incentives	T-8 Lamps and Electronic Ballasts	-	-	-	-	208.1	3.3	-	9.8	-	-	-	-	221.2
	High Intensity Discharge	-	-	-	-	115.8	-	-	14.9	-	-	-	-	130.7
	Controls	-	-	-	-	137.4	-	-	-	-	-	-	-	137.4
	Other	-	-	-	-	30.3	-	-	-	-	-	-	-	30.3
Customized Incentives Program Total		0.0	0.0	0.0	0.0	491.7	3.3	0.0	24.7	0.0	0.0	0.0	0.0	519.7
Customized Efficiency Options Program Total		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	97.0	97.0
Total		8,918.6	4,717.3	1,793.9	2,040.0	2,391.3	245.6	1,947.8	1,230.0	1,919.1	375.0	1,139.0	857.6	**27,575.0**

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

RE Program – Overall, more than 95 percent of the energy and demand impacts are from lighting technologies installed through the RE program.

Customized Incentives Program – The Customized Incentives Program plays a small role in the overall impact, with less than 3 percent of the energy and demand savings being attributable to this program. The largest Customized Incentives participation was found within the grocery business type, which contributed to more than 90 percent of that program’s impacts. HVAC and Refrigeration measures were found in the applications to be lumped under one MDSS record with a Lighting measure code.

High Participation Business Types – Office and retail business types represent almost half of the impacts, with office being the largest single segment, accounting for about one third of demand and one quarter of energy impacts. These business types have historically contributed a large share of lighting program impacts, which is driven by the large number of lighting retrofits performed within those particular business types.

High Participation Technologies – The four 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 high-intensity discharge (HID) lamps and ballasts in place of less efficient technologies; and the installation of compact fluorescent fixtures to replace incandescent lighting. These four technologies represent nearly 90 percent of the RE program energy and demand savings. T-8 lamps and electronic ballasts alone account for more than half 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 restaurant business type, primarily because of low participation within that segment. Lighting quality requirements help explain the predominance of incandescent installations in this segment, which are preferred over the more efficient alternatives because of their dimming capability.

Low Participation Technologies – The lowest energy impacts were contributed by the efficient ballast changeouts.

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	-160,760	-156,896	-15,371	-5,516	-3,034	-50,242	-63,633	-23,831	-434	-3,208	-73,214	-	-556,140
	Compact Fluorescent Lamps	-651,826	-145,930	-105,622	-298,778	-36,218	-121,781	-159,269	-297,386	-1,175	-19,241	-123,066	-7,831	-1,968,123
	Incandescent to Fluorescent Fixtures	-154,531	-77,183	-37,214	-208,862	-4,069	-8,558	-115,528	-103,347	-983	-1,148	-55,434	-6,327	-773,185
	Exit Signs	-373,721	-63,486	-47,190	-124,579	-3,181	-14,563	-104,400	-9,925	-1,480	-5,439	-118,559	-3,859	-870,381
	Efficient Ballast Changeouts	-34,242	-10,774	-3,110	-28,771	-3,277	-	-7,706	-88	-187	-673	-69,115	-643	-158,586
	T-8 Lamps and Electronic Ballasts	-7,381,048	-3,866,422	-548,696	-2,321,410	-769,780	-261,465	-1,088,346	-52,215	-81,585	-59,855	-963,106	-124,024	-17,517,951
	Delamp Fluorescent Fixtures	-6,420,959	-1,059,746	-245,498	-852,042	-146,585	-129,285	-472,042	-2,314	-126,926	-26,265	-363,322	-51,606	-9,896,589
	High Intensity Discharge	-618,863	-282,555	-44,989	-298,793	-149,667	-95,724	-12,946	-178	-260,151	-19,010	-379,720	-150,941	-2,313,535
	Controls	-755,342	-171,820	-53,258	-179,219	-1,374	-5,508	-72,691	-1,836	-1,669	-4,160	-98,476	-1,361	-1,346,715
Retrofit Express Program Total		-16,551,293	-5,834,812	-1,100,947	-4,317,968	-1,117,183	-687,127	-2,096,561	-491,119	-474,589	-139,000	-2,244,012	-346,593	-35,401,204
Customized Incentives	T-8 Lamps and Electronic Ballasts	-	-	-	-	-122,285	-9,124	-	-3,958	-	-	-	-	-135,367
	High Intensity Discharge	-	-	-	-	-67,561	-	-	-6,117	-	-	-	-	-73,678
	Controls	-	-	-	-	-97,956	-	-	-	-	-	-	-	-97,956
	Other	-	-	-	-	-	-	-	-	-	-	-	-	0
Customized Incentives Program Total		0	0	0	0	-287,802	-9,124	0	-10,075	0	0	0	0	-307,001
Customized Efficiency Options Program Total		0	0	0	0	0	0	0	0	0	0	0	-44,669	-44,669
Total		-16,551,293	-5,834,812	-1,100,947	-4,317,968	-1,404,985	-696,252	-2,096,561	-501,194	-474,589	-139,000	-2,244,012	-391,261	**-35,752,874**

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). Also shown are the overall program level NTG results, weighted across business type by the ex-post gross energy, demand and therm savings. 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	1.01	0.65	0.36
Retail	0.74	0.73	0.01
College/Univ	0.69	0.68	0.01
School	0.77	0.75	0.02
Grocery	0.76	0.76	0.00
Restaurant	0.81	0.81	0.00
Health Care	0.72	0.72	0.00
Hotel/Motel	0.70	0.68	0.01
Warehouse	0.78	0.74	0.04
Personal Svcs.	1.04	0.79	0.26
Comm. Svcs.	0.66	0.64	0.02
Misc.	0.98	0.73	0.25
Totals Weighted by:			
Energy	**0.82**	**0.71**	**0.10**
Demand	**0.84**	**0.70**	**0.14**
Therm	**0.87**	**0.69**	**0.18**

The overall NTG ratio ranged from 0.82 based on energy savings, to 0.87 based on therm savings. On average, free ridership was approximately 30 percent, overall. Spillover ranged from 10 percent for energy savings to 18 percent for therm savings. This variation is due to the distribution of ex-post energy, demand and therm savings across business types. It was found that the majority of spillover occurred in office buildings and community services, which reported the highest lighting adoption rates outside of the program. Because the majority of spillover occurs in these two business types and a larger proportion of therm and demand savings occurs in these business types, overall spillover for therm and demand savings is larger than for energy savings.

ex post net impacts

Exhibits 4-5 and 4-6 present the ex post net energy and demand indoor lighting impacts, for the RE, Customized Incentives, and CEO programs.

These exhibits show reductions of 18 percent in ex post program energy impacts and 16 percent in ex post program demand impacts (when compared to Exhibits 4-1 and 4-2, gross impacts), as result of the application of the NTG adjustments presented in Exhibit 4-4. T-8/electronic ballast, optical reflectors with delamp, compact fluorescents, and HID replacements still dominate the savings representing more than 80 percent of the energy and demand impacts. Among the various business segments, office and retail still dominate the impacts, yielding more than half 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	331,379	651,666	85,657	8,749	37,624	128,794	193,107	231,078	7,251	69,864	110,280	-	1,855,447
	Compact Fluorescent Lamps	1,343,623	606,120	588,602	473,862	449,192	312,182	483,335	2,883,555	19,623	418,984	185,369	76,681	7,841,127
	Incandescent to Fluorescent Fixtures	318,538	320,577	207,384	331,256	50,466	21,939	350,593	1,002,090	16,423	24,997	83,498	61,950	2,789,711
	Exit Signs	770,358	263,688	262,977	197,582	39,446	37,333	316,822	96,235	24,722	118,429	178,580	37,788	2,343,961
	Efficient Ballast Changeouts	70,584	44,750	17,331	45,631	40,640	-	23,387	849	3,125	14,662	104,105	6,297	371,360
	T-8 Lamps and Electronic Ballasts	15,214,699	16,059,147	3,057,743	3,681,758	9,547,227	670,255	3,302,803	506,291	1,362,765	1,303,371	1,450,685	1,214,397	57,371,143
	Delamp Fluorescent Fixtures	13,235,648	4,401,644	1,368,098	1,351,339	1,818,031	331,417	1,432,506	22,434	2,120,121	571,920	547,257	505,313	27,705,727
	High Intensity Discharge	775,785	389,157	137,007	258,967	615,524	81,368	23,891	1,202	1,638,959	137,264	347,827	898,802	5,305,753
	Controls	1,557,002	713,652	296,792	284,241	17,044	14,119	220,595	17,807	27,872	90,594	148,331	13,330	3,401,378
Retrofit Express Program Total		33,617,616	23,450,401	6,021,592	6,633,383	12,615,194	1,597,408	6,347,039	4,761,541	5,220,860	2,750,085	3,155,931	2,814,558	108,985,607
Customized Incentives	T-8 Lamps and Electronic Ballasts	-	-	-	-	1,516,645	23,389	-	38,379	-	-	-	-	1,578,414
	High Intensity Discharge	-	-	-	-	277,854	-	-	41,356	-	-	-	-	319,210
	Controls	-	-	-	-	1,214,903	-	-	-	-	-	-	-	1,214,903
	Other	-	-	-	-	296,265	-	-	-	-	-	-	-	296,265
Customized Incentives Program Total		0	0	0	0	3,305,667	23,389	0	79,735	0	0	0	0	3,408,792
Customized Efficiency Options Program Total		0	0	0	0	0	0	0	0	0	0	0	437,382	437,382
Total		33,617,616	23,450,401	6,021,592	6,633,383	15,920,861	1,620,797	6,347,039	4,841,277	5,220,860	2,750,085	3,155,931	3,251,939	**112,831,780**

Realization RAtes

Exhibits 4-8 through 4-11 present the gross and net realization rates for energy and demand impacts for the RE, Customized Incentives, and CEO indoor lighting applications. 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.

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.

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	91.0	94.6	18.3	2.2	4.0	14.8	45.9	40.4	1.4	9.0	27.8	-	349.4
	Compact Fluorescent Lamps	365.1	83.6	117.1	108.8	45.3	32.8	102.6	507.6	3.6	53.2	39.6	16.3	1,475.6
	Incandescent to Fluorescent Fixtures	86.5	47.0	43.5	78.1	5.3	2.5	80.3	179.1	3.1	3.4	19.1	13.9	561.8
	Exit Signs	118.6	22.2	36.1	27.4	3.4	3.2	48.7	15.9	2.3	9.3	27.2	5.7	320.0
	Efficient Ballast Changeouts	19.2	6.6	3.6	10.8	4.3	-	5.4	0.2	0.6	2.0	23.9	1.4	77.7
	T-8 Lamps and Electronic Ballasts	4,131.6	2,356.6	641.4	867.7	1,000.8	75.9	756.0	90.5	256.1	175.7	332.4	272.9	10,957.6
	Delamp Fluorescent Fixtures	3,594.2	645.9	287.0	318.5	190.6	37.5	327.9	4.0	398.5	77.1	125.4	113.6	6,120.1
	High Intensity Discharge	354.8	170.2	52.7	116.8	196.0	27.5	9.2	0.3	829.1	54.4	135.7	322.1	2,268.9
	Controls	238.3	59.8	40.5	39.1	1.5	1.2	33.8	2.9	2.5	7.1	22.6	2.0	451.5
Retrofit Express Program Total		8,999.3	3,486.5	1,240.3	1,569.2	1,451.2	195.5	1,409.7	840.9	1,497.2	391.2	753.7	747.9	22,582.6
Customized Incentives	T-8 Lamps and Electronic Ballasts	-	-	-	-	159.0	2.6	-	6.9	-	-	-	-	168.5
	High Intensity Discharge	-	-	-	-	88.5	-	-	10.4	-	-	-	-	98.9
	Controls	-	-	-	-	105.0	-	-	-	-	-	-	-	105.0
	Other	-	-	-	-	23.1	-	-	-	-	-	-	-	23.1
Customized Incentives Program Total		0.0	0.0	0.0	0.0	375.6	2.6	0.0	17.2	0.0	0.0	0.0	0.0	395.5
Customized Efficiency Options Program Total		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.3	95.3
Total		8,999.3	3,486.5	1,240.3	1,569.2	1,826.8	198.2	1,409.7	858.2	1,497.2	391.2	753.7	843.2	**23,073.4**

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	-162,215	-115,960	-10,627	-4,243	-2,318	-40,548	-46,053	-16,628	-339	-3,347	-48,447	-	-450,724
	Compact Fluorescent Lamps	-657,726	-107,856	-73,028	-229,822	-27,668	-98,282	-115,267	-207,491	-917	-20,073	-81,434	-7,700	-1,627,263
	Incandescent to Fluorescent Fixtures	-155,930	-57,045	-25,730	-160,659	-3,108	-6,907	-83,610	-72,107	-767	-1,198	-36,681	-6,221	-609,963
	Exit Signs	-377,103	-46,922	-32,627	-95,827	-2,430	-11,753	-75,556	-6,925	-1,155	-5,674	-78,452	-3,794	-738,219
	Efficient Ballast Changeouts	-34,552	-7,963	-2,150	-22,131	-2,503	-	-5,577	-61	-146	-702	-45,734	-632	-122,153
	T-8 Lamps and Electronic Ballasts	-7,447,851	-2,857,631	-379,373	-1,785,648	-588,071	-211,012	-787,661	-36,431	-63,651	-62,442	-637,300	-121,942	-14,979,014
	Delamp Fluorescent Fixtures	-6,479,072	-783,247	-169,739	-655,398	-111,983	-104,338	-341,628	-1,614	-99,025	-27,400	-240,415	-50,740	-9,064,600
	High Intensity Discharge	-624,464	-208,833	-31,105	-229,834	-114,338	-77,253	-9,369	-124	-202,965	-19,832	-251,266	-148,407	-1,917,790
	Controls	-762,178	-126,990	-36,823	-137,857	-1,050	-4,445	-52,608	-1,281	-1,302	-4,340	-65,163	-1,338	-1,195,376
Retrofit Express Program Total		-16,701,093	-4,312,446	-761,203	-3,321,419	-853,470	-554,539	-1,517,329	-342,662	-370,266	-145,007	-1,484,894	-340,776	-30,705,101
Customized Incentives	T-8 Lamps and Electronic Ballasts	-	-	-	-	-93,419	-7,364	-	-2,762	-	-	-	-	-103,545
	High Intensity Discharge	-	-	-	-	-51,613	-	-	-4,268	-	-	-	-	-55,881
	Controls	-	-	-	-	-74,833	-	-	-	-	-	-	-	-74,833
	Other	-	-	-	-	-	-	-	-	-	-	-	-	0
Customized Incentives Program Total		0	0	0	0	-219,866	-7,364	0	-7,030	0	0	0	0	-234,259
Customized Efficiency Options Program Total		0	0	0	0	0	0	0	0	0	0	0	-43,919	-43,919
Total		-16,701,093	-4,312,446	-761,203	-3,321,419	-1,073,335	-561,902	-1,517,329	-349,691	-370,266	-145,007	-1,484,894	-384,695	**-30,983,279**

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	1.37	2.62	1.43	1.12	3.67	3.35	1.27	1.74	1.49	2.35	1.07	-	1.81
	Compact Fluorescent Lamps	1.01	1.39	1.01	0.97	1.24	1.31	0.82	0.99	0.93	1.40	0.48	0.82	1.01
	Incandescent to Fluorescent Fixtures	1.07	1.51	1.15	1.02	1.34	1.67	1.02	1.20	1.14	1.55	0.67	0.94	1.13
	Exit Signs	0.90	1.56	1.01	0.98	1.59	1.62	0.91	0.76	1.31	1.54	0.97	0.83	1.01
	Efficient Ballast Changeouts	0.98	1.40	1.07	0.93	1.24	-	0.94	1.10	1.05	1.42	0.62	0.87	0.87
	T-8 Lamps and Electronic Ballasts	1.04	1.45	1.11	0.99	1.26	1.62	0.99	1.16	1.08	1.50	0.64	0.91	1.16
	Delamp Fluorescent Fixtures	1.07	1.51	1.15	1.01	1.35	1.67	1.02	1.20	1.14	1.55	0.67	0.94	1.15
	High Intensity Discharge	0.68	0.50	0.53	0.62	0.47	0.64	0.68	0.90	0.47	0.53	0.46	0.61	0.52
	Controls	0.93	1.62	1.02	1.02	1.65	1.68	0.94	0.79	1.36	1.55	0.98	0.86	1.08
Retrofit Express Program Total		1.03	1.44	1.08	0.97	1.17	1.51	0.98	1.06	0.78	1.38	0.64	0.79	1.08
Customized Incentives	T-8 Lamps and Electronic Ballasts													
	High Intensity Discharge													
	Controls													
	Other													
Customized Incentives Program Total		-	-	-	-	1.23	1.52	-	0.55	-	-	-	-	1.19
Customized Efficiency Options Program Total		-	-	-	-	-	-	-	-	-	-	-	0.91	0.91
Total		1.03	1.44	1.08	0.97	1.19	1.51	0.98	1.05	0.78	1.38	0.64	0.81	**1.08**

Exhibit 4-8 illustrates that the ex ante estimates are extremely close to the ex post impact estimates for RE measures, with the exception Halogens and HIDs. All other realization rates indicate that ex-ante and ex-post gross energy savings are within 20 percent of each other at the technology level.

Segment-level realization rates could not be developed for the Customized Incentives impacts because the MDSS does not adequately track ex ante estimates by technology group. When the unadjusted engineering estimates were developed, each application (represented by a single record in the MDSS) was classified under the various technology groups represented in these results tables.

The technology group results for Halogens and HIDs are discussed below (using information from the review of the ex ante estimates in conjunction with the billing analysis results).

Halogen - The 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. Ex ante estimates were also incorrectly calculated due to analysis procedures surrounding lamp life. Lamp life was incorrectly incorporated into the impact twice, resulting in artificially low estimates. Moreover, no evidence of this short measure life was uncovered during field inspection, nor 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 2 percent of the lighting program's total.

High Intensity Discharge, Low Billing Regression Coefficients – Although the SAE coefficients were estimated in most instances for individual or grouped business types, the SAE coefficient for HID technologies was estimated across all business types for that technology alone. The resulting SAE coefficient of 0.48 for HIDs explains why the average RE program realization rate for HID technologies was only 0.52.

The business type results presented in Exhibit 4-8 that are most significantly different from one are within the retail, restaurant, personal service and community service business types. These results are discussed below.

Retail, Restaurant and Personal Service Business Types – The SAE coefficient generated for these segments combined was 1.46 (excluding the HID technology, which was 0.48 as discussed above), 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 above one.

Community Services – The community services business type received the lowest gross energy realization rate, of 64 percent. This result is being driven partially by the low SAE coefficient derived for HID technologies, and the SAE coefficient of 80 percent being applied to the remaining technologies. In addition, the overall unadjusted gross engineering estimate for this business type was 14 percent lower than the ex-ante 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 25 percent higher than the ex ante values, as illustrated above. This 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 in previous evaluations). Evaluation estimates for operating factor are generally higher than the typical ex ante CDF of 0.67. In addition, the evaluation estimates include an HVAC interaction component, which was not accounted for in the ex ante values. For additional detail surrounding these engineering components of impact, refer to *Section 3.2*.

Some of the results presented in Exhibit 4-9 can be explained using information from review of the ex ante estimates and the evaluation engineering analyses. Specific comments and justifications for the results are as follows:

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	1.89	2.63	1.58	0.87	3.99	2.73	2.13	1.79	1.66	1.79	1.58	-	2.03
	Compact Fluorescent Lamps	1.41	1.36	1.05	0.70	1.32	0.99	1.05	1.05	1.04	1.06	0.61	1.04	1.06
	Incandescent to Fluorescent Fixtures	1.47	1.56	1.26	0.75	1.47	1.36	1.39	1.28	1.29	1.25	0.92	1.27	1.20
	Exit Signs	1.21	1.15	1.21	1.19	1.21	1.22	1.22	1.11	1.06	1.06	1.30	1.10	1.20
	Efficient Ballast Changeouts	1.35	1.42	1.16	0.68	1.33	-	1.26	1.16	1.16	1.14	0.84	1.15	0.98
	T-8 Lamps and Electronic Ballasts	1.43	1.49	1.21	0.73	1.38	1.31	1.35	1.24	1.21	1.21	0.88	1.22	1.26
	Delamp Fluorescent Fixtures	1.47	1.56	1.25	0.75	1.47	1.35	1.39	1.27	1.28	1.24	0.91	1.26	1.34
	High Intensity Discharge	1.57	1.53	1.06	0.88	1.55	1.56	1.56	1.34	1.42	1.25	1.08	1.32	1.35
	Controls	0.59	0.53	0.56	0.57	0.75	0.96	0.62	0.65	0.61	0.52	0.64	0.67	0.58
Retrofit Express Program Total		1.39	1.47	1.16	0.74	1.41	1.33	1.31	1.13	1.33	1.17	0.91	1.26	1.25
Customized Incentives	T-8 Lamps and Electronic Ballasts													
	High Intensity Discharge													
	Controls													
	Other													
Customized Incentives Program Total		-	-	-	-	1.52	0.94	-	0.89	-	-	-	-	1.46
Customized Efficiency Options Program Total		-	-	-	-	-	-	-	-	-	-	-	0.88	0.88
Total		1.39	1.47	1.16	0.74	1.43	1.32	1.31	1.13	1.33	1.17	0.91	1.20	**1.25**

Compact Fluorescents - The slightly lower-than-average realization rates are due to lower operating factors observed for this technology during field inspections. These operating factors partly offset the added impact attributed to the ex post HVAC interactive impact effects.

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.

Office, Retail, Grocery, Restaurant, Health Care, and Warehouse – Each realization rate for this particular set of business types is in excess of 1.30. The high realization rate is partially due to high open-period operating factors (as observed during on-site inspections), and high diversity factors (high percentage of facilities open during the peak hour). The ex-ante estimates are based off of an assumed peak diversity factor (the combined effect of operating factors and these schedules) of just 0.67. In addition, the HVAC interactive effect represents an additional 20 percent in net impact.

Schools - The low realization rate is a result of low diversity factor for schools (a high percentage of schools are closed during the summer peak hour).

Community Service - Like schools, these organizations have relatively low open-period operating factors during the summer peak hour (particularly for compact fluorescent technologies) and are also more likely than other business types to be closed during the summer weekday peak hour.

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 evenly distributed throughout the year, leading to a relatively lower peak demand impact than that contained in the MDSS.

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 can apply for 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.

Overview of Realization Rates

The net energy and demand impacts are higher than predicted by the ex ante impact estimates. The net ex post impacts exceed the net ex ante design estimates by 15 percent for energy and 36 percent for demand. To a certain extent, these results reflect the higher gross realization rates, in conjunction with the NTG ratios applied. The NTG adjustments apply equally to energy and demand impacts, since they represent the same behavioral effects regarding the decision to purchase energy-efficient equipment. However, these high realization rates are well documented and supportable based on the information developed during the evaluation.

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 4-10
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	1.79	2.51	1.29	1.12	3.64	3.51	1.19	1.58	1.51	3.18	0.92	-	1.82
	Compact Fluorescent Lamps	1.33	1.34	0.90	0.97	1.23	1.38	0.77	0.90	0.94	1.89	0.41	1.04	1.01
	Incandescent to Fluorescent Fixtures	1.40	1.45	1.03	1.02	1.33	1.75	0.96	1.08	1.16	2.10	0.57	1.20	1.10
	Exit Signs	1.18	1.50	0.91	0.98	1.58	1.70	0.85	0.69	1.33	2.08	0.84	1.06	1.06
	Efficient Ballast Changeouts	1.28	1.34	0.96	0.93	1.23	-	0.88	1.00	1.07	1.93	0.53	1.11	0.87
	T-8 Lamps and Electronic Ballasts	1.36	1.39	1.00	0.99	1.25	1.70	0.93	1.05	1.09	2.03	0.55	1.16	1.22
	Delamp Fluorescent Fixtures	1.40	1.45	1.03	1.01	1.33	1.75	0.96	1.08	1.16	2.10	0.57	1.20	1.28
	High Intensity Discharge	0.88	0.48	0.47	0.62	0.46	0.68	0.64	0.81	0.47	0.71	0.40	0.79	0.56
	Controls	1.22	1.56	0.92	1.02	1.64	1.76	0.88	0.72	1.38	2.10	0.84	1.10	1.18
Retrofit Express Program Total		1.35	1.38	0.97	0.97	1.17	1.58	0.92	0.96	0.79	1.87	0.55	1.01	1.14
Customized Incentives	T-8 Lamps and Electronic Ballasts													
	High Intensity Discharge													
	Controls													
	Other													
Customized Incentives Program Total		-	-	-	-	1.25	1.63	-	0.51	-	-	-	-	1.21
Customized Efficiency Options Program Total		-	-	-	-	-	-	-	-	-	-	-	1.19	1.19
Total		1.35	1.38	0.97	0.97	1.18	1.58	0.92	0.95	0.79	1.87	0.55	1.03	**1.15**

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	2.47	2.52	1.42	0.87	3.96	2.86	2.01	1.63	1.69	2.42	1.36	-	2.07
	Compact Fluorescent Lamps	1.84	1.30	0.94	0.70	1.30	1.04	0.99	0.95	1.05	1.44	0.52	1.33	1.07
	Incandescent to Fluorescent Fixtures	1.93	1.50	1.13	0.75	1.46	1.42	1.31	1.16	1.30	1.69	0.79	1.62	1.18
	Exit Signs	1.59	1.11	1.09	1.19	1.20	1.28	1.15	1.00	1.07	1.44	1.11	1.40	1.27
	Efficient Ballast Changeouts	1.77	1.36	1.04	0.68	1.32	-	1.18	1.05	1.17	1.55	0.72	1.47	0.99
	T-8 Lamps and Electronic Ballasts	1.87	1.43	1.09	0.72	1.37	1.38	1.27	1.12	1.22	1.63	0.75	1.56	1.36
	Delamp Fluorescent Fixtures	1.92	1.49	1.13	0.75	1.46	1.42	1.30	1.15	1.30	1.68	0.78	1.61	1.54
	High Intensity Discharge	2.05	1.47	0.95	0.88	1.54	1.64	1.47	1.22	1.44	1.69	0.92	1.68	1.44
	Controls	0.77	0.51	0.50	0.57	0.75	1.01	0.58	0.59	0.62	0.70	0.55	0.85	0.65
Retrofit Express Program Total		1.83	1.41	1.04	0.74	1.40	1.39	1.23	1.03	1.35	1.59	0.78	1.61	1.36
Customized Incentives	T-8 Lamps and Electronic Ballasts													
	High Intensity Discharge													
	Controls													
	Other													
Customized Incentives Program Total		-	-	-	-	1.55	1.01	-	0.83	-	-	-	-	1.48
Customized Efficiency Options Program Total		-	-	-	-	-	-	-	-	-	-	-	1.16	1.16
Total		1.83	1.41	1.04	0.74	1.43	1.38	1.23	1.02	1.35	1.59	0.78	1.54	**1.36**

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 Express	Halogen	1,325,524	219	-	0.67	0.10	1,020,743	169	-
	Compact Fluorescent Lamps	10,119,829	1,784	-	0.67	0.10	7,792,952	1,374	-
	Incandescent to Fluorescent Fixtures	3,296,166	620	-	0.67	0.10	2,538,270	477	-
	Exit Signs	2,863,122	327	-	0.67	0.10	2,204,797	251	-
	Efficient Ballast Changeouts	556,529	102	-	0.67	0.10	428,565	79	-
	T-8 Lamps and Electronic Ballasts	61,264,225	10,433	-	0.67	0.10	47,177,594	8,034	-
	Delamp Fluorescent Fixtures	28,115,005	5,169	-	0.67	0.10	21,650,454	3,981	-
	High Intensity Discharge	12,408,503	2,047	-	0.67	0.10	9,555,386	1,576	-
	Controls	3,741,003	908	-	0.67	0.10	2,880,825	699	-
Retrofit Express Program Total		123,689,904	21,608	-	0.67	0.10	95,249,586	16,639	-
Customized Incentives Program Total		3,741,287	355	-	0.65	0.10	2,806,211	266	-
Customized Efficiency Options Program Total		488,580	110	-	0.65	0.10	366,467	83	-
Total		127,919,770	22,073	-	0.67	0.10	98,422,264	16,988	-
			EX POST						
Retrofit Express	Halogen	2,395,158	445	-556,140	0.71	0.06	1,855,447	349	-450,724
	Compact Fluorescent Lamps	10,179,423	1,887	-1,968,123	0.70	0.07	7,841,127	1,476	-1,627,263
	Incandescent to Fluorescent Fixtures	3,728,139	742	-773,185	0.70	0.05	2,789,711	562	-609,963
	Exit Signs	2,884,546	393	-870,381	0.70	0.12	2,343,961	320	-738,219
	Efficient Ballast Changeouts	483,405	100	-158,586	0.69	0.08	371,360	78	-122,153
	T-8 Lamps and Electronic Ballasts	71,056,000	13,194	-17,517,951	0.72	0.09	57,371,143	10,958	-14,979,014
	Delamp Fluorescent Fixtures	32,216,554	6,909	-9,896,589	0.70	0.16	27,705,727	6,120	-9,064,600
	High Intensity Discharge	6,443,566	2,761	-2,313,535	0.72	0.10	5,305,753	2,269	-1,917,790
	Controls	4,037,819	527	-1,346,715	0.69	0.15	3,401,378	451	-1,195,376
Retrofit Express Program Total		133,424,611	26,958	-35,401,204	0.71	0.11	108,985,607	22,583	-30,705,101
Customized Incentives	T-8 Lamps and Electronic Ballasts	2,069,262	221	-135,367	0.76	0.00	1,578,414	168	-103,545
	High Intensity Discharge	422,982	131	-73,678	0.75	0.00	319,210	99	-55,881
	Controls	1,590,296	137	-97,956	0.76	0.00	1,214,903	105	-74,833
	Other	387,808	30	0	0.76	0.00	296,265	23	0
Customized Incentives Program Total		4,470,348	520	-307,001	0.76	0.00	3,408,792	396	-234,259
Customized Efficiency Options Program Total		444,848	97	-44,669	0.73	0.25	437,382	95	-43,919
Total		138,339,806	27,575	-35,752,874	0.71	0.10	112,831,780	23,073	-30,983,279
			REALIZATION RATES						
Retrofit Express	Halogen	1.81	2.03	-	-	-	1.82	2.07	-
	Compact Fluorescent Lamps	1.01	1.06	-	-	-	1.01	1.07	-
	Incandescent to Fluorescent Fixtures	1.13	1.20	-	-	-	1.10	1.18	-
	Exit Signs	1.01	1.20	-	-	-	1.06	1.27	-
	Efficient Ballast Changeouts	0.87	0.98	-	-	-	0.87	0.99	-
	T-8 Lamps and Electronic Ballasts	1.16	1.26	-	-	-	1.22	1.36	-
	Delamp Fluorescent Fixtures	1.15	1.34	-	-	-	1.28	1.54	-
	High Intensity Discharge	0.52	1.35	-	-	-	0.56	1.44	-
	Controls	1.08	0.58	-	-	-	1.18	0.65	-
Retrofit Express Program Total		1.08	1.25	-	-	-	1.14	1.36	-
Customized Incentives Program Total		1.19	1.46	-	-	-	1.21	1.48	-
Customized Efficiency Options Program Total		0.91	0.88	-	-	-	1.19	1.16	-
Total		1.08	1.25	-	-	-	1.15	1.36	-

* Weighted by ex-post Gross Energy impact

5. RECOMMENDATIONS

Recommendations that would enhance future program performance and evaluation are presented in this section. Recommendations regarding evaluation methods are followed by those affecting the program's design.

5.1 EVALUATION METHODS

The evaluation team offers the following comments and recommendations regarding methods used in the 1996 evaluation:

Trade on Established Information in Future Evaluations - This evaluation utilized extensive observed and measured operating factor and operating hours information on the highest participation segments from previous evaluations. QC recommends that PG&E continue to use this existing information in subsequent evaluations, thus minimizing the need to replicate operating hours and operating factor data for sectors where this information is unlikely to change. There is no reason to believe that the operating factor and operating hours information utilized in this evaluation will change significantly from year to year. This will allow PG&E and the CPUC to maximize return on money invested in future evaluations, resulting in better estimates for sectors that have yet to be definitively documented.

Calculation of Ex Ante Impacts - As part of the 1996 Lighting Evaluation, an attempt was made to reproduce the Retrofit Express Program impacts found in the MDSS. This resulted in several observations where ex ante impact methods were misapplied (in particular PG&E Measure Codes L12, L60, L61, L71, L72, and L160). Such errors could probably be avoided in the future with a regular and thorough review of the MDSS contents by the program manager or a qualified analyst.

Recording of Removed Lighting System Data - Ex ante impact estimates are calculated based on the assumption that a single type of removed fixture replaces each measure installed. We recommend that PG&E record the type of fixture removed for each program installation, particularly for delamping. This would enable a far more accurate assessment of program impacts, in particular enhancing future billing analysis results.

5.2 MEASURES OFFERED

The exhibits in *Section 4* allow identification of technologies or building types that should be reassessed in terms of their viability. This does not imply that these technologies are not valuable, but rather that the original estimate of design savings was higher than that actually achieved. The following segments should be reviewed for viability as part of the overall assessment.

Schools showed relatively low realization rates for both gross energy and demand impacts. The evaluation demand impacts were low because the operating factors for the school business type were substantially below those anticipated (when compared with ex ante impact methods). That is, many schools do not operate during several summer months (months coincident with the summer peak period), and are less likely to be air conditioned than other commercial buildings. However, excluding schools from participation in PG&E's programs is probably not a viable proposal.

Community service organizations had energy impact realization rates well below the average. As with schools, the operating factors for these building types were generally low, and did not offset the additional HVAC interactive benefits attributed to the ex post results.

Controls had low demand impact realization rates due to the evaluation assumption that impacts for this measure could not be predicted (with any certainty) temporally. Energy impacts were therefore evenly distributed across the year. Future evaluation efforts should be used to assess both a measured impact level and the allocation of impacts by time period.

Additional explanations are offered for other technologies or building segments with low realization rates in *Section 4*.