Customer Energy Efficiency Program
Measurement and Evaluation Program

EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1997 COMMERCIAL ENERGY EFFICIENCY INCENTIVES PROGRAM: LIGHTING TECHNOLOGIES

PG&E Study ID number: 333A

March 1, 1999

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Evaluation of Pacific Gas & Electric Company's 1997 Commercial Energy Efficiency Incentives Program for Lighting Technologies

PG&E Study ID number: 333A

Purpose of Study

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

This study evaluated the gross and net energy savings from lighting energy efficiency technologies for which rebates were paid in 1997 by Pacific Gas & Electric Company's Commercial Energy Efficiency Incentive (CEEI) Programs. Retrofits were performed under three different PG&E programs, the Retrofit Express (RE), Customized Efficiency Options (CEO), and Advanced Performance Options (APO) Programs.

Methodology

For this evaluation, there were two types of primary data collected: telephone survey data and on-site data. An integrated sample design was implemented for the lighting and HVAC end uses, due to the number of participant crossover among these end uses. A representative sample of the lighting participant population was selected by segmenting and ranking participants by technology, business type and contribution to total program avoided costs. A non-participant sample was developed based upon the business type and usage strata distribution that resulted from the participant sample allocation. The lighting end-use included 481 lighting participant and 549 nonparticipant telephone surveys, and 163 on-site audits.

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

Three separate models were implemented to estimate the components of the NTG ratio (free-ridership and spillover): a model based on self-reports, a net billing analysis model applying a double inverse Mills ratio (estimating free-ridership only), and a two-stage discrete choice model. The final NTG ratios applied to the ex post gross impacts were derived solely from the results of the discrete choice model. The discrete choice model results are the most conservative, and are within 10% of the self-reported results for all but three business types. The Mills results provided significantly higher levels of net participation.

Study Results

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

	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	25,300	-	0.757	0.100	0.857	21,683	-
kWh	127,373,806	-	0.757	0.100	0.857	109,166,513	-
Therms	-	-	-	-		-	-
EX POST							
kW	23,656	0.935	0.748	0.054	0.802	18,982	0.875
kWh	113,984,414	0.895	0.762	0.053	0.815	92,950,748	0.851
Therms	-35,561,437	-	0.733	0.056	0.789	-28,046,591	-

Regulatory Waivers and Filing Variances

A regulatory waiver was filed requesting that PG&E be allowed to forego the collection of additional lighting loggered data for the 1997 evaluation, and instead use a mean value of previous (1994 and 1995) evaluation results. This waiver was approved by CADMAC on June 17, 1998.

The CADMAC also approved a waiver on January 2, 1999, that allows the use of self -report based algorithms to estimate free ridership and spillover effects in the event discrete choice and LIRM models fail to produce statistically reliable results.

There were no E-Table variances.

EVALUATION OF PG&E'S 1997 COMMERCIAL EEI PROGRAM LIGHTING TECHNOLOGIES

PG&E Study ID#: 333A

FINAL REPORT

March 1, 1999

Submitted to

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1. EXECUTIVE SUMMARY

This section presents a summary of the impact results for the commercial indoor lighting technologies offered under Pacific Gas & Electric Company's (PG&E's) 1997 Commercial Energy Efficiency Incentive (CEEI) Program, referred to in this report as the Lighting Program. This evaluation covers indoor lighting technology retrofits that were rebated during 1997. These retrofits were performed under three different PG&E programs: the Retrofit Express (RE), Customized Efficiency Options (CEO) and Advanced Performance Options (APO) Programs. The results are presented in two sections: Evaluation Results Summary (covering the numerical results of the study) and Major Findings.

1.1 EVALUATION RESULTS SUMMARY

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

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

	Gross Savings	Gross Realization Rate	Net-To-Gross 1-FR	Net-To-Gross Spillover	Net-To-Gross NTG Ratio	Net Savings	Net Realization Rate
EX ANTE							
kW	25,300	-	0.757	0.100	0.857	21,683	-
kWh	127,373,806	-	0.757	0.100	0.857	109,166,513	-
Therms	-	-	-	-		-	-
EX POST							
kW	23,656	0.935	0.748	0.054	0.802	18,982	0.875
kWh	113,984,414	0.895	0.762	0.053	0.815	92,950,748	0.851
Therms	-35,561,437	-	0.733	0.056	0.789	-28,046,591	-

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. About 97 percent of the energy and demand impacts can be attributed to the RE program.

Gross Energy Impacts - The ex post gross energy impacts were 11 percent smaller than the ex ante gross estimates. The unadjusted engineering estimates of gross energy impact, however, were only 2 percent smaller.

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

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

Net Impacts - The net ex post impacts were 15 percent less than ex ante for energy and 12 percent less for demand. To a certain extent, these results reflect the lower 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 0.86 for both demand and energy, while the ex post NTG ratio was only 0.82 for energy and 0.80 for demand. Therefore, the ex post NTG ratios contribute an additional 6 percent and 9 percent decrease relative to ex ante for energy and demand, respectively.

1.2 MAJOR FINDINGS

The lower ex post energy and demand impacts are almost entirely attibutable to recent changes that have been made in the calculation of ex ante estimates. The following is a summary of the primary reasons why these differences exist, and more importantly, why the net realization rates have significantly decreased relative to previous evaluations:

- The ex ante estimates now include the HVAC interactive effects for the first time. This results in a 10 to 15 percent increase in both the energy and demand impact estimates for ex ante.

- The coincident diversity factors (CDF) for the ex ante estimates have increased significantly for the business types with the largest impacts.

- The annual operating hours for the ex ante estimates have changed slightly, resulting in a small increase in the savings estimates.

- The billing analysis detected less savings than in prior years' analyses. The algorithms for estimating the engineering estimates for the 1997 evaluation are nearly identical to those used in the 1996 evaluation. The resulting program-level SAE coefficient, however, dropped from 96% in 1996 to 92% for this evaluation.

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 Efficiency Options (CEO) Program and the Advanced Performance Options (APO) Program.

The evaluation effort includes customers who were paid rebates in 1997. The CEO and APO programs comprised only two and one paid application, respectively. The RE program, which contributed over 97 percent towards the total program impacts, is summarized below.

2.1 THE RETROFIT EXPRESS PROGRAM

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

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

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

2.2 EVALUATION OVERVIEW

The impact evaluation described in this report covers all lighting measures installed at commercial accounts, as determined by the Marketing Decision Support System (MDSS) sector code, that were included under the RE, CEO and APO programs and for which rebates were *paid* during calendar year 1997.

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

2.2.1 Objectives

The research objectives are as follows:

- Determine first-year gross energy, demand, and therm impacts by business type and technology group for RE, CEO and APO lighting technologies paid in 1997, 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, CEO and APO lighting technologies paid in 1997, 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, CEO and APO 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 Program's infrastructure has had on the lighting retrofit market. For example, adjustments were made to the gross savings estimates to account for customers that would have installed energy-efficient measures in the absence of the program (**free-riders**). The adjustment also included participant and nonparticipant **spillover** rates, defined as energy-efficient measures installed outside the program and as a result of the presence of the program.

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

2.2.2 Timing

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

2.2.3 Role of Protocols

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

2.3 EVALUATION APPROACH – AN OVERVIEW

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

2.3.1 Data Sources

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

Existing Data

All available data supplied by PG&E were used in the analysis of the Lighting program. Of particular importance were PG&E's historical billing data, program participant data (Marketing Decision Support System [MDSS]), paper copies of RE, CEO and APO 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

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

information was used to create sample designs for data collection and to leverage calibrated impact estimates from the telephone sample to the entire participant population.

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

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

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

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, CEO and APO Paper Application Files **-** QC requested and received complete copies of application files for a random 50 RE participants and all CEO and APO 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 CEO and APO 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 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.

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

Primary Data Collected

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

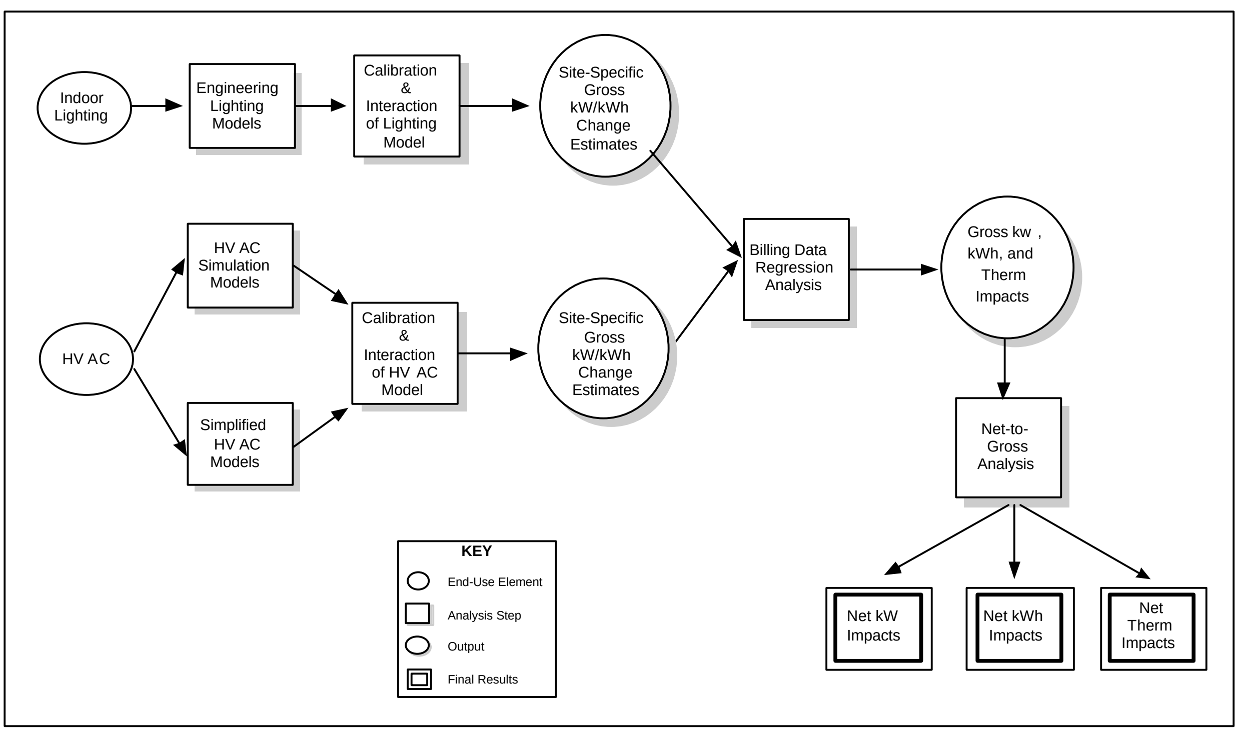
On-Site Audits. A total of 163 customer sites were visited by a QC engineer to gather site-specific data, primarily to be used in support of creating the retention panels for subsequent evaluations.

Telephone Survey Data. A significantly larger telephone survey sample was collected. A total of 481 lighting participant, 549 nonparticipant, and 3,619 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.

2.3.2 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. First, engineering estimates were developed for each participant. Second, 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 actions taken by PG&E customers outside the Lighting Program. Self-reported data were initially used to estimate the percentage of free-riders in the program; that is, the number of participants who would have undertaken the energy efficiency action promoted by the program in the absence of the program. In addition, self-reported data are used to calculate the percent of participant and nonparticipant spillover attributable to the program. The CADMAC has recently approved a waiver allowing that self-report based algorithms be used for the net-to-gross analysis in the event the discrete choice and LIRM methods do not produce statistically reliable results. This waiver is presented in Attachment 5.

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

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

2.4 REPORT LAYOUT

This report presents the results of the Lighting Evaluation. It is divided into four sections, plus attachments and appendices. *Sections 1 and 2* are the *Executive Summary* and the *Introduction*. *Section 3* presents the *Methodology* of the evaluation. *Section 4* presents the detailed results and a discussion of important findings. This section also includes the impacts by Time-of-Use costing periods. *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* includes key results summary tables. Specifically, it includes the results tables for the gross ex ante, net ex ante, and unadjusted engineering impacts, as well as the SAE coefficients, gross ex post, NTG adjustments, net ex post, and gross and net realization rates. *Attachment 2* also contains gross demand and energy savings by costing period for commercial indoor lighting measures. *Attachment 3* contains Protocol Tables 6 and 7 for the lighting end use. *Attachment 4* contains PG&E's rebuttal to the ORA's verification report and the Independent Reviewer's testimony for the 1996 CEEI Evaluation. 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 1997 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 (*Section 3.4)* 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 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), Retrofit Efficiency Options (REO), Advanced Performance Options (APO), 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 1998. 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.

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

3.1.4 Technology Segmentation

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

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

Exhibit 3-1
1997 Commercial Lighting Segmentation and Distribution of Unique Sites

Technology \ Business Type		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Indoor Lighting End Use Unique Sites		794	472	34	407	169	102	123	120	115	104	250	106	2,796
Indoor Lighting	Halogen	29	26	5	29	9	7	11	10	3	5	20	2	156
	Compact Fluorescent Lamps	345	122	22	245	37	43	58	94	33	22	114	33	1,168
	Incandescent to Fluorescent Fixtures	13	5	3	41	3	0	5	4	3	0	13	2	92
	Exit Signs	185	97	12	180	32	20	37	16	15	16	51	16	677
	Efficient Ballast Changeouts	18	19	4	16	3	0	2	1	2	3	3	3	74
	T-8 Lamps and Electronic Ballasts	670	385	30	365	134	75	98	35	87	65	205	80	2,229
	Delamp Fluorescent Fixtures	215	76	7	135	22	11	31	1	32	21	43	19	613
	High Intensity Discharge	56	39	9	81	16	5	7	12	32	8	43	26	334
	Controls	108	16	11	61	23	7	13	7	13	25	33	7	324
	Customized Lighting	1	0	0	0	0	0	0	0	0	1	1	0	3

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

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

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

The technology segmentation presented in Exhibit 3-1 above shows the level of segmentation that was performed for this evaluation. While the engineering analysis was conducted at the finest level of segmentation (the measure level), the statistical billing analysis was conducted at a much coarser level (the technology group).

3.1.5 Sample Allocation

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

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

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 450 Lighting participants were planned, which far exceeded the Protocol requirement of 350.

With an available sample frame of 2,796 unique Indoor Lighting sites (including 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 with the primary objective being to capture different operating characteristics among building types. The entire lighting participant population is first segmented by building type. Certain building types such as offices, retail stores and schools are further segmented by technologies as a result of the large sample size. The unique operating nature of High Intensity Discharge (HID) technologies warrant its own segment independent of building type. The segment groupings are listed by the "Strata Name" column of Exhibit 3-2.

Exhibit 3-2
Final Participant Lighting Quotas
Telephone Survey Sample

Strata Name	Avoided Costs	Percent of Avoided Costs	Sites: Total in Strata	Sites: Unique	Calculated Quota	Calculated Quota Ratio
HID	$ 5,148,037	9%	444	334	39	8.56
Office Delamp	$ 8,699,475	15%	307	215	66	3.26
Office T-8	$ 9,751,619	16%	1080	671	74	9.07
Office Other	$ 3,050,799	5%	960	479	23	20.83
Retail Other	$ 3,167,402	5%	417	253	24	10.54
Retail T-8	$ 3,401,150	6%	646	385	26	14.81
School Other	$ 3,993,551	7%	1098	312	30	10.40
School T-8	$ 3,742,445	6%	577	365	28	13.04
College/Univ	$ 1,671,230	3%	170	34	13	2.62
Grocery	$ 1,835,812	3%	320	161	14	11.50
Restaurant	$ 348,630	1%	206	100	3	33.33
Health Care	$ 3,356,642	6%	426	122	26	4.69
Hotel/Motel	$ 2,412,050	4%	244	118	18	6.56
Warehouse	$ 1,394,665	2%	278	93	11	8.45
Personal Service	$ 2,711,964	5%	210	100	21	4.76
Community Service	$ 3,622,091	6%	664	237	28	8.46
Miscellaneous	$ 833,010	1%	207	90	6	15.00
TOTALS	$ 59,140,572	100%	8254	2796	450	-

Data Source: 1997 PG&E Frozen MDSS Database (April 1998)

The avoided costs and percentage of avoided costs are calculated for each segment or "strata." These figures represent the total items rebated and correspond to the number of sites by item, as represented by the "Total in Strata" column. Because many participants were rebated for multiple technologies, the number of unique participants was identified to support the design of the sampling plan. The number of completes, or the "Calculated Quota," required for each strata was calculated by applying the product of the 450 desired points and percentage of avoided costs to the number of unique sites in that strata. The utilization of avoided costs to calculate each strata quota guarantees the necessary number of sites to represent its contribution to the Program.

As shown by the quota ratio (the number of required completes to the number of unique sites) in Exhibit 3-2, the number of available unique sites for certain strata such as school and college or university are fewer than optimal (less than three times the required quota). This may result in an increase of allocation to another strata to meet our sample requirements.

Comparison (nonparticipant) Sample

The primary objective of the nonparticipant telephone sample is to provide a control group for the net and gross billing analyses. The final comparison group sample frame consists of 187,524 commercial customers drawn from an eligible population of over 400,000. Since comparison group surveys were conducted only for customers in the commercial sector, the first step in creating the sample frame is to limit eligibility to only those accounts having SIC codes representing commercial business activities. In addition to the aforementioned criteria, the following screening rules were also used:

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

Quality of usage readings: Customers are required to have annual non-missing, non-zero usage values for 1995, 1996 and 1997. Customers with zero, or missing billing data, were removed from the sample.

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

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

The canvass sample included 50,000 randomly drawn customers within PG&E's service territory. It's primary function was to support the net-to-gross analysis by identifying nonparticipants who have installed program qualifying measures outside of the rebate programs. The sample design focused on identifying only nonparticipants who were not rebated in 1997. From a sample of 50,000 customers, the sample quota was targeted for 3,500 total completes with about 500 of the 3,500 having made lighting or HVAC changes.

Exhibit 3-3
Nonparticipant Survey Quotas
Telephone Survey Sample

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	18,976	57	1,140	Office	2,071	59	1,180	Office	300	22	440	Office	123	28	560
Retail	18,528	38	760	Retail	1,877	35	700	Retail	203	7	140	Retail	51	6	120
Col/Univ	375	6	120	Col/Univ	74	7	140	Col/Univ	10	1	20	Col/Univ	21	8	160
School	1,615	11	220	School	972	50	1,000	School	50	13	260	School	5	5	100
Grocery	5,593	8	160	Grocery	1,313	14	280	Grocery	345	6	120	Grocery	11	3	60
Restaurant	10,049	9	180	Restaurant	2,056	15	300	Restaurant	6	2	40	Restaurant	0	0	0
Health Care/Hosp	7,360	15	300	Health Care/Hosp	624	8	160	Health Care/Hosp	51	3	60	Health Care/Hosp	61	7	140
Hotel/Motel	1,637	9	180	Hotel/Motel	475	13	260	Hotel/Motel	39	3	60	Hotel/Motel	26	5	100
Warehouse	6,285	13	260	Warehouse	653	6	120	Warehouse	70	1	20	Warehouse	22	3	60
Personal Service	12,425	13	260	Personal Service	420	7	140	Personal Service	34	2	40	Personal Service	20	2	40
Community Service	13,945	28	560	Community Service	1,130	21	420	Community Service	95	4	80	Community Service	47	6	120
Misc. Commercial	11,237	11	220	Misc. Commercial	1,068	6	120	Misc. Commercial	185	2	40	Misc. Commercial	96	2	40
SUB-TOTAL		218	4,360	SUB-TOTAL		241	4,820	SUB-TOTAL		66	1,320	SUB-TOTAL		75	1,500
GRAND TOTAL		600	12,000												

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.

Exhibit 3-4
Data Collected by Program and End Use

			Data Collected		Data Used in HVAC Analysis	
Program	End Use	Available Population	Telephone Survey	On-Site Audits	Telephone Survey	On-Site Audits
Custom	Lighting	3	-	-	-	-
	HVAC	33	-	28	-	-
Retrofit	Lighting	2,794	481	163	481	163
	HVAC	1,309	443	128	443	-
Total	Lighting	2,796	481	163	481	163
	HVAC	1,337	443	156	443	-
Total Participants		3,957	860	262	860	163
Total Nonparticipants		411,188	549	-	549	-
Total Sites		415,145	1,409	262	1,409	163

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 1997. As 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 no CEO and APO participants completed a telephone survey. This is in part due to the fact that the sample frame consisted of only 6 sites. Contact was attempted for all 6 for the telephone survey.

Telephone surveys were collected for a total of 1,409 customers, 860 of which were participants, with the remaining 549 in the comparison group. Among the 860 participants, 481 were lighting participants. In addition, another 3,619 customers were contacted as part of the canvass survey.

On-site Audit Sample – Similarly to the telephone survey sample, the on-site sample was also structured to be approximately proportional to program-avoided costs, with a finer level of segmentation by technology. In all, a total of 163 lighting on-site surveys were conducted.

3.1.7 Relative Precision

Given a sample design, the relative precision, based upon total annual energy use, reflects the uncertainty regarding the extent to which the allocated sample sizes are large enough to control for the population variance in terms of annual energy usage. Precision for the telephone sample was calculated using the following procedure. First, the 1995 annual energy consumption was computed for all participants in the analysis dataset.

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

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

[3] Ibid. pp. 91-95

By survey, the following relative precision was achieved:

- For nonparticipants, the relative precision is 5.0 percent based upon a survey sample of 505[4].
- For Indoor Lighting, the relative precision is 5.7 percent based upon a survey sample of 432[5].

Exhibit 3-5
Telephone Sample Relative Precision Levels

Nonparticipants

Weight	Sample	Mean	STD	Standard Error	Relative Precision
89.1%	217	37,380	34,146	2,315	10.2%
9.8%	241	386,620	253,047	16,086	6.8%
1.1%	47	1,723,721	578,609	82,428	7.9%
TOTAL	505	89,863		2,746	5.0%
Large Customers					
Population = 684	38	5,538,526	3,616,668	554,106	16.5%

Lighting Participants

Weight	Sample	Mean	STD	Standard Error	Relative Precision
53.9%	243	54,119	50,859	2,722	8.3%
35.8%	160	466,477	398,859	26,358	9.3%
7.3%	29	1,656,539	597,427	94,853	9.4%
TOTAL	432	317,951		11,826	6.1%
Large Customers					
Population = 152	34	9,485,069	31,549,424	4,200,398	72.8%

[4] The nonparticipant sample size, 505, is the total sample of 549, less 38 very large cutomers, less 6 customers with missing billing data.

[5] The indoor lighting participant sample size, 432, is the total sample of 481, less 34 very large cutomers, less 15 customers with missing billing data.

3.1.8 Demonstration of Protocol Compliance

Sampling Procedures Adopted

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

Sample Definitions

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

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

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

Overall Sampling Procedures

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

Detailed Protocol Sample Requirement

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

Analysis Dataset Sample for Commercial Participants: The Protocols require that a program with more than 450 participants has a randomly drawn sample sufficiently large to achieve minimum energy use precision of ±10 percent at the 90 percent confidence level, and at least 350 contributing points in the analysis dataset. This requirement was exceeded.

As illustrated in Exhibit 3-5, the sample collected for the lighting end use achieved a relative precision of at least 6 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

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[6] Ibid. pp. 91-95

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 5 percent at a 90 percent confidence interval, well below the 10 percent allowable.

To ensure compliance with comparison group protocols, the telephone survey sample frame is drawn to meet the billing data requirements of Table 5, part D, paragraphs 3 and 4 of the Protocols. All customers in the analysis dataset have billing data from January 1993 to September 1998, which ensures an adequate pre- and post-installation billing period for customers who installed applicable measures between 1995 and 1998.

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.

3.2.1 Lighting Models

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

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%	174	Calibrated Model	Standard
		Compact Fluorescent Lamps	13.9%	1956	Calibrated Model	Standard
		Incandescent to Fluorescent Fixtures	1.9%	95	Calibrated Model	Standard
		Exit Signs	3.1%	742	Calibrated Model	Standard
		Efficient Ballast Changeouts	0.2%	81	Calibrated Model	Standard
		T-8 Lamps and Electronic Ballasts	43.7%	3488	Calibrated Model	Standard
		Delamp Fluorescent Fixtures	24.3%	807	Calibrated Model	Standard
		High Intensity Discharge	8.7%	444	Calibrated Model	Standard
		Controls	1.8%	461	Simplified Model	Standard
	Customized Efficiency Options	Customized Lighting	0.1%	1	Calibrated/Simplified	Standard
	Advanced Performance Options	Customized Lighting	2.3%	5	Calibrated/Simplified	Standard
	Indoor Lighting End-Use Total		100.0%	8254	-	-

A Retroactive Waiver was submitted to the CADMAC and approved in June of 1998 (see Attachment A). This Waiver ensures Protocol compliance for the engineering CE methods that were applied and the LIRM models performed, including the use of end use load shapes developed from the 1994 and 1995 Commercial Lighting studies. This is consistent with the evaluation methodology implemented for the 1996 Evaluation, which utilized the 1994 and 1995 evaluation results in an identical manner.

The 1994 and 1995 evaluation studies were Protocol compliant, including the collection and use of data as per Tables 5 and C-4. By using intermediate results from these studies that are based upon a Protocol compliant data collection and analysis plan, the 1997 study meets all Table C-4 analysis requirements. Additional data were collected to meet the Table 5 sample design requirements.

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

General Lighting Model Specifications

The engineering analyses conducted have combined information from telephone surveys with detailed on-site audit data to develop unadjusted engineering impacts (UEIs). The general lighting model used to estimate the impacts under the RE, CEO and APO 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.[7]

$HVAC$ = 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.

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).

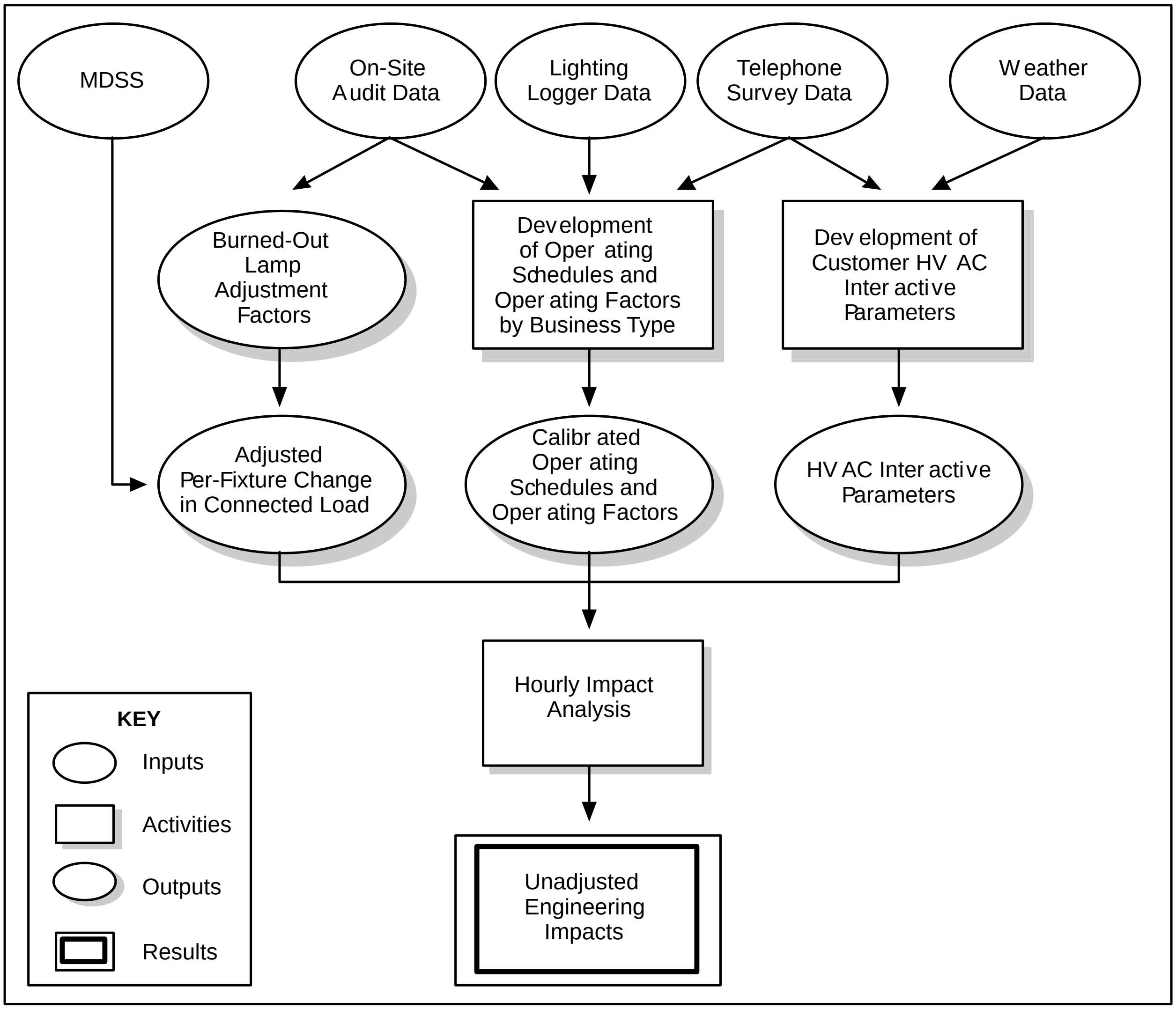
HVAC - HVAC interactive effects (HVAC) were developed using weather and telephone survey data. An increase in heating loads and a decrease in cooling loads are caused by a reduction in internal heat gains when retrofit technologies are installed.

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.

[7]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).

Exhibit 3-7
Method Used to Develop Hourly Engineering Estimates



3.2.2 Derivation of Engineering Parameters

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

Engineering Connected Load Estimates

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

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

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

Engineering Operating Schedule and Operating Factor Estimates

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

Engineering Operating Schedules - Calibrated hourly operating schedules (or profiles) for each daytype were developed, by business type, using data gathered from lighting loggers (from the 1994 and 1995 evaluations), on-site audits, and participant and non-participant telephone surveys. The method used is described below and depicted in Exhibit 3-8.

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[8] 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

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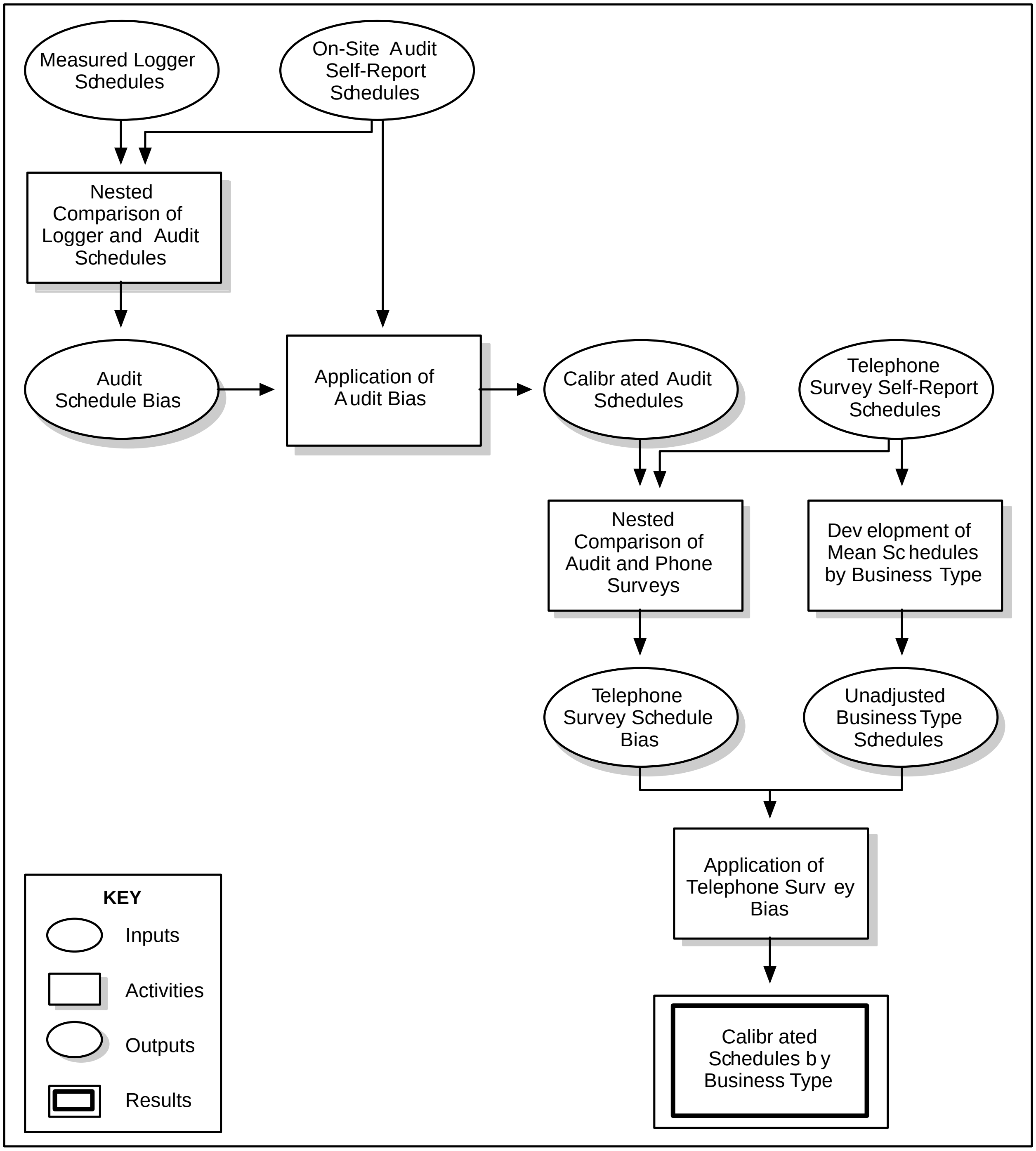
[8] Rundquist, R. *et al*. 1993. "Calculating Lighting and HVAC Interactions", ASHRAE Journal, November 1993, pages 28-37.

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.

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.

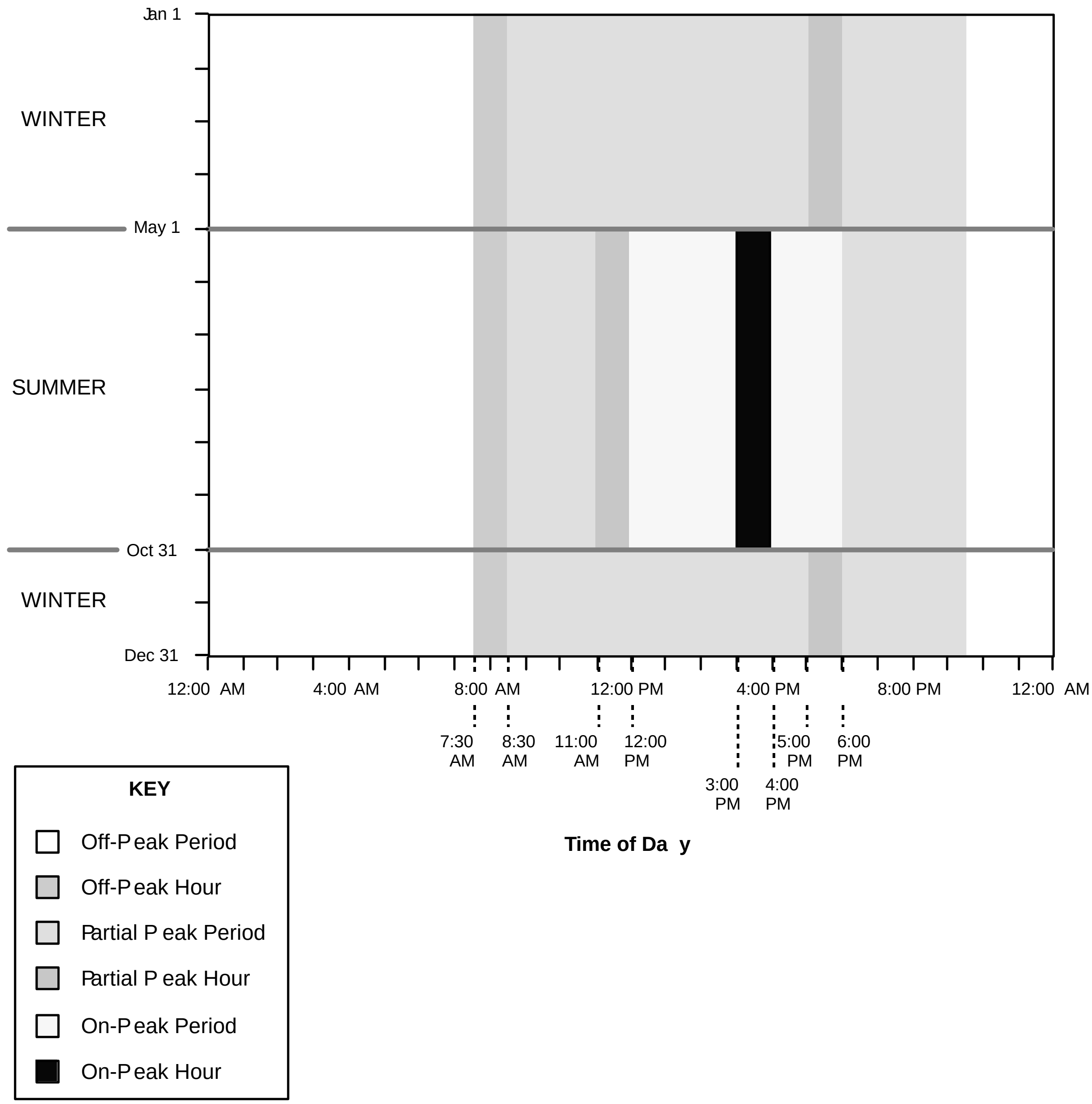
3.2.4 Aggregated Engineering Estimates by Time-of-Use Costing Period

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

The February 1996, March 1997 and March 1998 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 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 1997 program evaluation. It should be noted that PG&E is following the recommendation to include the HVAC interactive effects.

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 1997 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**	**1997**
Office	3,900	4,100	**4,000**	**3,900**
Retail	4,200	4,700	**4,450**	**4,200**
College/Univ	3,700	4,100	**3,900**	**3,700**
School	2,000	2,300	**2,150**	**2,000**
Grocery	6,800	4,800	**5,800**	**6,800**
Restaurant	4,800	4,400	**4,600**	**4,800**
Health Care	4,900	3,900	**4,400**	**4,900**
Hotel/Motel	5,400	5,600	**5,500**	**5,400**
Warehouse	3,100	4,000	**3,550**	**3,100**
Personal Service	NA†	4,100	**4,100**	**4,800**
Community Service	NA†	2,700	**2,700**	**4,800**
Misc.	4,800	4,200	**4,500**	**4,800**

† 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 1997 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**	**1997**
Office	0.78	0.85	**0.81**	**0.78**
Retail	0.90	0.87	**0.88**	**0.90**
College/Univ	0.61	0.76	**0.68**	**0.61**
School	0.46	0.38	**0.42**	**0.46**
Grocery	0.91	0.71	**0.81**	**0.91**
Restaurant	0.70	0.66	**0.68**	**0.70**
Health Care	0.78	0.70	**0.74**	**0.78**
Hotel/Motel	0.64	0.70	**0.67**	**0.64**
Warehouse	0.78	0.90	**0.84**	**0.78**
Personal Service	NA†	0.79	**0.79**	**0.71**
Community Service	NA†	0.48	**0.48**	**0.71**
Misc.	0.71	0.81	**0.76**	**0.71**

† 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 1997 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 1997 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

Technology Group \ Business Type	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 1997 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 1997 pre- and post-retrofit connected load assumptions to account for the higher probability of lamp burnout in the pre-retrofit technologies. The 1997 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 1997 impacts to account for the required allocation of impacts by costing period. The 1997 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).

† Interactive HVAC therm adjustments were not made in 1994.

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 1997 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 1997 Lighting RE document cited above. This difference in connected load is based upon both the measure definition specified under the Lighting RE program (and typical customer installations for each measure), and an assumed existing system that represents a typical customer configuration prior to retrofit.

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

Measure Group Descriptions	Application Year	Measure Code In MDSS Database	Per-Unit NC Impact (Watts)	Pre-Burn-Out Lamp Rate	Post-Burn-Out Lamp Rate	Adjusted per-unit NC Impact
Halogen						
< 50 watts	1995&6&7	L60	30.0			30.0
>= 50 watts	1994&5&6&7	L61	50.0			50.0
Compact Fluorescent						
Screw In CF- Reusable ballast						
5-13 watts	1994&5&6&7	L64	45.0	0.0213	0.0088	43.9
14-26 watts	1996&7	L174	57.0	0.0213	0.0088	55.6
>=27 watts	1996&7	L175	69.0	0.0213	0.0088	67.1
Hard Wired CF						
5-13 watts	1994&5&6&7	L66	45.0	0.0213	0.0088	43.9
14-26 watts	1996&7	L176	74.0	0.0213	0.0088	72.1
>=27 watts	1996	L177	75.0	0.0213	0.0088	73.1
Fluorescent Hardwire						
27-65 watts Incandescent to Fluorescent	1997	L178	142.0	0.0213	0.0039	138.0
27-65 watts Mercury Vapor to Fluorescent	1997	L179	67.0			67.0
66-156 watts Incandescent to Fluorescent	1997	L180	384.0	0.0213	0.0039	373.8
66-156 watts Mercury Vapor to Fluorescent	1997	L181	169.0			169.0
>=157 watts Incandescent to Fluorescent	1997	L182	576.0	0.0213	0.0039	560.7
>=157 watts Mercury Vapor to Fluorescent	1997	L183	280.0			280.0
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&7	L5	29.0			29.0
Incand. to LED or Electroluminescent Retrofit	1993&4&5&6&7	L137	36.0			36.0
Efficient Ballasts Changeouts						
Electronic Ballasts						
1 Lamp Electronic Ballast	1997	L114	5.4	0.0252	0.0039	4.6
2 Lamp Electronic Ballast	1993&4&5&6&7	L14	11.0	0.0252	0.0039	9.3
3 Lamp Electronic Ballast	1993&4&5&6&7	L15	16.0	0.0252	0.0039	13.6
4 Lamp Electronic Ballast	1993&4&5&6&7	L16	21.6	0.0252	0.0039	18.3
T8 Lamps and Electronic Ballasts						
New Fixtures						
Four-Lamp Fixture	1993		30.0	0.0252	0.0039	27.0
2'-1 U Tube or 2 lamps	1994&5		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		63.0	0.0252	0.0039	59.6
4'-1 lamp	1994&5	L72	8.8	0.0252	0.0039	8.0
4'-2 lamps	1994&5		18.0	0.0252	0.0039	16.3
4'-3 lamps	1994&5	L74	26.0	0.0252	0.0039	23.6
4'-2 lamps or 8'-1 lamps	1995		18.0	0.0252	0.0039	16.3
4'-4 lamps or 8'-2 lamps	1994&5		30.0	0.0252	0.0039	27.0
Fixture Modif.- Replace Lamps and Ballasts						
Replace Lamps & Ballasts - 2' Fixture	1993&4&5&6&7	L21	21.0	0.0252	0.0039	9.9
Replace Lamps & Ballasts - 3' Fixture	1993&4&5&6&7	L22	26.0	0.0252	0.0039	12.2
Replace Lamps & Ballasts - 4' Fixture	1993&4&5&6&7	L23	22.0	0.0252	0.0039	8.0
Replace Lamps & Ballasts - 8' Fixture	1993&4&5&6&7	L24	30.0	0.0252	0.0039	13.5
Replace Lamps & Ballasts - 8' High Output Fixture	1997	L184	40.0	0.0252	0.0039	17.6
Delamp Fluorescent Fixtures						
Fixture Modif.- Delamp and Reflector						
Removal - 2' Lamps & Ballasts	1993&4&5&6&7	L17	32.0	0.0252	0.0252	31.2
Removal - 3' Lamps	1993&4&5&6&7	L18	44.0	0.0252	0.0252	42.9
Removal - 4' Lamps	1993&4&5&6&7	L19	34.0	0.0252	0.0252	33.1
Removal - 8' Lamps	1993&4&5&6&7	L20	82.0	0.0252	0.0252	79.9

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

Measure Group Descriptions	Application Year	Measure Code In MDSS Database	Per-Unit NC Impact (Watts)	Pre-Burn-Out Lamp Rate	Post-Burn-Out Lamp Rate	Adjusted per-unit NC Impact
High Intensity Discharge						
Interior Compact HPS						
36-70 watts HPS	1994&5&6	L79	112.0			112.0
71-100 watts HPS	1994&5&6	L80	155.0			155.0
Interior Compact MH from Incandescent						
0-35 watts MH	1997		55.0			66.0
36-70 watts MH	1997	L187	110.0			110.0
71-100 watts MH	1997	L189	171.0			171.0
Interior Compact MH from Merc. Vapor						
0-35 watts MH	1997		29.0			35.0
36-70 watts MH	1997	L188	35.0			35.0
71-100 watts MH	1997	L190	71.0			71.0
Interior Standard MH from Merc. Vapor						
101-175 watts MH	1993&4&5&6	L26	75.0			75.0
176-250 watts MH	1994&5&6	L27	159.0			159.0
251-400 watts MH	1994&5&6	L81	540.0			540.0
Interior Standard MH from Incand.						
101-175 watts MH	1993&4&5&6&7	L191	290.0			290.0
176-250 watts MH	1994&5&6&7	L193	455.0			455.0
>=251 watts MH	1994&5&6&7	L195	540.0			540.0
Interior Standard MH from Merc. Vapor						
101-175 watts MH	1993&4&5&6&7	L192	75.0			75.0
176-250 watts MH	1994&5&6&7	L194	159.0			159.0
>=251 watts MH	1994&5&6&7	L196	448.0			448.0
Controls						
Time Clocks	1993&4&5&6&7	L31	380.0			380.0
Occupancy Sensors						
Wall Mounted	1994&5&6&7	L82	228.0			228.0
Ceiling Mounted	1994&5&6&7	L83	608.0			608.0
Photocell	1993&4&5&6&7	L36	380.0			380.0

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

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

Customized Lighting Evaluation

For the CEO and APO programs, non-coincident impacts were derived through a careful review of each 1997 hard copy application. 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.

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) 1997 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 primary objective of the billing analysis is to determine the first-year program energy impacts. A statistical analysis is employed to model the differences of customers' energy usage between pre- and post-installation periods using actual customer billing data. The model is specified using the billing data and independent variables gathered in the telephone survey that explain changes in customers' energy usage, including the engineering estimates of energy impact due to program participation. This statistically adjusted engineering (SAE) analysis is consistent with the requirements of the Load Impact Regression Model (LIRM) defined in the California Public Utilities Commission's (CPUC's) Measurement and Evaluation Protocols (the Protocols).

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

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

3.3.2 Data Sources for Billing Regression Analysis

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

Program Participant Tracking System

The participant tracking system for the Retrofit Express (RE), Advanced Performance Options (APO) 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 December 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 1998 through September 1998. 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 1998.

Weather Data

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

Telephone Survey Data

All available telephone surveys collected as part of the evaluation for the Commercial Sector Program (except for the Canvass surveys, which do not collect detailed information regarding changes that have occurred at the premise) were used as inputs to the billing regression analysis. Two telephone survey samples totaling 1,409 sample points (481 of which are lighting participants and 549 are nonparticipants) were collected for the Lighting Evaluation. Because of cross-over among participants across Commercial Program end uses, one integrated billing regression model was developed to evaluate both the Commercial Lighting and HVAC Program end uses.

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

Engineering Estimates

Engineering estimates of savings were estimated for each of the 481 lighting participants. Separate estimates of energy savings were calculated for every measure installed under the Commercial Sector Program. The engineering estimates were calculated based on expected savings from the pre-installation technology to the post-installation technology. For some technologies, such as Central A/Cs installed in the HVAC program, these savings estimates will differ from the impact estimates. This is due to the impacts being calculated relative to a baseline efficiency, compared to the savings estimates, which are based on a pre-existing unit's efficiency. In the example above, many CAC's existing efficiency had a SEER rating much lower than the program baseline estimate. Consequently, the savings estimate for energy would be much higher. The Engineering Analysis (*Section 3.2*) discusses the calculation of the savings estimates used in the billing analysis in greater detail.

3.3.3 Data Aggregation and Analysis Dataset Development

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

- Control number, which is the finest level of aggregation, and is usually unique to a customer's meter.
- Premise number, which is used to define a unique site, but can sometimes contain multiple buildings. The premise number may map to many control numbers, but a control number will always map to a unique premise number.
- Corporation number, which is used to define a unique corporation, which can map to many premise numbers. A premise number maps to a unique corporation number.

Of the three, the premise number serves as the best indicator of a unique site. However, there are some premise numbers that contain multiple sites. To address this issue, the customer's service address was also used to help identify a unique site. If there was more than one service address for a premise number, it was broken out into multiple sites. Therefore, a unique site was defined as all of the control numbers within a unique combination of service address,[9] 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.

[9] 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.

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 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 3-18 and 3-19 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 3-18
Billing Analysis Sample Frame
Pre-Censoring
Indoor Lighting End-Use Technologies

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen		1			1						1		3
	Compact Fluorescent Lamps	33	6	4	15	3	2	7	22	8	6	18	4	128
	Incandescent to Fluorescent Fixtures		2						1					3
	Exit Signs	16	2	2	8	1		5	2	1	3	6	1	47
	Efficient Ballast Changeouts	3	2		2	1					1	2	2	13
	T-8 Lamps and Electronic Ballasts	57	35	2	24	10	3	9	2	7	9	23	5	186
	Delamp Fluorescent Fixtures	21	12		2	1		8		7	2	3		56
	High Intensity Discharge	3	9		2	2	1		1	8	1	7	4	38
	Controls	4	1					1			1			7
Retrofit Express Program Total		137	70	8	53	19	6	30	28	31	23	60	16	481
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total														
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total														
Total		137	70	8	53	19	6	30	28	31	23	60	16	**481**

Exhibit 3-19
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	146	84	15	62	28	24	30	28	22	24	59	27	**549**

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 1997 actually installed measures in 1993, 1994, 1995, 1996 or 1997 with 1997 installations accounting for approximately one half of total installations. Lighting installations prior to 1996 accounted for less than 1 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 (less than 6 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 70 percent of the MDSS records, a pre- and post-installation inspection date was collected. In most cases 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 variable found in the MDSS, project completion date, is populated 85 percent of the time. Analysis of the project completion date lead us to believe it was the best "largely populated" variable. It was very similar to the project completion date, and fell within the pre- and post-installation inspection dates. However, another variable was needed to fill in the remaining 15 percent of installation dates. Yet 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 almost 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 4 percent of the time). Consequently, the application received date served as an excellent proxy for the remaining installation dates, when the project completion date was not populated.

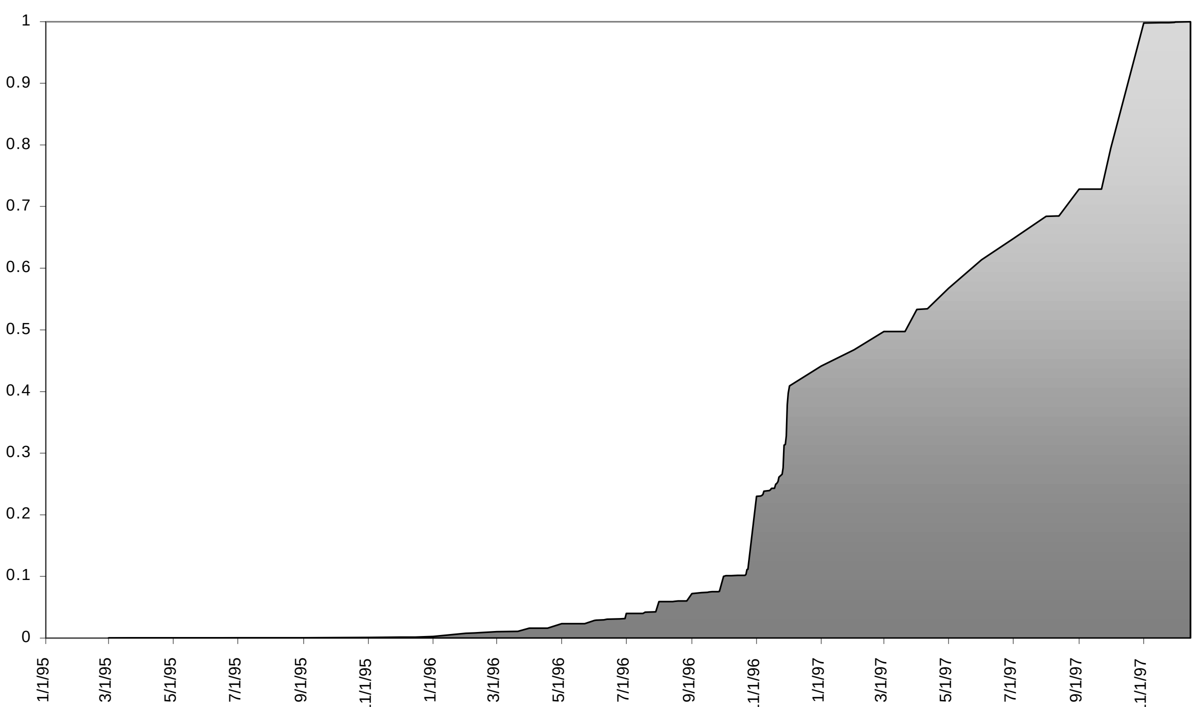
In addition to the dates recorded in the MDSS, the telephone survey asked every participant to estimate the installation date. If their self-reported installation date fell between the pre- and post-installation inspection dates (as recorded in the MDSS), the customer reported date was used.

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 1998. To maximize the number of post installation months in the regression model, a post period of October 1997 through September 1998 was used. As illustrated in Exhibit 3-20, this post period occurs after 90 percent of the installation dates.

Exhibit 3-20
Commercial Lighting Rebated Technologies
By Estimated Installation Date



Based on the selection of post period, there are only two feasible pre-periods that could have been used: October 1994 through September 1995 (a 1995 pre-period), and October 1995 through September 1996 (a 1996 pre-period). Exhibit 3-20 suggests that almost every installation occurred between January 1996 and December 1997. 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 1995 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 3-20 provides the cumulative participation by month for the participants that are part of the billing analysis sample frame.

3.3.5 Data Censoring

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

Invalid Usage

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

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

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

The number of employees at the facility could not have doubled, or been cut in half. This criteria is only applied to customers with at least 100 employees. Furthermore, the size of the facility in square feet could not have doubled, or been cut in half. If either of these criteria occurred, the customer was removed from the analysis.

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

Exhibit 3-21 presents the number of participants and nonparticipants that were deleted for each of the above criteria. Note that only 29 nonparticipants were deleted, whereas 99 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 99 participants, 69 were deleted due to the zero bill criteria.

Large Customers

Customers whose annual pre-installation energy consumption exceeded three million kWh were excluded from the billing analysis. A total of 49 participants and 34 nonparticipants were dropped for this reason. This decision was made *a priori* to collecting the survey data, as is documented in the Evaluation Research Plan; and is based upon the results of the previous three Lighting Evaluations, all of which were unsuccessful in obtaining reliable results when including customers with usage above this level. This is also consistent with the recommendations made by the Verification Reports of PG&E's 1995 and 1996 Commercial Lighting Evaluation, which stated in 1995 that "program effects can be difficult to detect for large customers," and recommended censoring large customers for the final billing analyses.

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

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

Participant or Nonparticipant	Zero Monthly Bills >= 4	Employee or Square Footage Double or Cut in Half	Usage Tripled or Cut by a Third	Measure Caused Increase in Usage	Number Removed From Analysis
NP	NO	NO	YES	NO	1
NP	NO	YES	NO	NO	2
NP	YES	NO	NO	NO	18
NP	YES	NO	YES	NO	8
TOTAL					29
P	NO	NO	NO	YES	4
P	NO	NO	YES	NO	19
P	NO	YES	NO	NO	7
P	YES	NO	NO	NO	14
P	YES	NO	YES	NO	55
TOTAL					99

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 241 HVAC and/or lighting 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 10th percentile of the participant population. These 241 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 241 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 the customer's energy impacts were greater than 25 percent of their pre-installation usage and 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, 61 of the 241 premises were removed. Of the 61 removed customers, 24 also failed the invalid usage data screening checks. Therefore, only an additional 37 premises were removed based solely upon the data screening criteria described above.

Exhibit 3-22 presents the number of participants that were removed from the analysis for each of the above criteria.

Exhibit 3-22
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 Removed From Analysis
NO	NO	NO	YES	NO	2
YES	NO	NO	NO	YES	7
YES	NO	NO	YES	NO	3
NO	NO	YES	NO	YES	1
YES	NO	YES	NO	YES	2
YES	NO	YES	YES	NO	3
NO	YES	NO	NO	YES	1
YES	YES	NO	NO	YES	7
YES	YES	NO	YES	NO	7
NO	YES	YES	NO	YES	2
NO	YES	YES	YES	NO	1
YES	YES	YES	NO	NO	8
YES	YES	YES	NO	YES	6
YES	YES	YES	YES	NO	11
TOTAL					61

In summary, out of the original sample frame of 549 nonparticipants, 62 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 860 HVAC and lighting participants, 181 were removed because of bad billing, improper site aggregation, or because they were large customers. Of these 181 customers, 106 were lighting participants.

Exhibit 3-23 summarizes the total number of participants and nonparticipants that were removed from the billing analysis. Exhibits 3-24 and 3-25 present the final sample sizes used in the billing analysis by business type and technology for participants and by business type for nonparticipants.

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

Participant or Nonparticipant	Zero Monthly Bills >= 4	Employee or Square Footage Double or Cut in Half	Usage Tripled or Cut by a Third	Measure Caused Increase in Usage	Large Customer	Bill Not Aggregated Properly	Number Removed From Analysis
NP	NO	NO	NO	NO	YES	NO	33
NP	NO	NO	YES	NO	NO	NO	1
NP	NO	YES	NO	NO	NO	NO	1
NP	NO	YES	NO	NO	YES	NO	1
NP	YES	NO	NO	NO	NO	NO	18
NP	YES	NO	YES	NO	NO	NO	8
TOTAL							62
P	NO	NO	NO	NO	NO	YES	37
P	NO	NO	NO	NO	YES	NO	45
P	NO	NO	NO	YES	NO	NO	4
P	NO	NO	YES	NO	NO	NO	8
P	NO	NO	YES	NO	NO	YES	10
P	NO	NO	YES	NO	YES	NO	1
P	NO	YES	NO	NO	NO	NO	4
P	NO	YES	NO	NO	YES	NO	3
P	YES	NO	NO	NO	NO	NO	11
P	YES	NO	NO	NO	NO	YES	3
P	YES	NO	YES	NO	NO	NO	44
P	YES	NO	YES	NO	NO	YES	11
TOTAL							181

Exhibit 3-24
Billing Analysis Sample Used
Post-Censoring
Indoor Lighting End-Use Technologies

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen		1			1						1		3
	Compact Fluorescent Lamps	24	6	3	13	1	2	5	13	7	6	15	3	98
	Incandescent to Fluorescent Fixtures		2						1					3
	Exit Signs	12	1	1	7			3	2	1	3	6	1	37
	Efficient Ballast Changeouts	3	1		1	1					1	1	2	10
	T-8 Lamps and Electronic Ballasts	49	33		23	9	1	8	2	7	9	17	5	163
	Delamp Fluorescent Fixtures	15	8		2	1		3		4	2	2		37
	High Intensity Discharge	2	3		1	2	1		1	3		3	2	18
	Controls	4						1			1			6
Retrofit Express Program Total		109	55	4	47	15	4	20	19	22	22	45	13	375
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total														
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total														
Total		109	55	4	47	15	4	20	19	22	22	45	13	**375**

Exhibit 3-25
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	130	81	15	59	27	24	23	23	16	19	51	19	**487**

3.3.6 Model Specification

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

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

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

Baseline Model

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

$$kWh_{post,i} = \sum_j (b_j kWh_{pre,i}) + g(\Delta CDD_i) * kWh_{pre,i} + \sum_k h_k NChg_{i,k} + e$$

Where,

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

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

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

b, g and h are the estimated slopes on their respective independent variables. Separate slopes on pre-usage are estimated by business type; and,

e is the random error term of the model.

For each customer in the analysis dataset (participants and nonparticipants), a post-installation predicted usage value is calculated using the parameters of the baseline models estimated for the 1995 to 1998 analysis period. They both take the same functional form with different segment-level intercept series and slopes (b and g):

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

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

This issue was a major point of contention during the verification study of the 1996 CEEI Evaluation. The recommendation made by the verification study was to include the change variables in the estimation of the post-installation predicted usage. However, the Independent Reviewers agreed with PG&E that these change variables should not be included in the post-installation predicted usage. Attachment 4 provides PG&E's rebuttal to the verification study, which provides a detailed justification for the model specification used in both this year's and previous years' evaluations.

PG&E and Quantum Consulting, who has acted as PG&E's evaluation contractor for the past four years, met with the ORA's verification contractor, ECONorthwest, to discuss this issue in more detail. ECONorthwest agreed that applying the nonparticipant parameters for the change variables to the participants was not correct for the reasons described above and in PG&E's rebuttal in Attachment 4. However, ECONorthwest raised an additional concern regarding the lack of inclusion of nonparticipants in the second stage SAE Model. ECONorthwest suggested the use of a switching regression[10] to address their concerns with the inclusion of the nonparticipants. PG&E and Quantum Consulting have researched this approach and implemented various alternative models, including the model suggested in the 1996 verification study, which are presented in Section 3.3.8.

Exhibit 3-26 summarizes the final baseline model results that were estimated using 487 nonparticipant customers, as discussed in the *Data Censoring* section.

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

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

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

Exhibit 3-26
Billing Regression Analysis Final Baseline Model Outputs

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
Pre-Usage					
Small Office	SM_OFF5	kWh	1.043700	1.95	47
Large Office	OTH_OFF5	kWh	1.130374	48.30	83
Small Retail	SM_RET5	kWh	1.003485	1.40	32
Large Retail	OTH_RET5	kWh	1.108575	41.15	49
Small Schools	SM_SCH5	kWh	1.052200	26.71	72
Large Schools	OTH_SCH5	kWh	1.009962	18.71	2
Grocery	GROCERY5	kWh	1.066998	33.19	27
Restaurant	RESTRNT5	kWh	1.192380	22.15	24
Hospital	HOSP5	kWh	0.993186	16.78	23
Hotel/Motel	HOTMOT5	kWh	1.198843	30.87	23
Warehouse	WHRSE5	kWh	0.903872	4.68	16
Personal Service	PERSVC5	kWh	1.092735	18.37	19
Small Comm. Service	SM_COM5	kWh	1.091094	2.36	23
Large Comm. Servcie	OTH_COM5	kWh	1.028249	26.66	28
Miscellaneous	MISC5	kWh	1.191013	16.24	19
Weather Changes					
Change in CDD CliZone 2	CDD2_85	CDD*kWh	0.001419	2.09	37
Change in CDD CliZone 3	CDD3_85	CDD*kWh	0.001144	2.23	137
Change in CDD CliZone 1,4,5	CDD4_85	CDD*kWh	-0.003439	-3.04	48
Change in CDD CliZone 11	CDD11_85	CDD*kWh	0.000667	1.06	41
Change in CDD CliZone 12	CDD12_85	CDD*kWh	-0.001024	-3.59	70
Change in CDD CliZone 13,16	CDD13_85	CDD*kWh	0.000034	0.08	48
Positive Change in CDD CliZone 1-5	PDD1_85	CDD*kWh	0.001732	3.55	43
Positive Change in CDD CliZone 11-16	PDD11_85	CDD*kWh	-0.000353	-1.37	63
Other Site Changes					
Lighting Changes	LGT_CHG5	kWh	-0.042143	-1.66	47
HVAC Changes	AC_CHG5	kWh	-0.022783	-0.76	60
Other Equipment Changes	OTH_CHG5	kWh	0.137414	3.74	40
Square Footage Changes	SQFT_CH5	# Sqft*kWh	12.151441	4.58	31
Employee Changes	EMP_CHG5	# Emp*kWh	574.101061	1.88	91

Exhibit 3-26 above summarizes the independent variables used in the baseline model, together with the t-statistics and the sample sizes available for each parameter estimate used to predict the post-period usage. The final functional relation is estimated as follows:

Baseline Model (1995 to 1998):

$$
\begin{aligned}
k\hat{W}h_{98,i} = & 1.04 * SM\_OFF5 + 1.13 * OTH\_OFF5 + 1.00 * SM\_RET5 + 1.11 * OTH\_RET5 \\
& + 1.05 * SM\_SCH5 + 1.01 * OTH\_SCH5 + 1.07 * GROCERY5 + 1.19 * RESTRNT5 \\
& + 0.99 * HOSP5 + 1.20 * HOTMOT5 + 0.90 * WHRSE5 + 1.09 * PERSVC5 \\
& + 1.09 * SM\_COM5 + 1.03 * OTH\_COM5 + 1.19 * MISC5 \\
& + 0.001419 * CDD2_{98-95,i} * kWh_{95,i} + 0.001144 * CDD3_{98-95,i} * kWh_{95,i} \\
& - 0.003439 * CDD4_{98-95,i} * kWh_{95,i} + 0.000667 * CDD11_{98-95,i} * kWh_{95,i} \\
& - 0.001024 * CDD12_{98-95,i} * kWh_{95,i} + 0.000034 * CDD13_{98-95,i} * kWh_{95,i} \\
& + 0.001732 * PDD1_{98-95,i} * kWh_{95,i} - 0.000353 * PDD11_{98-95,i} * kWh_{95,i}
\end{aligned}
$$

SAE Model

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

$$
\begin{aligned}
kWh_{98,i} - k\hat{W}h_{98,i} &= kWh_{98,i} - F_{95}(kWh_{95}, \Delta CDD) \\
&= \sum_m b'_m Eng_m + \sum_k r'_k PChg_{i,k} + \sum_k h'_k NChg_{i,k} + m_i
\end{aligned}
$$

Where,

$kWh_{98,i}$ and $kWh_{95,i}$ 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;

$b'_m Eng_m$ are the participant engineering impacts;

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

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

The difference between predicted and actual usage in 1998 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 1998 usage as a function of 1995 usage and change of cooling degree days from 1995 to 1998. 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 3-27 summarizes the final SAE model results that were estimated using 1,166 customers (679 participants and 487 nonparticipants), as discussed in the *Data Censoring* section. The exhibit illustrates the independent variables used in the SAE model, together with the t-statistics and the sample sizes available for each parameter estimate.

Exhibit 3-27
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	LGTOFF5	kWh	-0.856125	-5.15	154
Lighting Retails	LGTRET5	kWh	-1.357155	-2.10	78
Lighting Schools	LGTSCH5	kWh	-0.613314	-1.91	51
Lighting Miscellaneous	LGTMSC5	kWh	-0.859361	-2.35	92
HVAC End Use					
Retrofit Express Measures	RETX5	kWh	-1.061511	-3.43	324
ASDs	ASD5	kWh	-0.853041	-2.94	25
Custom HVAC	CSTHVC5	kWh	-10.290247	-4.05	3
Other End Uses					
Other Impacts	OTHMEAS5	kWh	1.413001	2.45	22
Change Variables					
Part Lighting Changes	LGT_CHG5	kWh	-0.174985	-8.83	74
Part HVAC Changes	AC_CHG5	kWh	-0.004323	-0.22	123
Part Other Equipment Changes	OTH_CHG5	kWh	0.148858	5.00	39
Part Square Footage Changes	SQFT_CH5	# Sqft*kWh	2.540250	0.92	32
Part Employee Changes	EMP_CHG5	# Emp*kWh	138.243740	0.92	137
Nonpart Lighting Changes	LGT_NON5	kWh	-0.042143	-2.06	47
Nonpart HVAC Changes	AC_NON5	kWh	-0.022783	-1.01	60
Nonpart Other Equipment Changes	OTH_NON5	kWh	0.137414	4.27	40
Nonpart Square Footage Changes	SQFT_NO5	# Sqft*kWh	12.151441	4.57	31
Nonpart Employee Changes	EMP_NON5	# Emp*kWh	574.101061	1.97	91

The dependent variable is the difference between the actual and predicted 1998 usage using the 1995 baseline model.

SAE coefficients are calculated for seven 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.

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 93 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, as well as changes made to the size (square footage) of the building and with the number of employees. Separate change variables were developed for participants and nonparticipants for the reasons discussed above and provided in Attachment 4. Section 3.3.8 below discusses in more detail the decision to include nonparticipants in the SAE model.

Of these change variables, the parameter estimates for participant and nonparticipant lighting and other equipment changes, and for nonparticipant square footage and employee changes are significant at the 90 percent confidence level. All of the signs on these coefficients were as expected.

The final SAE coefficients for the Lighting end use is provided in Exhibit 3-28. The SAE coefficient is multiplied by the evaluation estimates of gross energy impact to calculate the gross ex post energy impacts.

Exhibit 3-28
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	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Compact Fluorescent Lamps	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Incandescent to Fluorescent Fixtures	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Exit Signs	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Efficient Ballast Changeouts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	T-8 Lamps and Electronic Ballasts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Delamp Fluorescent Fixtures	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	High Intensity Discharge	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Controls	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
Retrofit Express Program Total													
CEO	Halogen	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Compact Fluorescent Lamps	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Efficient Ballast Changeouts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	T-8 Lamps and Electronic Ballasts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Delamp Fluorescent Fixtures	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	Controls	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
Customized Efficiency Options Program Total													
APO	Halogen	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
	T-8 Lamps and Electronic Ballasts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86
Advanced Performance Options Program Total													
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. There are a total of four analysis segments that were explicitly modeled, and the relative precision estimates based upon the model output are presented in Exhibit 3-29 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.

$$\text{Total Adjusted Energy Impact} = \sum_i \hat{a}_i Eng_i$$

Where b_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:[11]

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

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

Where,

$CV_i = \frac{std(b_i)}{b_i}$ 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 3-29 presents the relative precision calculations.

Exhibit 3-29
Relative Precision Calculation

SAE Analysis Level	Gross Engineering Energy Impact (kWh)	SAE Coefficient	t-Statistic	Relative Precision at 80%	Relative Precision at 90%
Lighting End Use					
Lighting Offices	55,380,844	-0.86	5.15	25%	32%
Lighting Schools	21,002,283	-0.61	1.91	67%	86%
Lighting Retail	25,017,368	-1.36	2.10	61%	78%
Lighting Miscellaneous	22,968,285	-0.86	2.35	55%	70%
Lighting Total	124,368,780	-0.92	5.31	24%	31%

3.3.8 Alternative Gross Billing Model Specifications

As discussed above, the manner in which the nonparticipant change variables were applied in the estimate of the post-period usage, was a major point of contention during the verification study for the 1996 CEEI Evaluation. One of the major recommendations made in the verification study was to include the change variables in the estimation of the post-installation predicted usage. However, the Independent Reviewers agreed with PG&E that these change variables should not be included in the post-installation predicted usage. Attachment 4 provides PG&E's rebuttal to the verification study, which gives a detailed justification for the model specification used in both this year's and previous years' evaluations, along with the Independent Reviewers' testimony regarding this decision.

PG&E, Quantum Consulting (QC) and ECONorthwest met prior to conducting this year's analysis to discuss this issue in more detail in an attempt to resolve any issues that may arise in the future. ECONorthwest agreed that applying the nonparticipant parameters for the change variables to the participants was not correct for the reasons described above and in PG&E's rebuttal in Attachment 4. As discussed above, ECONorthwest raised an additional concern regarding the lack of inclusion of nonparticipants in the second stage SAE Model, and suggested the use of a switching regression to address this issue.

PG&E and QC have researched this approach and implemented various alternative models, which are presented here. All together five separate model specifications were attempted, as described below.

The first model implemented, referred to as the "**1996 QC Model**", was identical to that implemented for the 1996 evaluation. This model did not apply the nonparticipant changes to the estimate of post-period usage. In the second stage SAE Model, only participants were included, and the change variables were also included.

1996 QC MODEL

Baseline Model

$$kWh_{post,i} = \sum_j (b_j kWh_{pre,i}) + g(\Delta CDD_i) * kWh_{pre,i} + \sum_k h_k Chg_{i,k} + e$$

Predicted Participant Post Usage

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

SAE Model – Participants Only

$$kWh_{post,i} - k\hat{W}h_{post,i} = kWh_{post,i} - F_{pre}(kWh_{pre}, \Delta CDD) = \sum_m b'_m Eng_m + \sum_k h'_k Chg_{i,k} + m_i$$

Where,

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

The second, third and fourth models implemented, referred to as "SR Model 1" through "SR Model 3", implemented switching regressions. Each model was similar in that it did not apply the nonparticipant changes to the estimate of post-period usage, and in the second stage SAE Model, both participants and nonparticipants were included. However, the three models differed in the way that the change variables were handled in the second stage SAE Model.

SR Model 1 included five common change variables (lighting, HVAC, other equipment, SQFT, and employees), which indicated that the change occurred at either a participant or nonparticipant facility. Therefore, the participants and nonparticipants had the same parameter estimates for each change variable. This model is specified as follows:

SR MODEL 1

Baseline Model

$$kWh_{post,i} = \sum_j (b_j kWh_{pre,i}) + g(\Delta CDD_i) * kWh_{pre,i} + \sum_k h_k Chg_{i,k} + e$$

Predicted Participant and Nonparticipant Post Usage

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

SAE Model – Participants and Nonparticipants

$$kWh_{post,i} - k\hat{W}h_{post,i} = kWh_{post,i} - F_{pre}(kWh_{pre}, \Delta CDD)$$
$$= \sum_m b'_m Eng_m + \sum_k h'_k Chg_{i,k} + m_i$$

Where,

$Chg_{i,k}$ in the baseline model includes only nonparticipant self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses, and changes in number of employees and in facility square footage; the SAE Model includes both participant and nonparticipant change variables.

SR Model 2 included ten change variables, which were the same five change variables (lighting, HVAC, other equipment, SQFT, and employees) interacted with participation type. Therefore, the participants and nonparticipants had different parameter estimates for each change variable. This model is specified as follows:

SR MODEL 2

Baseline Model

$$kWh_{post,i} = \sum_j (b_j kWh_{pre,i}) + g(\Delta CDD_i) * kWh_{pre,i} + \sum_k h_k NChg_{i,k} + e$$

Predicted Participant and Nonparticipant Post Usage

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

SAE Model – Participants and Nonparticipants

$$kWh_{post,i} - k\hat{W}h_{post,i} = kWh_{post,i} - F_{pre}(kWh_{pre}, \Delta CDD)$$
$$= \sum_m b'_m Eng_m + \sum_k r'_k PChg_{i,k} + \sum_k h'_k NChg_{i,k} + m_i$$

Where,

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

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

SR Model 3 included eight change variables. This model included the same five change variables (lighting, HVAC, other equipment, SQFT, and employees); however, the lighting, HVAC and other equipment variables were interacted with participation type, but the SQFT and employee variables were shared. Therefore, the participants and nonparticipants had different parameter estimates for the lighting, HVAC and other equipment variables, but the same parameter estimate for the SQFT and employee variables. This model is specified as follows:

SR MODEL 3

Baseline Model

$$kWh_{post,i} = \sum_j (b_j kWh_{pre,i}) + g(\Delta CDD_i) * kWh_{pre,i}$$
$$+ \sum_k s_k GChg_{i,k} + \sum_k h_k NChg_{i,k} + e$$

Predicted Participant and Nonparticipant Post Usage

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

SAE Model – Participants and Nonparticipants

$$kWh_{post,i} - k\hat{W}h_{post,i} = kWh_{post,i} - F_{pre}(kWh_{pre}, \Delta CDD)$$
$$= \sum_m b'_m Eng_m + \sum_k s'_k GChg_{i,k} + \sum_k r'_k PChg_{i,k} + \sum_k h'_k NChg_{i,k} + m_i$$

Where,

$GChg_{i,k}$ are the participant and nonparticipant self-reported change variables from the survey data associated with changes in number of employees and in facility square footage;

$PChg_{i,k}$ are the participant self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses;

$NChg_{i,k}$ are the nonparticipant self-reported change variables from the survey data, including adding, replacing, or removing equipment associated with major end uses.

The fifth model implemented, referred to as the "**ORA Model**", was identical to that recommended in the verification study. This model applied the nonparticipant changes to the estimate of post-period usage. In the second stage SAE Model, only participants were included, and no change variables were included.

ORA MODEL

Baseline Model

$$kWh_{post,i} = \sum_j (b_j kWh_{pre,i}) + g(\Delta CDD_i) * kWh_{pre,i} + \sum_k h_k NChg_{i,k} + e$$

Predicted Participant Post Usage

$$k\hat{W}h_{post,i} = F_{pre}(kWh_{pre}, \Delta CDD) = \sum_j (b_j kWh_{pre,i}) + g(\Delta CDD_i) * kWh_{pre,i} + \sum_k h_k NChg_{i,k}$$

SAE Model – Participants Only

$$kWh_{post,i} - k\hat{W}h_{post,i} = kWh_{post,i} - F_{pre}(kWh_{pre}, \Delta CDD) = \sum_m b'_m Eng_m + m_i$$

Where,

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

Obviously, we feel strongly that results of the ORA Model should *not* be applied to the final ex post gross estimates for reasons stated above and in Attachment 4. Similarly, we do *not* recommend SR Model 1 because the participants and nonparticipants share the same parameter estimates for each of the five change variables.

We developed and tested SR Model 3 because it was more of a compromise between the 1996 QC Model and the ORA Model, where some of the change variables were shared. We felt that if any of the effects due to the five changes would be similar, it might be for the SQFT and employee changes. Because the effects of changing equipment (lighting, HVAC and other) are dependent on the decision maker who selects the equipment, and because we believe a participant and nonparticipant decision maker are inherently different, we do not feel that the effects of changing equipment are similar for participants and nonparticipants. However, the effects of SQFT and employee changes are not as dependent on the decision maker, and may therefore be more likely to be similar across participants and nonparticipants.

We still believe, however, that these changes may differ across these two groups. For example, a space expansion may include more efficient equipment in participant facility than in a nonparticipant facility. Furthermore, additional employees placed in a participant facility may increase energy consumption less than in a nonparticipant facility, because of the more efficient equipment at the participating facility. For these reasons, we do *not* recommend SR Model 3.

Exhibit 3-30 provides the parameter estimates for each model, along with the resulting ex post gross energy impact for the HVAC and Lighting end uses. Interestingly, the ORA Model results in the highest total ex post gross energy impacts across the two end uses. Furthermore, the model we have recommended, SR Model 2, results in the lowest total ex post gross energy impacts across the two end uses.

To address the concerns raised by the ORA and ECONorthwest, we recommend SR Model 2. However, this specification yields the same SAE coefficients as the 1996 QC Model. As such, the results do not show that one specification is superior to the other.

Exhibit 3-30
Comparison of Alternative Gross Billing Model Specifications

Parameter Descriptions	Analysis Variable Name	Units	Models				
			QC Model	SR Model 1	SR Model 2	SR Model 3	ORA Model
Lighting End Use							
Lighting Offices	LGTOFF5	kWh	0.856125	0.931647	0.856125	0.852326	0.961982
Lighting Retails	LGTRET5	kWh	1.357155	1.402516	1.357155	1.383929	1.445053
Lighting Schools	LGTSCH5	kWh	0.613314	0.69299	0.613314	0.604266	0.721422
Lighting Miscellaneous	LGTMISC5	kWh	0.859361	0.879648	0.859361	0.859597	0.900617
HVAC End Use							
Retrofit Express Measures	RETX5	kWh	1.061511	1.026778	1.061511	1.061579	1.014407
ASDs	ASD5	kWh	0.853041	0.862949	0.853041	0.830127	0.827548
Custom HVAC	CSTHVC5	kWh	10.290247	10.270224	10.290247	10.336554	10.341767
Lighting Total		kWh	29,698,734	29,340,559	29,698,734	29,442,522	28,776,130
HVAC Total		kWh	113,984,414	121,441,034	113,984,414	114,259,229	125,263,935
TOTAL		**kWh**	**143,683,148**	**150,781,593**	**143,683,148**	**143,701,751**	**154,040,065**

Model Definitions

	QC Model	SR Model 1	SR Model 2	SR Model 3	ORA Model
Apply NP change parameter estimates to Part post-usage	No	No	No	No	Yes
Run 2nd Stage Model with NP change variables					
- Same change variables as Part					
- All different change variables as Part					
- Different change variables but with EMP & SQFT the same					
- No Nonpart					
- No changes without Nonpart					

3.3.9 Net Billing Analysis

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

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

One solution to this problem is to include an Inverse Mills Ratio in the model to correct for self-selection bias. This method was developed by Heckman (1976, 1979)[12] and is used by others

[12] 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.

(Goldberg and Train, 1996[13]) to address the problem of self-selection into energy retrofit programs. This assumes that the unobserved factors that are influencing participation are distributed normally. Including an Inverse Mills Ratio in the model as an explanatory variable controls for the influence of the characteristics that cause participants to self-select into the retrofit program. This corrects for the self-selection bias in the net savings regression as the unobserved factors affecting participation are now controlled for in the model. As a result, standard regression techniques should produce unbiased coefficient estimates.

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

To calculate the Inverse Mills Ratios, a probit model of program participation is estimated separately for the Lighting and HVAC retrofit programs. Once the probit model is estimated, the parameters of the participation model are used to calculate an Inverse Mills Ratio for both participants and nonparticipants. This Mills Ratio is included in a net savings regression that combines both participants and nonparticipants into one model. If the Mills Ratio controls for those unobserved factors that determine participation (i.e. the self-selection bias), and the other model assumptions are met, then the net savings model will produce unbiased estimates of net savings.

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

Probit Model of Participation

The first stage of calculating the Mills Ratio is to develop a probit model of Lighting Program participation. The probit model is a discrete choice model with a dependent variable of either zero or one indicating whether or not an event occurred. In this application, individuals receive a value of one if they participated in the Lighting Program and a zero otherwise. The sample includes 481 Lighting Program participants and 3,393 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 3,844 survey respondents were used to estimate the participation probit for the Lighting Program.

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

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

[13] 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.

$$\text{PARTICIPATION} = a + b'\text{X} + g'\text{Y} + J'\text{Z} + e$$

A description of the explanatory variables is given in Exhibit 3-31. The dependent variable PARTICIPATION has a value of one if the customer participated in the 1997 Lighting Program and a zero if they did not participate. The independent variables used are those characteristics that are likely to influence program participation. The first set of variables (X) used in the participation probit indicate whether a respondent was aware of the lighting program prior to 1997. There are three of these variables. The first is AWARE, which takes a value of one if a respondent indicates awareness. The second and third awareness variables also take on values of either zero or one. They will take on a value of one if the respondent is aware prior to 1997, **and** claims to have been informed of the program by their lighting contractor (LT_INFO) or their PG&E representative (PGE_INFO). Including these variables allows the model to differentiate between respondents who simply claim they were aware, and those who also state the source of their information. The latter group is likely to have more complete and accurate information about the program, and therefore will be affected in a different way by their awareness. The second group of variables (Y) reflect the building characteristics. Examples of these include ownership, recent changes at the facility, as well as total energy use. The third group of variables (Z) contain information on business type and type of lighting. Finally, the error term (ε) is assumed to be normally distributed for the probit specification.

Probit Estimation Results

The estimation results for the lighting probit are given in Exhibit 3-32. In general, the estimation results conform to expectations. For the lighting probit customers who were aware of the program prior to 1997, and those who changed their cooling equipment are more likely to participate in the lighting program. Size, as indicated by energy use, also has a positive effect on the probability of participation. Those that have short-term leases and whose primary lighting type is incandescent were less likely to participate. All of the building type variables have negative coefficient estimates. Of these, only HOTEL is not statistically different from zero.

Exhibit 3-31
Variables Used in Lighting Probit Model

Variable Name	Units	Variable Type	Description
AWARE	0,1	X	Aware of program prior to 1997
ARCOOL	0,1	Y	Cooling equipment was added and removed since 1/95
B4_78	0,1	Y	Building was constructed before 1978
EMPCHG	0,1	Y	Employee change by 10% since 1/95
FLOR	0,1	Z	Fluorescent is main type of lighting
GROCERY	0,1	Z	Grocery
HEALTH	0,1	Z	Health Care Building
HID	0,1	Z	Primary lighting is HID
HOTEL	0,1	Z	Hotel
INCAN	0,1	Z	Incandescent is primary type of lighting
LT_INFO	0,1	X	Made aware of the program by lighting contractor
MISCCOM	0,1	Z	Miscellaneous commercial building
OFFICE	0,1	Z	Office building
OWN	0,1	Y	Own building
PERSONL	0,1	Z	Personal services building
PGE_INFO	0,1	X	Made aware of the program by PG&E representative
RESTR	0,1	Z	Restaurant
RETAIL	0,1	Z	Retail building
SCHOOL	0,1	Z	School
SFADD	0,1	Y	Square footage added to the facility
SHTLEASE	0,1	Y	Lease less than 1 year long
USE	KwH	Y	Energy use in 1995
TENACT	0,1	Y	Tenants active in equipment purchse decisions
WARE	0,1	Z	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:

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

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

Where,

$$Q = a + b'X + g'Y + J'Z$$

Exhibit 3-32
Lighting Probit Estimation Results

Variable Name	Units	Variable Type	Coefficient Estimate	Standard Error	Significance Level
AWARE	0,1	X	0.89	0.07	1%
ARCOOL	0,1	Y	0.12	0.08	13%
B4_78	0,1	Y	-0.07	0.06	27%
EMPCHG	0,1	Y	0.03	0.07	67%
FLOR	0,1	Z	-0.89	0.08	1%
GROCERY	0,1	Z	-0.86	0.15	1%
HEALTH	0,1	Z	-0.81	0.13	1%
HID	0,1	Z	-0.66	0.21	1%
HOTEL	0,1	Z	-0.30	0.16	7%
INCAN	0,1	Z	-1.48	0.17	1%
LT_INFO	0,1	X	0.36	0.10	1%
MISCCOM	0,1	Z	-1.19	0.14	1%
OFFICE	0,1	Z	-0.60	0.08	1%
OWN	0,1	Y	-0.14	0.08	7%
PERSONL	0,1	Z	-0.92	0.13	1%
PGE_INFO	0,1	X	0.32	0.09	1%
RESTR	0,1	Z	-1.73	0.21	1%
RETAIL	0,1	Z	-0.73	0.10	1%
SCHOOL	0,1	Z	-0.40	0.13	1%
SFADD	0,1	Y	-0.11	0.11	29%
SHTLEASE	0,1	Y	-0.62	0.15	1%
USE	kWh	Y	0.00	0.00	6%
TENACT	0,1	Y	0.12	0.09	17%
WARE	0,1	Z	-0.69	0.13	1%

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

Net Billing Model Specification

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

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

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

$$kWh_{98,i} - k\hat{W}h_{98,i} = kWh_{98,i} - F_{95}(kWh_{95,i}, \Delta CDD_i)$$
$$= J_1 Mills_{Light,i} + J_2 Mills_{HVAC,i} + \sum_m d_m Mills_{Light,i} * Eng_{Light,m,i}$$
$$+ \sum_m d_m Mills_{HVAC,i} * Eng_{HVAC,m,i} + \sum_k h_k^{'} NChg_{i,k} + \sum_k r_k^{'} PChg_{i,k} + e$$

Where,

$kWh_{98,i}$ and $kWh_{95,i}$ are customer i's annualized energy usage for the post- and pre-installation periods, respectively;

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

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

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

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

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

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

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

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

e is the random error term of the model.

This net SAE model was run with the same set of 487 nonparticipants and 679 participants that were used in the gross billing analysis model. The results of the model are presented in Exhibit 33. The parameter estimates, t-statistics and sample sizes are presented for all of the net SAE coefficients and Mills ratios.

Exhibit 3-33
Net Billing Regression Analysis Final Model Outputs

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
Mills Ratios					
Lighting	LRMILLS	Unitless	-5562.883553	-1.04	1166
HVAC	HRMILLS	Unitless	-177.727669	-0.04	1166
SAE Coefficients					
Lighting End Use					
Lighting Offices	LGTOFFM	Mills * kWh	-0.638500	-4.88	154
Lighting Retails	LGTRETM	Mills * kWh	-0.831063	-1.64	78
Lighting Schools	LGTSCHM	Mills * kWh	-0.329297	-1.63	51
Lighting Miscellaneous	LGTMSCM	Mills * kWh	-0.692109	-2.15	92
HVAC End Use					
Retrofit Express Measures	RETXM	Mills * kWh	-0.614631	-2.64	324
ASDs	ASDM	Mills * kWh	-0.687758	-2.66	25
Custom HVAC	CSTHVCM	Mills * kWh	-7.594930	-3.98	3
Change Variables					
Part Lighting Changes	LGT_CHG5	kWh	-0.168599	-8.56	74
Part HVAC Changes	AC_CHG5	kWh	-0.012201	-0.64	123
Part Other Equipment Changes	OTH_CHG5	kWh	0.168041	5.94	39
Part Square Footage Changes	SQFT_CH5	# Sqft*kWh	2.717169	0.98	32
Part Employee Changes	EMP_CHG5	# Emp*kWh	128.395011	0.85	137
Nonpart Lighting Changes	LGT_NON5	kWh	-0.042238	-2.06	47
Nonpart HVAC Changes	AC_NON5	kWh	-0.023976	-1.06	60
Nonpart Other Equipment Char	OTH_NON5	kWh	0.137176	4.26	40
Nonpart Square Footage Chang	SQFT_NO5	# Sqft*kWh	12.034442	4.51	31
Nonpart Employee Changes	EMP_NON5	# Emp*kWh	558.696396	1.91	91

It was found that the net billing model results were significant at the 90 percent level in all cases. 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:

$$(1-FR)_m = \frac{Mills_m * d_m}{b_m}$$

Where,

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

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

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

Exhibit 3-34 illustrates the resulting estimate of net, or one minus free-ridership.

Exhibit 3-34
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	
SAE Coefficients						
Lighting End Use						
Lighting Offices	LGTOFFM	-0.639	LGTOFF5	-0.856	1.215	0.906
Lighting Retails	LGTRETM	-0.831	LGTSCH5	-1.357	1.234	0.756
Lighting Schools	LGTSCHM	-0.329	LGTHOT5	-0.613	1.144	0.614
Lighting Miscellaneous	LGTMSCM	-0.692	LGTMSC5	-0.859	1.504	1.211

Alternative Net Billing Model Specifications

As discussed above, Goldberg and Train (1996) developed the technique of including a second Inverse Mills Ratio in the savings regression, interacted with the energy savings estimate, to account for the possibility that participation is correlated with the size of energy savings. The specification suggested by Goldberg and Train is:

$$\begin{aligned} kWh_{post,i} - k\hat{W}h_{post,i} &= kWh_{post,i} - F_{pre}(kWh_{pre,i}, \Delta CDD_i) \\ &= J_1 Mills_{Light,i} + J_2 Mills_{HVAC,i} + \sum_m b'_m Eng_m \\ &\quad + \sum_m d_m Mills_{Light,i} * Eng_{Light,m,i} + \sum_m d_m Mills_{HVAC,i} * Eng_{HVAC,m,i} \\ &\quad + \sum_k h'_k Chg_{i,k} + e \end{aligned}$$

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;

Eng_m are engineering saving estimates of participants ;

$Mills_{Light,i}$ 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;

$Chg_{i,k}$ 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;

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

e is the random error term of the model.

We found that there was considerable correlation between the engineering estimate of savings and the Inverse Mills Ratio interacted with the engineering estimate. Therefore, we altered the model specification by only including the Inverse Mills Ratio interacted with savings, and dropped the engineering estimate. To test the sensitivity of this change, we ran the net billing model both ways: with and without the engineering estimate of savings. Furthermore, we decided to test the Inverse Mills Ratio approach without interacting the Inverse Mills Ratio with the engineering estimate at all, following Heckman's approach (1976, 1979).

These three models can be specified as follows:

MILLS ONLY METHOD:

$$\begin{aligned} kWh_{post,i} - k\hat{W}h_{post,i} &= kWh_{post,i} - F_{pre}(kWh_{pre,i}, \Delta CDD_i) \\ &= J_1 Mills_{Light,i} + J_2 Mills_{HVAC,i} + \sum_m b'_m\, Eng_m + \sum_k h'_k Chg_{i,k} + e \end{aligned}$$

MILLS + MILLS*ENG METHOD:

$$\begin{aligned} kWh_{post,i} - k\hat{W}h_{post,i} &= kWh_{post,i} - F_{pre}(kWh_{pre,i}, \Delta CDD_i) \\ &= J_1 Mills_{Light,i} + J_2 Mills_{HVAC,i} + \sum_m d_m Mills_{Light,i} * Eng_{Light,m,i} \\ &\quad + \sum_m d_m Mills_{HVAC,i} * Eng_{HVAC,m,i} + \sum_k h'_k Chg_{i,k} + e \end{aligned}$$

MILLS + ENG + MILLS*ENG METHOD:

$$\begin{aligned} kWh_{post,i} - k\hat{W}h_{post,i} &= kWh_{post,i} - F_{pre}(kWh_{pre,i}, \Delta CDD_i) \\ &= J_1 Mills_{Light,i} + J_2 Mills_{HVAC,i} + \sum_m b'Eng_m \\ &+ \sum_m d_m Mills_{Light,i} * Eng_{Light,m,i} + \sum_m d_m Mills_{HVAC,i} * Eng_{HVAC,m,i} \\ &+ \sum_k h_k' Chg_{i,k} + e \end{aligned}$$

The results of each of these models is provided in Exhibit 3-35. The method we recommend (Mills + Mills*Eng), provided the lowest estimate of ex post net energy impacts, indicating that our methodology is more conservative than either of the other two model specifications.

Exhibit 3-35
Comparison of Inverse Mills Ratio Approaches

Parameter Descriptions	Analysis Variable Name	Models Mills + Eng	 Mills + Mills*Eng	 Mills + Eng + Mills*Eng
Lighting End Use				
Lighting Offices	LGTOFF	1.01	1.01	0.94
Lighting Retails	LGTRET	0.90	0.85	0.97
Lighting Schools	LGTSCH	0.94	0.71	0.76
Lighting Miscellaneous	LGTMISC	0.94	1.31	1.71
HVAC End Use				
Retrofit Express Measures	RETX	1.25	1.04	1.23
ASDs	ASD	1.26	1.12	1.20
Custom HVAC	CSTHVC	1.21	1.14	1.16
Lighting Total		109,310,568	111,013,275	119,378,265
HVAC Total		36,959,206	32,327,751	35,912,280
TOTAL		146,269,775	143,341,026	155,290,545

The verification study recommended a completely different alternative net billing model. They recommended that the probability of participating estimated in the probit model be used to replace the Inverse Mills Ratio, as follows:

PROB + PROB*ENG METHOD:

$$kWh_{post,i} - k\hat{W}h_{post,i} = kWh_{post,i} - F_{pre}(kWh_{pre,i}, \Delta CDD_i)$$
$$= J_1 \Pr ob_{Light,i} + J_2 \Pr ob_{HVAC,i} + \sum_m d_m \Pr ob_{Light,i} * Eng_{Light,m,i}$$
$$+ \sum_m d_m \Pr ob_{HVAC,i} * Eng_{HVAC,m,i} + \sum_k h_k^{'} Chg_{i,k} + e$$

Where,

$\Pr ob_{Light,i}$ is the Probability of Participation for the Lighting end use for customer i;

$\Pr ob_{HVAC,i}$ is the Probability of Participation for the HVAC end use for customer i;

Even though no theory exists on how the use of the probability of participating in the model specification corrects for self-selection bias, we decided to test the sensitivity of our model by implementing ECONorthwest's model specification. Exhibit 3-36 compares the results of the Double Inverse Mills Ratio model specification we recommend, with the net billing model specification recommended in the verification study. Overall, the approach suggested in the verification study results in higher net ex post energy impacts.

Exhibit 3-36
Comparison of Alternative Net Billing Model Specifications

Parameter Descriptions	Analysis Variable Name	Models: Mills + Mills*Eng	Prob + Prob*Eng
Lighting End Use			
Lighting Offices	LGTOFF	1.01	1.00
Lighting Retails	LGTRET	0.85	1.04
Lighting Schools	LGTSCH	0.71	0.45
Lighting Miscellaneous	LGTMISC	1.31	0.44
HVAC End Use			
Retrofit Express Measures	RETX	1.04	0.74
ASDs	ASD	1.12	1.00
Custom HVAC	CSTHVC	1.14	1.66
Lighting Total		111,013,275	120,608,585
HVAC Total		32,327,751	34,205,794
TOTAL		143,341,026	154,814,379

3.4 NET-TO-GROSS ANALYSIS

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

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

3.4.1 Data Sources

The primary data sources used in the net-to-gross analysis include the 860 HVAC and lighting participant, 549 nonparticipants and 3,619 canvass telephone surveys collected in 1998. Other data used in this analysis include the MDSS and CIS databases, and information from the Advice Filings.

3.4.2 Self-report Methods

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

Self-report Method for Scoring Free Ridership

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

Overview of Methodology

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

1. In the absence of the CEEI program, the participant would not have installed any new equipment
2. In the absence of the CEEI program, the participant would have installed standard efficiency equipment

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

Customers who fall into the first three categories can be considered net program participants in the calculation of first year net impacts. Customers who fall into the fourth category should be considered free riders. The self-report estimates of free ridership were based on these four categories. Data used to calculate the self-report free ridership estimates was collected as part of a telephone survey of 860 CEEI program participants. The survey collected information on the participants' likely lighting retrofit behavior, with regards to the CEEI program. Responses consistent with category 4 were counted towards free ridership. Responses consistent with categories one through three were counted towards net participation.

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

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

<u>Scoring Method and Scoring Algorithms</u>

Responses were initially scored based on the following questions:

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

	4 = We wouldn't have installed high efficiency lighting at all 8 = (Refused) 9 = (Don't Know)

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

pd110 = 1 or 3

pd110 = 2 AND pd115 = 3

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

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

pd110 = 2 AND pd115 = 1 or 2

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

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

pd110 = 2 AND pd115=4

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

pd110 = Refused /Don't Know

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

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

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

pd100 = 1 or 3

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

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

pd100 = 4

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

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

pd100 = 2

pd100=Refused/Don't Know

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

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

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

pd050 = 3 or 4

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

The response was not used if:

pd050 = 1 or 2

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

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

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

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

Data Sources

Data used in deriving the self-report estimates of free ridership included responses from 860 completed telephone surveys of CEEI program participants. The responses included 481 lighting end use adopters. The surveys were conducted between July and September of 1998 as part of a comprehensive telephone survey of CEEI program participants.

Results

Self-reported estimates of free ridership are presented below by technology group. Similar to the 1996 Program estimates, the technology group with the lowest rate of free ridership was the Delamp Flourescent Fixtures category, comprised of flourescent delamping actions implemented by the respondents. The rate for this group was estimated to be 12.9%. The second lowest rate was found among those who replaced incandescent with fluorescent fixtures. The ratio for this group was estimated to be 16.7%. The highest rate of free ridership was found in the Efficient Ballast Changeouts, with a rate of 54.5%. These free ridership rates were developed within technology group by weighting each site by the avoided cost associated with the technology retrofit.

Exhibit 3-37
Weighted Self-report Estimates of Free Ridership
for Lighting Technology Groups in the 1997 CEEI Program

Technology Group	***Sample***	***Free Ridership***
Halogen	26	30.4%
Compact Fluorescent Lamps	165	36.7%
Incandescent to Fluorescent Fixtures	14	16.7%
Exit Signs	79	36.5%
Efficient Ballast Changeouts	12	54.5%
T-8 Lamps and Electronic Ballasts	323	23.1%
Delamp Fluorescent Fixtures	83	12.9%
High Intensity Discharge	52	49.2%
Controls	56	23.9%

Self-report Method for Scoring Spillover

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

<u>Overview of Methodology</u>

The self-report methodology is composed of three steps:

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

The spillover rate is the 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 information from the surveys, as described below. Multiplying the participant or nonparticipant population by the respective spillover rate provides an estimate of the total number of 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 estimate of impact per spillover adoption is based on the equipment installed as reported in the surveys. The contribution of spillover to the net-to-gross ratio can then be estimated as:

Participant Spillover:

NTGpart_spill = SP_RATEpart * POPpart*IMPACTpart_spill / IMPACTpop

Where,

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

SP_RATEpart = the participant spillover rate

POPpart = the participant population, in number of sites

IMPACTpart_spill = the per participant site impact associated with spillover

IMPACTpop = the total CEEI Program impact

Nonparticipant Spillover:

NTGnp_spill = SP_RATEnp * POPnp*IMPACTnp_spill / IMPACTpop

Where,

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

SP_RATEnp = the nonparticipant spillover rate

POPnp = the nonparticipant population, in number of sites

IMPACTnp_spill = the per nonparticipant site impact associated with spillover

IMPACTpop = the total CEEI Program impact

Identification of the Spillover Rate

The participant and nonparticipant spillover rates were estimated as the percentage of participants or nonparticipants surveyed that indicated they were influenced by the CEEI program to install non-rebated, high-efficiency lighting equipment.

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

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

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

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

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

Identifying Participant Spillover Actions

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

For Condition 1:

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

br020	*Since January 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 br050 was used to verify that the out-of-program lighting adoption occurred after the respondent participated in the Retrofit Program. This is conservative way of ensuring the respondent was aware of the program before making the non-rebated, high efficiency action. The question text for br050 is as follows:

br050	*Were these changes made after you participated in the Retrofit Program?*

For Condition 3:

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

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

For Condition 4:

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

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

Participant Spillover Scoring Algorithm

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

If sp010 = 2, 3 or 4

AND equipment is high efficiency

then spillover = 1

else spillover = 0

If a respondent scores a 1 for spillover, they have met all four spillover conditions set forth above. As described above, the total number of 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 860 participants surveyed, there were 15 respondents who met all of the spillover criteria excluding efficiency. Fourteen of these 15 respondents installed high efficiency equipment, and the remaining respondent had inconclusive data regarding efficiency. Consistent with the methodology applied to nonparticipant spillover, this respondent was categorized as high efficiency based upon the distribution of the 14 adoptions with efficiency information. Thus, a total of 15 participants were identified as contributing to lighting spillover. This results in a participant spillover rate of 1.7%. Because there were a total of 5,308 participants in the 1997 program year, this represents a total of 93 participant spillover lighting actions in the population.

Identifying Nonparticipant Spillover Actions

For Condition 1:

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

For Condition 2:

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

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

For Condition 3:

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

For Condition 4:

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

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

<u>Nonparticipant Spillover Scoring Algorithm</u>

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

If sp080 = 2, 3 or 4

AND equipment is high efficiency

then spillover = 1

else spillover = 0

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

<u>Nonparticipant Self-report Spillover Results</u>

Of the 4,168 nonparticipants surveyed, there were 17 respondents who met all of the spillover criteria excluding efficiency. Of these 17 respondents, 4 installed standard efficiency equipment, and 11 installed high efficiency equipment. The remaining 2 respondents had inconclusive data regarding efficiency. These 2 were divided between standard and high efficiency categories based on the distribution of respondents who met all spillover criteria and had conclusive efficiency information. Thus 11/15 of the 2 remaining respondents were categorized as spillover actions. Finally, a total of 12.5 respondents were identified as contributing to lighting spillover.

Nonparticipants' reported installations spanned approximately a 43-month period (from January 1995 through approximately July 1998). In order to calculate the 1997 spillover rate, the portion of all reported high efficiency lighting adoptions occurring in 1997 was used as an estimator. The portion of reported high efficiency adoptions that occurred in 1997 was 30.8%. That is, the 1997 rate was calculated by multiplying the spillover rate for the entire period by 0.308. This results in a nonparticipant spillover rate of 0.092%.

The approach to distributing the spillover across the 43-month analysis period is conservative relative to alternative allocation methods. For example, one alternative method would be to mimic the distribution of all lighting adoptions, both standard and high efficiency. The portion of all reported lighting adoptions that occurred in 1997 is 33.6%. This method yields a higher spillover rate than the method chosen: 0.100%. As a second alternative, the 1997 rate could be estimated by applying the time distribution of the 17 adoptions that qualified as spillover under all criteria excluding efficiency. This method would have resulted in a much higher 1997 spillover rate (0.168%) because 56.3% of these adoptions occurred in 1997. Finally, 40% of the high efficiency spillover adoptions took place in 1997. All four of these alternative methods would have resulted in a notable increase in the nonparticipant spillover rate for lighting technologies.

From PG&E's 1997 CIS, there were 416,496 unique sites identified, resulting in a total of 411,188 nonparticipant sites after subtracting the 5,308 participants. Therefore, because there were a total of 411,188 nonparticipants, the spillover rate represents a total of 343 nonparticipant spillover lighting actions.

Calculation of Impacts Associated With Spillover

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

Participant Spillover Impact Calculation

Fifteen participants were identified as contributing to spillover. Rather than using only these 15 installations to calculate an average spillover impact, the survey sample of out-of-program, high efficiency installations was used.

There were 72 participant respondents who made non-rebated high efficiency lighting equipment adoptions. These 72 installations were used to estimate the average participant impact associated with spillover. To calculate the impacts associated with spillover, avoided cost was used as a proxy for impact.

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

The 72 high efficiency installations were then used to determine the distribution of installations across equipment types. Applying this distribution, to our estimate of savings by equipment type resulted in an estimate of average avoided cost per participant installation. Exhibit 3-38 below, presents the average avoided cost per installation by fixture type, along with the distribution of installations across fixture type. This method yielded an estimate of the average avoided cost per participant spillover adoption of $18,694.

Exhibit 3-38
Participant Adoption Distribution

Fixture Type	*# Fixtures*	*#Lamps Per Fixture*	*Per Lamp Av Cost*	*Total Av Cost*	*Distribution of Installs*
2 Foot T8 Fixtures	58	2	23	$2,725	7%
4 Foot T8 Fixtures	861	2.5	18	$39,091	41%
8 Foot T8 Fixtures	164	2	30	$9,804	2%
Incandescent to Flourescent	10	1	344	$3,445	1%
HID fixtures-Standard	8	1	950	$7,409	7%
HID fixtures-Compact	0	1	319	$0	0%
Compact Flourescents-Screw In Modular	47	1	70	$3,256	12%
Compact Flourescents-Hardwire	27	1	213	$5,721	7%
Exit Signs-CF	4	1	117	$469	3%
Exit Signs-LED	23	1	145	$3,270	3%
Halogens	7	1	7	$49	6%
Install Reflecters	0	2	74	$0	0%
Electronic Ballasts	367	1	14	$5,289	8%
Occ Sensor	85	1	166	$14,150	1%
Bypass/Delay Timer	120	1	160	$19,212	1%
Weighted Average *by Distribution of Installs*	401		117	$18,694	

Nonparticipant Spillover Impact Calculation

Fewer than 13 nonparticipants were identified as contributing to spillover. Rather than using only these 13 installations to calculate an average spillover impact, the whole survey sample of out-of-program high efficiency lighting installations was used.

There were 239 nonparticipant respondents who made high efficiency lighting equipment adoptions. These installations were used to estimate the average nonparticipant impact associated with spillover. To calculate the impacts associated with spillover, avoided cost was used as a proxy for impact.

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

The 239 high efficiency installations were then used to determine the distribution of installations across equipment type. Applying this distribution to our estimates of savings by equipment type resulted in the overall average avoided cost per nonparticipant installation. Exhibit 3-39 below, presents the average avoided cost per nonparticipant installation by fixture type, along with the distribution of installations across fixture type. Based on the distribution of the 239 high efficiency nonparticipant installations, the average avoided cost per nonparticipant was estimated to be $10,932.

It should be noted that the average avoided cost associated with a nonparticipant installation contributing towards spillover was just 58% of the average avoided cost associated with a participant installation contributing towards spillover.

Exhibit 3-39
Nonparticipant Adoption Distribution

Fixture Type	# Fixtures	#Lamps Per Fixture	Per Lamp Av Cost	Total Av Cost	Distribution of Installs
2 Foot T8 Fixtures	52	2	23	$2,412	10%
4 Foot T8 Fixtures	346	2.5	18	$15,708	44%
8 Foot T8 Fixtures	30	2	30	$1,764	7%
Incandescent to Flourescent	21	1	344	$7,284	3%
HID fixtures-Standard	26	1	950	$25,096	9%
HID fixtures-Compact	9	1	319	$2,924	3%
Compact Flourescents-Screw In Modular	30	1	70	$2,088	0%
Compact Flourescents-Hardwire	65	1	213	$13,845	3%
Exit Signs-CF	17	1	117	$1,994	1%
Exit Signs-LED	1	1	145	$145	0%
Halogens	25	1	7	$177	10%
Install Reflecters	206	2	74	$30,302	2%
Electronic Ballasts	102	1	14	$1,475	8%
Occ Sensor	37	1	166	$6,076	1%
Weighted Average *by Distribution of Installs*	180		126	$10,932	

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

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

Participant Spillover:

NTGpart_spill = SP_RATEpart * POPpart*AV_COSTpart_spill / AV_COSTpop

Where,

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

SP_RATEpart = the participant spillover rate

POPpart = the participant population, in number of sites

AV_COSTpart = the per participant site avoided cost associated with spillover

AV_COSTpop = the total avoided cost for the CEEI Program

Nonparticipant Spillover:

NTGnp_spill = SP_RATEnp * POPnp*AV_COSTnp_spill / AV_COSTpop

Where,

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

SP_RATEnp = the nonparticipant spillover rate

POPnp = the nonparticipant population, in number of sites

AV_COSTnp = the per nonparticipant site avoided cost associated with spillover

AV_COSTpop = the total avoided cost for the CEEI Program

These equations are identical to those presented earlier, with the exception of using avoided cost as a proxy for impact. Each of the components required for calculating the contribution to participant and nonparticipant spillover have been identified and are discussed above, except for the total avoided cost. The total avoided cost as reported in the MDSS is $59,140,572 for Lighting.

Participant Spillover NTG Calculation

Exhibit 3-40 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 2.93%.

Exhibit 3-40
Participant Spillover Estimate

Avoided Cost Per Participant	$18,694
Spillover Rate	1.74%
Number of Participants	5,308
Number Contributing to Spillover	93
Spillover Avoided Cost	$1,730,714
Lighting Avoided Cost	$59,140,572
NTG Contribution from Participant Spillover	**2.93%**

Nonparticipant Spillover NTG Calculation

Exhibit 3-41 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 7.00%.

Exhibit 3-41
Nonparticipant Spillover Estimate

Avoided Cost Per Nonparticipant	$10,932
Spillover Rate	0.092%
Number of Nonparticipants	411,188
Number Contributing to Spillover	378
Spillover Avoided Cost	$4,137,013
Lighting Avoided Cost	$59,140,572
NTG Contribution from Nonparticipant Spillover	**7.00%**

3.4.3 Discrete Choice Model

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

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

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

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

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

Data Sources for the Net-to-Gross Analysis

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

The sample used to estimate the purchase model contains information on 3,023 customers, who made 1,498 lighting purchases. Of these, 2,299 are nonparticipants that did not make any lighting equipment purchases either in or outside the program. There were 724 customers who purchased lighting equipment between January of 1995 and July of 1998. Of those that did make lighting equipment purchases, 439 customers did so within the lighting program. Two hundred and fifty-one customers purchased high efficiency equipment outside the program. Finally, 75 customers reported purchasing standard lighting equipment. Some customers made more than one type of purchase.

Stage 1 -- Purchase Model Specification

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

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

Variable definitions are given in Exhibit 3-42. The explanatory variables X contain information on rebate and program awareness that capture the effect of the Lighting Program. Building characteristics such as square footage and changes to the facility are contained in Y. Variable group Z contains variables indicating building type and type of lighting. The error term ε is assumed to be distributed logistic, consistent with the logit model specification.

There are four variables specified to capture the effect of the Lighting Program on the decision to make a purchase, AWARE, LT_INFO, PGE_INFO and CINDEX. For AWARE, customers are given a value of one if they indicated that they were aware of the retrofit program before they made the decision to purchase new lighting equipment. If they became aware of the program after or at the same time they selected the equipment, they are given a value of zero for

AWARE. This definition of awareness is used to take into account that the process of shopping for lighting equipment may result in some customers becoming aware of the Lighting Program. When awareness is set to zero to simulate the absence of the program, only those who started shopping after they became aware of the program will be affected since it is assumed that the program influenced them to shop for new lighting equipment. This definition of program awareness avoids the problem of having program awareness affect those customers who were already looking for lighting equipment when they became aware of the program.

Relative to the 1996 Lighting Program Evaluation, two new awareness variables have been added. The variables LT_INFO and PGE_INFO are included to enhance the model's ability to identify the effects of program awareness. These two variables can take the value of either zero or one. LT_INFO takes on a value of one if:

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

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

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

Eighty-two percent of program participants were aware of the Lighting Program prior to making the decision to purchase their lighting equipment. Among those that did not make any lighting purchases, 18 percent were aware of the lighting program. For the entire sample, 29 percent of the customers were coded as being aware of the Lighting Program.

Of those participants who were aware of the program, 23 percent claimed to have been made aware of the program by their lighting contractor. Those who stated that their PG&E representative told them about the program comprised 45 percent of the participants who were aware. Among those who made out-of-program purchases and were aware, 14 percent received program information from their lighting contractor; 30 percent from their PG&E representative. Overall, 32 percent of those who were aware received information from their PG&E representative, and 17 percent from their lighting contractor.

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

CINDEX = (Cost – Rebate) / Cost

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

Exhibit 3-42
Purchase Model Variable Definitions

Variable Name	Units	Variable Type	Description
AWARE	0,1	X	Aware of program prior to purchase
ARCOOL	0,1	Y	Cooling equipment was added and removed since 1/95
B4_78	0,1	Y	Building was constructed before 1978
CINDEX	ratio	X	(Cost-Rebate)/Cost
EMPCHG	0,1	Y	Employee change by 10% since 1/95
FLOR	0,1	Z	Fluorescent is main type of lighting
GROCERY	0,1	Z	Grocery
HEALTH	0,1	Z	Health Care Building
HID	0,1	Z	Primary lighting is HID
HOTEL	0,1	Z	Hotel
INCAN	0,1	Z	Incandescent is primary type of lighting
LT_INFO	0,1	X	Made aware by lighting contractor prior to purchase
MISCCOM	0,1	Z	Miscellaneous commercial building
OFFICE	0,1	Z	Office building
OWN	0,1	Y	Own building
PERSONL	0,1	Z	Personal services building
PGE_INFO	0,1	X	Made aware by PG&E representative prior to purchase
RESTR	0,1	Z	Restaurant
RETAIL	0,1	Z	Retail building
SCHOOL	0,1	Z	School
SFADD	0,1	Y	Square footage added to the facility
SHTLEASE	0,1	Y	Lease less than 1 year long
SQFEET	Square ft.	Y	Square footage of facility
TENACT	0,1	Y	Tenants active in equipment purchse decisions
WARE	0,1	Z	Warehouse

Purchase Model Estimation Results

The estimation results from the purchase model are given in Exhibit 3-43. A likelihood ratio test yields a test statistic of over 2173 with 25 degrees of freedom, which is well above the critical value at any of the conventional levels of significance.

In addition, Exhibit 3-44 shows that the estimated probability of making a purchase is relatively high for those customers who made purchases both in and outside the program, which conforms to *a priori* expectations. These factors suggest that the purchase model does have significant explanatory power.

The coefficient estimates from the purchase model are shown in Exhibit 3-43. As expected, program awareness has a strong positive effect on the decision to purchase lighting equipment. Further, this effect is greater if either their lighting contractor or PG&E representative informed the respondent of the program.

Exhibit 3-43
Purchase Model Estimation Results

Variable Name	Variable Type	Coefficient Estimate	Standard Error	Significance Level
AWARE	X	1.43	0.10	1%
ARCOOL	Y	0.31	0.12	1%
B4_78	Y	0.39	0.10	1%
CINDEX	X	-4.43	0.23	1%
EMPCHG	Y	0.58	0.11	1%
FLOR	Z	0.60	0.15	1%
GROCERY	Z	0.38	0.24	11%
HEALTH	Z	0.49	0.22	2%
HID	Z	0.92	0.32	1%
HOTEL	Z	0.84	0.29	1%
INCAN	Z	-0.28	0.21	18%
LT_INFO	X	0.63	0.19	1%
MISCCOM	Z	-0.23	0.22	31%
OFFICE	Z	0.69	0.15	1%
OWN	Y	1.76	0.15	1%
PERSONL	Z	0.25	0.22	26%
PGE_INFO	X	0.49	0.15	1%
RESTR	Z	-0.22	0.26	40%
RETAIL	Z	0.51	0.17	1%
SCHOOL	Z	0.81	0.22	1%
SFADD	Y	0.67	0.17	1%
SHTLEASE	Y	-0.32	0.21	14%
SQFEET	Y	0.00	0.00	1%
TENACT	Y	1.57	0.16	1%
WARE	Z	0.56	0.21	1%

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

Relative to the 1996 Lighting Program Evaluation, two new building characteristics variables were added to the purchase model specification. These are B4_78 and SHTLEASE. The first, B4_78, is a dummy variable indicating whether a building was constructed before 1978. The coefficient for this variable is positive, confirming our expectation that older buildings would be more likely to be in need of new lighting equipment. The second new variable, SHTLEASE, is a dummy variable indicating whether a tenant has a lease less than one year long. The coefficient estimate for this variable is negative, confirming our expectation that tenants with shorter leases would be less likely to purchase new lighting equipment.

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

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

where $Q = a + b'X + g'U + J'Z$

The estimated probabilities for different customer groups are given in Exhibit 3-44. As expected, Lighting Program participants have a high probability of making an equipment purchase with an estimated purchase probability of 0.74. Conversely, those that did not make any purchases have a low estimated probability of purchasing new lighting equipment at 0.20.

Exhibit 3-44
Estimated Purchase Probabilities

Customer Group	With Program	Without Program
No Purchase	0.20	0.15
Participants	0.74	0.28
Purchase HE Outside Program	0.45	0.24
Purchase Std Efficiency	0.30	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 purchase decision model. This is done by setting AWARE, LT_INFO and PGE_INFO equal to zero and setting CINDEX equal to one to reflect the absence of a rebate. The probability of making a lighting purchase is then recalculated using the logistic density function given above. All other variable values remain the same, as they are not expected to change in absence of the program.

The new probabilities of a lighting purchase in absence of the Lighting Program are also given in Exhibit 3-44. In the absence of the Lighting Program, the probability of purchasing lighting equipment among participants drops from 0.74 to 0.28. This indicates that many of those who purchased lighting equipment would not have done so without the Lighting Program. The

Lighting Program also decreases the probability that those outside the program will purchase new lighting equipment. For those purchasing high-efficiency equipment outside the program, removing the program decreases the probability of a purchase from 0.45 to 0.24.

Stage 2 -- Equipment Choice Model Specification

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

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

The conditional logit model specification for equipment choice is:

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

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

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

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

PREDISP = Predisposition towards high efficiency equipment

SQFEET = Square footage of the facility

CINDEX = (cost – rebate) / cost

SAVINGS = Annual dollar amount of electricity savings expected from equipment

BLDTYPE = Vector of dummy variables indicating building type

ε = Random error term assumed logistically distributed.

The explanatory variables used in the equipment choice model are described in Exhibit 3-45. In this stage of the model, a customer is considered aware of the program (AWARE = 1) if he became aware of the program before or at the same time he selected the lighting equipment. This is slightly different from the definition of awareness used in the purchase model, where a customer is coded as aware only if they became aware before they began shopping for new lighting equipment. Awareness is redefined in the equipment choice model since, although program awareness does not encourage all customers to make a purchase, it will tend to influence more people to purchase high efficiency if they are aware of the program at the time they make the purchase. This modified definition of aware is applied to the other awareness variables: LT_INFO and PGE_INFO. That is, LT_INFO was given a value of one if the respondent was aware of the program at the time new lighting equipment was purchased **and** received program information from their lighting contractor. PGE_INFO takes a value of one if the respondent was similarly aware, **and** was informed of the program by their PG&E representative.

Exhibit 3-45
Equipment Choice Model Variable Definitions

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

A characteristic of the conditional logit specification is that variables that do not vary over choices will drop out of the model.[17] For instance, firmographic variables such as size do not vary across the equipment options and therefore cannot be included in the model. One way to avoid this problem is to interact firmographic variables with choice specific dummy variables. This method is used in this application to allow for firm specific variables such as size, building type, and program awareness to influence equipment choice. All of the variables except CINDEX and SAVINGS are interacted with a dummy variable for the high efficiency equipment options. As a result, these variables have positive values for seven of the nine choices and values of zero for the two standard efficiency choices.

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

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

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

Estimation of Cost, Savings, and Rebates

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

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

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

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

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

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

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

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

Equipment Choice Model Estimation Results

The estimation results for the equipment choice model are given in Exhibit 3-46. 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. Further, both LT_INFO and PGE_INFO are positive, indicating the effect of awareness is greater for those who were made aware of the program through either their lighting contractor or their PG&E representative. While the coefficient for PGE_INFO is relatively large and significant, the LT_INFO coefficient is small and insignificant. This could be due to more complete and accurate program information coming from the PG&E representatives than from lighting contractors.

Also as was expected, the coefficient estimate on PREDISP is positive, indicating that those identified as predisposed to purchasing high efficiency do in fact tend to choose high efficiency equipment. SQFEET is the square footage of the facility interacted with a dummy variable for the high efficiency equipment options. The coefficient estimate on SQFEET is positive (although small in magnitude), indicating a tendency for larger firms to purchase high efficiency equipment. The remaining variables indicate business type. Of these, OFFICE, SCHOOL, RETAIL, and PERSONL (personal service) have positive coefficient estimates. Of all the business types, only RESTR (restaurant) and HOTEL are statistically significant.

Exhibit 3-46
Equipment Choice Model Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
AWARE	1.74	0.30	1%
CINDEX	-2.46	0.21	1%
GROCERY	-0.21	0.58	72%
HEALTH	-0.50	0.46	28%
HOTEL	-0.98	0.48	4%
LT_INFO	0.06	0.51	91%
MISCOM	0.45	0.55	41%
OFFICE	0.41	0.36	25%
PERSONL	0.53	0.62	39%
PREDISP	0.16	0.39	69%
PGE_INFO	1.13	0.51	3%
RETAIL	0.34	0.37	35%
RESTR	-1.34	0.46	1%
SAVINGS	0.00	0.00	1%
SCHOOL	0.92	0.75	22%
SQFEET	0.00	0.00	85%
WARE	-0.39	0.44	38%

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

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

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

As is done with the purchase probability, the equipment choice probability is calculated both with and in the absence of the program. To simulate the absence of the program, AWARE, LT_INFO and PGE_INFO are set to zero and CINDEX is set to one for all of the lighting equipment options. For program participants, the probability of choosing high efficiency equipment is the sum of the individual probabilities for the seven high efficiency options. The probability of choosing standard equipment is the sum of the two remaining probabilities. For participants, the probability of purchasing high efficiency equipment is 0.71 with the program and falls about 70 percent to 0.22 without the program. This result is almost identical 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, LT_INFO, PGE_INFO and CINDEX. This gives the total probability with the existence of the program. Next, the total probability is calculated in absence of the program. This is done by setting the awareness variables equal to zero and CINDEX equal to one to reflect the absence of rebates. While the awareness variables are set to zero, PREDISP retains its original value since this variable captures the effect of those that are predisposed to high efficiency equipment who would likely purchase the equipment even if the Lighting Program did not exist.

The estimated impacts are weighted up to the population based on participation. Participants are weighted to reflect the Lighting Program participation population in the MDSS. Nonparticipants are assigned weights based on the nonparticipant population represented in the sample. For those that reported making a lighting purchase since January of 1995, the weight was scaled down to reflect the portion of those adoptions which would have occurred during the 1997 program year. To estimate this portion, the survey data regarding high efficiency lighting adoptions that occurred in 1997 were used. The percentage of all self-reported high efficiency adoptions that occurred in 1997 was 30.8%. This percentage is used to adjust the nonparticipant weight. The nonparticipant weight is scaled to adjust for the fact that only 30.8% of these actions were likely to have been done during the 1997 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 1997 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 seven high efficiency equipment options to get a total expected impact for each customer. The calculation is given by:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The expected impacts by building type are shown below in Exhibit 3-47. The net-to-gross ratios range from 1.07 for community service buildings to 0.59 for schools. The overall net-to-gross ratio for all business types is 0.76, which results in a free ridership rate of 0.24. The total spillover rate for participants and nonparticipants is 0.05. This results in a final net-to-gross ratio estimate including spillover of 0.82 for the entire Lighting Program.

Exhibit 3-47
Estimated NTG Ratios by Building Type

Building Type	NTG
Office	0.81
Retail	0.82
College/univ	0.83
School	0.59
Grocery	0.91
Restaurant	0.85
Healthcare	0.81
Hotel	0.84
Warehouse	0.80
Personal Service	0.84
Community Service	1.07
Misc. Com.	0.92

Alternative Model Specifications

As discussed above, we added four new variables to the discrete choice model relative to the 1996 Lighting Program Evaluation. Two of these four variables (LT_INFO and PGE_INFO) are included to enhance the model's ability to accurately interpret the impact of program awareness. We believe that respondents who claim they were aware of the program **and** can cite the source of their program information are likely to be more completely and accurately informed than respondents who simply claim to be aware. Perhaps more importantly, the addition of these two variables reduces the concern evaluators commonly have with customers falsely claiming they are aware of the program. By including these additional dummy variables, the model can assign different impacts to the different quality awareness these information sources produce. We expected the coefficients for both of these variables to be positive, reflecting a greater impact from awareness that can be traced to a reliable source. This expectation was validated by our results in both the purchase model and the equipment choice model. However, in the equipment choice model, the coefficient for LT_INFO was small and not statistically different from zero. This may reflect that high quality program information is more likely to come from a PG&E representative than a lighting contractor.

Also as discussed above, we added two new building characteristics variables to the purchase model. These are SHTLEASE and B4_78. SHTLEASE takes a value of one if the respondent has a lease for the property that is shorter than one year, and a zero otherwise. We expect that tenants with short leases will be less likely to purchase new lighting equipment. This expectation is borne out by the purchase model results. The second variable, B4_78, is also a dummy variable. This variable takes on a value of one if the building was constructed prior to 1978. Our expectation was that older buildings would be more likely to remodel and/or be in need of new lighting, and therefore be more likely to make a lighting purchase. This expectation was also borne out by the results.

We explored the marginal impact of including these four new variables in the model by examining the results using alternative model specifications. Specifically, we ran the model with the following four different specifications to measure the marginal impacts of the new variables. The "baseline model" referred to below is the model described in the preceding section, which includes all four new variables. The four alternative specifications are:

1) The baseline model without the LT_INFO and PGE_INFO
2) The baseline model without SHTLEASE
3) The baseline model without B4_78
4) The baseline model without all four new variables

The net-to-gross ratios resulting from these four alternative model specifications are shown in Exhibit 3-48 below. The new awareness variables have the effect of moderately increasing the net to gross ratio, while the new building characteristics variables each moderately reduce the final result. Overall, the four new variables slightly increase the net to gross ratio, but the effect is only about one half of one percent.

Exhibit 3-48
NTG Results with Alternative Model Specifications

	NTG Ratio
Base Case	0.815
Without LT_INFO and PGE_INFO	0.805
Without SHTLEASE	0.817
Without B4_78	0.819
Without All New	0.809

3.4.4 Final Net-to-Gross Ratios

As discussed above, three separate models were implemented to estimate the components of the net-to-gross ratio (free ridership and spillover). The first approach relied on a net billing analysis model and applied the double inverse Mills ratio methodology, which resulted in estimates of free ridership only. The second methodology relied on self-reported estimates of free ridership, participant spillover and nonparticipant spillover to estimate the net-to-gross ratios. 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 accurate and unbiased responses to their hypothetical actions in the absence of the program.

Exhibit 3-49 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 3-49
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	0.81	0.76	0.05	0.88	0.78	0.10	0.91
Retail	0.82	0.80	0.02	0.81	0.71	0.10	0.76
College/Univ	0.83	0.78	0.05	0.82	0.72	0.10	0.61
School	0.59	0.58	0.01	0.84	0.74	0.10	0.61
Grocery	0.91	0.67	0.24	0.84	0.74	0.10	1.21
Restaurant	0.85	0.83	0.01	0.82	0.72	0.10	0.76
Health Care	0.81	0.80	0.01	0.86	0.76	0.10	1.21
Hotel/Motel	0.84	0.82	0.01	0.75	0.65	0.10	0.76
Warehouse	0.80	0.79	0.01	0.79	0.69	0.10	1.21
Personal Svcs.	0.84	0.78	0.06	0.86	0.76	0.10	1.06
Comm. Svcs.	1.07	0.79	0.28	0.78	0.69	0.10	0.91
Misc.	0.92	0.82	0.10	0.78	0.68	0.10	1.21
Total	**0.82**	**0.76**	**0.05**	**0.84**	**0.74**	**0.10**	**0.87**

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 two percent of the self-reported results, with free ridership estimates also differing by about three 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, and are within 10% for all but three. 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 also provides a strong validation for the two sets of results. The self-reported results are within 20% of the discrete choice model results for every business type but one.

The free ridership estimates generated using the Mills approach appear to provide significantly higher estimates of net participation. This is in part due to the large net estimates for the

Grocery, Health Care, Warehouse and Miscellaneous business types[19]. 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 retail businesses, the Mills approach provides a result that is within 6 percent of both the discrete choice and self report methods.

The final net-to-gross ratios applied to the gross ex-post impacts are based solely on the discrete choice model. As discussed above, these model results are considered to be the most accurate and are 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 3-50 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 3-50
Final Net-to-Gross Ratios

Business Type	***NTG***	***1-FR***	***Spill***
Office	0.81	0.76	0.05
Retail	0.82	0.80	0.02
College/Univ	0.83	0.78	0.05
School	0.59	0.58	0.01
Grocery	0.91	0.67	0.24
Restaurant	0.85	0.83	0.01
Health Care	0.81	0.80	0.01
Hotel/Motel	0.84	0.82	0.01
Warehouse	0.80	0.79	0.01
Personal Svcs.	0.84	0.78	0.06
Comm. Svcs.	1.07	0.79	0.28
Misc.	0.92	0.82	0.10
Totals Weighted by:			
Energy	**0.82**	**0.76**	**0.05**
Demand	**0.80**	**0.75**	**0.05**
Therm	**0.79**	**0.73**	**0.06**

[19] 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.

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: Retrofit Express (RE), Customized Efficiency Options (CEO), and Advanced Performance Options (APO). All results are aggregated to the total commercial sector.

4.1 EX POST GROSS IMPACT RESULTS

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

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

RE Program – Overall, 97 percent of the energy and demand impacts are from lighting technologies installed through the RE program.

Customized Efficiency Options Program – The CEO Program plays a smaller role in the overall impact. Less than 3 percent of the total energy and demand savings is attributable to this program. Both of the applications installed for this program were within the office and personal services business type.

Advanced Performace Options Program – Only one application was rebated under the APO Program. Less than 0.1 percent of the total energy and demand savings being attributable to this program. The application installed for this program was within the community services business type.

High Participation Business Types – The office and retail business types represent over half of the impacts. The office business type is the largest single segment, accounting for over 40 percent of demand and one third of energy impacts. These business types have historically comprised a large share of lighting program impacts. This is a result of the large number of lighting retrofits performed within these business types.

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	338,321	1,526,222	36,720	76,844	83,345	108,901	91,920	684,141	5,133	42,556	150,946	21,029	3,166,078
	Compact Fluorescent Lamps	2,913,984	5,077,382	327,325	1,499,128	413,030	304,535	772,545	9,721,495	100,579	203,984	520,396	157,444	22,011,828
	Incandescent to Fluorescent Fixtures	231,504	95,924	145,512	856,515	54,929	-	70,238	257,894	16,305	-	61,887	27,579	1,818,288
	Exit Signs	1,802,316	172,789	116,385	433,236	48,635	27,365	511,011	201,358	78,489	48,287	205,481	58,693	3,704,045
	Efficient Ballast Changeouts	46,426	28,491	23,355	17,868	3,046	-	1,558	176	725	1,224	840	854	124,564
	T-8 Lamps and Electronic Ballasts	16,264,017	8,414,404	1,236,175	4,203,017	2,033,210	596,463	3,170,970	1,003,566	1,071,224	1,098,056	2,339,594	720,434	42,151,130
	Delamp Fluorescent Fixtures	15,500,978	2,817,206	322,057	1,748,179	389,629	127,701	1,194,054	1,272	825,073	859,871	921,599	360,264	25,067,883
	High Intensity Discharge	1,709,356	2,393,523	365,293	805,253	223,459	69,351	63,846	152,483	1,253,179	118,113	1,988,471	729,967	9,872,294
	Controls	1,363,138	137,015	188,725	479,408	9,497	15,150	131,104	17,639	96,487	171,740	92,974	32,424	2,735,302
	Retrofit Express Program Total	40,170,040	20,662,956	2,761,547	10,119,447	3,258,780	1,249,466	6,007,246	12,040,023	3,447,196	2,543,832	6,282,190	2,108,689	110,651,411
CEO	Halogen	4,805	-	-	-	-	-	-	-	-	53,517	-	-	58,322
	Compact Fluorescent Lamps	72,929	-	-	-	-	-	-	-	-	426,526	-	-	499,455
	Efficient Ballast Changeouts	1,002	-	-	-	-	-	-	-	-	-	-	-	1,002
	T-8 Lamps and Electronic Ballasts	636,419	-	-	-	-	-	-	-	-	1,317,855	-	-	1,954,274
	Delamp Fluorescent Fixtures	77,930	-	-	-	-	-	-	-	-	1,046	-	-	78,975
	Controls	56,369	-	-	-	-	-	-	-	-	573,363	-	-	629,732
Customized Efficiency Options Program Total		849,453	0	0	0	0	0	0	0	0	2,372,307	0	0	3,221,760
APO	Halogen	-	-	-	-	-	-	-	-	-	-	54,779	-	54,779
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	56,464	-	56,464
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	111,242	0	111,242
Total		41,019,493	20,662,956	2,761,547	10,119,447	3,258,780	1,249,466	6,007,246	12,040,023	3,447,196	4,916,139	6,393,432	2,108,689	**113,984,414**

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	86	238	11	28	15	14	20	61	1	9	35	4	525
	Compact Fluorescent Lamps	737	754	94	497	71	34	152	876	28	44	104	31	3,422
	Incandescent to Fluorescent Fixtures	59	15	44	292	10	-	15	24	5	-	13	6	481
	Exit Signs	258	16	23	87	7	3	73	17	11	6	29	8	538
	Efficient Ballast Changeouts	12	5	7	6	1	-	0	0	0	0	0	0	31
	T-8 Lamps and Electronic Ballasts	4,110	1,329	375	1,432	362	73	673	92	301	252	499	150	9,648
	Delamp Fluorescent Fixtures	3,917	445	98	596	69	16	253	0	232	197	197	75	6,094
	High Intensity Discharge	394	331	4	122	25	-	9	-	349	13	393	144	1,784
	Controls	194	12	37	95	1	1	19	1	13	23	13	5	416
	Retrofit Express Program Total	9,768	3,146	694	3,155	561	140	1,214	1,072	939	545	1,283	423	22,940
CEO	Halogen	1	-	-	-	-	-	-	-	-	12	-	-	13
	Compact Fluorescent Lamps	18	-	-	-	-	-	-	-	-	92	-	-	111
	Efficient Ballast Changeouts	0	-	-	-	-	-	-	-	-	-	-	-	0
	T-8 Lamps and Electronic Ballasts	161	-	-	-	-	-	-	-	-	302	-	-	463
	Delamp Fluorescent Fixtures	20	-	-	-	-	-	-	-	-	0	-	-	20
	Controls	8	-	-	-	-	-	-	-	-	77	-	-	85
Customized Efficiency Options Program Total		208	0	0	0	0	0	0	0	0	483	0	0	691
APO	Halogen	-	-	-	-	-	-	-	-	-	-	13	-	13
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	12	-	12
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	25	0	25
Total		9,976	3,146	694	3,155	561	140	1,214	1,072	939	1,028	1,308	423	**23,656**

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 nearly 40 percent of the gross energy and demand savings. The large impacts attributable to these technologies are driven by the equally large participation within those particular measure categories.

Low Participation Business Types – The lowest energy impacts were contributed by the restaurant business type, primarily because of small installations made within that segment.

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

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

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-154,119	-292,389	-6,586	-53,876	-8,729	-36,912	-20,323	-25,205	-358	-3,466	-61,710	-1,958	-665,631
	Compact Fluorescent Lamps	-1,327,439	-972,711	-58,707	-1,051,052	-43,256	-103,220	-170,805	-358,157	-7,022	-16,616	-212,748	-14,657	-4,336,391
	Incandescent to Fluorescent Fixtures	-105,460	-18,377	-26,098	-600,510	-5,753	-	-15,529	-9,501	-1,138	-	-25,301	-2,567	-810,234
	Exit Signs	-821,029	-33,103	-20,874	-303,745	-5,093	-9,275	-112,982	-7,418	-5,480	-3,933	-84,004	-5,464	-1,412,401
	Efficient Ballast Changeouts	-21,149	-5,458	-4,189	-12,528	-319	-	-345	-6	-51	-100	-344	-79	-44,567
	T-8 Lamps and Electronic Ballasts	-7,408,926	-1,612,008	-221,712	-2,946,773	-212,936	-202,168	-701,084	-36,973	-74,792	-89,443	-956,470	-67,067	-14,530,353
	Delamp Fluorescent Fixtures	-7,061,330	-539,712	-57,762	-1,225,664	-40,805	-43,284	-263,999	-47	-57,606	-70,042	-376,767	-33,538	-9,770,556
	High Intensity Discharge	-694,159	-406,187	-2,596	-240,605	-14,517	-	-9,159	-	-85,339	-4,767	-727,416	-66,184	-2,250,928
	Controls	-620,965	-26,249	-33,848	-336,117	-995	-5,135	-28,986	-650	-6,737	-13,989	-38,010	-3,018	-1,114,699
	Retrofit Express Program Total	-18,214,575	-3,906,194	-432,372	-6,770,871	-332,403	-399,994	-1,323,212	-437,958	-238,523	-202,356	-2,482,770	-194,533	-34,935,761
CEO	Halogen	-2,189	-	-	-	-	-	-	-	-	-4,359	-	-	-6,548
	Compact Fluorescent Lamps	-33,222	-	-	-	-	-	-	-	-	-34,743	-	-	-67,965
	Efficient Ballast Changeouts	-456	-	-	-	-	-	-	-	-	-	-	-	-456
	T-8 Lamps and Electronic Ballasts	-289,915	-	-	-	-	-	-	-	-	-107,347	-	-	-397,262
	Delamp Fluorescent Fixtures	-35,500	-	-	-	-	-	-	-	-	-85	-	-	-35,585
	Controls	-25,678	-	-	-	-	-	-	-	-	-46,704	-	-	-72,382
Customized Efficiency Options Program Total		-386,961	0	0	0	0	0	0	0	0	-193,238	0	0	-580,199
APO	Halogen	-	-	-	-	-	-	-	-	-	-	-22,395	-	-22,395
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-23,083	-	-23,083
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	-45,478	0	-45,478
Total		-18,601,536	-3,906,194	-432,372	-6,770,871	-332,403	-399,994	-1,323,212	-437,958	-238,523	-395,595	-2,528,248	-194,533	**-35,561,437**

4.2 NET-TO-GROSS ADJUSTMENTS

The NTG results are designed to account for all of the market spillover effects (free-ridership, participant spillover, and nonparticipant spillover) by measure. Exhibit 4-4 presents the NTG values by business type, separating out the effects of free ridership and spillover (note that due to rounding, values may not sum properly). Also shown are the overall program level NTG results, weighted across business types 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	0.81	0.76	0.05
Retail	0.82	0.80	0.02
College/Univ	0.83	0.78	0.05
School	0.59	0.58	0.01
Grocery	0.91	0.67	0.24
Restaurant	0.85	0.83	0.01
Health Care	0.81	0.80	0.01
Hotel/Motel	0.84	0.82	0.01
Warehouse	0.80	0.79	0.01
Personal Svcs.	0.84	0.78	0.06
Comm. Svcs.	1.07	0.79	0.28
Misc.	0.92	0.82	0.10
Totals Weighted by:			
Energy	**0.82**	**0.76**	**0.05**
Demand	**0.80**	**0.75**	**0.05**
Therm	**0.79**	**0.73**	**0.06**

The overall NTG ratio ranged from 0.79 based on therm savings, to 0.82 based on energy savings. On average, free ridership and spillover were approximately 25 and 5 percent, overall, respectively. The variation is due to the distribution of ex-post energy, demand and therm savings across business types.

4.3 EX POST NET IMPACTS

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

These exhibits show reductions of 18 percent in ex post program energy impacts and 20 percent in ex post program demand impacts (when compared to Exhibits 4-1 and 4-2, gross impacts). The reductions are a 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 90 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	272,902	1,248,004	30,422	45,266	75,843	92,212	74,830	573,422	4,119	35,863	161,868	19,422	2,634,173
	Compact Fluorescent Lamps	2,350,529	4,151,818	271,181	883,086	375,853	257,864	628,915	8,148,203	80,700	171,901	558,050	145,412	18,023,513
	Incandescent to Fluorescent Fixtures	186,740	78,438	120,553	504,544	49,985	-	57,179	216,157	13,083	-	66,365	25,471	1,318,516
	Exit Signs	1,453,816	141,291	96,422	255,204	44,257	23,172	416,005	168,771	62,977	40,692	220,349	54,208	2,977,163
	Efficient Ballast Changeouts	37,449	23,297	19,349	10,526	2,772	-	1,269	148	582	1,031	901	789	98,112
	T-8 Lamps and Electronic Ballasts	13,119,169	6,880,528	1,024,142	2,475,855	1,850,201	505,054	2,581,431	841,152	859,505	925,350	2,508,877	665,375	34,236,641
	Delamp Fluorescent Fixtures	12,503,673	2,303,653	266,817	1,029,793	354,559	108,131	972,058	1,066	662,004	724,628	988,282	332,731	20,247,394
	High Intensity Discharge	1,378,831	1,957,204	302,636	474,348	203,345	58,723	51,976	127,806	1,005,498	99,536	2,132,348	674,180	8,466,430
	Controls	1,099,558	112,039	156,354	282,403	8,642	12,828	106,729	14,784	77,417	144,728	99,702	29,946	2,145,131
Retrofit Express Program Total		32,402,668	16,896,272	2,287,876	5,961,024	2,965,458	1,057,984	4,890,393	10,091,509	2,765,885	2,143,729	6,736,742	1,947,533	90,147,074
CEO	Halogen	3,876	-	-	-	-	-	-	-	-	45,099	-	-	48,975
	Compact Fluorescent Lamps	58,828	-	-	-	-	-	-	-	-	359,440	-	-	418,268
	Efficient Ballast Changeouts	808	-	-	-	-	-	-	-	-	-	-	-	808
	T-8 Lamps and Electronic Ballasts	513,359	-	-	-	-	-	-	-	-	1,110,579	-	-	1,623,938
	Delamp Fluorescent Fixtures	62,861	-	-	-	-	-	-	-	-	881	-	-	63,742
	Controls	45,469	-	-	-	-	-	-	-	-	483,182	-	-	528,652
Customized Efficiency Options Program Total		685,201	0	0	0	0	0	0	0	0	1,999,182	0	0	2,684,383
APO	Halogen	-	-	-	-	-	-	-	-	-	-	58,742	-	58,742
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	60,549	-	60,549
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	119,292	0	119,292
Total		33,087,868	16,896,272	2,287,876	5,961,024	2,965,458	1,057,984	4,890,393	10,091,509	2,765,885	4,142,912	6,856,034	1,947,533	**92,950,748**

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	70	195	9	16	14	11	16	51	1	8	38	4	434
	Compact Fluorescent Lamps	594	616	78	293	65	29	124	734	22	37	111	29	2,733
	Incandescent to Fluorescent Fixtures	47	12	37	172	9	-	12	20	4	-	14	5	332
	Exit Signs	208	13	19	51	7	2	59	14	9	5	31	8	426
	Efficient Ballast Changeouts	9	4	6	4	0	-	0	0	0	0	0	0	24
	T-8 Lamps and Electronic Ballasts	3,315	1,087	311	843	330	62	548	77	241	212	535	139	7,700
	Delamp Fluorescent Fixtures	3,160	364	81	351	63	13	206	0	186	166	211	69	4,870
	High Intensity Discharge	318	271	4	72	23	-	7	-	280	11	421	133	1,539
	Controls	157	10	31	56	1	1	15	1	11	19	14	4	321
Retrofit Express Program Total		7,879	2,572	575	1,859	511	119	989	898	754	459	1,376	390	18,380
CEO	Halogen	1	-	-	-	-	-	-	-	-	10	-	-	11
	Compact Fluorescent Lamps	15	-	-	-	-	-	-	-	-	78	-	-	92
	Efficient Ballast Changeouts	0	-	-	-	-	-	-	-	-	-	-	-	0
	T-8 Lamps and Electronic Ballasts	130	-	-	-	-	-	-	-	-	255	-	-	384
	Delamp Fluorescent Fixtures	16	-	-	-	-	-	-	-	-	0	-	-	16
	Controls	6	-	-	-	-	-	-	-	-	65	-	-	71
Customized Efficiency Options Program Total		168	0	0	0	0	0	0	0	0	407	0	0	575
APO	Halogen	-	-	-	-	-	-	-	-	-	-	14	-	14
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	13	-	13
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	27	0	27
Total		8,047	2,572	575	1,859	511	119	989	898	754	866	1,402	390	**18,982**

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	-124,318	-239,089	-5,456	-31,737	-7,943	-31,255	-16,545	-21,126	-288	-2,921	-66,175	-1,808	-548,660
	Compact Fluorescent Lamps	-1,070,762	-795,394	-48,637	-619,139	-39,363	-87,402	-139,050	-300,194	-5,634	-14,002	-228,141	-13,537	-3,361,256
	Incandescent to Fluorescent Fixtures	-85,068	-15,027	-21,622	-353,740	-5,235	-	-12,642	-7,964	-913	-	-27,131	-2,371	-531,713
	Exit Signs	-662,273	-27,068	-17,294	-178,926	-4,635	-7,854	-91,976	-6,218	-4,397	-3,315	-90,083	-5,046	-1,099,084
	Efficient Ballast Changeouts	-17,060	-4,463	-3,470	-7,380	-290	-	-280	-5	-41	-84	-368	-73	-33,515
	T-8 Lamps and Electronic Ballasts	-5,976,319	-1,318,153	-183,683	-1,735,844	-193,770	-171,185	-570,740	-30,990	-60,010	-75,375	-1,025,676	-61,941	-11,403,687
	Delamp Fluorescent Fixtures	-5,695,935	-441,327	-47,854	-721,997	-37,133	-36,650	-214,917	-39	-46,221	-59,025	-404,028	-30,975	-7,736,102
	High Intensity Discharge	-559,935	-332,142	-2,150	-141,732	-13,210	-	-7,456	-	-68,472	-4,017	-780,049	-61,126	-1,970,290
	Controls	-500,894	-21,464	-28,043	-197,995	-905	-4,348	-23,597	-545	-5,405	-11,789	-40,760	-2,788	-838,533
	Retrofit Express Program Total	-14,692,563	-3,194,128	-358,210	-3,988,491	-302,483	-338,694	-1,077,203	-367,081	-191,381	-170,529	-2,662,412	-179,666	-27,522,840
CEO	Halogen	-1,766	-	-	-	-	-	-	-	-	-3,674	-	-	-5,439
	Compact Fluorescent Lamps	-26,798	-	-	-	-	-	-	-	-	-29,279	-	-	-56,077
	Efficient Ballast Changeouts	-368	-	-	-	-	-	-	-	-	-	-	-	-368
	T-8 Lamps and Electronic Ballasts	-233,856	-	-	-	-	-	-	-	-	-90,463	-	-	-324,319
	Delamp Fluorescent Fixtures	-28,636	-	-	-	-	-	-	-	-	-72	-	-	-28,708
	Controls	-20,713	-	-	-	-	-	-	-	-	-39,358	-	-	-60,071
Customized Efficiency Options Program Total		-312,137	0	0	0	0	0	0	0	0	-162,845	0	0	-474,982
APO	Halogen	-	-	-	-	-	-	-	-	-	-	-24,015	-	-24,015
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-24,754	-	-24,754
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	-48,769	0	-48,769
Total		-15,004,700	-3,194,128	-358,210	-3,988,491	-302,483	-338,694	-1,077,203	-367,081	-191,381	-333,374	-2,711,181	-179,666	**-28,046,591**

4.4 REALIZATION RATES

Exhibits 4-8 through 4-11 present the gross and net realization rates for energy and demand impacts for the RE, CEO, and APO 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.

4.4.1 Gross Realization Rates for Energy Impacts

The gross energy realization rates are presented in Exhibit 4-8. These values represent, by segment, the ratio of the ex post gross impact evaluation findings to the gross ex ante program design estimates. These realization rates illustrate how well the ex ante estimates predicted energy savings, before taking into account customer behavior effects, both inside and outside the rebate programs. These results vary considerably across business type and technology; from 0.40 to 3.08. However, the overall result, 0.89 is reasonably close to one.

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.22	2.14	0.93	0.74	2.03	3.08	1.60	3.08	1.01	1.37	1.17	1.60	1.90
	Compact Fluorescent Lamps	0.90	1.33	0.62	0.65	0.70	1.12	0.68	1.34	0.72	0.64	0.40	0.71	1.04
	Incandescent to Fluorescent Fixtures	1.15	1.41	0.80	0.70	0.79	-	1.10	2.34	0.77	-	0.72	1.02	0.89
	Exit Signs	0.89	1.33	0.62	0.63	0.86	1.38	0.90	1.37	0.81	0.83	0.96	0.82	0.87
	Efficient Ballast Changeouts	0.71	1.16	0.55	0.54	0.60	-	0.66	1.26	0.73	0.56	0.44	0.61	0.69
	T-8 Lamps and Electronic Ballasts	0.84	1.32	0.63	0.61	0.68	1.30	0.75	1.45	0.84	0.63	0.50	0.71	0.82
	Delamp Fluorescent Fixtures	0.92	1.44	0.69	0.68	0.75	1.42	0.82	1.59	0.91	0.70	0.55	0.78	0.89
	High Intensity Discharge	0.98	1.30	0.58	0.57	0.74	1.36	1.05	1.36	0.82	0.77	0.70	0.86	0.86
	Controls	0.92	1.39	0.65	0.65	0.91	1.45	0.93	1.48	0.84	0.84	0.98	0.86	0.85
	Retrofit Express Program Total	0.89	1.38	0.64	0.63	0.71	1.33	0.78	1.41	0.84	0.68	0.57	0.78	0.89
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		1.68	-	-	-	-	-	-	-	-	0.82	-	-	0.95
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		-	-	-	-	-	-	-	-	-	-	2.64	-	2.64
Total		0.90	1.38	0.64	0.63	0.71	1.33	0.78	1.41	0.84	0.74	0.58	0.78	**0.89**

Relative to the 1996 program year evaluation, the gross realization rate for energy has decreased by 18% (the gross energy realization rate was 108% for the 1996 evaluation). There are three factors that have lead to this change:

- The ex ante estimates now include the HVAC interactive effects for the first time. This results in a 10 to 15 percent increase in the savings estimates, which explains most of the difference between the 1996 and 1997 gross realization rate.

- The annual operating hours for the ex ante estimates have changed slightly, resulting in a slight increase in the savings estimates.

- The billing analysis detected less savings. The algorithms for estimating the engineering estimates for the 1997 evaluation are nearly identical to those used in the 1996 evaluation. The resulting program-level SAE coefficient, however, dropped from 96% in 1996 to 92% for this evaluation. This explains another large component of the difference between the 1996 and 1997 gross energy realization rates.

Exhibit 4-8 illustrates, however, that the ex ante estimates are still very close to the ex post impact estimates for RE measures, with the exception of Halogens and efficient ballast changeouts. 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 CEO and APO 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 efficient ballasts 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. Lamp life ranges from 0.3 years up to 1.5 years, depending on the wattage of the halogen and the business type in which it is installed. During field inspections, no evidence of this short measure life was uncovered, nor was it detected in the billing regression analysis. The high realization rates for halogen lamps, however, have only a small effect on the overall lighting end-use realization rate because the energy impact of this technology accounts for less than 3 percent of the lighting program's total.

Efficient Ballast Changeouts – Overall, ex post energy impacts only differ from ex ante energy impacts by 31%. The average SAE coefficient applied to this segment was 82%, accounting for about half of this difference. The other half was attributable to the differences in the ex ante and ex post engineering algorithms, which differed by only 15%. This 15% is not a significant difference, and is due to differences in the operating hours, HVAC interactive effects, and burn-out rates applied to the measure.

The business type results presented in Exhibit 4-8 indicate the most significant differences between ex post and ex ante are within the retail, college, school, restaurant, hotel/motel and community service business types. These results are discussed below.

Retail, Restaurant and Hotel/Motel Types – The SAE coefficient generated for these segments combined was 1.36, 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. The difference between the ex ante and ex post engineering estimates for these segments as a whole is less than 2 percent.

Colleges and Schools – The college and school business types received the lowest SAE coefficient, 61 percent. This SAE coefficient explains why the gross energy realization rates for these business types are all less than one. The difference between the ex ante and ex post engineering estimates for these segments as a whole is less than 4 percent.

Community Services – The community services business type received the lowest gross energy realization rate, 58 percent. This result is being driven partially by the SAE coefficient of 86 percent. The overall unadjusted gross engineering estimate for this business type, however, was 32 percent lower than the ex-ante estimate. This difference is almost entirely explained by the difference in the annual operating hours applied in each methodology. The ex ante estimate assumed 4,800 annual operating hours, versus 2,700 for the ex post engineering estimate.

4.4.2 Gross Realization Rates for Demand Impacts

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

Overall, the gross demand estimates are only 7 percent lower than the ex ante values, as illustrated above. Relative to the 1996 program year evaluation, the gross realization rate for demand has decreased by 26% (the gross demand realization rate was 125% for the 1996 evaluation). There are two primary factors that have lead to this change:

- The ex ante estimates now include the HVAC interactive effects for the first time. This results in a 15 to 20 percent increase in the savings estimates, which explain a large component of the difference between the 1996 and 1997 gross realization rate.

- The coincident diversity factors (CDF) for the ex ante estimates have increased significantly for the largest business types. For example, the CDF for the retail business type increased by 34%. Prior to this year, the CDFs applied in the ex ante estimates were 0.67 for all business types and most technology groups; in 1997 the CDF values range from 0.46 to 0.91. This also contributes a large component of the difference between the 1996 and 1997 gross realization rate.

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	1.42	1.42	1.57	1.05	2.45	2.39	2.00	2.13	1.03	1.84	1.67	1.99	1.53
	Compact Fluorescent Lamps	1.04	0.84	0.97	0.82	0.87	0.79	0.76	0.91	0.76	0.84	0.49	0.86	0.87
	Incandescent to Fluorescent Fixtures	1.47	1.56	1.26	0.75	1.47	-	1.39	1.28	1.29	-	0.92	1.27	0.91
	Exit Signs	1.01	0.96	0.98	0.99	1.01	1.02	1.02	0.92	0.88	0.88	1.08	0.92	1.00
	Efficient Ballast Changeouts	0.78	0.82	1.01	0.79	0.67	-	0.74	0.81	0.68	0.79	0.58	0.79	0.82
	T-8 Lamps and Electronic Ballasts	1.01	0.87	0.99	0.83	0.81	0.93	0.95	1.01	0.88	0.85	0.63	0.87	0.91
	Delamp Fluorescent Fixtures	1.05	0.96	1.15	0.90	0.90	1.07	0.99	1.12	0.91	0.98	0.72	0.99	1.00
	High Intensity Discharge	1.26	1.15	0.39	0.64	1.20	-	1.54	-	1.08	0.96	0.91	1.05	1.03
	Controls	0.51	0.48	0.49	0.51	0.76	0.61	0.55	0.96	0.43	0.46	0.62	0.48	0.50
Retrofit Express Program Total		1.02	0.92	0.97	0.81	0.86	0.95	0.94	0.96	0.94	0.87	0.72	0.94	0.93
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		1.86	-	-	-	-	-	-	-	-	0.98	-	-	1.14
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		-	-	-	-	-	-	-	-	-	-	0.72	-	0.72
Total		1.03	0.92	0.97	0.81	0.86	0.95	0.94	0.96	0.94	0.92	0.72	0.94	**0.93**

The only technologies that differed from ex ante by more than 20 percent were halogens and controls. The only business type result that differs by more than 20 percent was community services, showing a 28 percent difference. Specific comments and justifications for these results are as follows:

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

Controls - The estimated impacts for controls are low because the ex ante assumptions regarding the relationship between energy and coincident demand impacts were not confirmed. As a result, energy impacts were more evenly distributed throughout the year, leading to a relatively lower peak demand impact than that contained in the MDSS.

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

4.4.3 Net Realization Rates

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

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

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

Relative to the 1996 program year evaluation, the net realization rates for energy and demand have decreased by 26% and 35%, respectively (the net energy and demand realization rates were 1`15 and 136% for the 1996 evaluation, respectively). As we have already discussed above, the gross realization rates have decreased by 18 percent and 26 percent, for energy and demand, respectively. The additional decrease in realization rates, compare to the 1996 evaluation, can be explained by the increase in the ex ante's net-to-gross ratio. The net-to-gross ratio increased from 0.77 in 1996 to 0.86 in 1997.

4.5 OVERVIEW OF REALIZATION RATES

The net energy and demand impacts are lower than predicted by the ex ante impact estimates. The net ex post impacts are 15 percent and 12 percent lower than the net ex ante design estimates for energy and demand, respectively. These decreases are almost entirely attributable to changes that have been made in the ex ante algorithms. The following is a summary of the primary differences, and more importantly, why the net realization rates have significantly decreased relative to previous evaluations:

- The ex ante estimates now include the HVAC interactive effects for the first time. This results in a 10 to 20 percent increase in both the energy and demand impact estimates.

- The coincident diversity factors (CDF) for the ex ante estimates have increased significantly for the business types with the largest impacts.

- The annual operating hours for the ex ante estimates have changed slightly, resulting in a small increase in the savings estimates.

- The billing analysis detected less savings. The algorithms for estimating the engineering estimates for the 1997 evaluation are nearly identical to those used in the 1996 evaluation. The resulting program-level SAE coefficient, however, dropped from 96% in 1996 to 92% for this 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	1.15	2.04	0.89	0.51	2.15	3.04	1.51	3.00	0.94	1.35	1.46	1.72	1.84
	Compact Fluorescent Lamps	0.84	1.26	0.60	0.45	0.74	1.10	0.64	1.30	0.67	0.62	0.50	0.77	0.99
	Incandescent to Fluorescent Fixtures	1.08	1.34	0.77	0.48	0.84	-	1.04	2.28	0.71	-	0.90	1.09	0.75
	Exit Signs	0.83	1.27	0.60	0.43	0.91	1.36	0.85	1.33	0.75	0.81	1.20	0.88	0.81
	Efficient Ballast Changeouts	0.66	1.10	0.53	0.37	0.63	-	0.62	1.23	0.68	0.54	0.55	0.66	0.64
	T-8 Lamps and Electronic Ballasts	0.79	1.26	0.61	0.42	0.72	1.28	0.71	1.41	0.78	0.62	0.62	0.76	0.77
	Delamp Fluorescent Fixtures	0.86	1.37	0.67	0.47	0.79	1.40	0.78	1.55	0.85	0.68	0.68	0.83	0.83
	High Intensity Discharge	0.92	1.23	0.56	0.39	0.78	1.34	0.99	1.32	0.77	0.76	0.87	0.92	0.85
	Controls	0.86	1.32	0.62	0.45	0.97	1.43	0.88	1.44	0.78	0.82	1.22	0.92	0.77
	Retrofit Express Program Total	0.83	1.31	0.62	0.43	0.75	1.31	0.74	1.37	0.78	0.67	0.71	0.84	0.85
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		1.81	-	-	-	-	-	-	-	-	0.93	-	-	1.06
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		-	-	-	-	-	-	-	-	-	-	3.77	-	3.77
Total		0.84	1.31	0.62	0.43	0.75	1.31	0.74	1.37	0.78	0.77	0.72	0.84	**0.85**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.33	1.35	1.51	0.72	2.60	2.35	1.89	2.08	0.96	1.80	2.08	2.14	1.47
	Compact Fluorescent Lamps	0.98	0.80	0.94	0.56	0.92	0.77	0.72	0.89	0.71	0.83	0.61	0.92	0.81
	Incandescent to Fluorescent Fixtures	1.38	1.48	1.21	0.52	1.56	-	1.32	1.25	1.20	-	1.14	1.36	0.73
	Exit Signs	0.95	0.91	0.95	0.68	1.06	1.00	0.97	0.90	0.82	0.86	1.34	0.98	0.92
	Efficient Ballast Changeouts	0.73	0.78	0.97	0.54	0.71	-	0.71	0.78	0.63	0.77	0.72	0.85	0.74
	T-8 Lamps and Electronic Ballasts	0.95	0.82	0.96	0.57	0.86	0.92	0.90	0.98	0.82	0.84	0.78	0.93	0.84
	Delamp Fluorescent Fixtures	0.98	0.91	1.11	0.62	0.96	1.05	0.94	1.09	0.85	0.96	0.90	1.06	0.93
	High Intensity Discharge	1.18	1.09	0.37	0.44	1.26	-	1.46	-	1.01	0.95	1.14	1.13	1.03
	Controls	0.47	0.46	0.47	0.35	0.80	0.60	0.52	0.93	0.40	0.45	0.78	0.51	0.45
	Retrofit Express Program Total	0.96	0.88	0.93	0.56	0.92	0.94	0.89	0.93	0.87	0.86	0.89	1.01	0.87
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		2.01	-	-	-	-	-	-	-	-	1.10	-	-	1.27
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		-	-	-	-	-	-	-	-	-	-	1.03	-	1.03
Total		0.97	0.88	0.93	0.56	0.92	0.94	0.89	0.93	0.87	0.96	0.89	1.01	**0.88**

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

Program and Technology Group		Gross Program Impact			NTG Adjustment*		Net Program Impact		
		kWh	kW	Therm	(1-FR)	Spillover	kWh	kW	Therm
EX ANTE									
Retrofit	Halogen	1,666,589	343	-	0.76	0.10	1,433,290	295	-
Express	Compact Fluorescent Lamps	21,140,790	3,923	-	0.76	0.10	18,181,387	3,373	-
	Incandescent to Fluorescent Fixtures	2,047,678	531	-	0.76	0.10	1,761,033	456	-
	Exit Signs	4,278,110	538	-	0.76	0.10	3,679,237	462	-
	Efficient Ballast Changeouts	179,643	38	-	0.76	0.10	154,496	32	-
	T-8 Lamps and Electronic Ballasts	51,614,563	10,638	-	0.76	0.10	44,389,275	9,147	-
	Delamp Fluorescent Fixtures	28,262,824	6,093	-	0.76	0.10	24,306,439	5,239	-
	High Intensity Discharge	11,521,370	1,733	-	0.76	0.10	9,908,546	1,490	-
	Controls	3,236,730	825	-	0.76	0.10	2,783,635	709	-
	Retrofit Express Program Total	123,948,298	24,662	-	0.76	0.10	106,597,338	21,204	-
Customized Efficiency Options Program Total		3,383,318	604	-	0.65	0.10	2,537,531	453	-
Advanced Performance Options Program Total		42,190	34	-	0.65	0.10	31,643	26	-
Total		127,373,806	25,300	-	0.76	0.10	109,166,513	21,683	-
EX POST									
Retrofit	Halogen	3,166,078	525	-665,631	0.79	0.04	2,634,173	434	-548,660
Express	Compact Fluorescent Lamps	22,011,828	3,422	-4,336,391	0.79	0.03	18,023,513	2,733	-3,361,256
	Incandescent to Fluorescent Fixtures	1,818,288	481	-810,234	0.69	0.04	1,318,516	332	-531,713
	Exit Signs	3,704,045	538	-1,412,401	0.75	0.05	2,977,163	426	-1,099,084
	Efficient Ballast Changeouts	124,564	31	-44,567	0.74	0.04	98,112	24	-33,515
	T-8 Lamps and Electronic Ballasts	42,151,130	9,648	-14,530,353	0.75	0.06	34,236,641	7,700	-11,403,687
	Delamp Fluorescent Fixtures	25,067,883	6,094	-9,770,556	0.75	0.05	20,247,394	4,870	-7,736,102
	High Intensity Discharge	9,872,294	1,784	-2,250,928	0.77	0.09	8,466,430	1,539	-1,970,290
	Controls	2,735,302	416	-1,114,699	0.74	0.05	2,145,131	321	-838,533
	Retrofit Express Program Total	110,651,411	22,940	-34,935,761	0.76	0.05	90,147,074	18,380	-27,522,840
CEO	Halogen	58,322	13	-6,548	0.78	0.06	48,975	11	-5,439
	Compact Fluorescent Lamps	499,455	111	-67,965	0.78	0.06	418,268	92	-56,077
	Efficient Ballast Changeouts	1,002	0	-456	0.76	0.05	808	0	-368
	T-8 Lamps and Electronic Ballasts	1,954,274	463	-397,262	0.77	0.06	1,623,938	384	-324,319
	Delamp Fluorescent Fixtures	78,975	20	-35,585	0.76	0.05	63,742	16	-28,708
	Controls	629,732	85	-72,382	0.78	0.06	528,652	71	-60,071
Customized Efficiency Options Program Total		3,221,760	691	-580,199	0.78	0.06	2,684,383	575	-474,982
APO	Halogen	54,779	13	-22,395	0.79	0.28	58,742	14	-24,015
	T-8 Lamps and Electronic Ballasts	56,464	12	-23,083	0.79	0.28	60,549	13	-24,754
Advanced Performance Options Program Total		111,242	25	-45,478	0.79	0.28	119,292	27	-48,769
Total		113,984,414	23,656	-35,561,437	0.76	0.05	92,950,748	18,982	-28,046,591
REALIZATION RATES									
Retrofit	Halogen	1.90	1.53	-	-	-	1.84	1.47	-
Express	Compact Fluorescent Lamps	1.04	0.87	-	-	-	0.99	0.81	-
	Incandescent to Fluorescent Fixtures	0.89	0.91	-	-	-	0.75	0.73	-
	Exit Signs	0.87	1.00	-	-	-	0.81	0.92	-
	Efficient Ballast Changeouts	0.69	0.82	-	-	-	0.64	0.74	-
	T-8 Lamps and Electronic Ballasts	0.82	0.91	-	-	-	0.77	0.84	-
	Delamp Fluorescent Fixtures	0.89	1.00	-	-	-	0.83	0.93	-
	High Intensity Discharge	0.86	1.03	-	-	-	0.85	1.03	-
	Controls	0.85	0.50	-	-	-	0.77	0.45	-
	Retrofit Express Program Total	0.89	0.93	-	-	-	0.85	0.87	-
Customized Efficiency Options Program Total		0.95	1.14	-	-	-	1.06	1.27	-
Advanced Performance Options Program Total		2.64	0.72	-	-	-	3.77	1.03	-
Total		0.89	0.93	-	-	-	0.85	0.88	-

* Weighted by ex-post Gross Energy impact

Attachments

Attachment 1

Waiver

ATTACHMENT 1

**PACIFIC GAS & ELECTRIC COMPANY
REQUEST FOR RETROACTIVE WAIVER FOR
1997 CEEI PROGRAM: LIGHTING END USE
Study ID # 333a**

Date Approved: 6/17/98

Program Background

Pacific Gas & Electric Company's (PG&E's) 1997 Commercial sector lighting end-use DSM programs were designed to promote the installation of energy efficient lighting system retrofits. These programs offered a wide variety of energy efficient prescriptive lighting measures ranging from compact fluorescent lamps to custom non-prescriptive lighting.

The 1997 programs are being evaluated by PG&E, with one of the objectives being to assess the actual load impacts resulting from the lighting measures rebated during 1997.

1997 Program Summary: Indoor Lighting End Use

Technology	Unique Sites	Avoided Cost	Percentage of Avoided Cost
Compact Fluorescent Lamps	1,168	8,194,724	13.9%
Controls	324	1,086,778	1.8%
Customized Lighting	3	1,388,314	2.3%
Delamp Fluorescent Fixtures	613	14,394,387	24.3%
Efficient Ballast Changeouts	74	90,564	0.2%
Exit Signs	677	1,810,353	3.1%
Halogen	156	80,706	0.1%
High Intensity Discharge	334	5,148,037	8.7%
Incandescent to Fluorescent Fixtures	92	1,128,552	1.9%
T-8 lamps and Electronic Ballasts	2,229	25,818,156	43.7%
TOTAL (Unique Sites)	2,796	59,140,572	100.0%

Proposed Waiver

The purpose of this waiver is to state PG&E's interpretation of the Protocols[1] for use in conducting the 1997 Commercial Sector EEI Evaluation of the Lighting End Use (Commercial Lighting Program). PG&E seeks the California DSM Measurement Advisory Committee's (CADMAC's) approval to use the following methods for impact measurement for the 1997 Commercial Lighting Program first year study:

[1] Protocols and Procedures for the Verification of Costs, Benefits, and Shareholder Earnings for Demand-Side Management Programs, as adopted by California Public Utilities Commission Decision 93-05-063, revised January 1997.

1. For the estimation of first year electric energy impacts, a load impact regression model (LIRM) will be performed. In addition, the LIRM will include calibrated engineering estimates of energy savings, based on interim results from the 1994 and 1995 Commercial Lighting Programs to estimate the following parameters: full load hours of operation, coincident diversity factors, HVAC interactive effects, and burned-out lamp rates.

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

Parameters and Protocol Requirements

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

Rationale

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

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

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

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

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

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

- PG&E has worked diligently to improve its load forecasting parameters during these two years of evaluation activities. With regards to generating a mean estimate from two years', PG&E does not believe that adding results from a third year would significantly improve the current load forecasting results.
- The 1997 engineering-based evaluation analysis activities will include the use of 1997 paid year on-site customer records. In particular, analyses will be conducted to assess the accuracy of PG&E Management Decision Support System (MDSS) records surrounding the number of items installed. That is, the engineering evaluation will incorporate premise specific data from on-site audits, but not for determining lighting system operating schedules and operating factors (and thus annual operating hours and coincident diversity factors).
- Analyses will also incorporate a comparison between self-report operating schedules for 1994 and 1995 vs. 1997 participants, in an effort to assess differences in these schedules. If significant differences are observed, then adjustments will be made to the mean annual operating hours and coincident diversity factors.
- These mean forecasting results will be used as priors to an SAE energy impact analysis, which will yield an SAE realization rate, serving to calibrate those results. That is, the analysis approach will still incorporate premise specific information used in deriving lighting program impacts.

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

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

Conclusion

PG&E is seeking a retroactive waiver to clearly define, in advance, acceptable methods for performing the 1997 Commercial Lighting Program evaluation. Recommendations in this waiver are designed to maximize the quality and value of evaluation results. The waiver allowing the use of previous year's evaluation results will allow for the most cost-effective and reliable set of first year load impact estimates.

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Attachment 2

Results Tables

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	276,311	712,985	39,591	103,233	41,108	35,328	57,537	222,110	5,073	30,999	129,176	13,137	1,666,589
	Compact Fluorescent Lamps	3,249,914	3,822,092	525,127	2,301,770	587,727	271,832	1,141,347	7,271,324	139,811	320,680	1,288,531	220,634	21,140,790
	Incandescent to Fluorescent Fixtures	201,632	68,219	182,949	1,216,639	69,453	-	63,887	110,350	21,296	-	86,151	27,104	2,047,678
	Exit Signs	2,034,331	129,668	186,553	692,824	56,614	19,823	569,775	147,156	97,407	58,204	214,249	71,507	4,278,110
	Efficient Ballast Changeouts	65,493	24,570	42,119	33,331	5,104	-	2,368	140	1,000	2,201	1,922	1,395	179,643
	T-8 Lamps and Electronic Ballasts	19,314,427	6,370,899	1,948,647	6,907,156	3,001,673	459,435	4,218,542	691,596	1,282,070	1,731,967	4,671,331	1,016,819	51,614,563
	Delamp Fluorescent Fixtures	16,917,580	1,952,038	466,058	2,573,217	521,593	89,658	1,452,953	800	910,750	1,236,216	1,678,518	463,442	28,262,824
	High Intensity Discharge	1,745,124	1,845,248	631,254	1,403,132	303,030	51,100	60,811	112,355	1,527,786	152,459	2,836,388	852,682	11,521,370
	Controls	1,482,877	98,659	291,462	737,483	10,388	10,467	140,618	11,951	115,326	204,583	95,120	37,797	3,236,730
Retrofit Express Program Total		45,287,689	15,024,378	4,313,761	15,968,787	4,596,690	937,644	7,707,838	8,567,782	4,100,519	3,737,308	11,001,386	2,704,516	123,948,298
CEO	Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Compact Fluorescent Lamps	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Efficient Ballast Changeouts	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	T-8 Lamps and Electronic Ballasts	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Delamp Fluorescent Fixtures	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Efficiency Options Program Total		505,873	0	0	0	0	0	0	0	0	2,877,444	0	0	3,383,318
APO	Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	T-8 Lamps and Electronic Ballasts	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	42,190	0	42,190
Total		45,793,562	15,024,378	4,313,761	15,968,787	4,596,690	937,644	7,707,838	8,567,782	4,100,519	6,614,752	11,043,577	2,704,516	**127,373,806**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	237,631	613,177	34,049	88,782	35,354	30,383	49,483	191,018	4,363	26,659	111,093	11,298	1,433,290
	Compact Fluorescent Lamps	2,794,973	3,287,055	451,617	1,979,556	505,454	233,780	981,575	6,253,444	120,239	275,789	1,108,156	189,749	18,181,387
	Incandescent to Fluorescent Fixtures	173,406	58,669	157,339	1,046,328	59,730	-	54,944	94,903	18,315	-	74,091	23,309	1,761,033
	Exit Signs	1,749,554	111,516	160,438	595,839	48,689	17,048	490,015	126,556	83,772	50,056	184,258	61,497	3,679,237
	Efficient Ballast Changeouts	56,325	21,130	36,223	28,666	4,389	-	2,036	120	860	1,893	1,653	1,200	154,496
	T-8 Lamps and Electronic Ballasts	16,610,688	5,479,066	1,675,865	5,940,255	2,581,483	395,121	3,628,007	594,783	1,102,599	1,489,517	4,017,413	874,479	44,389,275
	Delamp Fluorescent Fixtures	14,549,365	1,678,781	400,817	2,213,004	448,578	77,108	1,249,561	688	783,258	1,063,164	1,443,550	398,567	24,306,439
	High Intensity Discharge	1,500,832	1,586,940	542,888	1,206,714	260,610	43,947	52,298	96,627	1,313,918	131,117	2,439,335	733,319	9,908,546
	Controls	1,275,296	84,848	250,662	634,246	8,934	9,002	120,933	10,278	99,182	175,944	81,805	32,506	2,783,635
Retrofit Express Program Total		38,948,071	12,921,183	3,709,897	13,733,389	3,953,220	806,387	6,628,852	7,368,417	3,526,506	3,214,139	9,461,352	2,325,923	106,597,338
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		379,412	0	0	0	0	0	0	0	0	2,158,120	0	0	2,537,531
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	31,643	0	31,643
Total		39,327,482	12,921,183	3,709,897	13,733,389	3,953,220	806,387	6,628,852	7,368,417	3,526,506	5,372,259	9,492,996	2,325,923	**109,166,513**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	395,177	1,124,574	59,872	125,294	96,985	80,242	106,963	504,099	5,973	49,521	176,313	24,470	2,749,483
	Compact Fluorescent Lamps	3,403,690	3,741,196	533,699	2,444,307	480,624	224,392	898,976	7,163,143	117,039	237,368	607,851	183,211	20,035,495
	Incandescent to Fluorescent Fixtures	270,410	70,680	237,256	1,396,535	63,919	-	81,733	190,025	18,974	-	72,288	32,093	2,433,911
	Exit Signs	2,105,202	127,317	189,763	706,385	56,594	20,164	594,641	148,367	91,335	56,190	240,013	68,299	4,404,268
	Efficient Ballast Changeouts	54,229	20,993	38,080	29,134	3,544	-	1,813	130	844	1,424	982	993	152,166
	T-8 Lamps and Electronic Ballasts	18,997,245	6,200,031	2,015,567	6,852,960	2,365,956	439,495	3,689,916	739,463	1,246,536	1,277,759	2,732,772	838,337	47,396,038
	Delamp Fluorescent Fixtures	18,105,975	2,075,817	525,110	2,850,381	453,394	94,095	1,389,467	937	960,101	1,000,594	1,076,478	419,223	28,951,571
	High Intensity Discharge	1,996,620	1,763,633	595,605	1,312,954	260,029	51,100	74,295	112,355	1,458,269	137,443	2,322,641	849,430	10,934,373
	Controls	1,592,218	100,958	307,714	781,668	11,051	11,163	152,560	12,997	112,277	199,846	108,599	37,731	3,428,782
Retrofit Express Program Total		46,920,765	15,225,200	4,502,664	16,499,619	3,792,096	920,651	6,990,363	8,871,517	4,011,348	2,960,143	7,337,935	2,453,787	120,486,089
CEO	Halogen	5,612	-	-	-	-	-	-	-	-	62,275	-	-	67,887
	Compact Fluorescent Lamps	85,185	-	-	-	-	-	-	-	-	496,329	-	-	581,514
	Efficient Ballast Changeouts	1,170	-	-	-	-	-	-	-	-	-	-	-	1,170
	T-8 Lamps and Electronic Ballasts	743,371	-	-	-	-	-	-	-	-	1,533,530	-	-	2,276,901
	Delamp Fluorescent Fixtures	91,026	-	-	-	-	-	-	-	-	1,217	-	-	92,243
	Controls	65,842	-	-	-	-	-	-	-	-	667,197	-	-	733,039
Customized Efficiency Options Program Total		992,207	0	0	0	0	0	0	0	0	2,760,547	0	0	3,752,754
APO	Halogen	-	-	-	-	-	-	-	-	-	-	63,985	-	63,985
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	65,953	-	65,953
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	129,937	0	129,937
Total		47,912,972	15,225,200	4,502,664	16,499,619	3,792,096	920,651	6,990,363	8,871,517	4,011,348	5,720,691	7,467,872	2,453,787	**124,368,780**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Compact Fluorescent Lamps	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Incandescent to Fluorescent Fixtures	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Exit Signs	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Efficient Ballast Changeouts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	T-8 Lamps and Electronic Ballasts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Delamp Fluorescent Fixtures	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	High Intensity Discharge	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Controls	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
Retrofit Express Program Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CEO	Halogen	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Compact Fluorescent Lamps	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Efficient Ballast Changeouts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	T-8 Lamps and Electronic Ballasts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Delamp Fluorescent Fixtures	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	Controls	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
Customized Efficiency Options Program Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
APO	Halogen	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
	T-8 Lamps and Electronic Ballasts	0.86	1.36	0.61	0.61	0.86	1.36	0.86	1.36	0.86	0.86	0.86	0.86	[illegible]
Advanced Performance Options Program Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.92

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	338,321	1,526,222	36,720	76,844	83,345	108,901	91,920	684,141	5,133	42,556	150,946	21,029	3,166,078
	Compact Fluorescent Lamps	2,913,984	5,077,382	327,325	1,499,128	413,030	304,535	772,545	9,721,495	100,579	203,984	520,396	157,444	22,011,828
	Incandescent to Fluorescent Fixtures	231,504	95,924	145,512	856,515	54,929	-	70,238	257,894	16,305	-	61,887	27,579	1,818,288
	Exit Signs	1,802,316	172,789	116,385	433,236	48,635	27,365	511,011	201,358	78,489	48,287	205,481	58,693	3,704,045
	Efficient Ballast Changeouts	46,426	28,491	23,355	17,868	3,046	-	1,558	176	725	1,224	840	854	124,564
	T-8 Lamps and Electronic Ballasts	16,264,017	8,414,404	1,236,175	4,203,017	2,033,210	596,463	3,170,970	1,003,566	1,071,224	1,098,056	2,339,594	720,434	42,151,130
	Delamp Fluorescent Fixtures	15,500,978	2,817,206	322,057	1,748,179	389,629	127,701	1,194,054	1,272	825,073	859,871	921,599	360,264	25,067,883
	High Intensity Discharge	1,709,356	2,393,523	365,293	805,253	223,459	69,351	63,846	152,483	1,253,179	118,113	1,988,471	729,967	9,872,294
	Controls	1,363,138	137,015	188,725	479,408	9,497	15,150	131,104	17,639	96,487	171,740	92,974	32,424	2,735,302
	Retrofit Express Program Total	40,170,040	20,662,956	2,761,547	10,119,447	3,258,780	1,249,466	6,007,246	12,040,023	3,447,196	2,543,832	6,282,190	2,108,689	110,651,411
CEO	Halogen	4,805	-	-	-	-	-	-	-	-	53,517	-	-	58,322
	Compact Fluorescent Lamps	72,929	-	-	-	-	-	-	-	-	426,526	-	-	499,455
	Efficient Ballast Changeouts	1,002	-	-	-	-	-	-	-	-	-	-	-	1,002
	T-8 Lamps and Electronic Ballasts	636,419	-	-	-	-	-	-	-	-	1,317,855	-	-	1,954,274
	Delamp Fluorescent Fixtures	77,930	-	-	-	-	-	-	-	-	1,046	-	-	78,975
	Controls	56,369	-	-	-	-	-	-	-	-	573,363	-	-	629,732
Customized Efficiency Options Program Total		849,453	0	0	0	0	0	0	0	0	2,372,307	0	0	3,221,760
APO	Halogen	-	-	-	-	-	-	-	-	-	-	54,779	-	54,779
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	56,464	-	56,464
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	111,242	0	111,242
Total		41,019,493	20,662,956	2,761,547	10,119,447	3,258,780	1,249,466	6,007,246	12,040,023	3,447,196	4,916,139	6,393,432	2,108,689	**113,984,414**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.22	2.14	0.93	0.74	2.03	3.08	1.60	3.08	1.01	1.37	1.17	1.60	1.90
	Compact Fluorescent Lamps	0.90	1.33	0.62	0.65	0.70	1.12	0.68	1.34	0.72	0.64	0.40	0.71	1.04
	Incandescent to Fluorescent Fixtures	1.15	1.41	0.80	0.70	0.79	-	1.10	2.34	0.77	-	0.72	1.02	0.89
	Exit Signs	0.89	1.33	0.62	0.63	0.86	1.38	0.90	1.37	0.81	0.83	0.96	0.82	0.87
	Efficient Ballast Changeouts	0.71	1.16	0.55	0.54	0.60	-	0.66	1.26	0.73	0.56	0.44	0.61	0.69
	T-8 Lamps and Electronic Ballasts	0.84	1.32	0.63	0.61	0.68	1.30	0.75	1.45	0.84	0.63	0.50	0.71	0.82
	Delamp Fluorescent Fixtures	0.92	1.44	0.69	0.68	0.75	1.42	0.82	1.59	0.91	0.70	0.55	0.78	0.89
	High Intensity Discharge	0.98	1.30	0.58	0.57	0.74	1.36	1.05	1.36	0.82	0.77	0.70	0.86	0.86
	Controls	0.92	1.39	0.65	0.65	0.91	1.45	0.93	1.48	0.84	0.84	0.98	0.86	0.85
	Retrofit Express Program Total	0.89	1.38	0.64	0.63	0.71	1.33	0.78	1.41	0.84	0.68	0.57	0.78	0.89
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		1.68	-	-	-	-	-	-	-	-	0.82	-	-	0.95
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		-	-	-	-	-	-	-	-	-	-	2.64	-	2.64
Total		0.90	1.38	0.64	0.63	0.71	1.33	0.78	1.41	0.84	0.74	0.58	0.78	**0.89**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Compact Fluorescent Lamps	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Incandescent to Fluorescent Fixtures	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Exit Signs	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Efficient Ballast Changeouts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	T-8 Lamps and Electronic Ballasts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Delamp Fluorescent Fixtures	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	High Intensity Discharge	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Controls	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
Retrofit Express Program Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
CEO	Halogen	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Compact Fluorescent Lamps	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Efficient Ballast Changeouts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	T-8 Lamps and Electronic Ballasts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Delamp Fluorescent Fixtures	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	Controls	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
Customized Efficiency Options Program Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
APO	Halogen	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
	T-8 Lamps and Electronic Ballasts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	
Advanced Performance Options Program Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	272,902	1,248,004	30,422	45,266	75,843	92,212	74,830	573,422	4,119	35,863	161,868	19,422	2,634,173
	Compact Fluorescent Lamps	2,350,529	4,151,818	271,181	883,086	375,853	257,864	628,915	8,148,203	80,700	171,901	558,050	145,412	18,023,513
	Incandescent to Fluorescent Fixtures	186,740	78,438	120,553	504,544	49,985	-	57,179	216,157	13,083	-	66,365	25,471	1,318,516
	Exit Signs	1,453,816	141,291	96,422	255,204	44,257	23,172	416,005	168,771	62,977	40,692	220,349	54,208	2,977,163
	Efficient Ballast Changeouts	37,449	23,297	19,349	10,526	2,772	-	1,269	148	582	1,031	901	789	98,112
	T-8 Lamps and Electronic Ballasts	13,119,169	6,880,528	1,024,142	2,475,855	1,850,201	505,054	2,581,431	841,152	859,505	925,350	2,508,877	665,375	34,236,641
	Delamp Fluorescent Fixtures	12,503,673	2,303,653	266,817	1,029,793	354,559	108,131	972,058	1,066	662,004	724,628	988,282	332,731	20,247,394
	High Intensity Discharge	1,378,831	1,957,204	302,636	474,348	203,345	58,723	51,976	127,806	1,005,498	99,536	2,132,348	674,180	8,466,430
	Controls	1,099,558	112,039	156,354	282,403	8,642	12,828	106,729	14,784	77,417	144,728	99,702	29,946	2,145,131
Retrofit Express Program Total		32,402,668	16,896,272	2,287,876	5,961,024	2,965,458	1,057,984	4,890,393	10,091,509	2,765,885	2,143,729	6,736,742	1,947,533	90,147,074
CEO	Halogen	3,876	-	-	-	-	-	-	-	-	45,099	-	-	48,975
	Compact Fluorescent Lamps	58,828	-	-	-	-	-	-	-	-	359,440	-	-	418,268
	Efficient Ballast Changeouts	808	-	-	-	-	-	-	-	-	-	-	-	808
	T-8 Lamps and Electronic Ballasts	513,359	-	-	-	-	-	-	-	-	1,110,579	-	-	1,623,938
	Delamp Fluorescent Fixtures	62,861	-	-	-	-	-	-	-	-	881	-	-	63,742
	Controls	45,469	-	-	-	-	-	-	-	-	483,182	-	-	528,652
Customized Efficiency Options Program Total		685,201	0	0	0	0	0	0	0	0	1,999,182	0	0	2,684,383
APO	Halogen	-	-	-	-	-	-	-	-	-	-	58,742	-	58,742
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	60,549	-	60,549
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	119,292	0	119,292
Total		33,087,868	16,896,272	2,287,876	5,961,024	2,965,458	1,057,984	4,890,393	10,091,509	2,765,885	4,142,912	6,856,034	1,947,533	**92,950,748**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.15	2.04	0.89	0.51	2.15	3.04	1.51	3.00	0.94	1.35	1.46	1.72	1.84
	Compact Fluorescent Lamps	0.84	1.26	0.60	0.45	0.74	1.10	0.64	1.30	0.67	0.62	0.50	0.77	0.99
	Incandescent to Fluorescent Fixtures	1.08	1.34	0.77	0.48	0.84	-	1.04	2.28	0.71	-	0.90	1.09	0.75
	Exit Signs	0.83	1.27	0.60	0.43	0.91	1.36	0.85	1.33	0.75	0.81	1.20	0.88	0.81
	Efficient Ballast Changeouts	0.66	1.10	0.53	0.37	0.63	-	0.62	1.23	0.68	0.54	0.55	0.66	0.64
	T-8 Lamps and Electronic Ballasts	0.79	1.26	0.61	0.42	0.72	1.28	0.71	1.41	0.78	0.62	0.62	0.76	0.77
	Delamp Fluorescent Fixtures	0.86	1.37	0.67	0.47	0.79	1.40	0.78	1.55	0.85	0.68	0.68	0.83	0.83
	High Intensity Discharge	0.92	1.23	0.56	0.39	0.78	1.34	0.99	1.32	0.77	0.76	0.87	0.92	0.85
	Controls	0.86	1.32	0.62	0.45	0.97	1.43	0.88	1.44	0.78	0.82	1.22	0.92	0.77
Retrofit Express Program Total		0.83	1.31	0.62	0.43	0.75	1.31	0.74	1.37	0.78	0.67	0.71	0.84	0.85
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		1.81	-	-	-	-	-	-	-	-	0.93	-	-	1.06
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		-	-	-	-	-	-	-	-	-	-	3.77	-	3.77
Total		0.84	1.31	0.62	0.43	0.75	1.31	0.74	1.37	0.78	0.77	0.72	0.84	**0.85**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	61	168	7	27	6	6	10	29	1	5	21	2	343
	Compact Fluorescent Lamps	706	896	97	604	82	44	199	960	37	52	210	36	3,923
	Incandescent to Fluorescent Fixtures	40	10	35	388	7	-	11	18	4	-	14	5	531
	Exit Signs	256	16	23	87	7	2	72	18	12	7	27	9	538
	Efficient Ballast Changeouts	15	5	7	8	1	-	0	0	0	0	0	0	38
	T-8 Lamps and Electronic Ballasts	4,075	1,537	377	1,723	447	78	705	91	343	294	794	173	10,638
	Delamp Fluorescent Fixtures	3,734	463	85	660	77	15	256	0	253	201	274	76	6,093
	High Intensity Discharge	313	288	11	190	21	-	6	-	323	14	431	137	1,733
	Controls	384	26	76	188	2	2	34	2	31	50	21	9	825
Retrofit Express Program Total		9,584	3,408	719	3,875	649	147	1,292	1,118	1,005	624	1,792	447	24,662
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		112	0	0	0	0	0	0	0	0	493	0	0	604
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	34	0	34
Total		9,695	3,408	719	3,875	649	147	1,292	1,118	1,005	1,117	1,827	447	**25,300**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	52	145	6	23	5	5	9	25	1	4	18	2	295
	Compact Fluorescent Lamps	607	770	83	520	70	38	171	825	31	45	181	31	3,373
	Incandescent to Fluorescent Fixtures	34	8	30	334	6	-	9	16	3	-	12	4	456
	Exit Signs	220	14	20	75	6	2	61	16	11	6	23	8	462
	Efficient Ballast Changeouts	13	5	6	7	1	-	0	0	0	0	0	0	32
	T-8 Lamps and Electronic Ballasts	3,504	1,321	324	1,482	384	67	606	78	295	253	682	149	9,147
	Delamp Fluorescent Fixtures	3,211	398	73	567	66	13	220	0	218	173	235	65	5,239
	High Intensity Discharge	269	247	10	163	18	-	5	-	278	12	370	118	1,490
	Controls	330	22	66	162	2	2	29	1	27	43	18	8	709
Retrofit Express Program Total		8,240	2,931	618	3,332	558	126	1,111	962	864	537	1,541	385	21,204
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		84	0	0	0	0	0	0	0	0	369	0	0	453
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	26	0	26
Total		8,324	2,931	618	3,332	558	126	1,111	962	864	906	1,567	385	**21,683**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	86	238	11	28	15	14	20	61	1	9	35	4	525
	Compact Fluorescent Lamps	737	754	94	497	71	34	152	876	28	44	104	31	3,422
	Incandescent to Fluorescent Fixtures	59	15	44	292	10	-	15	24	5	-	13	6	481
	Exit Signs	258	16	23	87	7	3	73	17	11	6	29	8	538
	Efficient Ballast Changeouts	12	5	7	6	1	-	0	0	0	0	0	0	31
	T-8 Lamps and Electronic Ballasts	4,110	1,329	375	1,432	362	73	673	92	301	252	499	150	9,648
	Delamp Fluorescent Fixtures	3,917	445	98	596	69	16	253	0	232	197	197	75	6,094
	High Intensity Discharge	394	331	4	122	25	-	9	-	349	13	393	144	1,784
	Controls	194	12	37	95	1	1	19	1	13	23	13	5	416
Retrofit Express Program Total		9,768	3,146	694	3,155	561	140	1,214	1,072	939	545	1,283	423	22,940
CEO	Halogen	1	-	-	-	-	-	-	-	-	12	-	-	13
	Compact Fluorescent Lamps	18	-	-	-	-	-	-	-	-	92	-	-	111
	Efficient Ballast Changeouts	0	-	-	-	-	-	-	-	-	-	-	-	0
	T-8 Lamps and Electronic Ballasts	161	-	-	-	-	-	-	-	-	302	-	-	463
	Delamp Fluorescent Fixtures	20	-	-	-	-	-	-	-	-	0	-	-	20
	Controls	8	-	-	-	-	-	-	-	-	77	-	-	85
Customized Efficiency Options Program Total		208	0	0	0	0	0	0	0	0	483	0	0	691
APO	Halogen	-	-	-	-	-	-	-	-	-	-	13	-	13
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	12	-	12
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	25	0	25
Total		9,976	3,146	694	3,155	561	140	1,214	1,072	939	1,028	1,308	423	**23,656**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	86	238	11	28	15	14	20	61	1	9	35	4	525
	Compact Fluorescent Lamps	737	754	94	497	71	34	152	876	28	44	104	31	3,422
	Incandescent to Fluorescent Fixtures	59	15	44	292	10	-	15	24	5	-	13	6	481
	Exit Signs	258	16	23	87	7	3	73	17	11	6	29	8	538
	Efficient Ballast Changeouts	12	5	7	6	1	-	0	0	0	0	0	0	31
	T-8 Lamps and Electronic Ballasts	4,110	1,329	375	1,432	362	73	673	92	301	252	499	150	9,648
	Delamp Fluorescent Fixtures	3,917	445	98	596	69	16	253	0	232	197	197	75	6,094
	High Intensity Discharge	394	331	4	122	25	-	9	-	349	13	393	144	1,784
	Controls	194	12	37	95	1	1	19	1	13	23	13	5	416
Retrofit Express Program Total		9,768	3,146	694	3,155	561	140	1,214	1,072	939	545	1,283	423	22,940
CEO	Halogen	1	-	-	-	-	-	-	-	-	12	-	-	13
	Compact Fluorescent Lamps	18	-	-	-	-	-	-	-	-	92	-	-	111
	Efficient Ballast Changeouts	0	-	-	-	-	-	-	-	-	-	-	-	0
	T-8 Lamps and Electronic Ballasts	161	-	-	-	-	-	-	-	-	302	-	-	463
	Delamp Fluorescent Fixtures	20	-	-	-	-	-	-	-	-	0	-	-	20
	Controls	8	-	-	-	-	-	-	-	-	77	-	-	85
Customized Efficiency Options Program Total		208	0	0	0	0	0	0	0	0	483	0	0	691
APO	Halogen	-	-	-	-	-	-	-	-	-	-	13	-	13
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	12	-	12
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	25	0	25
Total		9,976	3,146	694	3,155	561	140	1,214	1,072	939	1,028	1,308	423	**23,656**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.42	1.42	1.57	1.05	2.45	2.39	2.00	2.13	1.03	1.84	1.67	1.99	1.53
	Compact Fluorescent Lamps	1.04	0.84	0.97	0.82	0.87	0.79	0.76	0.91	0.76	0.84	0.49	0.86	0.87
	Incandescent to Fluorescent Fixtures	1.47	1.56	1.26	0.75	1.47	-	1.39	1.28	1.29	-	0.92	1.27	0.91
	Exit Signs	1.01	0.96	0.98	0.99	1.01	1.02	1.02	0.92	0.88	0.88	1.08	0.92	1.00
	Efficient Ballast Changeouts	0.78	0.82	1.01	0.79	0.67	-	0.74	0.81	0.68	0.79	0.58	0.79	0.82
	T-8 Lamps and Electronic Ballasts	1.01	0.87	0.99	0.83	0.81	0.93	0.95	1.01	0.88	0.85	0.63	0.87	0.91
	Delamp Fluorescent Fixtures	1.05	0.96	1.15	0.90	0.90	1.07	0.99	1.12	0.91	0.98	0.72	0.99	1.00
	High Intensity Discharge	1.26	1.15	0.39	0.64	1.20	-	1.54	-	1.08	0.96	0.91	1.05	1.03
	Controls	0.51	0.48	0.49	0.51	0.76	0.61	0.55	0.96	0.43	0.46	0.62	0.48	0.50
Retrofit Express Program Total		1.02	0.92	0.97	0.81	0.86	0.95	0.94	0.96	0.94	0.87	0.72	0.94	0.93
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		1.86	-	-	-	-	-	-	-	-	0.98	-	-	1.14
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		-	-	-	-	-	-	-	-	-	-	0.72	-	0.72
Total		1.03	0.92	0.97	0.81	0.86	0.95	0.94	0.96	0.94	0.92	0.72	0.94	**0.93**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Compact Fluorescent Lamps	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Incandescent to Fluorescent Fixtures	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Exit Signs	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Efficient Ballast Changeouts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	T-8 Lamps and Electronic Ballasts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Delamp Fluorescent Fixtures	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	High Intensity Discharge	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Controls	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
Retrofit Express Program Total		0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	[illegible]	[illegible]	0.92	[illegible]
CEO	Halogen	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Compact Fluorescent Lamps	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Efficient Ballast Changeouts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	T-8 Lamps and Electronic Ballasts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Delamp Fluorescent Fixtures	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Controls	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
Customized Efficiency Options Program Total		0.81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
APO	Halogen	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	T-8 Lamps and Electronic Ballasts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
Advanced Performance Options Program Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total		0.81	[illegible]	0.83	0.59	0.91	0.85	[illegible]	0.84	0.80	0.84	[illegible]	0.92	[illegible]

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	70	195	9	16	14	11	16	51	1	8	38	4	434
	Compact Fluorescent Lamps	594	616	78	293	65	29	124	734	22	37	111	29	2,733
	Incandescent to Fluorescent Fixtures	47	12	37	172	9	-	12	20	4	-	14	5	332
	Exit Signs	208	13	19	51	7	2	59	14	9	5	31	8	426
	Efficient Ballast Changeouts	9	4	6	4	0	-	0	0	0	0	0	0	24
	T-8 Lamps and Electronic Ballasts	3,315	1,087	311	843	330	62	548	77	241	212	535	139	7,700
	Delamp Fluorescent Fixtures	3,160	364	81	351	63	13	206	0	186	166	211	69	4,870
	High Intensity Discharge	318	271	4	72	23	-	7	-	280	11	421	133	1,539
	Controls	157	10	31	56	1	1	15	1	11	19	14	4	321
Retrofit Express Program Total		7,879	2,572	575	1,859	511	119	989	898	754	459	1,376	390	18,380
CEO	Halogen	1	-	-	-	-	-	-	-	-	10	-	-	11
	Compact Fluorescent Lamps	15	-	-	-	-	-	-	-	-	78	-	-	92
	Efficient Ballast Changeouts	0	-	-	-	-	-	-	-	-	-	-	-	0
	T-8 Lamps and Electronic Ballasts	130	-	-	-	-	-	-	-	-	255	-	-	384
	Delamp Fluorescent Fixtures	16	-	-	-	-	-	-	-	-	0	-	-	16
	Controls	6	-	-	-	-	-	-	-	-	65	-	-	71
Customized Efficiency Options Program Total		168	0	0	0	0	0	0	0	0	407	0	0	575
APO	Halogen	-	-	-	-	-	-	-	-	-	-	14	-	14
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	13	-	13
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	27	0	27
Total		8,047	2,572	575	1,859	511	119	989	898	754	866	1,402	390	**18,982**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	1.33	1.35	1.51	0.72	2.60	2.35	1.89	2.08	0.96	1.80	2.08	2.14	1.47
	Compact Fluorescent Lamps	0.98	0.80	0.94	0.56	0.92	0.77	0.72	0.89	0.71	0.83	0.61	0.92	0.81
	Incandescent to Fluorescent Fixtures	1.38	1.48	1.21	0.52	1.56	-	1.32	1.25	1.20	-	1.14	1.36	0.73
	Exit Signs	0.95	0.91	0.95	0.68	1.06	1.00	0.97	0.90	0.82	0.86	1.34	0.98	0.92
	Efficient Ballast Changeouts	0.73	0.78	0.97	0.54	0.71	-	0.71	0.78	0.63	0.77	0.72	0.85	0.74
	T-8 Lamps and Electronic Ballasts	0.95	0.82	0.96	0.57	0.86	0.92	0.90	0.98	0.82	0.84	0.78	0.93	0.84
	Delamp Fluorescent Fixtures	0.98	0.91	1.11	0.62	0.96	1.05	0.94	1.09	0.85	0.96	0.90	1.06	0.93
	High Intensity Discharge	1.18	1.09	0.37	0.44	1.26	-	1.46	-	1.01	0.95	1.14	1.13	1.03
	Controls	0.47	0.46	0.47	0.35	0.80	0.60	0.52	0.93	0.40	0.45	0.78	0.51	0.45
Retrofit Express Program Total		0.96	0.88	0.93	0.56	0.92	0.94	0.89	0.93	0.87	0.86	0.89	1.01	0.87
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		2.01	-	-	-	-	-	-	-	-	1.10	-	-	1.27
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		-	-	-	-	-	-	-	-	-	-	1.03	-	1.03
Total		0.97	0.88	0.93	0.56	0.92	0.94	0.89	0.93	0.87	0.96	0.89	1.01	**0.88**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-	-	-	-	-	-	-	-	-	-	-	-	0
	Compact Fluorescent Lamps	-	-	-	-	-	-	-	-	-	-	-	-	0
	Incandescent to Fluorescent Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	0
	Exit Signs	-	-	-	-	-	-	-	-	-	-	-	-	0
	Efficient Ballast Changeouts	-	-	-	-	-	-	-	-	-	-	-	-	0
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-	-	0
	Delamp Fluorescent Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	0
	High Intensity Discharge	-	-	-	-	-	-	-	-	-	-	-	-	0
	Controls	-	-	-	-	-	-	-	-	-	-	-	-	0
Retrofit Express Program Total		0	0	0	0	0	0	0	0	0	0	0	0	0
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		0	0	0	0	0	0	0	0	0	0	0	0	0
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	0	0	0	0	0	0	0	0	**0**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-	-	-	-	-	-	-	-	-	-	-	-	0
	Compact Fluorescent Lamps	-	-	-	-	-	-	-	-	-	-	-	-	0
	Incandescent to Fluorescent Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	0
	Exit Signs	-	-	-	-	-	-	-	-	-	-	-	-	0
	Efficient Ballast Changeouts	-	-	-	-	-	-	-	-	-	-	-	-	0
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-	-	0
	Delamp Fluorescent Fixtures	-	-	-	-	-	-	-	-	-	-	-	-	0
	High Intensity Discharge	-	-	-	-	-	-	-	-	-	-	-	-	0
	Controls	-	-	-	-	-	-	-	-	-	-	-	-	0
Retrofit Express Program Total		0	0	0	0	0	0	0	0	0	0	0	0	0
CEO	Halogen													
	Compact Fluorescent Lamps													
	Efficient Ballast Changeouts													
	T-8 Lamps and Electronic Ballasts													
	Delamp Fluorescent Fixtures													
	Controls													
Customized Efficiency Options Program Total		0	0	0	0	0	0	0	0	0	0	0	0	0
APO	Halogen													
	T-8 Lamps and Electronic Ballasts													
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	0	0	0
Total		0	0	0	0	0	0	0	0	0	0	0	0	**0**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-154,119	-292,389	-6,586	-53,876	-8,729	-36,912	-20,323	-25,205	-358	-3,466	-61,710	-1,958	-665,631
	Compact Fluorescent Lamps	-1,327,439	-972,711	-58,707	-1,051,052	-43,256	-103,220	-170,805	-358,157	-7,022	-16,616	-212,748	-14,657	-4,336,391
	Incandescent to Fluorescent Fixtures	-105,460	-18,377	-26,098	-600,510	-5,753	-	-15,529	-9,501	-1,138	-	-25,301	-2,567	-810,234
	Exit Signs	-821,029	-33,103	-20,874	-303,745	-5,093	-9,275	-112,982	-7,418	-5,480	-3,933	-84,004	-5,464	-1,412,401
	Efficient Ballast Changeouts	-21,149	-5,458	-4,189	-12,528	-319	-	-345	-6	-51	-100	-344	-79	-44,567
	T-8 Lamps and Electronic Ballasts	-7,408,926	-1,612,008	-221,712	-2,946,773	-212,936	-202,168	-701,084	-36,973	-74,792	-89,443	-956,470	-67,067	-14,530,353
	Delamp Fluorescent Fixtures	-7,061,330	-539,712	-57,762	-1,225,664	-40,805	-43,284	-263,999	-47	-57,606	-70,042	-376,767	-33,538	-9,770,556
	High Intensity Discharge	-694,159	-406,187	-2,596	-240,605	-14,517	-	-9,159	-	-85,339	-4,767	-727,416	-66,184	-2,250,928
	Controls	-620,965	-26,249	-33,848	-336,117	-995	-5,135	-28,986	-650	-6,737	-13,989	-38,010	-3,018	-1,114,699
Retrofit Express Program Total		-18,214,575	-3,906,194	-432,372	-6,770,871	-332,403	-399,994	-1,323,212	-437,958	-238,523	-202,356	-2,482,770	-194,533	-34,935,761
CEO	Halogen	-2,189	-	-	-	-	-	-	-	-	-4,359	-	-	-6,548
	Compact Fluorescent Lamps	-33,222	-	-	-	-	-	-	-	-	-34,743	-	-	-67,965
	Efficient Ballast Changeouts	-456	-	-	-	-	-	-	-	-	-	-	-	-456
	T-8 Lamps and Electronic Ballasts	-289,915	-	-	-	-	-	-	-	-	-107,347	-	-	-397,262
	Delamp Fluorescent Fixtures	-35,500	-	-	-	-	-	-	-	-	-85	-	-	-35,585
	Controls	-25,678	-	-	-	-	-	-	-	-	-46,704	-	-	-72,382
Customized Efficiency Options Program Total		-386,961	0	0	0	0	0	0	0	0	-193,238	0	0	-580,199
APO	Halogen	-	-	-	-	-	-	-	-	-	-	-22,395	-	-22,395
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-23,083	-	-23,083
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	-45,478	0	-45,478
Total		-18,601,536	-3,906,194	-432,372	-6,770,871	-332,403	-399,994	-1,323,212	-437,958	-238,523	-395,595	-2,528,248	-194,533	**-35,561,437**

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-154,119	-292,389	-6,586	-53,876	-8,729	-36,912	-20,323	-25,205	-358	-3,466	-61,710	-1,958	-665,631
	Compact Fluorescent Lamps	-1,327,439	-972,711	-58,707	-1,051,052	-43,256	-103,220	-170,805	-358,157	-7,022	-16,616	-212,748	-14,657	-4,336,391
	Incandescent to Fluorescent Fixtures	-105,460	-18,377	-26,098	-600,510	-5,753	-	-15,529	-9,501	-1,138	-	-25,301	-2,567	-810,234
	Exit Signs	-821,029	-33,103	-20,874	-303,745	-5,093	-9,275	-112,982	-7,418	-5,480	-3,933	-84,004	-5,464	-1,412,401
	Efficient Ballast Changeouts	-21,149	-5,458	-4,189	-12,528	-319	-	-345	-6	-51	-100	-344	-79	-44,567
	T-8 Lamps and Electronic Ballasts	-7,408,926	-1,612,008	-221,712	-2,946,773	-212,936	-202,168	-701,084	-36,973	-74,792	-89,443	-956,470	-67,067	-14,530,353
	Delamp Fluorescent Fixtures	-7,061,330	-539,712	-57,762	-1,225,664	-40,805	-43,284	-263,999	-47	-57,606	-70,042	-376,767	-33,538	-9,770,556
	High Intensity Discharge	-694,159	-406,187	-2,596	-240,605	-14,517	-	-9,159	-	-85,339	-4,767	-727,416	-66,184	-2,250,928
	Controls	-620,965	-26,249	-33,848	-336,117	-995	-5,135	-28,986	-650	-6,737	-13,989	-38,010	-3,018	-1,114,699
Retrofit Express Program Total		-18,214,575	-3,906,194	-432,372	-6,770,871	-332,403	-399,994	-1,323,212	-437,958	-238,523	-202,356	-2,482,770	-194,533	-34,935,761
CEO	Halogen	-2,189	-	-	-	-	-	-	-	-	-4,359	-	-	-6,548
	Compact Fluorescent Lamps	-33,222	-	-	-	-	-	-	-	-	-34,743	-	-	-67,965
	Efficient Ballast Changeouts	-456	-	-	-	-	-	-	-	-	-	-	-	-456
	T-8 Lamps and Electronic Ballasts	-289,915	-	-	-	-	-	-	-	-	-107,347	-	-	-397,262
	Delamp Fluorescent Fixtures	-35,500	-	-	-	-	-	-	-	-	-85	-	-	-35,585
	Controls	-25,678	-	-	-	-	-	-	-	-	-46,704	-	-	-72,382
Customized Efficiency Options Program Total		-386,961	0	0	0	0	0	0	0	0	-193,238	0	0	-580,199
APO	Halogen	-	-	-	-	-	-	-	-	-	-	-22,395	-	-22,395
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-23,083	-	-23,083
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	-45,478	0	-45,478
Total		-18,601,536	-3,906,194	-432,372	-6,770,871	-332,403	-399,994	-1,323,212	-437,958	-238,523	-395,595	-2,528,248	-194,533	**-35,561,437**

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

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

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Compact Fluorescent Lamps	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Incandescent to Fluorescent Fixtures	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Exit Signs	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Efficient Ballast Changeouts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	T-8 Lamps and Electronic Ballasts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Delamp Fluorescent Fixtures	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	High Intensity Discharge	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Controls	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
Retrofit Express Program Total		0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
CEO	Halogen	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Compact Fluorescent Lamps	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Efficient Ballast Changeouts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	T-8 Lamps and Electronic Ballasts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Delamp Fluorescent Fixtures	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	Controls	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
Customized Efficiency Options Program Total		0.81	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.84	[illegible]	[illegible]	[illegible]
APO	Halogen	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
	T-8 Lamps and Electronic Ballasts	0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	1.07	0.92	[illegible]
Advanced Performance Options Program Total		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total		0.81	0.82	0.83	0.59	0.91	0.85	0.81	0.84	0.80	0.84	[illegible]	[illegible]	[illegible]

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

Program and Technology Group		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Svcs.	Comm. Svcs.	Misc.	Total
Retrofit Express	Halogen	-124,318	-239,089	-5,456	-31,737	-7,943	-31,255	-16,545	-21,126	-288	-2,921	-66,175	-1,808	-548,660
	Compact Fluorescent Lamps	-1,070,762	-795,394	-48,637	-619,139	-39,363	-87,402	-139,050	-300,194	-5,634	-14,002	-228,141	-13,537	-3,361,256
	Incandescent to Fluorescent Fixtures	-85,068	-15,027	-21,622	-353,740	-5,235	-	-12,642	-7,964	-913	-	-27,131	-2,371	-531,713
	Exit Signs	-662,273	-27,068	-17,294	-178,926	-4,635	-7,854	-91,976	-6,218	-4,397	-3,315	-90,083	-5,046	-1,099,084
	Efficient Ballast Changeouts	-17,060	-4,463	-3,470	-7,380	-290	-	-280	-5	-41	-84	-368	-73	-33,515
	T-8 Lamps and Electronic Ballasts	-5,976,319	-1,318,153	-183,683	-1,735,844	-193,770	-171,185	-570,740	-30,990	-60,010	-75,375	-1,025,676	-61,941	-11,403,687
	Delamp Fluorescent Fixtures	-5,695,935	-441,327	-47,854	-721,997	-37,133	-36,650	-214,917	-39	-46,221	-59,025	-404,028	-30,975	-7,736,102
	High Intensity Discharge	-559,935	-332,142	-2,150	-141,732	-13,210	-	-7,456	-	-68,472	-4,017	-780,049	-61,126	-1,970,290
	Controls	-500,894	-21,464	-28,043	-197,995	-905	-4,348	-23,597	-545	-5,405	-11,789	-40,760	-2,788	-838,533
Retrofit Express Program Total		-14,692,563	-3,194,128	-358,210	-3,988,491	-302,483	-338,694	-1,077,203	-367,081	-191,381	-170,529	-2,662,412	-179,666	-27,522,840
CEO	Halogen	-1,766	-	-	-	-	-	-	-	-	-3,674	-	-	-5,439
	Compact Fluorescent Lamps	-26,798	-	-	-	-	-	-	-	-	-29,279	-	-	-56,077
	Efficient Ballast Changeouts	-368	-	-	-	-	-	-	-	-	-	-	-	-368
	T-8 Lamps and Electronic Ballasts	-233,856	-	-	-	-	-	-	-	-	-90,463	-	-	-324,319
	Delamp Fluorescent Fixtures	-28,636	-	-	-	-	-	-	-	-	-72	-	-	-28,708
	Controls	-20,713	-	-	-	-	-	-	-	-	-39,358	-	-	-60,071
Customized Efficiency Options Program Total		-312,137	0	0	0	0	0	0	0	0	-162,845	0	0	-474,982
APO	Halogen	-	-	-	-	-	-	-	-	-	-	-24,015	-	-24,015
	T-8 Lamps and Electronic Ballasts	-	-	-	-	-	-	-	-	-	-	-24,754	-	-24,754
Advanced Performance Options Program Total		0	0	0	0	0	0	0	0	0	0	-48,769	0	-48,769
Total		-15,004,700	-3,194,128	-358,210	-3,988,491	-302,483	-338,694	-1,077,203	-367,081	-191,381	-333,374	-2,711,181	-179,666	**-28,046,591**

Attachment 2-25

Commercial Indoor Lighting Net Therm Impact Realization Rates

By Business Type and Technology Group

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

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

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

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

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

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

Attachment 3

Protocol Tables 6 and 7

PROTOCOL TABLES 6 AND 7

1997 COMMERCIAL EEI PROGRAM
EVALUATION OF LIGHTING TECHNOLOGIES

PG&E STUDY ID #333A

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

Table 6 Assumptions

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

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

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

Protocol Table 6
Items 1-5
PG&E Lighting Study ID #333A

Table Item			Relative Precision	
Item Number	Description	Estimate	90% Confidence	80% Confidence
1.A†	Pre-installation usage, Base usage, and Base usage per designated unit of measurement.	N/A	N/A	N/A
1.B†	Impact Year usage, Impact year usage per designated unit of measurement.	N/A	N/A	N/A
2.A	Gross Peak kW (Demand) Impacts	23,656	53%	42%
	Gross kWh (Energy) Impacts	113,984,414	31%	24%
	Gross thm (Therm) Impacts	-35,561,437	53%	42%
	Net Peak kW (Demand) Impacts	18,982	53%	42%
	Net kWh (Energy) Impacts	92,950,748	31%	24%
	Net thm (Therm) Impacts	-28,046,591	53%	42%
2.B	Per designated unit* Gross Demand (kW) Impacts	0.0001	79%	62%
	Per designated unit* Gross Energy (kWh) Impacts	0.3474	66%	52%
	Per designated unit Gross Therm Impacts	-0.1084	79%	62%
	Per designated unit* Net Demand (kW) Impacts	0.0001	79%	62%
	Per designated unit* Net Energy (kWh) Impacts	0.2833	66%	52%
	Per designated unit Net Therm Impacts	-0.0855	79%	62%
2.C†	Percent change in usage (relative to base usage) of the participant group and comparison group.	N/A	N/A	N/A
2.D	Gross Demand Realization Rate	0.930	53%	42%
	Gross Energy Realization Rate	0.890	31%	24%
	Gross Therm Realization Rate §	N/A	N/A	N/A
	Net Demand Realization Rate	0.880	53%	42%
	Net Energy Realization Rate	0.850	31%	24%
	Net Therm Realization Rate §	N/A	N/A	N/A
3.A	Net-to-Gross ratio based on Avg. Load Impacts	0.815	4%	3%
3.B	Net-to-Gross ratio based on Avg. Load Impacts per designated unit* of measurement.	0.815	4%	3%
3.C†	Net-to-Gross ratio based on Avg. Load Impacts as a percent change from base usage	N/A	N/A	N/A
4.A	Pre-installation Avg. (mean) Sq. Foot (participant group)	53,731	17.7%	13.8%
	Pre-installation Avg. (mean) Sq. Foot (comparison group)	54,569	20.3%	15.8%
	Pre-installation Avg. Hours of Operation¥ (participant group)	4,022	2.0%	1.5%
	Pre-installation Avg. Hours of Operation¥ (comparison group)	3,826	2.4%	1.9%
4.B	Post-installation Avg. (mean) Sq. Foot (participant group)	54,695	17.5%	13.6%
	Post-installation Avg. (mean) Sq. Foot (comparison group)	55,934	20.5%	16.0%
	Post-installation Avg. Hours of Operation¥ (participant group)	4,022	2.0%	1.5%
	Post-installation Avg. Hours of Operation¥ (comparison group)	3,826	2.4%	1.9%

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

Protocol Table 6
Item 6: Lighting Measure Count Data
PG&E Study ID #333A

	Number of Measures Paid in 1997		
Program and Technology Group Description	**All Participants (Item 6.B)**	**Participant Sample (Item 6.A)**	**Comparison Group (Item 6.C)**
Retrofit Express Program			
Compact Fluorescent	61,880	4,926	2,004
Incandescent to Fluorescent	3,276	459	911
Efficient Ballast	6,284	1,962	3,556
T8 Lamps and Electronic Ballasts	1,368,766	123,853	36,288
Delamp Fluorescent Fixture	195,710	19,899	1,379
High Intensity Discharge	8,236	667	643
Halogen	11,199	674	599
Exit Signs	13,989	1,711	54
Controls	6,788	1,257	73
Total for Retrofit Express:	**1,676,128**	**155,408**	**45,507**
Customized Efficiency Options Program			
Other	5	0	
Total for CEO:	**5**	**0**	**0**
Advanced Performance Options Program			
Other	1	0	
Total for APO:	**1**	**0**	**0**
TOTAL:	**1,676,133**	**155,408**	**45,507**

Protocol Table 6
Item 7.A: Lighting Market Segment Data by Business Type
PG&E Study ID # 333A

Business Type	Indoor Lighting	
	# of Part.	**% of Part.**
Office	795	28%
Retail	472	17%
Col/Univ	34	1%
School	407	15%
Grocery	169	6%
Restaurant	102	4%
Health Care/Hospital	123	4%
Hotel/Motel	121	4%
Warehouse	115	4%
Personal Service	103	4%
Community Service	248	9%
Misc. Commercial	107	4%
TOTAL:	**2796**	**100%**

Protocol Table 6
Item 7.B: Lighting Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 333A

	Lighting	
Industry (3-Digit SIC Code)	# of Part.	% of Part.
821	406	15%
652	310	11%
701	115	4%
541	114	4%
581	102	4%
603	101	4%
602	89	3%
866	79	3%
553	66	2%
799	63	2%
650	52	2%
922	48	2%
422	46	2%
533	44	2%
573	43	2%
594	43	2%
919	40	1%
784	38	1%
525	36	1%
753	33	1%
806	33	1%
822	30	1%
823	29	1%
549	28	1%
551	28	1%
653	28	1%
599	27	1%
801	25	1%
809	25	1%
531	22	1%
737	21	1%
571	18	1%
832	18	1%
592	17	1%
508	16	1%
721	16	1%
864	16	1%
514	15	1%
873	14	1%

Protocol Table 6
Item 7.B: Lighting Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 333A

	Lighting	
Industry (3-Digit SIC Code)	# of Part.	% of Part.
561	13	0%
633	13	0%
802	13	0%
431	12	0%
769	12	0%
565	11	0%
591	11	0%
593	11	0%
723	11	0%
754	11	0%
836	11	0%
539	10	0%
811	9	0%
871	9	0%
913	9	0%
921	9	0%
504	8	0%
506	8	0%
521	8	0%
569	8	0%
738	8	0%
971	8	0%
495	7	0%
546	7	0%
562	7	0%
655	7	0%
872	7	0%
606	6	0%
641	6	0%
733	6	0%
804	6	0%
805	6	0%
458	5	0%
481	5	0%
554	5	0%
703	5	0%
752	5	0%
793	5	0%
835	5	0%

Protocol Table 6
Item 7.B: Lighting Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 333A

Industry (3-Digit SIC Code)	Lighting	
	# of Part.	% of Part.
944	5	0%
411	4	0%
483	4	0%
511	4	0%
518	4	0%
519	4	0%
552	4	0%
566	4	0%
621	4	0%
636	4	0%
704	4	0%
807	4	0%
862	4	0%
72	3	0%
74	3	0%
415	3	0%
472	3	0%
502	3	0%
507	3	0%
513	3	0%
523	3	0%
572	3	0%
616	3	0%
631	3	0%
662	3	0%
824	3	0%
863	3	0%
943	3	0%
962	3	0%
75	2	0%
357	2	0%
421	2	0%
494	2	0%
501	2	0%
512	2	0%
517	2	0%
526	2	0%
543	2	0%
556	2	0%

Protocol Table 6
Item 7.B: Lighting Market Segment Data
by 3-Digit SIC Code
PG&E Study ID # 333A

Industry (3-Digit SIC Code)	Lighting	
	# of Part.	% of Part.
651	2	0%
702	2	0%
729	2	0%
734	2	0%
736	2	0%
783	2	0%
833	2	0%
839	2	0%
861	2	0%
869	2	0%
931	2	0%
951	2	0%
17	1	0%
179	1	0%
327	1	0%
344	1	0%
349	1	0%
367	1	0%
449	1	0%
484	1	0%
489	1	0%
490	1	0%
505	1	0%
509	1	0%
516	1	0%
527	1	0%
542	1	0%
557	1	0%
564	1	0%
614	1	0%
615	1	0%
637	1	0%
679	1	0%
724	1	0%
731	1	0%
735	1	0%
750	1	0%
751	1	0%
794	1	0%

Protocol Table 6
Item 7.B: Lighting Market Segment Data
by 3-Digit SIC Code
PG&E Study ID # 333A

	Lighting	
Industry (3-Digit SIC Code)	# of Part.	% of Part.
820	1	0%
829	1	0%
874	1	0%
899	1	0%
941	1	0%
964	1	0%
972	1	0%
16	0	0%
254	0	0%
473	0	0%
498	0	0%
503	0	0%
515	0	0%
544	0	0%
555	0	0%
559	0	0%
632	0	0%
672	0	0%
726	0	0%
764	0	0%
791	0	0%
792	0	0%
808	0	0%
841	0	0%
953	0	0%
TOTAL	**2796**	**100%**

PROTOCOL TABLE 7

1997 COMMERCIAL EEI PROGRAM EVALUATION OF LIGHTING TECHNOLOGIES PG&E STUDY ID #333A

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

A. OVERVIEW INFORMATION

1. Study Title and Study ID Number

Study Title: Evaluation of PG&E's 1997 Commercial EEI Program for Lighting Technologies.

Study ID Number: 333A

2. Program, Program Year and Program Description

Program: PG&E Commercial EEI Program.

Program Year: Rebates Received in the 1997 Calendar Year.

Program Description:

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

The RE Program comprises 97 percent of the total impacts. The RE Program offers fixed rebates to PG&E's customers that install specific gas or electric energy-efficient equipment in their facilities. The RE Program covers most common energy-saving measures: lighting, air conditioning, refrigeration/food service, and motors. To receive a rebate, the customer is required to submit proof of purchase along with the application. This Program is primarily marketed to small and medium commercial, industrial, and agricultural customers. The maximum total rebate amount allowable for the RE Program is $300,000 per account. This includes participation in any combination of the lighting, air conditioning, refrigeration/food service, and motor program options.

3. *End Uses and/or Measures Covered*

End Use Covered: Indoor Lighting Technologies.

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

4. *Methods and Models Used*

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

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

or

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

or

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

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

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

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

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

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

5. *Participant and Comparison Group Definition*

Participant

Participants are defined as those PG&E commercial customers who received PG&E rebates in the 1997 calendar year for installing at least one lighting measure under the Commercial EEI Program.

Comparison Group

The comparison group for this study is defined as a group of PG&E commercial customers who did not receive any lighting end-use rebates in the 1997 calendar year under the Commercial EEI Program, and who share as many characteristics as possible with the commercial sector participant group in terms of annual usage and business type distribution. Customers who participated in previous years or those who simply participated by installing a non-lighting end-use measure, are eligible for the comparison group.

6. *Analysis Sample Size*

The final analysis dataset has 1,409 observations based upon 1,409 telephone survey completes (of which 481 were lighting end-use participants, and the remaining 928 served as a comparison group for that sample). The distribution of the sample by business type and technology is presented in *Section 3.1.*

B. DATABASE MANAGEMENT

1. Data Description and Flow Chart

The Commercial Lighting Evaluation was based on a sample design approach that was fully Protocol compliant. 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.

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

2. Key Data Elements and Sources

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

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

PG&E Billing Data. The PG&E billing data were obtained from two separate data requests. The original nonresidential billing dataset contains monthly energy usage for all nonresidential accounts in PG&E's service territory, and was used in the sample design as described in *Section 3.1*. The billing histories contained in this database run for 1993 through 1997.

The second billing dataset, was later obtained from PG&E's Load Data Services.[1] This billing dataset contains bill readings that run for January 1998 through September 1998, and was therefore used in the billing regression analysis. In addition, the billing series from this database is the PG&E pro-rated monthly usage data, a series calculated by PG&E for each calendar month.

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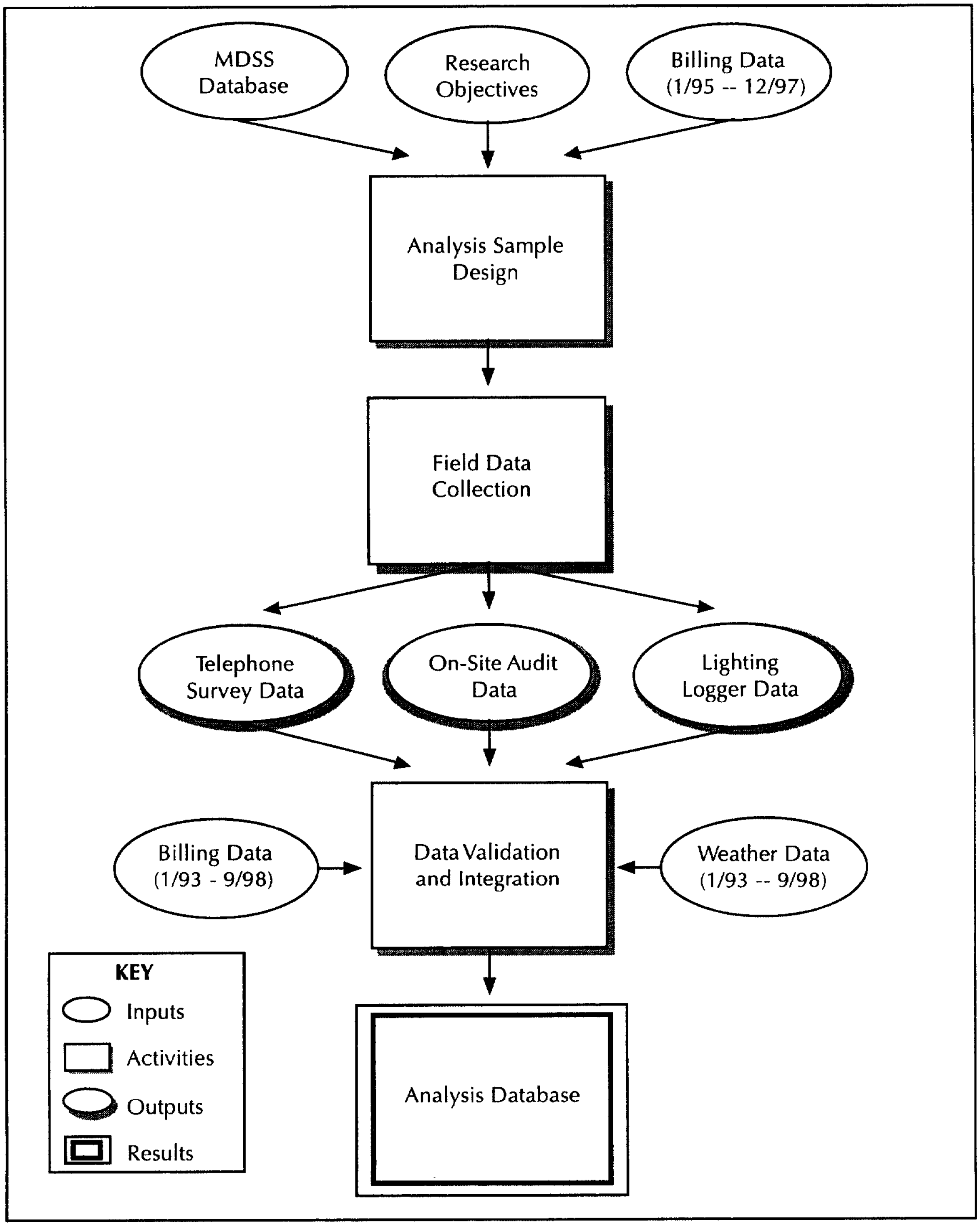
[1] A preliminary analysis has concluded that the monthly usage and bill read date information in these two datasets is consistent.

Exhibit A
Analysis Database Development



Telephone Survey Data. Two telephone survey samples (481 participants and 928 comparison group customers) were collected as part of this evaluation. They were designed to be representative of the population by each business type. The telephone survey supplies information on customer decision-making, equipment operating characteristics, equipment stocks, and energy-related changes at each site for the billing period covered by the statistical billing analysis.

On-Site Audit Data. On-site audit data were collected as part of this evaluation for the participant group, but only to support future retention analyses. A retroactive waiver was submitted to the CADMAC and approved in June 1998. The waiver ensures Protocol compliance for the engineering models that were applied, based on evaluation results from the 1994 and 1995 Commercial Lighting Evaluations. On-site audit data from these evaluations were used in support of this year's engineering results.

Lighting Logger Data. No lighting logger data was collected as part of the 1997 Commercial Lighting Evaluation. Lighting logger data from the 1994 and 1995 Commercial Lighting Evaluations were applied to current evaluation-year engineering results.

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

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

3. Data Attrition Process

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

4. Internal Data Quality Procedures

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

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

Pre-Survey Usage and Account Characteristic Data Validation. The goal of this stage of data validation was to screen out customers who had unreasonable or unreliable usage data, or who had changes in key elements of their billing data over the 1995 to 1997 period. Accounts for which changes were observed in account numbers, service addresses, SIC codes, electric rate schedules, electric meter numbers, or corporation and premise identification variables, were excluded from sample eligibility. Usage data reliability screening first eliminated from the sample, all accounts which experienced service interruptions, exhibited inconsistent read dates, or for which bills were estimated. Additionally, based on comparisons of account usage between years, and between different months in the same year, customers with unusual usage patterns such as unusually high variation in monthly or yearly usage were given special attention and, in some cases, excluded from the sample frame. A more detailed discussion of the steps undertaken in the pre-survey usage and account characteristics data validation, is provided in the discussion of survey sample creation in *Section 3.1*.

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

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

5. *Unused Data Elements*

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

C. *SAMPLING*

1. *Sampling Procedures and Protocols*

The sample design for the Commercial Lighting Evaluation was based upon analysis of 1997 program participation data and PG&E billing data. The goal of the sample design was to achieve the most efficient utilization of project resources in order to estimate the first-year gross and net impacts in a manner that met the sample size and evaluation accuracy requirements defined by the Protocols.

The telephone survey sample was selected based upon the stratified random sampling techniques for both participant and comparison groups. The objective of stratification is to improve the overall reliability of estimates by restricting the sample to reasonably homogeneous segments, while at the same time ensuring that sufficient representation of the population is preserved. The sample segmentation is developed across two dimensions: business types and technology groups.

The customer segment is defined primarily by the business types, which were determined based upon the MDSS database (for participants), and the Second Standard Industrial Classification (SIC2) code—which represents building activity—from the billing dataset (for the comparison group). Within each business type, the annual energy consumption is used as proxies to group customers into usage bins, and sample points are selected to reflect the underlying distribution of the participant population.

Technology segmentation is important because the use of electricity, and therefore the program impacts, varies by program measure. Therefore, by grouping together common technologies, the variation in impacts is reduced, which, in turn, results in more accurate estimates of the SAE realization rates. For example, all T12 to T8 retrofit measures are grouped together, despite the fact that some installations are new fixtures; while others are retrofits, and different measures have different levels of projected energy impacts. These factors are directly accounted for in the engineering estimates. That is, the engineering estimates account for inter-participant variation so that what is assumed is that the fraction of the expected impact is stable within a segment, rather than the level of the impact. This assumption is the basis for SAE models.

Seventeen segments were developed based on business types and technology groups to be used in the sample design and sample allocation for the lighting evaluation. For each segment, the sample was allocated in proportion to avoided costs. The purpose of this weighting scheme is to identify which technologies and business type segments account for the greatest impact on the program's resource and shareholder values.

The sampling unit for both participant and comparison groups was defined as customer premise. A premise is defined as all billing accounts that correspond to the same location and customer. The final participant sample frame consists of 2,796 premises drawn from the eligible population of program participants who were paid in 1997 from the RE, CEO and APO programs.

The comparison group sample frame consists of 187,524 customers drawn from the eligible population of over 400,000 commercial accounts. In drawing the sample frame, targets are established for each business type and usage segment, so that the sample frame distribution, by business type and usage segment, is the same as that of the participant population.

The process of reduction to the eligible sample involved the elimination of customers that had 1) moved during the period of interest; or 2) had billing records with significant missing data. Customers were further screened to identify those who had high-quality data for each month, for all three years of the analysis window.

Finally, the achieved samples and their distributions can be found in *Section 3.1*. Based on the total energy usage, the sample relative precision's were estimated to be 5.7 percent at the 90 percent level. The procedures used in the relative precision calculation and a summary of how the Evaluation sample design meets the Protocols' requirement in terms of sample size and relative precision are presented in *Section 3.1*.

2. *Survey Information*

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

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

3. *Statistical Descriptions*

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

D. DATA SCREENING AND ANALYSIS

A detailed discussion of the billing data regression data analysis is presented in *Section* 3.3. The statistical billing model described in this section incorporates analysis for two distinct end uses: lighting and HVAC (for Study ID's 333A and 333B, respectively). Specific procedures and modeling issues are discussed below.

1. *Outliers, Missing Data and Weather Adjustment*

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

Invalid Usage

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

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

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

The number of employees at the facility could not have doubled, or been cut in half. This criteria is only applied to customers with at least 100 employees. Furthermore, the size of the facility in square feet could not have doubled, or been cut in half. If either of these criteria were met, the customer was removed from the analysis.

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

Section 3.3 presents the number of participants and nonparticipants that were deleted for each of the above criteria. Note that only 29 nonparticipants were deleted, whereas 99 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 99 participants, 69 were deleted due to the zero bill criteria.

Large Customers

Customers whose annual pre-installation energy consumption exceeded three million kWh were excluded from the billing analysis. A total of 49 participants and 34 nonparticipants were dropped for this reason. This decision was made *a priori* to collecting the survey data, as is documented in the Evaluation Research Plan; and is based upon the results of the previous three Lighting Evaluations, all of which were unsuccessful in obtaining reliable results when including customers with usage above this level. This is also consistent with the recommendations made by the Verification Reports of PG&E's 1995 and 1996 Commercial Lighting Evaluation, which stated in 1995 that "program effects can be difficult to detect for large customers," and recommended censoring large customers for the final billing analyses.

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

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 241 HVAC and/or lighting 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 241 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 241 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 the customer's energy impacts were greater than 25 percent of their pre-installation usage and 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, 61 of the 241 premises were removed. Of the 61 removed customers, 24 also failed the invalid usage data screening checks. Therefore, only an additional 37 premises were removed based solely upon the data screening criteria described above.

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

In summary, out of the original sample frame of 549 nonparticipants, 62 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 860 HVAC and lighting participants, 181 were removed because of bad billing, improper site aggregation, or because they were large customers. Of these 181 customers, 106 were lighting participants.

2. *Background Variables*

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

3. *Data Screen Process*

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

4. Regression Statistics

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

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

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

The dependent variable is the difference between the actual and predicted 1998 usage using the 1995 baseline model.

SAE coefficients are calculated for seven 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. All but one of the lighting SAE coefficients are significant at the 95 percent confidence level (t-statistics greater than 1.96), with the exception being significant at the 93 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.

Exhibit B
Final SAE Model Output

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients					
Lighting End Use					
Lighting Offices	LGTOFF5	kWh	-0.856125	-5.15	154
Lighting Retails	LGTRET5	kWh	-1.357155	-2.10	78
Lighting Schools	LGTSCH5	kWh	-0.613314	-1.91	51
Lighting Miscellaneous	LGTMSC5	kWh	-0.859361	-2.35	92
HVAC End Use					
Retrofit Express Measures	RETX5	kWh	-1.061511	-3.43	324
ASDs	ASD5	kWh	-0.853041	-2.94	25
Custom HVAC	CSTHVC5	kWh	-10.290247	-4.05	3
Other End Uses					
Other Impacts	OTHMEAS5	kWh	1.413001	2.45	22
Change Variables					
Part Lighting Changes	LGT_CHG5	kWh	-0.174985	-8.83	74
Part HVAC Changes	AC_CHG5	kWh	-0.004323	-0.22	123
Part Other Equipment Changes	OTH_CHG5	kWh	0.148858	5.00	39
Part Square Footage Changes	SQFT_CH5	# Sqft*kWh	2.540250	0.92	32
Part Employee Changes	EMP_CHG5	# Emp*kWh	138.243740	0.92	137
Nonpart Lighting Changes	LGT_NON5	kWh	-0.042143	-2.06	47
Nonpart HVAC Changes	AC_NON5	kWh	-0.022783	-1.01	60
Nonpart Other Equipment Changes	OTH_NON5	kWh	0.137414	4.27	40
Nonpart Square Footage Changes	SQFT_NO5	# Sqft*kWh	12.151441	4.57	31
Nonpart Employee Changes	EMP_NON5	# Emp*kWh	574.101061	1.97	91

Impact estimates from the MDSS for other end uses were included in the model for customers that installed measures outside the Lighting and HVAC end uses. It is not recommended that this value be used because the sample may not be representative of the population of participants installing these measures.

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

5. *Model Specification*

The model specifications are presented in *Section 3.3*. Specific model specification issues are further explored below:

Cross-sectional Variation. The final model specification recognizes the potential heterogeneity problem in the model and uses the following procedures to eliminate the impacts of the cross-sectional variation: (1) observations with highest usage values were removed in the model to reduce the overall variance of the sample in terms of usage and size; and (2) independent variables were all interacted with pre-installation usage to ensure that change of independent variable will be proportional to the usage value.

Time Series Variation. The key factors to control for the time series variation in the final model are: (1) use of the comparison group to define the relationship of the energy consumption between two different time periods; and (2) elimination of the multiple time period interactions by only one yearly pre-installation period and one yearly post-installation period for each stage.

Self-selection. One solution to the problem of self-selection in the gross billing model is to include an Inverse Mills Ratio in the model to correct for self-selection bias. This method was addressed by Heckman (1976, 1979[2]) and is used by others (Goldberg and Train, 1996[3]). Goldberg and Train develop the technique of including a second Inverse Mills Ratio in the savings regression to account for the possibility that participation is correlated with the size of energy savings. The second Mills Ratio is interacted with a measure of energy savings, which allows the amount of net savings to vary with participation. A complete description of the methods used to calculate the Inverse Mills Ratios, and the results of the net billing model, are described in detail in *Section 3.3.9.*

Collinearity. Various statistical tests (such as COLLIN and VIF options in SAS) were used to check multiple collinearity problem among independent variables in the model to ensure that the final parameter estimates are robust.

Net Impact. As mentioned in the Self-selection section above, a net billing model was implemented using the double inverse Mills ratio approach. The net billing model's estimates of the term (1-FR) were used to verify the results of the self-report and discrete choice models. The net billing model's estimates of (1-FR) were the highest of all three models tested. To be both conservative and consistent, the net impacts were derived from the gross billing analysis model and adjusted by a net-to-gross ratio using the discrete choice method. For a detailed discussion on the selection of the NTG ratios, refer to *Section 3.4.4.*

6. *Measurement Errors*

For the billing data regression analysis, the main source of measurement errors is the telephone survey. Our approach has been to proactively stop the problem before it happens so that statistical corrections are kept to a minimum.

Measurement errors are a combination of random and non-random error components that plague all survey data. The non-random error frequently takes the form of systematic bias,

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[2] Heckman, J. 'The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models.", Annals of Economic and Social Measurement, Vol. 5, pp. 475-492, 1976.

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

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

which includes, but is not limited to, ill-formed or misleading questions and mis-coded study variables. In this project, we have implemented several controls to reduce systematic bias in the data. These steps included: (1) thorough auditor/coder training; (2) instrument pretest; and (3) cross-validation between on-site audit data and telephone survey responses.

The random measurement error, such as data entry error, has no impact on estimating mean values because the errors are typically unbiased. For the measures that were modeled in the billing regression analysis, the impact of random unbiased measurement errors was accounted for as part of the overall standard variance in the parameter estimate.

7. *Autocorrelation*

The autocorrelation problem exists if the residuals in one time period are correlated with the residuals in the previous time period. Since the final model is based on a yearly pre- and post-installation period comparison with only one year in each period, the autocorrelation problem was unlikely to occur under this scenario, as was confirmed by examining the Durbin-Watson statistic for these models.

8. *Heteroskdasticity*

See discussion above.

9. *Collinearity*

See discussion above.

10. *Influential Data Points*

See discussion above.

11. *Missing Data*

See discussion above.

12. *Precision*

The precision calculation for the gross SAE realization rates are presented in *Section 3.3*. Relative precision's for net estimates were calculated using the following procedure:

- First, NTG ratios, N_i, were computed for all technology groups that were represented in the telephone survey.

- Then, the program level NTG and program level standard error for the NTG were calculated using the classic stratified sample techniques. The program level NTG was a weighted average of technology level NTG values with adjusted gross impacts per technology group providing the weights.[4] The functional relation can be best described in the following equations:

  $$\overline{N} = \sum_i w_i * \overline{N_i} \text{ with } w_i = MWh_i$$

  $$StdErr_{NTG} = \sqrt{\sum_i \left[(w_i)^2 * StdErr_i^2\right]}$$

  Where,

  NTG = Net-to-Gross Value;

  i = Technology Group i; and,

  w_i = Weight of technology group i.

- Then, the relative precision[5] for the program NTG value for energy was calculated and combined with the relative precision of the gross energy impact to yield an overall relative precision for the net energy impacts:

  $$RP_{NTG\_Energy} = \frac{t_{\alpha=10} * StdErr}{NetMWh}$$

  $$RP_{NetEnergy} = \sqrt{RP_{NTG\_Energy}^2 + RP_{GrossEnergy}^2}$$

- Finally, the relative precision net demand impacts were calculated using a scaled version of the relative precision for the net energy impact. The sample sizes of the on-site audits and telephone surveys served as the scalars:

  $$RP_{NetDemand} = RP_{NetEnergy} * \sqrt{\frac{N_{OnSite}}{N_{Telephone}}}$$

- Per-unit NTG relative precision data appearing in Table 6 (Items 1-5) were calculated in a similar fashion.

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[4] Technology groups with no standard errors were excluded from this calculation.

[5] The example shown is for the 90 percent confidence level. Relative precision was also calculated at the 80 percent confidence level.

E. DATA INTERPRETATION AND APPLICATION

The program net-to-gross analysis was conducted based on a discrete choice analysis and on survey self-report. For a detailed NTG analysis discussion, see *Section 3.4*.

Self Report Method

The self-report method used to score free-ridership uses participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. The complete text of the participant surveys may be found in the *Survey Appendices, Appendix A*. Questions used for the self-report analysis are summarized in *Section 3.4*.

The net-to-gross ratio using the self-report method included estimates of free-ridership and spillover. While none of the values were used in the final NTG ratios, they were used to verify the results of the discrete choice method, described next.

Discrete Choice Method

A discrete choice logit model is used to estimate both a net-to-gross ratio and the free ridership rate associated with PG&E's Commercial Lighting Retrofit Program (the Lighting Program). The decision to purchase high-efficiency equipment is explained in the logit model by the cost and savings of the equipment, any rebate offered by the Lighting Program, awareness of the Lighting Program, and other customer characteristics. Once estimated, the model can be used to determine the probability of purchasing high-efficiency equipment in the absence of the Lighting program. This is simulated by setting both the rebate and program awareness variables to zero and re-calculating the probability of purchasing high efficiency lighting equipment.

The net-to-gross ratio is calculated using the probability of purchasing high-efficiency equipment both with and without the existence of the retrofit program. The expected impact with the program is the probability of choosing high-efficiency equipment multiplied by the energy impact of the equipment. Similarly, the expected energy impact in absence of the Lighting program is the probability of purchasing high-efficiency equipment without the program multiplied by the energy impact of the equipment. The net-to-gross ratio is the net savings due to the program divided by the expected energy that results from having the program. As discussed in *Section 3.4*, this method is also used to determine free ridership rates and nonparticipant spillover.

The final NTG ratios applied to the statistically adjusted estimates of energy, and the unadjusted estimates of demand and therms, were taken from the results of the discrete choice method.

Attachment 4

PG&E Response to Verification Report for Studies #349 & 351

And

Independent Reviewers' Report to the CPUC Regarding Studies #349 & 351

M e m o r a n d u m

FROM: Elsia Galawish, PG&E

TO: Joshua Faulk, Randy Podzena, ECONorthwest

DATE: 9 September, 1998

RE: Response to Verification Report for PG&E CEEI Studies # 349 and 351

CC: Don Schultz, CPUC-ORA; Ralph Prahl, Jeff Schlegel, Independent Reviewers

The purpose of this memo is to respond to the recommendations and assessments made in the verification report (VR). Because the issues surrounding PG&E's response are nearly identical for the lighting and HVAC reports, we have combined our response into one memo.

This response is divided into two sections. The first section is directed towards addressing the recommended changes to the load impacts presented in Table 6 of the CEEI Study #349 & #351 VRs. The second section discusses our concerns about statements made in both lighting and HVAC VRs,.

Section I: Response to Overall Recommendations

Although the VR presented alternative methods and results for many different aspects of the evaluation, the report only recommended two changes to the final evaluation results.

- The first was to **adjust the Gross Billing Analysis** such that a consistent set of "change" variables was maintained. Specifically, the VR recommends that the coefficients on site-change variables estimated in the baseline model be used to predict the baseline energy use of participants, and these variables be removed from the participant gross impact regression.

- The second recommendation was specific only to the HVAC evaluation, where a **slight modification was made to the self-report free ridership estimate**. The recommendation was to delete from the analysis, customers that provided contradictory responses regarding their hypothetical HVAC purchase action in the absence of the program. **Because the reasoning behind the change is reasonable and justified, PG&E agrees to implement this change to the approach.**

1. <u>Gross Billing Model Analysis.</u>

PG&E's response is structured in the following manner:

- Clarification of the intention of our modeling approach. PG&E believes the VR team's recommendation stems, in part, from the erroneous perception that we have violated our own modeling intentions;
- Detailed explanation of the approach chosen for the Gross Billing Analysis; and
- Illustration that shows the recommended approach should not be applied given sample limitations.

a. Model Intention

The VR team recommends that the coefficients on site-change variables estimated in the baseline model be used to predict the baseline energy use of participants; and these variables should then be removed from the participant gross impact regression.

On pages 7 and 8, the VR claims that "failure to employ the site-change variables for participants in the baseline model potentially introduces bias in the impact estimates. That is, we cannot be certain that the estimated (baseline) kWh will represent what it is intended to represent: the amount of energy that these participants would have used in the absence of the CEEI program." Furthermore, in the VR's summary of our analysis on page 4, the VR states that our approach estimated "post-period kWh for lighting and HVAC program participants in the absence of these incentive programs."

Both of these statements have incorrectly assessed the intent and thus the final outcome of our modeling approach. The intent of the baseline model and application of the results to the participants was never intended to estimate "the amount of energy that these participants would have used in the absence of the CEEI program." The objective of this step in the analysis was to estimate what post-period usage would have been for participants in the absence of *ANY* changes made at the facility. This is clearly documented not only on page 3-40 of the Final Lighting Report and page 3-44 of the Final HVAC Report, but also on page 2-27 of the Final CEEI Research Plan (*see Attachment 1*), which was authored prior to any analysis taking place.

The VR claims that there is inconsistency and bias in our model. However, the VR provides little or no basis for these assessments, other than to incorrectly state the intent of our approach. For example, on page 8, the VR states that "the estimated (post-period) kWh will only represent the amount of energy that nonparticipants would have used had they both not participated in the CEEI program and not made any site changes.

This statement correctly defines the objective of our approach. However, the use of the word "only" indicates that ORA may not have understood that this was the model's intention. The VR team goes on to claim that this approach may not be an unbiased estimate of baseline participant behavior. It is unclear why it may not be unbiased, as it is unclear how The VR team is defining baseline participant behavior.

PG&E's approach is to estimate baseline participant behavior in the absence of any changes at the facility, in which case our estimate *is* unbiased. However, the VR reflects the perception that we are trying to estimate baseline participant behavior in the absence of the program. This is neither the intent nor the application of our approach.

b. Model Justification

Justification for PG&E's approach begins with a discussion two types of events that would cause a business' energy consumption to change:

- *Controlled* events, such as remodeling, retrofitting, or expansion.
- *Uncontrolled* events, such as changes in weather or economic indicators.

Recall that the nonparticipant baseline model estimates post-period usage as a function of pre-period usage, interacted with business type and size, changes in weather, and other site changes made at the facility. The nonparticipant baseline model specification attempts to account for changes in energy usage that are attributable to controlled and uncontrolled events. The uncontrolled events are appropriately accounted for by the business type and size, and weather variables; whereas the controlled events are accounted for with the other site-change variables.

Uncontrolled events are simply that, uncontrolled. The business operators and decision makers have no control over the weather, for example. We would expect that uncontrolled events affect similar businesses in similar climate zones in a similar fashion. If there were no uncontrolled events that occurred (e.g., weather was constant), we would expect the majority of changes in energy usage over time to be due to controlled events.

Controlled events are a function of actions taken by building operators and decision makers. These events may not effect similar businesses in a similar fashion. The decisions building operators and decision makers make are dependent on much more than their business type and size. For example, awareness of PG&E's energy efficiency program may affect the decisions that they make. The fact of their participation distinguishes the character of their business decisions in the area of equipment adoption.

PG&E believes that a comparison group of nonparticipants is best utilized to estimate the effects on participant usage over time due to *uncontrolled* events. Furthermore, using a comparison group of nonparticipants is likely to provide a *biased* estimate of the effects of controlled events on participant usage. The building operators and decision makers among nonparticipants are not representative of the building operators and decision makers among participants. It is for this reason that we do not apply the coefficients for the nonparticipant site-change variables to estimate the effects of non-rebated site-changes on participant usage.

Take for example, the case where changes in weather between a pre- and post-period are negligible. We would then expect the estimate of post-period usage in the absence of any site-changes to be very similar to the pre-period usage. In fact, this was the case for the 1996 CEEI evaluation, where the majority of the coefficients on pre-period usage interacted with business type were near to one. Under this scenario, the post-period would have been near equal to the pre-period had no controlled events occurred. Therefore, the difference between the pre- and post-period usage for a group of participants can be explained by the measures installed under the program plus any additional changes made at the facility. This is exactly how our approach is intended to simulate behavior: by estimating as a baseline, what the post-period usage would have been if no uncontrolled events occurred.

Consider another scenario where no uncontrolled events occurred over the pre- to post-periods, and participants and nonparticipants each made an equivalent number of HVAC, lighting, employee and other equipment changes outside of the program. In this example, "equivalent" refers to the number of participants or nonparticipants that make changes, without regard to size, efficiency, or application. Under this scenario, the VR suggests that, for the participants, the difference between the pre- and post-period usage should equal the savings associated with measures installed under the program plus the *nonparticipants'* savings associated with the measures they installed.

The approach recommended in the VR assumes that the nonparticipants make similar types of changes with regard to type, efficiency and application. Given that these are controlled events, driven by the building operators and decision makers, it is very unlikely that the nonparticipants would have made similar types of changes: they are less likely to be aware of PG&E's programs, less likely to be aware of the benefits of energy efficiency, and less likely to have recently made the decision to install energy efficiency measures under the program. Furthermore, some of the nonparticipant changes *were rebated* in other program years, which may not be representative of the types of non-rebated measures being installed by participants.[1] It is evident that the nonparticipant changes would be different from those installed by participants outside of the program.

c. Sample Design Issues

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[1] A nonparticipant is defined as a customer that did not receive a rebate in 1996 through PG&E's CEEI program. Therefore, customers receiving rebates in 1994, 1995 or 1997 may be included in the nonparticipant control group.

Using the approach suggested in the VR hinges on the fact that the effects on energy usage due to controlled events are similar among nonparticipant actions and participant non-rebated actions. Regardless of whether or not this statement is true, there is still the issue of sample representativeness to consider.

The Protocols require a sample of 350 nonparticipants to be used in the final analysis dataset. We exceeded this value by including 428 nonparticipants in our analysis. This sample was developed to be representative of the participants with respect to business type and size, specifically to account for uncontrolled events. In order for the nonparticipant sample to be representative of controlled events, we would require a sufficient sample of controlled events to have occurred across the nonparticipant sample. Among the 428 nonparticipants, only 41 made lighting changes and 53 made HVAC changes. Given the diversity of the sample in terms of building type and size, and given the variety of types of lighting and HVAC changes that may have occurred, it is unreasonable to expect a representative sample of nonparticipant changes. This is why we conducted a canvass survey of an additional 3,796 nonparticipants. This enabled us to obtain a representative sample of nonparticipant changes for use in the net-to-gross analysis.

We were able to isolate the effects of the controlled events in our nonparticipant baseline model, such that we obtained an accurate relationship between the uncontrolled events and energy usage. We believe that our sample of 428 nonparticipants is representative of the participants with respect to business type and size, such that we can apply the relationship of uncontrolled events and energy usage from the nonparticipant sample to the participants. However, we do not believe that the coefficients estimated for site-change variables are representative of the participant population.

Conclusion

To summarize, the objective of the nonparticipant baseline model was to develop an estimate of what participant post-period usage would have been in the absence of *ANY* changes made at the facility. Our approach utilizes a nonparticipant group to account for uncontrolled events, such as changes in weather. We believe that nonparticipants and participants in similar businesses, of similar size, will behave similarly with respect to uncontrolled events, such as changes in weather. Furthermore, we do not believe that nonparticipants *choose to undertake* controlled events in a manner similar to participants because of underlying differences in the decision makers. Therefore, we do not believe the nonparticipant group should be used to estimate the effects on post-period usage of non-rebated participant changes.

This decision was made *a priori*, as is documented in our evaluation research plan (see Attachment 1). We would also like to point out this was an issue in last year's evaluation, where the independent reviewers stated that the "handling of specific business change variables essentially boil down to a matter of differing modeling preferences." The independent reviewer made no statements regarding inconsistency or bias with this approach.

Section II. Concerns with the Verification Reports Assessment of the Evaluation

PG&E has serious concerns about statements that are made in the VR. It would appear that the verification team is attempting to justify its recommended results by (a) illustrating how it could have produced much lower results had it chosen to do so, and by (b) making false and unfounded claims that PG&E results were "cherry picked".

- First, the VR produces an extra set of results for Protocol Table 6, even though the VR team does not recommend using the results. These results are based on a discrete choice model that we believe to be seriously flawed, and provides unrealistically low estimates of net effects. Our concern is that the VR team may have chosen to report these results, hoping that the reader may incorrectly infer that the VR recommendations are conservative or represent a "middle ground". We discuss our concerns with the changes to the discrete choice model in more detail below.

- Second, the report makes the statement more than once that all of the modifications explored by VR team have the effect of lowering the estimated net impacts. This is contradictory to the fact that the alternative model that the VR team explored for the net billing analysis for HVAC measures had the effect of *increasing* the net-to-gross ratio. In addition, by following the VR team's recommendation of removing the HVPART variable in the net billing model, and following the remainder of the Study's net billing model approach, the net lighting impacts *increase*. Finally, by removing the interaction of the Mills ratio from the net billing model as suggested by the VR, and reverting to a single Inverse Mills Ratio approach, the net impacts would also *increase*.

One would expect that a goal of the verification team is to reduce net impacts. Therefore, while exploring alternative methods, PG&E expects that the verification team would attempt to identify changes that would reduce the net load impacts. We take great offense to their accusation that we "cherry-picked" methodologies. In fact, there are a number of recommendations that were made by PG&E where a methodology was selected that provided *lower* net load impacts. (For example, page 79 of the Lighting Report states "the selection of the discrete choice model provides the most conservative estimates of the three net-to-gross approaches.") We will point out these instances, as well as provide examples of reasonable modifications to our models that we would expect the verification team to have explored during their verification process, which resulted in higher net impacts.

1. Discrete Choice Analysis

The VR had two criticisms of the discrete choice model used for the net to gross analysis. The first concerns using program awareness as an exogenous variable in the discrete choice model. The second involves an accusation of 'cherry picking' or deliberately constructing the model to give only the most favorable results. Each of these issues is discussed below.

In the discrete choice model, PG&E uses an awareness variable (AWARE2) that indicates those customers that became aware of the program before they began shopping for lighting or HVAC equipment. Awareness of the program is included in the model for two reasons. The obvious reason is that only those that are aware of the program will be able to participate. In addition, program awareness serves as a proxy for all of the other program benefits outside the rebate. Program awareness plays an important role in the purchase decision and omitting it entirely from the purchase model would result in a serious mis-specification. When awareness is excluded from the model, program effects are only captured through equipment rebates in the model. As a result, there is no mechanism in the model to estimate spillover, since actions outside the program are not affected by rebates. Therefore, at a minimum, all effects of spillover are ignored, not to mention the incremental effects awareness has on participants beyond the effects of the rebate.

Considerable effort was spent designing survey questions to get an accurate measure of program awareness. The issues raised by the independent reviewers on the discrete choice model implemented during the 1997 AEAP (PY1995 CEEI evaluation) were addressed during the PY1996 CEEI evaluation.[2] It was our intention from the start to implement a more conservative definition of program awareness that could be used as an exogenous determinant of equipment purchases.

To get an estimate of program awareness, questions were asked to ascertain when people became aware of the program and to screen out those who became aware of the program while they were shopping for equipment, even if they ultimately participated in the program. In addition, a high efficiency predisposition variable (PREDISP) was created to flag those customers that have a predisposition to purchase high efficiency equipment and likely would have done so in the absence of the program. The result is a definition of awareness which includes only those customers that became aware of the program before they began shopping for the equipment. For this group of customers it can be said that awareness of

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[2] The independent reviewers raised two primary concerns with how awareness was used in the discrete choice model in the PY95 Evaluation: (1) that the act of shopping for equipment may cause awareness of the program, and (2) that a customer's predisposition to purchase high efficiency equipment may increase their likelihood to also be aware of the program. We addressed these issues by first defining the awareness variable in the purchase model to only flag customers as being aware if they were aware of the program prior to shopping for equipment. Furthermore, we addressed the second issue by including an independent variable in the equipment selection model, PREDISP, that flagged those customers that have a predisposition to purchase high efficiency equipment and likely would have done so in the absence of the program

the program encouraged them to purchase high efficiency lighting. Under this more conservative definition of awareness, only 80 percent of the participants in the sample were aware of the program before they began shopping for equipment, in contrast to 100 percent of participants who ultimately became aware of the program.
The VR suggests that this awareness variable may be biased, since customers were asked about program awareness after they had already purchased the equipment. While awareness was asked after the fact, it is the *only* way that awareness can be determined since it is virtually impossible to identify purchasers and determine program awareness before the equipment is purchased.

The VR also suggests that respondents may not answer the awareness questions accurately and may overstate program awareness to please the interviewer. However, it is equally plausible that a portion of respondents may understate their awareness of the program. For example, respondents may also claim that they did not become aware of the program until after they began shopping for equipment when in fact they were aware before then. Both types of measurement error would have the effect of biasing the coefficient estimate on awareness toward zero. In this case, the model used by PG&E would understate the importance of awareness rather than overstating as the VR claims.

A more serious issue suggested in the verification report is that PG&E "cherry-picked" the models to provide only the highest net estimates. This is an incorrect statement. As demonstrated below, reasonable and protocol-compliant variations on the reported model will produce substantially higher net to gross estimates.

The model relies on two program variables AWARE2 and CINDEX, the latter of which is defined as cost minus rebate divided by cost. Obviously, removing either of these variables will reduce the overall net to gross estimate, as the verification report shows. However, alternative model specifications using these variables result in even higher net to gross estimates. These alternative specifications were apparently not explored by the verification team but are discussed below.

- In the first alternative model, the conservative awareness variable AWARE2 is replaced with a less stringent AWARE, where a customer is coded as aware of the program if they became aware before or at the same time as when they purchased the equipment. Using this definition of awareness, one minus free ridership increases from the original .71 to .81 and the resulting net to gross ratio rises from .81 to .94.

- A second alternative model uses the original awareness variable, but in the equipment choice model the CINDEX variable is replaced with COST and REBATE as separate variables. This alternative yields a net to gross estimate of 1.16, 43 percent higher than the .81 originally reported.

Both of these alternative models are reasonable specifications and provide higher net to gross estimates than what were ultimately reported. The fact that we did not report these results and went with a lower estimate shows that we were not 'cherry picking' but were in fact concerned with developing the most applicable, defensible, and Protocol-compliant model possible.

2. PG&E Selected CONSERVATIVE Net-to-Gross Ratios, NOT the Highest

As mentioned above, the VR suggests that PG&E may have made a "'cherry picking' approach to model and variable selection," with regard to estimating net-to-gross effects. Three approaches were taken to model the net-to-gross effects. Exhibit 3-47 of the lighting report and Exhibit 3-42 of the HVAC report provide the results of each of the three approaches.

In the case of lighting, the Discrete Choice model provided a net-to-gross ratio of 82%, compared to a result of 85% based on self-report and 99% based on the net billing model. Both models follow the Quality Assurance Guidelines, are Protocol-compliant, and have been used in previous evaluations. Clearly, the recommended result using the Discrete Choice model provided significantly lower net load impacts. Had we chosen the net billing model, our result would have been 21% larger.

Similarly, in the case of HVAC, the Discrete Choice model provided a net-to-gross ratio of 53%, compared to a result of 54% based on self-report and 90% based on the net billing model. In this case, had we chosen the net billing model, our result would have been 67% larger.

3. Incorrect Statement Made in Verification Report

The VR provides suggestions on how each of these models could, or should, be modified. In each case, the VR suggests a method that results in lower net-to-gross ratios, and claims that "all modifications explored by the VR team have the effect of lowering the estimated net impacts." Clearly, it is the objective of the ORA and their verification team to identify alternative approaches that have the effect of reducing net impacts, which in itself may bias the approaches investigated by the VR team. However, we have identified three cases where we have followed all or a portion of the VR team's recommendations, which resulted in *higher* net-to-gross and/or net impact estimates.

On page 9 of the HVAC VR for Study ID #351, Table 2 presents a comparison of results between PG&E's Net Billing Model, and the revised Net Billing Model explored by the VR team. Under the VR's methodology, the resulting net-to-gross ratio for Retrofit Express Measures and ASDs increase from 76% to 88%, and from 93% to 115%, respectively; whereas the resulting net-to-gross ratio for Custom HVAC decreases from 103% to 92%. The overall result is that the total HVAC net-to-gross ratio *increases* when the verification teams recommended model is applied.

On page 11 of the lighting VR for Study ID #349, the VR recommends re-estimating the probit model without the HVPART variable. If this recommendation is implemented, and the remainder of the Study's net billing model approach is followed, the resulting net load impacts *increase*.

Finally, page 9 of Study #351 VR states that its "primary concern with the (net billing) model was the use of the Mills ratio interacted with other variables." If we address this concern by reverting to the single Inverse Mills Ratio approach, which is not interacted with other variables, the resulting net load impacts *increase*.

4. Examples of Modifications Resulting in Higher Load Impacts

As discussed above, three models were employed to estimate the net-to-gross ratios: self-report, net billing model, and discrete choice model. The VR states that "all modifications explored by the VR team have the effect of lowering the estimated net impacts." We have already pointed out that recommendations made in the VR surrounding the net billing model have resulted in higher net impacts, not less as stated in the VR. Furthermore, the self-report results recommended by the VR resulted in a change in net impacts by less than one tenth of one percent. Finally, the recommended revisions to the discrete choice model were to remove variables that could *only reduce* net effects, because they were (awareness) variables that explained the net benefits provided by the program.

Below, PG&E provides examples of how reasonable and Protocol-compliant modifications to the self-report and net billing model would have resulted in higher net impacts. The section above which discusses the discrete choice model also provides two examples of how the model could have been modified to increase the net impacts. In fact, we are surprised to find that the verification team did not test at least one of these changes. Two of the modifications shown below directly address concerns raised by the VR team.

a. Modifications to the Self-Report Model

The changes recommended to the self-report model by the verification team result in negligible decreases in net load impacts: less than one tenth of one percent. The self-report approach looks at three sets of survey questions to assign an estimate of free ridership. It attempts to assign the estimate of free ridership base on the first set of questions (e.g., PD110/PD115 for Lighting), and if data are missing or indeterminant, it uses the second set (e.g., PD110 for Lighting), and then the third set (e.g., PD050 for Lighting),. One alternative to this method would be to change the order in which the sets of survey questions are analyzed. If we simply switch the order of the first two sets of questions (e.g., for lighting we first analyze PD100, and then PD110/PD115), we would get a lower free ridership estimate. In the case of lighting, free ridership decreases from 13% to 11% when we change the order of the algorithm. Similarly, for HVAC, free ridership decreases from 48% to 44%.

b. Modifications to the Net Billing Model

The VR states that its "primary concern with (the net billing) model was the use of the Mills ratio interacted with other variables." The VR team claims that it is "unnecessary" to interact the Mills ratio with the engineering estimates in addition to being included in level form" and that it "potentially confounds the effect of the self-selection bias correction."

Although our model is a slight variant[3] on the Double Inverse Mills Ratio approach (DIMR) developed by Goldberg and Train (1996)[4], the DIMR approach does interact the Mills ratio with the engineering estimates in addition to being included in level form. The DIMR is a widely accepted methodology in this industry and was presented to the CADMAC Subcommittee on Base Efficiency as a recommended approach for estimating net savings for Commercial Energy Efficiency Incentive programs. The VR team provides no justification for why they believe the DIMR approach should not be used, nor do they provide any basis for the approach that they have recommended.

Nevertheless, as discussed above, the VR states it has a concern with interacting the Mills ratio with the engineering estimates. As discussed above, an obvious alternative methodology would then be to apply the (single) Inverse Mills Ratio approach, which does not interact the Mills ratio with the engineering estimate, and is another common industry methodology used in estimating net effects. This methodology provided similar results to the DIRM approach, with slightly lower net impact results for the lighting technologies, and slightly higher net impact results for the HVAC technologies. In addition, the Study's results are all statistically significant with one exception. However, the approach recommended in the VR did not provide statistically significant results for *any* of the HVAC measures.

PG&E would also like to address a comment that was made in the VR, with which we do not agree. The report attempts to justify the removal of a variable (HVPART) in the probit model that estimates the probability of participating in the lighting program, by stating "the HVAC participation decision is likely made simultaneously with the lighting participation decision." Of the 3,253 sites participating in lighting in PY96, only 124 (or 4%) participated in the PY96

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[3] Our method does not include the engineering estimate without interacting it with the Mills Ratio, as is suggested by Goldberg and Train, referenced below.

[4] 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. Other references for correcting for self-selection bias using the Mills ratio technique include:
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.

HVAC program. Furthermore, of these 124 customers, only 52 submitted an application for the PY96 HVAC program during the same month. In addition, 225 PY96 lighting participants participated in either the PY94, PY95 or PY97 HVAC program. These statistics lead us to believe that the HVAC participation decision is *not* made simultaneously with the lighting participation decision. Furthermore, as is discussed above, the removal of the HVPART in the Study's net billing model results in *higher* net impacts.

Conclusion

In summary, PG&E is left with the impression that the strategy taken by the VR team was to attempt to lead the reader into believing that:

1. PG&E's filed results are an upper bound of net impacts because the methodologies used were "cherry-picked";

2. The revised net impacts using the modified discrete choice model provide a lower bound of net impacts; and

3. The net impacts recommended by the VR are some "middle ground", and therefore, reasonable (as inferred by presenting alternative results in Table 6, which are not recommended, and are unrealistically low).

PG&E has clearly illustrated that all three of these points are incorrect and misleading. We have shown that:

1. PG&E's filed results are conservative, reasonable, protocol-compliant and unbiased;

2. The VR's results based on the modified discrete choice model are unrealistically low, in fact should be considered below any acceptable lower bound; and

3. The VR team's recommended results are biased and underestimate the gross and net load impacts.

Closing Comments

The only significant recommendation made by the VR team is the change to the gross billing model. PG&E has clearly justified the intent of our model, and illustrated that it is not an inconsistent or biased approach. The VR team provides no justification for its claims of inconsistency or bias.

When comparing PG&E's filed results to the results recommended by the VR, the result presented for the modified discrete choice model should be ignored. This result is not recommended, it does not represent a lower bound, and it provides an unrealistically low result as it ignores the effects of program awareness and all related program benefits.

We look forward to discussing our response in more detail with any of the ORA staff.

ATTACHMENT 1
Excerpt from PY96 CEEI Research Plan
Pages 2-26 to 2-29

2.3.4 Model Specifications

Because many participants tend to install rebated measures in more than one program, it is expected that many customers will have participated in both the lighting and HVAC end uses. Therefore, one integrated billing model will be run incorporating participants from both these end uses.

Gross Billing Regression Analysis

Two separate multivariate regression models will be integrated to provide unbiased and robust model estimates of gross energy impacts. The key feature to this approach is that it employs a simultaneous equation approach to account for both the year-to-year and cross-sectional variation in a manner that consistently and efficiently isolates program impacts.

A baseline model will initially be estimated using only the comparison group (nonparticipant) sample. This model will estimate a relationship that is then used to forecast the post-installation-year energy consumption for all participants as a function of pre-installation year usage. In this way, baseline energy usage is forecasted for participants by assuming their usage will change, on average, in the same way that usage did for the comparison group. The baseline model explains post-installation usage as a function of pre-installation energy usage, weather changes, and customer self-reports of factors that could affect energy usage. The baseline model has the following functional form:

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

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 and ΔHDD_i are the annual change of cooling and heating degree days (base 65°F) between the post-installation year and pre-installation year;

$Elec_i$ is an indicator variable (0/1) for the ith customer, which equals 1 if the customer has electric heating;

$Chg_{i,k}$ 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;

α_j is the indicator variable (0/1) for the jth business type, which equals 1 if the customer is in that business type and 0 otherwise;

β, γ and ϕ 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 will be calculated using the parameters of the baseline models estimated for the pre to post analysis period. They both take the same functional form with different segment-level intercept series (α_j) and slopes (β, γ and ϕ).

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

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

$$kWh_{post,i} - F_{pre}(kWh_{pre}, \Delta CDD, \Delta HDD) = \sum_m \beta'_m Eng_m + \sum_k \eta'_k Chg_{ik} + \mu_i$$

The difference between predicted and actual usage in the post period will be used as the dependent variable in the SAE model. Based upon the estimated participation month, the pro-rated engineering estimates and change variables will be used to explain the deviation in actual usage from the predicted usage. As discussed above, the predicted usage will be estimated using only the comparison group to forecast the post period usage as a function of pre period usage and change of cooling and heating degree days from pre to post. This usage prediction presents what would have happened in the absence of the program and other changes that may have occurred at the premise.

The coefficients of the engineering impact, termed the SAE coefficients, will then be used to calculate the ex post gross energy impacts. Independent realization rates will be estimated to provide PG&E with business type and technology group level results.

Net Billing Regression Analysis

The net billing regression analysis uses a model specification similar to the baseline model used in the gross billing analysis, with three significant differences:

- Both participants and nonparticipants are included in the model.
- An Inverse Mills Ratio (Mills Ratio) is entered into the model in two ways. First, an Mills Ratio is entered for participants and nonparticipants to correct for self-selection

bias. Second, an additional Mills Ratio term is interacted with a participation indicator variable.

- Using two different model specifications, the Mills Ratio terms are used to estimate both impacts and net-to-gross ratios at the technology level.

To calculate the Mills Ratio, the first step is to estimate a probit model of program participation. The probit model will include all factors thought to influence the decision to make an equipment purchase:

$$\text{PARTICIPATE} = \alpha + \beta'X + \beta'Y + \beta'Z + \varepsilon$$

where PARTICIPATE is an indicator variable with a value of one for program participants and a value of zero for nonparticipants. The X term includes firmographic variables such as business type and electricity usage, Y includes variables reflecting equipment characteristics such as cost and electricity savings, and Z reflects program variables such as rebate amount and program awareness. Information on these variables for both participants and nonparticipants will be obtained from the MDSS as well as from the participant and nonparticipants surveys.
From the probit estimation results, a Mills Ratio is calculated for both participants and nonparticipants:

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

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

where ϕ is the probability density function and Φ is the cumulative density function for the normal distribution.

In the net billing model, the first Mills Ratio is included for both participants and nonparticipants to control for self-selection bias. The second Mills Ratio is interacted with the participation indicator variable so that only participants have a nonzero value for this term. The result is a coefficient estimate reflecting the impact for participants that corrects for any unobserved influences that affect both program participation and size of impact for participants.

Using the Double Inverse Mills Ratio technique, two separate net billing regression models will be estimated. In both models, the second Mills Ratio term is broken out by technology type. Model 1 includes engineering estimates interacted with the Mills Ratio. With this model, the coefficient estimates on the second Mills Ratio will reflect one minus the free-ridership rate for that technology. Model 2 is similar to Model 1 except that the second Mills Ratio is not interacted with an engineering impact estimate. This results in the coefficient estimate on the second Mills Ratio to be the net impact associated with that technology. Both model specifications are given below.

Model 1

$$kWhPost_i = \Sigma_j (\alpha_j + \beta_j\text{'}kWhpre_i) + \gamma\text{'}(\Delta CDD)*kWhpre_i + \phi\text{'}(\Delta HDD)*Elec_i*kWhpre_i + \Sigma_k\eta\text{'}chg_{i,k} + \delta\text{'}Mills + \Sigma_k \lambda_k\text{'}Mills*D_i + \varepsilon$$

Model 2

$$kWhPost_i = \Sigma_j (\alpha_j + \beta_j\text{'}kWhpre_i) + \gamma\text{'}(\Delta CDD)*kWhpre_i + \phi\text{'}(\Delta HDD)*Elec_i*kWhpre_i + \Sigma_k\eta\text{'}chg_{i,k} + \delta\text{'}Mills + \Sigma_k \lambda_k\text{'}Mills*Eng_k*D_i + \varepsilon$$

Where,

$kWhpost_i$ and $kWhpre_i$ are customers i's annualized energy usage for the post- and per-installation periods;

ΔCDD and ΔHDD are the annual change of cooling and heating degree days between the post-installation and pre-installation year;

$Elec_i$ is an indicator variable which equals 1 if the customer has electric heating and 0 otherwise;

$Chg_{i,k}$ are the customer self-reported change variables from the survey data;

Mills is the Mills Ratio;

D is a indicator variable indicating program participation;

α_j is an indicator variable for the jth business type;

Eng_k is the ex post engineering impact for the kth technology;

β, γ, δ, λ, η are coefficients to be estimated;

i,j, and k are index variables indexing customers, business types, and technology respectively;

ε is the normally distributed random error term.

Application Nos: 98-05-001, 98-05-005,
98-05-013, 98-05-018

Exhibit No: ____________________

ALJ: Meg Gottstein

REPORT TO THE CPUC ENERGY DIVISION ON DISPUTED SAVINGS CLAIMS IN THE 1998 AEAP AND CONSENSUS RECOMMENDATIONS FOR PROTOCOL CHANGES

1998 Annual Earnings Assessment Proceeding (AEAP)
ALJ: Meg Gottstein

October 12, 1998

By
Ralph Prahl and Jeff Schlegel
Independent Reviewers

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INTRODUCTION

This report summarizes the findings of Ralph Prahl and Jeff Schlegel, independent reviewers of the activities of CADMAC for the CPUC Energy Division, regarding two issues for the 1998 AEAP: (1) consensus recommendations for changes to the protocols; and (2) a number of disputes over utility savings claims.

CONSENSUS RECOMMENDATIONS FOR PROTOCOL CHANGES

CADMAC included two consensus proposals for protocol modifications in its testimony dated September 8, 1998 (section II, sub-sections A and B). We have reviewed both of these consensus proposals. In addition, following the renewal of our contracts with the CPUC on May 20, one or both of us attended all of the CADMAC meetings at which these consensus proposals were developed, discussed, and approved by CADMAC. At these meetings, we provided comments and suggestions on proposals that appeared to be nearing consensus so that the issues could be discussed fully at CADMAC. We also reviewed and provided comments on a draft of the CADMAC testimony to ensure that any unresolved issues associated with the consensus protocols were addressed in the testimony.

Based on our review, we find that both of the consensus proposed protocol modifications are reasonable. Both provide benefits, and do so without increasing risks in a major or unacceptable manner. For example, the proposed language regarding handling of persistence studies in support of the third and fourth earnings claims should help to reduce future controversies due to ambiguities regarding these issues, while the proposed modifications to the *Quality Assurance Guidelines* should help to improve the quality of studies in the remaining years of the utility shareholder incentive mechanisms. For these reasons, we recommend that the CPUC adopt both of the consensus proposed protocol modifications.

We note, however, that one of the proposed protocol modifications, the modifications to the *Quality Assurance Guidelines*, described on pages 22-24 and reproduced on pages 25-79 of the testimony, appears to have already become implicated in the disputes between ORA and the utilities regarding several specific studies. Because we believe the *Guidelines* are not problematic in and of themselves, we discuss the role of the *Guidelines* in the disputed studies in the context of the sections of this report on the relevant disputes, rather than here.

Finally, in regard to the market effects studies ordered in the 1996 AEAP and described on pages 79-80 of the CADMAC testimony, we note that: (1) as discussed in the testimony, all of these studies have now been completed under the direction of the CADMAC Market Effects subcommittee, which includes, in addition to the utilities, ourselves and several other non-utility parties; and (2) we believe these studies have already made valuable contributions to the CBEE's efforts to develop and implement effective programs to address the Commission's new market transformation objectives.

SAVINGS DISPUTES

The disputes covered by this report involve both load impact studies for program year 1996 and ex-ante load impact estimates for program year 1997. In the remainder of this section we discuss the approach we used to review these disputes; the scope of our report on the disputes; the organization of the remainder of the report; and two miscellaneous issues pertaining to our recommendations.

Approach

Our assessment of the disputes over savings results was based on the following data sources:

- Review of the original studies, and in some cases of supplementary material provided by the utilities.
- Review of the review memos and verification reports prepared by ORA consultants.
- Review of the testimony and supporting exhibits filed by ORA and by the utilities.
- Review of the data requests exchanged between parties, as well as of a small number of data requests of our own.
- Participation in the Case Management Meeting on October 8.

For reasons of availability, this year Ralph Prahl took the lead in reviewing all disputes, and will be our primary witness regarding both this issue and the consensus proposed protocol modifications. Jeff Schlegel also briefly reviewed the disputes we viewed as most significant either in their financial impact or the importance of the principles being disputed, and consulted with Mr. Prahl on remaining disputes. Both reviewers are in full agreement on all of the findings and recommendations contained in this report.

As in past years, while we were producing this report, discussions were proceeding between the utilities and ORA on some of the disputed issues. In late September, we notified the parties that we would include in our report all significant disputes identified in the utilities' reply testimony to ORA's report, except for any issues for which we received written notification from both the utility and ORA by October 2 that the dispute has been settled. As we did not receive notification of any such settlements by October 2 (or later, for that matter) we did not end up excluding any disputes due to early settlement. On October 7, in connection with the Case Management Meeting, we released a draft summary of our findings and recommendations, intended for purposes of information only. On October 8, we participated in the Case Management Meeting by phone.

Scope of This Report

We have included in the review only those disputes where there are non-trivial differences between ORA and each utility regarding shareholder earnings recommendations. We note that the utilities have disputed some ORA findings and conclusions regarding impact evaluation results which do not, for one reason or another, have any immediate effect on shareholder earnings. We do not plan to comment on these disputes unless directed to do so by the Administrative Law Judge.

For disputes over 1996 load impact studies, our report addresses all those significant disputes of which we are aware. However, for disputes involving ex-ante load impact estimates for 1997, this report addresses only two major issues: (1) the handling of savings claims associated with production increments, or savings from industrial measures which are associated with an increase in efficiency that coincides with an increase in production; and (2) a dispute between SDG&E and ORA regarding how to determine which cases to include in the 1997 program year, which hinges on the definition of program year. While there were a significant number of ex-ante disputes involving other issues still open at the time we completed this report, we have a number of reasons for leaving these disputes out of this report. First, ORA and the utilities are still discussing these issues, and all indications are that many of them -- though not necessarily all -- will be resolved by the time the AEAP hearing commences. Second, these disputes tend to be highly case-specific, often involving differences of opinion over the appropriateness of the value the utility assumed for a specific engineering parameter for a specific participant. We did not believe it was an effective use of our time to review such case-specific disputes until it was clear that ORA and the utilities could not resolve them. Finally, to date, most of these disputes have not been documented adequately by either side for us to develop an informed opinion on them.

We would like to suggest to the utilities that their October 20 rebuttal testimony to this report might be an appropriate forum in which to document any remaining differences with ORA regarding 1997 ex-ante load impact estimates that cannot be resolved between the parties. We would then review these disputes and attempt to be prepared to answer questions regarding them at the hearing.

Organization of This Report

In past years, we have structured our report primarily around individual programs and the disputed studies associated with these programs. However, this year we have done things a little differently. Our review found that there were a large number of disputes that spanned individual studies and programs, and involved ORA taking a common position against multiple utilities. For purposes of narrative clarity, we have tried to reflect this fact in the structure of our report. Where a dispute appears to be limited to a specific study performed in support of a specific program, we have provided a separate section on the program as in past years. However, in several cases we have combined the discussion of multiple programs and even multiple utilities into a single section discussing the set of disputed issues that these programs and utilities have in common.

First, for 1996 Nonresidential New Construction programs, because both PG&E and SCE are involved in disputes with ORA over the same core set of issues, we have combined the discussion of these two programs into a single section.

Second, for PG&E, SCE and SDG&E's 1996 Industrial Energy Efficiency Incentive programs, our review showed a high, albeit incomplete, degree of overlap in the underlying issues driving the disputes between the utilities and ORA. To repeat our basic analysis of these issues for each utility would be repetitious. For this reason, we have grouped our discussion of the IEEI programs together toward the end of the report, and prefaced them with a cross-cutting section that analyzes the underlying differences between ORA and the utilities and provides recommendations regarding the resolution of these differences.

Third, because the disputes between the utilities and ORA over savings associated with production increments span both multiple utilities and multiple program years, we have organized our discussion of this issue into a single section near the end of the report. Consistent with our practice of deferring comment on disputes over the assumptions made in connection with individual cases until it is clear that the parties cannot resolve their differences over these cases, we have limited ourselves to discussing generic principles we believe should be observed in resolving production increment disputes.

Finally, because the dispute between SDG&E and ORA over which cases to include in the 1997 program year is the only issue discussed in the report that is limited solely to the 1997 program year, it is presented at the end of the report.

As in previous years, each section of our report generally contains four sub-sections: (1) a description of the disputed study or issue; (2) a summary of the disputes between ORA and the utility; (3) a discussion of our findings regarding these disputes; and (4) our recommendations.

Two Notes on Recommendations

Finally, we note two miscellaneous issues pertaining to our recommendations.

First, this is the fourth consecutive year in which we have prepared this report, and in that time we have accreted a large number of positions on certain perennially debated energy efficiency impact evaluation issues. Because we believe it is important that regulatory policy on such issues be consistent, where earlier precedents exist, we have generally attempted to make clear why we believe our current recommendation is consistent with them, often quoting directly from our earlier reports.

Second, as in past years, we have generally not attempted in this report to recalculate shareholder earnings for each program and program year based on our recommendations. These calculations are fairly labor-intensive, and in most cases require the use of primary data that we did not have at our command. Instead, we generally recommend that either the utility or ORA be directed to file new E-tables that are consistent with our recommended resolution to each dispute. Whether we recommend that the utility file new tables or ORA do so depends on which set of existing E-tables appears to require the least work to make them consistent with our recommendations.

PG&E 1996 CEEI PROGRAM
Study Numbers 349 (Lighting) and 351 (HVAC)

DESCRIPTION OF STUDY

This large and complex effort was the primary study conducted by PG&E in support of its 1996 earnings claim for the Commercial Energy Efficiency Incentives program. Both PG&E and ORA's consultants have treated the analysis performed for each of the two end-uses listed above as a separate study, resulting in two different evaluation reports and two different verification reports. However, in actuality, the two end-uses were part of the same tightly integrated study, and the two evaluation reports and verification reports are essentially identical except for the numbers they present and a small number of issues unique to each end-use. Thus in this report we treat the disputes between PG&E and ORA surrounding the 1996 CEEI program as involving a single study.

This study used exactly the same research framework, and contractor, that were used to perform last year's study of PG&E's CEEI program. Last year the study was the subject of numerous disputes, which were ultimately resolved outside of the hearing process. PG&E appears to have revised the study framework to address many of the issues that were disputed last year, with the result that far fewer issues are being disputed this year. Methodologically, the study used the following approaches to develop estimated load impacts for the CEEI program:

1. Enhanced ex-post engineering estimates applied to a portion of the program population, using a nested sample of lighting loggers, on-site audits, telephone surveys, and tracking estimates of savings.

2. A billing analysis approach that attempted to estimate the percentage of the gross savings predicted by the enhanced engineering estimates that was actually realized, using both participant and non-participant billing and survey data (henceforth referred to as "the gross savings billing analysis.") This gross savings billing analysis consisted of three phases: (1) a baseline model applied to non-participants that attempted to explain how various kinds of customers changed their consumption over time; (2) application of the results of the baseline model to participants to yield an estimate of what each participant's consumption would have been in the 1997 in the absence of the program; and (3) a Load Impact Regression Model that sought to explain differences between each participant's actual and predicted consumption in 1996 as a function of program participation, among other factors.

3. An entirely separate billing analysis that used participant and non-participant billing data and the survey data to estimate net program savings (henceforth referred to as "the net savings billing analysis.")

4. An analysis of free riding among participants and spillover effects among both participants and non-participants based on self-reports from the surveys. Multiple questions were asked on the issue of free riding, and algorithms were developed to interpret the sometimes conflicting responses.

5. A behavioral model that used survey data to attempt to estimate the overall effect of the program on the adoption of energy efficiency measures by both participants and non-participants, including both free riding and spillover effects.

These disparate analyses are integrated in various ways to yield estimates of program energy, demand and therm savings by end-use.

SUMMARY OF DISPUTES

The only issue for this study that is disputed and has a financial impact involves the specific modeling methods PG&E used to perform the gross savings billing analysis described in #2 above. The dispute over these methods focuses not on the broad approach followed by PG&E but on the specific independent variables PG&E used in its models to represent changes in participating businesses other than participation in the program. Such changes, which can include changes in the number of employees, the size of the building, and equipment holdings, are both a constant challenge in billing analysis studies and a perennial source of contention between the performers and the reviewers of these studies. In this case, PG&E used the following approach to incorporate business changes into its models:

- Several specific business change variables based on customers' self-reports were included in the baseline model applied to non-participants.

- Similarly, several specific business change variables, which overlapped partially with those used in the baseline model, were included in the load impact regression model.

ORA argues that this approach to representing business changes was inappropriate, and that instead of the approach described above, PG&E should have applied the coefficients for business change variables resulting from the non-participant baseline model to participants – i.e., it should have multiplied these coefficients by the values of the parallel business change variables for participants and added the result to predicted 1997 consumption in the absence of the program. In the words of the Verification Report by ORA's consultants:

> ...The failure to employ the site-change variables for participants in the baseline model potentially introduces bias in the impact estimates.
>
> That is, we cannot be certain that the estimated (baseline) kWh will represent what it is intended to represent: the amount of energy that these participants would have used in the absence of the CEEI program. Instead, the estimated kWh will only represent the amount of energy that nonparticipants would have used had they both not participated in the CEEI program and not made any site changes... The participant site-change variables are ultimately included in the gross impact regression that is estimated using participant data, but there is no reason to believe that this compensates for the bias. (ORA Verification Report for Study 349, pp. 7-8.)

ORA's consultants accordingly re-performed the gross savings billing analysis making the recommended change in the modeling procedure. The result is a lower overall energy savings estimate for the program, with a resulting decrease of approximately $2.6 million in the estimated shareholder incentives for which PG&E is eligible.

In its rebuttal testimony and in a technical memo distributed to us and to ORA, PG&E argues that its approach to modeling business changes was appropriate, and ORA's inappropriate. Specifically, it argues that: (1) contrary to the interpretation given in the Verification Report, the baseline model and the application of the results of this model to participants was never intended to estimate the amount of energy that participants would have used in the absence of the program, but to estimate what post-period usage would have been for participants in the absence of any facility changes of any kind; (2) business changes were instead modeled appropriately in the final savings model; (3) this approach to modeling business changes was planned up front as part of an explicit effort to distinguish between the modeling of *uncontrolled* changes in consumption such as weather in the estimation of baseline consumption, and of *controlled* changes such as business changes; (4) ORA has not shown that this approach to modeling business changes can be expected to result in bias; and (5) ORA's alternative approach produces bias because it fails to recognize either that there are likely to be differences in the business change patterns of participants and non-participants, or that the lighting measures undertaken by non-participants are not likely to be equivalent to the non-rebated lighting measures adopted by participants.

In addition to the key dispute described above, a number of other issues have been disputed in connection with this program that either do not have any immediate financial impact or did not make their way into PG&E's rebuttal testimony. Notably, the Verification Report suggests that PG&E's modeling efforts show some evidence of "cherry picking," or of systematically basing subjective modeling decisions on which approach yields the higher savings estimate. In the technical memos distributed to the parties, PG&E took vigorous objection to this accusation, arguing that in a number of different cases it voluntarily chose a modeling approach that yielded lower savings than the alternative.

Finally, in the Verification Report, ORA's consultants identified what they characterized as a problem with the algorithms used to interpret the survey results, and adjusted the algorithms to correct for this alleged problem. PG&E does not appear to object to ORA's diagnosis of this problem or its adjustment to the algorithms, so this issue results in a minor, undisputed change in PG&E's initial savings estimates.

FINDINGS

We focus our review of the issues solely on the key dispute over modeling techniques that drives the $2.6 million gap between PG&E's and ORA's estimates of shareholder earnings. While we would regard any evidence of "cherry picking" on PG&E's part as a serious matter if a convincing case could be made, as will become clear, we do not believe it is necessary to assess whether or not PG&E engaged in cherry picking in general in order to assess the objectivity of the decisions it made in connection with the specific modeling decisions that drive the gap in earnings estimates.

The exact same issue regarding how to model participant business changes was the subject of dispute in connection with last year's study of the same program, and we addressed this issue in our report for the 1997 AEAP. Because we believe it is important that there be continuity and consistency in the way methodological disputes are handled, we will quote at length from our previous report:

> *Handling of Specific Business Change Variables.* We regard ORA's... criticisms of PG&E's handling of business change issues as... ambiguous... We believe the reason PG&E chose to exclude the business change coefficients resulting from the non-participant baseline model in estimating participants' baseline 1996 consumption is that it included these variables in the final participant savings model. Also including business change issues in the estimation of baseline consumption would have resulted in double-counting...In short, it appears to us that ORA's secondary criticisms of PG&E's handling of specific business change variables essentially boil down to a matter of differing modeling preferences. Our own preferences are closer to ORA's than to PG&E's...While we do not regard PG&E's decision to represent business change issues in the participant savings model rather than in the estimation of baseline participant consumption as a straightforward error, we do tend to believe it would have been more justifiable on theoretical grounds to take the opposite tack -- as did ORA in its re-estimation of the model -- reflecting the fact that business changes affect energy consumption regardless of the presence or absence of the program.
>
> While we prefer ORA's approach to the handling of specific business change variables, we were initially undecided as to whether it offers enough comparative advantages to justify overturning PG&E's handling of the issue. After all, researchers need to have some flexibility to build billing analysis models based on their own modeling procedures and preferences, as long as these do not represent

> clear errors or instances of one-sidedness. For this reason, in our data request we asked PG&E to provide information intended to help us assess the magnitude of the impact of the secondary disputes involving business change variables compared to the impact of the critical "other business change" issue discussed above. The results suggest that the impact of the handling of specific business change variables has very little effect on the results of the model. Given that there is little impact, we are comfortable that it is reasonable to rely on the results of ORA's approach. (Independent Reviewers' 1997 AEAP report, pp. 23-24.)

In short, last year we saw arguments on both sides of the issue. On ORA's side, we concluded that, while PG&E's approach to modeling business changes was not erroneous, and did in fact capture participant business changes in a reasonable manner, ORA's approach might be an improvement in that it correctly represented the fact that business changes affect consumption regardless of the presence or absence of the program. On PG&E's side, we concluded that it was unclear whether or not any improvement was sufficient to justify overturning PG&E's modeling decisions given that no clear error had been made. Ultimately, we did not attempt to resolve the issue but recommended accepting ORA's estimate simply because: (1) which approach was used had very little effect on the final savings estimate; and (2) since we had sided with ORA on other modeling-related issues, accepting ORA's modeling technique avoided the need to ask one of the parties to produce another iteration of a rather complicated analysis framework.

This year the same difference in modeling techniques that produced little difference in savings estimates in 1997 produces a $2.6 million difference in shareholder earnings. Should PG&E's modeling decisions again be overturned?

We believe the answer is no. Our reasons are as follows.

First, we believe ORA's consultants are incorrect in arguing that PG&E's modeling efforts do not adjust for site changes among participants. They simply do so in a different manner than ORA's consultants would prefer. PG&E's approach to billing analysis uses a system of three different, tightly interwoven regression equations to estimate savings. The ability of this approach to provide an unbiased measure of savings can only be determined by assessing this system as a whole, not by focusing on what confounding effects are captured by any one equation in the system.

Second, we believe PG&E has made a stronger case this year than it did last year that ORA's alternative modeling approach would be likely to lead to bias due to differences in business change trends and non-rebated lighting retrofits between participants and non-participants. While ORA's consultants have argued that any admission of such differences on PG&E's part would be tantamount to admitting that the entire modeling framework is suspect, we do not agree with this analysis. Self-selection effects in regression analysis, of which this is an example, are both ubiquitous and extremely difficult to control for. After years of debate among evaluators regarding proper techniques, full consensus still does not exist. We regard the assertion made by PG&E in its technical memos that self-selection effects regarding business change trends bar ORA's modeling approach as simply a recognition of the fact that, despite its best efforts, these effects probably have not been entirely controlled for.

Third, and perhaps most importantly, we continue to be uncomfortable with the concept of ORA's consultants substituting their modeling judgment for PG&E's when they have not identified a clear error in PG&E's procedures. Even if ORA's modeling approach did constitute an improvement over PG&E's – and as the preceding paragraph should make clear, it is not at all clear to us that this is the case – we believe the proper scope of ORA's review activities is to identify and correct for errors and instances of one-sidedness in the utilities' procedures, and not to substitute its own subjective modeling preferences for PG&E's.

Finally, we are comfortable that, regardless of whether or not PG&E indulged in cherry picking in the study as a whole, it did not do so in its selection of this particular modeling technique. First, as noted by PG&E, the company clearly described the approach it would use to model participant business changes before it began the study. Second, as shown in the passage from our report from last year that is excerpted above, PG&E vigorously defended its chosen modeling approach in the 1997 AEAP, despite the fact that virtually no dollars were at stake on the basis of it. These facts lead us to conclude that PG&E's preference for its own modeling technique over ORA's is not being driven by financial considerations, but instead reflects a legitimate difference of opinion regarding the relative merits of two technically plausible approaches.

RECOMMENDATIONS

We recommend that: (1) PG&E be directed to produce new e-tables identical to those it filed initially, with the sole exception that the error that both parties agree exists in the algorithm for interpretation of free rider survey data be corrected; and (2) PG&E's shareholder incentives be based on these tables.

Certificate of Service

I, Ralph Prahl, hereby certify that I have this day caused a copy of the *Report to the CPUC Energy Division on Disputed Savings Claims in the 1998 AEAP and Consensus Recommendations for Protocol Changes*, dated October 12, 1998, to be mailed to all parties of record in Application 98-05-001, et al.

Executed at Madison, Wisconsin, on October 12, 1998.

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Ralph Prahl

Attachment 5

PG&E Retroactive Waiver for 1997 Commercial Sector EEI Programs

Lighting and HVAC End Use Net-to-Gross Analysis

PACIFIC GAS & ELECTRIC COMPANY
RETROACTIVE WAIVER FOR
1997 COMMERCIAL SECTOR EEI PROGRAMS
Lighting and HVAC End Use
Net-to-Gross Analysis
STUDY IDs: 333a & 333b
Approved by CADMAC on January 20, 1999

Program Background

Pacific Gas & Electric Company (PG&E) fielded DSM programs to the Commercial sector (among others) during 1997. The primary purpose of the 1997 Commercial Program (Programs) was to promote the installation of energy efficient equipment retrofits. The Programs offered a wide variety of energy efficient prescriptive lighting and HVAC measures ranging from compact fluorescent lamps to custom non-prescriptive lighting and HVAC measures. The impact evaluation associated with this waiver is designed to assess the actual load impacts resulting from the lighting and HVAC measures rebated during 1997.

1997 Program Summary: Indoor Lighting End Use

Technology	Unique Sites	Avoided Cost	Percentage of Avoided Cost
Compact Fluorescent Lamps	1,956	8,194,724	13.9%
Controls	461	1,086,778	1.8%
Customized Lighting	6	1,388,314	2.3%
Delamp Fluorescent Fixtures	807	14,394,387	24.3%
Efficient Ballast Changeouts	81	90,564	0.2%
Exit Signs	742	1,810,353	3.1%
Halogen	174	80,706	0.1%
High Intensity Discharge	444	5,148,037	8.7%
Incandescent to Fluorescent Fixtures	95	1,128,552	1.9%
T-8 lamps and Electronic Ballasts	3,488	25,818,156	43.7%
TOTAL (Unique Sites)	2,796	59,140,572	100.0%

1997 Program Summary: HVAC End Use

Technology	Unique Sites	Avoided Cost	Percentage of Avoided Cost
Adjustable Speed Drives	136	1,639,531	14.8%
Central A/C	1,266	3,988,213	35.9%
Convert To VAV	1	44,489	0.4%
Cooling Towers	3	41,073	0.4%
Customized EMS	4	305,430	2.8%
Other Customized Equip	1	320,628	2.9%
Other HVAC Technologies	16	229,621	2.1%
Package Terminal A/C	115	397,752	3.6%
Reflective Window Film	243	874,147	7.9%
Set-Back Thermostat	438	1,041,759	9.4%
Water Chillers	25	2,223,580	20.0%
TOTAL (Unique Sites)	1,337	11,106,223	100.0%

Proposed Waiver

This waiver requests deviations from the Protocols by PG&E for the 1997 Commercial Sector Evaluation, lighting and HVAC end uses. PG&E seeks CADMAC approval to allow the use of self-report based algorithms to estimate free ridership and spillover effects for certain technologies should the discrete choice and LIRM models fail to produce statistically reliable results of net-to-gross estimates. Therefore, the self-report methodology would only apply to those technologies (not the entire end-use) for which the discrete choice and LIRM models fail to produce statistically reliable results.

Rationale

It is our expectation that the discrete choice model will provide statistically reliable results for all lighting technologies and CAC HVAC technologies, as was the case in the 1996 evaluation. However, for custom types of HVAC installations and lower penetrated HVAC technologies, sample sizes of nonrebated installations are too small to implement a discrete choice model. Furthermore, low levels of participation for some of these technologies also reduce the likelihood of obtaining statistically reliable results from a LIRM model.

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

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