Customer Energy Efficiency Program
Measurement and Evaluation Program

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

PG&E Study ID number: 404D

March 1, 2000

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EVALUATION OF
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PRE-1998 COMMERCIAL ENERGY EFFICIENCY INCENTIVES PROGRAM CARRY-OVER
FOR TRAFFIC SIGNAL TECHNOLOGIES

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Purpose of Study

This study was conducted in compliance with the general 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. Because the Protocols do not explicitly cover the Traffic Signal end-use, a waiver stating the methodology for estimating load impacts for the Traffic Control Signal Program was submitted to the California DSM Measurement Advisory Committee (CADMAC), and approved on May 20, 1999.

This study evaluated the gross and net energy savings from LED Traffic Signal technologies for which rebates were paid in 1998 by Pacific Gas & Electric Company's Commercial Energy Efficiency Incentive (CEEI) Programs. These retrofits were performed under a pilot program offered under the Retrofit Efficiency Options (REO) program in 1997.

Methodology

Based on an assessment of existing data, program evaluation requirements were established for additional data to be collected. This data was gathered via telephone surveys. There were a total of 54 sites that participated in the REO Program and received a rebate from PG&E in 1998. A complete census of the population was needed to meet the goals of the telephone survey. A non-participant sample was developed by identifying commercial customers with the same jurisdiction type and SIC codes as the participant sample. In addition, non-participant customers were required to have a 'TC 1' rate schedule code, and non-missing usage values for 1997, 1998, and 1999. The Traffic Signal end-use included 48 participant and 51 non-participant telephone surveys.

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 and demand impacts for specified time-of-use costing periods. The engineering analysis combined information from telephone surveys, manufacturer specifications, and traffic signal logger data (collected by the Power Saving Partners Program) 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 regression analysis model, and a difference-of-differences approach. The final NTG ratios applied to the ex post gross impacts are based on the results of the self-report model. Both LIRM models (net billing and difference-of-differences) produced incomplete estimates of the net-to-gross ratio, and were also determined to be potentially statistically biased. The self-report method resulted in a complete net-to-gross estimate, and was also the most conservative result. For these reasons, the self-report results were selected as the final net-to-gross ratio estimate.

Study Results

The results of the analyses for Traffic Signal technologies are summarized below:

	Gross Savings	Gross Realization Rate	1-FR	Net-To-Gross Spillover	NTG Ratio	Net Savings	Net Realization Rate
				EX ANTE			
kW	2,351	-	0.800	0.100	0.900	2,116	-
kWh	20,607,303	-	0.800	0.100	0.900	18,546,573	-
				EX POST			
kW	2,321	0.987	0.769	0.058	0.828	1,921	0.908
kWh	19,262,102	0.935	0.769	0.058	0.828	15,945,168	0.860

Regulatory Waivers and Filing Variances

As stated above, the CADMAC approved a waiver on May 20, 1999, which stipulated the methodology used for estimating the load impacts for the Traffic Control Signal Program.

There were no E-Table variances.

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

PG&E Study ID#: 404D

FINAL REPORT

March 1, 2000

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1. EXECUTIVE SUMMARY

This section presents a summary of the impact results for the LED Traffic Signal technologies offered under Pacific Gas & Electric Company's (PG&E's) Pre-1998 Commercial Energy Efficiency Incentive (CEEI) Program Carry-Over, referred to in this report as the Traffic Signal Program. This evaluation covers LED traffic signal technology retrofits that were rebated during 1998, which was offered in 1997. These retrofits were performed under a single PG&E program, the Retrofit Efficiency Options (REO) Program. The results are presented in two sections: Evaluation Results Summary (covering the numerical results of the study) and Major Findings.

1.1 EVALUATION RESULTS SUMMARY

The evaluation results are summarized in terms of energy savings (kWh), demand savings (kW), 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 and demand 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 Traffic Signal Applications

	Gross Savings	Gross Realization Rate	Net-To-Gross 1-FR	Spillover	NTG Ratio	Net Savings	Net Realization Rate
			EX ANTE				
kW	2,351	-	0.800	0.100	0.900	2,116	-
kWh	20,607,303	-	0.800	0.100	0.900	18,546,573	-
			EX POST				
kW	2,321	0.987	0.769	0.058	0.828	1,921	0.908
kWh	19,262,102	0.935	0.769	0.058	0.828	15,945,168	0.860

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

These ex post results illustrate the following key points about the gross and net traffic signal impacts:

Gross Energy Impacts - The ex post gross energy impacts were 6.5 percent smaller than the ex ante gross estimates. The unadjusted engineering estimates of gross energy impact, however, were 9 percent smaller.

Gross Demand Impacts - The ex post gross impacts for demand were only 1 percent smaller than the ex ante gross estimates. The difference is primarily the result of small variations between ex ante and ex post engineering parameters.

Net Impacts - The net ex post impacts were 14 percent less than ex ante for energy and 9 percent less for demand. The net realization rate for energy and demand impacts are lower than the gross realization rates because of the lower ex post net-to-gross (NTG) ratios relative to ex ante. The majority of the lower NTG ratio is due to the free-ridership rate. The ex ante NTG ratio was 0.90, while the ex post NTG ratio was 0.828 for both energy and demand. Therefore, the ex post NTG ratios contribute an additional 8 percent decrease relative to ex ante for energy and demand impacts.

1.2 MAJOR FINDINGS

Gross Realization Rates.

The only technology group with a gross energy realization rate greater than one was 12-inch Red Arrow Signals at 1.15. The technology group with the smallest realization rate was Orange Pedestrian Walk Signals, at 0.83. These results are discussed below using information from the review of the ex ante estimates in conjunction with the billing analysis results.

12-inch Red Arrow Signals - The relatively high realization rates for 12-inch Red Arrow Signal technologies are due to the difference between ex ante and ex post duty cycle estimates. The ex post duty cycle estimate is 18 percent higher than the ex ante estimate. The ex post change in connected load is slightly lower than the ex ante, which helps to offset the difference in the duty cycle estimates. The high realization rates for 12-inch Red Arrow Signals have a significant effect on the overall traffic signal end-use realization rate because the energy impact of this technology accounts for almost one third of the traffic signal program's total.

Orange Pedestrian Walk Signals – Overall, ex post energy impacts differ from ex ante energy impact by about 17 percent. The low realization rate is entirely due to the difference between the ex ante and ex post duty cycle estimates. The ex post connected load estimate was slightly lower than the ex ante connected load estimate, but not enough to make a significant impact. The ex post duty cycle estimate, however, is almost 17 percent lower than the ex ante estimate. QC believes that the ex ante duty cycle estimates for the Orange Pedestrian Walk Signals and the 12-inch Red Arrows were inverted. This also helps to explain the high realization rate of the 12-inch Red Arrow Signals.

Overall, the gross demand estimates are only 1 percent lower than the ex ante values. The technology that differed the most from ex ante estimates was 12-inch Red Ball Signals. Specific comments and justifications for these results are as follows:

12-inch Red Ball Signals - The low realization rate for 12-inch Red Ball Signal technologies results from ex ante estimates for this technology, which are based on an assumed average duty cycle instead of a peak period duty cycle. Ex ante estimates also assume almost a slightly larger change in connected load than the ex post estimates.

12-inch Red Arrow Signals - The ex post estimated impacts for 12-inch Red Arrows are high due to the ex ante duty cycle estimate, which was most likely switched with the Orange Pedestrian Walk Signal estimate.

Net Realization Rates

The net ex post energy impact is 14 percent lower than the net ex ante impact estimates. This difference is explained primarily by the fact that the free-ridership is high for the Traffic Signal Program, at 23 percent. The unadjusted gross ex post engineering estimates are only 8.5 percent lower than the ex ante estimates. This difference combined with a program-level SAE coefficient of 102 percent resulted in a gross realization rate of 93 percent. A lower ex post net-to-gross adjustment relative to ex ante brought the net realization rate even lower to 86 percent.

The net ex post realization rate for demand impacts is 91 percent. The ex post gross demand impacts are 99 percent of ex ante gross demand impacts. Again, the lower ex post net-to-gross adjustment relative to ex ante resulted in a lower net realization rate relative to gross, at 91 percent.

2. INTRODUCTION

This report summarizes the impact evaluation of Pacific Gas & Electric Company's (PG&E's) Pre-1998 Commercial Energy Efficiency Incentive (CEEI) Program Carry-Over for traffic control signal technologies (the Traffic Signal Evaluation). These technologies are covered by the Retrofit Efficiency Options (REO) Program. The evaluation effort includes customers who were paid rebates in 1998, but participated under the 1997 CEEI program. A summary description of the REO program is provided below.

2.1 THE RETROFIT EFFICIENCY OPTIONS PROGRAM

The Retrofit Efficiency Options REO Program provided a choice of incentives, including financing, design and implementation assistance, to commercial, industrial, and agricultural customers who install specific energy efficiency measures. Customers were eligible to apply for low-interest financing through PG&E's Capital Advantage Program or design and implementation assistance through PG&E's Tailored Energy Planning Assistance option.

The REO Program focused on a limited number of proven cost-effective technologies and provided prescriptive incentives for energy efficiency improvements. The REO program covered measures too complex for Retrofit Express, but those that could still use a prescriptive rather than a customized application approach. The prescriptive incentives were based on typical cases as defined by multiple parameters. Applicants completed pre-approved standard calculation worksheets to request project incentives.

The REO program was divided into five end use/sector categories that included:

- Refrigeration
- Building Systems
- Industrial
- Municipal
- Agricultural

There were a total of 26 REO measures, of which 4 were traffic control signal technologies. All of the traffic control signal technologies are covered under the Municipal end use/sector category, and include the following four pilot measures:

- LED Traffic Lights – 12" Red Ball
- LED Traffic Lights – 8" Red Ball
- LED Traffic Lights – 12" Red Arrow
- LED Traffic Lights – Orange Hand Signal

2.2 *EVALUATION OVERVIEW*

The impact evaluation described in this report covers all traffic control signal measures installed under the REO Program, as determined by the Marketing Decision Support System (MDSS) sector code, for which rebates were *paid* during calendar year 1998.

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

2.2.1 Objectives

The research objectives are as follows:

- Determine first-year gross energy and demand impacts for REO traffic control signal technologies paid in 1998, as required by the California Public Utilities Commission (CPUC) Protocols.

- Determine first-year net energy and demand impacts for REO traffic signal technologies paid in 1998, as required by the CPUC protocols.

- Compare evaluation results (ex post) with PG&E's (ex ante) estimates, and investigate and explain any discrepancies between the two.

- Assess free-ridership and spillover rates, and investigate and explain differences between evaluation and program design estimates.

- Complete tables 6 and 7 of the Protocols.

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 Traffic Signal Program has had on the traffic control signal market. For example, adjustments were made to the gross savings estimates to account for customers that would have installed LED traffic control signal measures in the absence of the program (**free-riders**). The adjustment also included participant and nonparticipant **spillover** rates, defined as LED traffic control signal measures installed outside the program and as a result of the presence of the program.

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

2.2.2 Timing

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

2.2.3 Role of Protocols

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

2.3 EVALUATION APPROACH – AN OVERVIEW

This overview of the integrated evaluation approach begins by presenting the data sources used for the Traffic Signal 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 Traffic Signal 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 Traffic Signal program. Of particular importance were PG&E's historical billing data, program participant data (Marketing Decision Support System [MDSS]), and other program-related data. Each of the existing data sources is described briefly below.

Program Participant Tracking System - The participant tracking system data, maintained in the PG&E MDSS, contains program, project, and technical information about measure installation. It also provides expected impact estimates based upon the ex ante engineering algorithms. This information was used to create sample designs for data collection and to leverage calibrated impact estimates from the telephone sample to the entire participant population.

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

PG&E Billing Data - The PG&E nonresidential billing database contains monthly energy-consumption information for all commercial customers in PG&E's service territory. This information is used to calibrate the engineering estimates to actual pre- and post-installation energy usage.

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[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.

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 includes assumptions such as operating hours and operating factors, by traffic control signal measure. This document supplies the best information available on ex ante estimates and assumptions, thus facilitating knowledge-based comparisons to ex post estimates. The 1997 version was used rather than the 1998 version because the evaluation is for carry-over participants.

Manufacturer Information - In order to establish baseline levels and new equipment performance levels, information from traffic signal manufacturers was used to verify application or telephone survey data.

Primary Data Collected

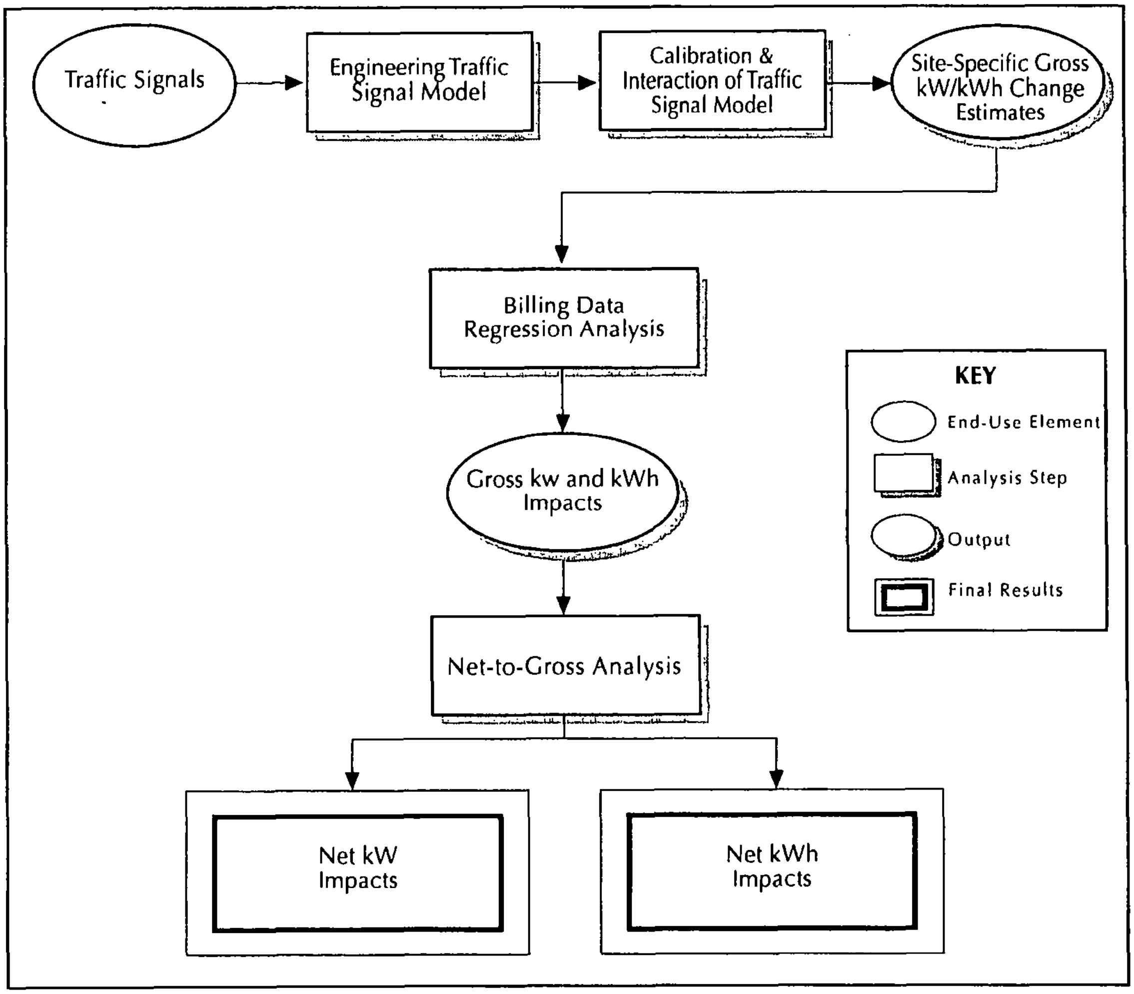
Based on an assessment of existing data, program evaluation requirements were established for additional data to be collected. This data was gathered via telephone surveys. A total of 48 traffic signal participant and 51 nonparticipant surveys were completed to gather customer profiles used in all of the analyses. The nonparticipant survey was similar to the participant survey, and served as a control group in the SAE analysis and 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 Traffic Signal 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.*

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

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 time the 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 traffic signal logger data obtained from the Power Saving Partners (PSP) Program in conjunction with 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 and equipment purchased under the program.

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

Engineering Analysis

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

Gross unadjusted engineering impacts were developed for each customer and retrofit measure. Average hourly demand impacts were developed using the net change in fixture connected load in conjunction with average duty cycles for each measure. Aggregating average hourly impacts for every hour in a year and for all fixtures retrofit for the customer derived gross engineering energy impacts. 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 for each customer and retrofit measure using the same change in connected load developed for the gross engineering energy estimates. However, instead of aggregating the hourly impacts, demand impacts were determined by multiplying the change in connected load by the peak period duty cycle.

Billing Analysis

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

Net-to-Gross Analysis

The NTG analysis is designed to adjust gross program impacts for free ridership and actions taken by PG&E customers outside the 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.

Two LIRM methods were also implemented for this study, a net billing model and a difference of differences model. The California DSM Measurement Advisory Committee (CADMAC) has approved a waiver allowing that self-report based algorithms be used for the net-to-gross analysis in the event the LIRM methods do not produce statistically reliable results. This waiver is presented in Attachment 1.

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 Traffic Signal 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 accepted by the CPUC that establishes a protocol-compliant methodology for estimating the load impacts for the Traffic Signal Program. *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 3* contains a memo summarizing results from the PSP evaluation of traffic signal duty cycles used in the Traffic Signal Evaluation. *Attachment 4* contains the Protocol Tables 6 and 7 for the Traffic Signal end use. *Attachment 5* provides the survey instruments for both participants and non-participants.

3. METHODOLOGY

This section provides the specifics surrounding the methods used to conduct the Pre-1998 Pacific Gas & Electric Company (PG&E) Commercial Energy Efficiency Incentive (CEEI) Program Carry-Over Evaluation for traffic control signal technologies (the Traffic Evaluation). This section begins with a detailed discussion on the sampling plan for the Traffic 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 Traffic Evaluation. First, the overall sample design approach is discussed, followed by the resulting sample allocation. The section concludes with a discussion of the California Public Utilities Commission (CPUC) Evaluation and Measurement Protocols (the Protocols) requirements.

3.1.1 Existing Data Sources

The participant tracking system contains the Retrofit Efficiency Options (REO) Program which is maintained as part of PG&E's Marketing Decision Support System (MDSS). 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 REO program, participation was tracked at both an application and measure level. They are linked by application code and program year. Each application can cover multiple measures and accounts, and each measure is linked to a PG&E electrical service location where the measures are supposed to be installed. For this program, all accounts contained the 'TC 1' rate code and 'STL' segment code. The Traffic Control rate code and Street Lighting segment code identified all the accounts as traffic control signals on street intersections. 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 this Evaluation cover a period from January 1993 to September 1999. PG&E's billing data contain monthly energy-consumption as well as other customer information, such as customer name, service location, rate schedule, and Standard Industrial Classification (SIC) code.

3.1.2 Sample Design Overview

Program participants who were paid a rebate in 1998 were carry-over applicants in the 1997 program. Their traffic control signal projects were initiated prior to 1997 but they only received a rebate in 1998 when their projects reached the final implementation stage. There were a total of 54 sites that participated in the REO Program and received a rebate from PG&E in 1998. A complete census of the population was needed to meet the goals of the telephone survey.

3.1.3 Sample Segmentation

Evaluation of the Traffic Control Signal 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 at the jurisdiction level (city or county[1]) and technology segmentation. As will become apparent, a key feature of the sample design is that the sampling unit is a unique jurisdiction contact site. Significant effort was undertaken to aggregate billing and participation records to this level.

The first step in the participant segmentation process grouped accounts by jurisdiction type. Jurisdiction type was determined by billing information as recorded in the MDSS and PG&E's CIS billing data. There are two jurisdiction types used to segment a customer: by city or county. All rebated measures are aggregated to a city or county level since the decision to participate in the program was made at this level. Exhibit 3-1 presents the distribution of unique customer sites across the jurisdiction type and technology group segmentation.

Exhibit 3-1
1998 Commercial Traffic Control Signal Segmentation and Distribution of Unique Sites

	Jurisdiction Type		
Technology	City	County	Total
12 " Red Ball Signal	43	7	50
12" Red Arrow Signal	40	7	47
8 " Red Ball Signal	38	6	44
Orange Pedestrian Walk Signal	30	5	35
Total Unique Contact Sites	**46**	**8**	**54**

3.1.4 Sample Allocation

For this evaluation, only telephone survey data was collected. The results of the telephone survey 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 was developed to meet each of the analysis objectives. The following sections describe these objectives and sampling strategies.

[1] Two Business Park customers were reclassified as "CITY" jurisdiction type.

Participant Telephone Sample

The telephone sample was designed to be used for the engineering, billing and net-to-gross analyses. With an available sample frame of 54 jurisdiction sites, a census of all eligible participants was taken for the telephone survey.

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 a census of 131 jurisdiction customers, 106 city and 25 county. 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 the same jurisdiction type and SIC codes as the participant sample. 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 'TC 1' rate schedule code for all years spanned by the billing data.

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

3.1.5 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 jurisdiction site, which defines a unique city or county contact person. Applications in the MDSS database may cover contact persons serving the role of both a city and county contact person.

The final sample distribution for the telephone collection is summarized in Exhibit 3-2 jurisdiction type. Telephone surveys were collected for a total of 99 jurisdiction customers, 48 of which were participants, with the remaining 51 in the comparison group.

On May 20, 1999, the California DSM Measurement Advisory Committee (CADMAC) approved a waiver to apply the method described above to the telephone survey. The waiver is included in Attachment 1.

Exhibit 3-2
Data Collected by Jurisdiction Type

Jurisdiction Type	Available			Collected		
	Parts	Nonparts	Total	Parts	Nonparts	Total
City	46	106	152	41	47	88
County	8	25	33	7	4	11
Total	54	131	185	48	51	99

3.1.6 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. A census of available participant and nonparticipant sample was drawn for the commercial telephone sample.

Detailed Protocol Sample Requirement

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

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

Each participant chosen for the telephone sample is required to have at least nine months of post-installation billing data, and 12 months of pre-installation data, as per the Protocols, Table 5, part D, paragraphs 2 and 1, respectively. This requirement is met, with a pre- and post-installation period of 1 year used in the statistical billing analysis.

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

To ensure compliance with comparison group protocols, the telephone survey sample frame is drawn to meet the billing data requirements of Table 5, part D, paragraphs 3 and 4 of the Protocols. All customers in the analysis dataset have billing data from January 1993 to September 1999, which ensures an adequate pre- and post-installation billing period for customers who installed applicable measures between 1996 and 1999.

3.2 ENGINEERING ANALYSIS

The comprehensive engineering approach is presented in this section for the gross impact evaluation of the Traffic Management end-use, which specifically applies to retrofitting incandescent traffic signals with LED traffic signals (8 & 12 inch red balls, 12 inch red arrows, and orange pedestrian don't walk signals). The analysis approach implemented was a calibrated engineering model. The analysis applied to all retrofit signals that were paid rebates in 1998.

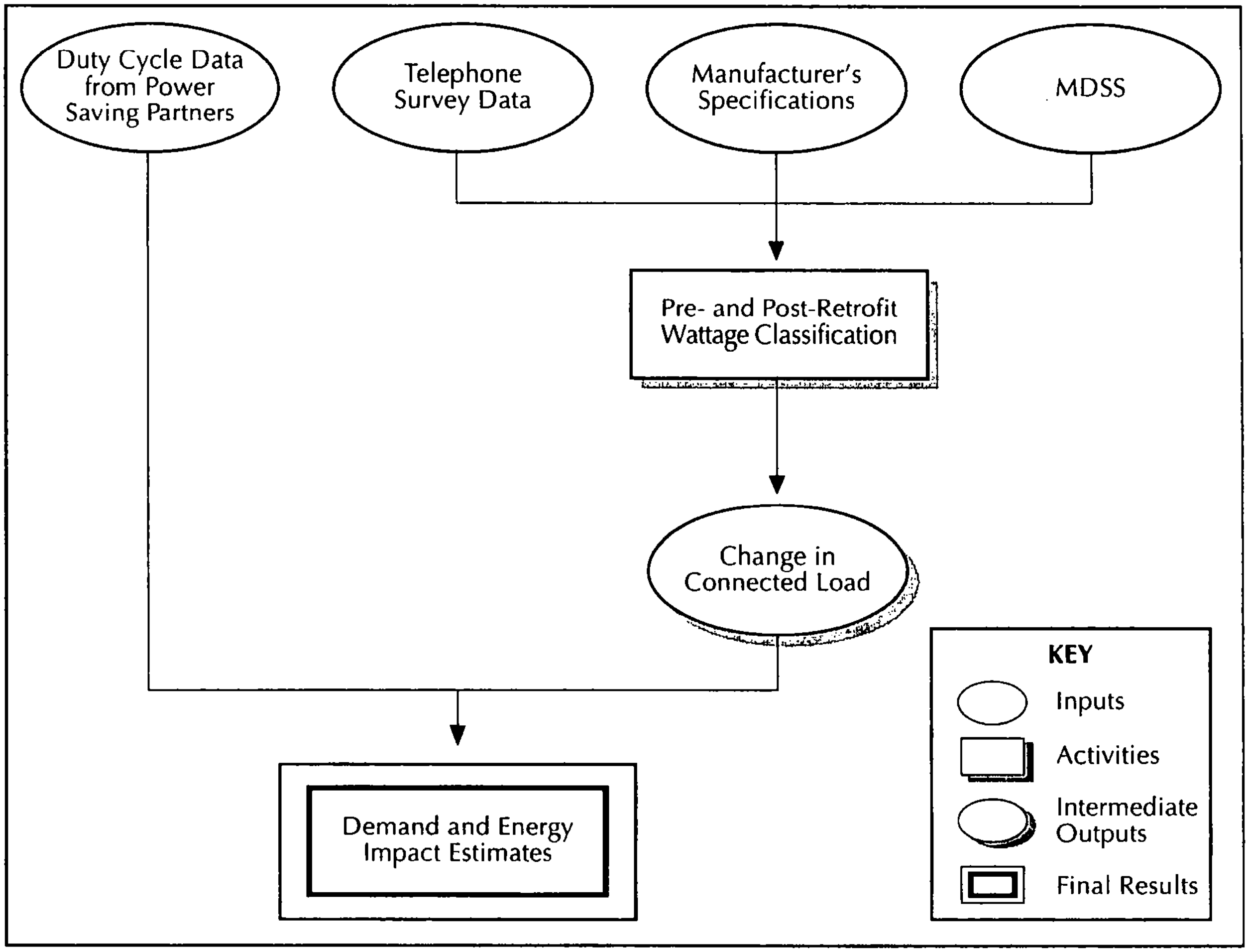
3.2.1 Traffic Signal Models

The data collection and analysis approach employed in PG&E's traffic management evaluations has incorporated three key data sources: traffic signal logger data, telephone survey data, and manufacturer specifications. The application of this thorough approach in assessing traffic management impacts, and the virtually constant nature of traffic signal wattage and duty cycles allowed a detailed analysis using self reported survey data instead of on-site audits.

A Retroactive Waiver was submitted to the CADMAC and approved in May of 1999 (see Attachment A). This Waiver ensures Protocol compliance for the engineering CE methods that were applied and the LIRM models performed, including the use of Power Saving Partners' end use metered duty cycle data.

Exhibit 3-3 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 analysis, while *Section 3.2.3* and *Section 3.2.4* describe how hourly impacts were derived, and used to develop demand and energy impacts.

Exhibit 3-3
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 pre- and post-retrofit connected loads were determined for each fixture using pre- and post-retrofit information obtained from several sources. As PG&E did not require this information in the REO application, a methodology was developed that utilized the most accurate data available.

The pre-retrofit incandescent traffic signal connected load was obtained primarily through a battery of survey questions. If the pre-retrofit connected load for each of the measures was not obtained, the industry standard values were substituted.

For the post-retrofit LED traffic signals, the primary source of connected load information was from the application. Although the connected load is not required in the application, the manufacturer and model numbers are often provided with the invoices. In some cases, the connected load is also provided on the invoice. When this information was missing, the manufacturer from the survey data was used. Connected loads were obtained from the manufacturers and accepted for the ex post analysis. If the connected load was not identifiable from the application or telephone survey, then the survey connected load data was used. If the survey respondent was unable to supply the LED connected load, then the ex ante values were accepted. This method allowed the most accurate connected load information available to be used.

Engineering Duty Cycle Estimates

For each type of traffic signal (main signal, turn signal, and pedestrian signal), average duty cycles were developed by the Power Saving Partners. This duty cycle variable is based upon end use meter data on CalTrans intersections gathered and analyzed by Electro-test, Inc. (ETI) and verified by Schiller Associates for the Power Saving Partners. ETI monitored 160 signals over 29 intersections. A complete copy of the monitoring results is included as Attachment 2. Note that the "Main Signal" type includes both 8 inch and 12 inch red ball signals.

The peak period duty cycle is derived using the annual full load hours of operation for each type of traffic signal during the Summer On-Peak period. For each traffic signal type, the Summer On-Peak hours of operation is simply divided by the total number of hours for the Summer On-Peak period. Average and peak period duty cycles used in the impact analysis are presented in Exhibit 3-4.

Exhibit 3-4
Peak Period and Average Duty Cycle Estimates for Traffic Signals

Traffic Signal Type	Peak Period		Average	
	Hours of Operation	Duty Cycle	Hours of Operation	Duty Cycle
Main Signal	441	0.561	4479	0.511
Turn Signal	664	0.845	7759	0.886
Ped Hand	760	0.967	8458	0.966

Full Load Hours of Operation - Full load hours account for the total time that the traffic signal lamp is in operation. Exhibits 3-4 also present results for annual average and Summer On-Peak hours of operation for each type of signal.

3.2.3 *Development of Engineering Demand and Hourly Energy Estimates*

The engineering analyses conducted have combined information from telephone surveys with manufacturer's specifications and EUM data obtained from the Power Saving Partners to develop unadjusted engineering impacts (UEIs). The LED traffic signal model used to estimate the impacts under the REO program was founded on the decomposition of traffic signal impacts into manageable engineering parameters (referred to as the "impact decomposition approach"). This approach was used to develop hourly impacts by customer and measure. The impact decomposition equation that was used to estimate demand UEIs is displayed below.

$$UEI_{kW,i,j} = PEAK\_DC_i * (PRE_{kW,i,j} - POST_{kW,i,j}) * T_{i,j}$$

Where,

$UEI_{kW,i,j}$ = peak unadjusted demand impacts for each measure i and customer j

$PEAK\_DC_i$ = percent of hour that signal is lit during peak period for measure i

$PRE_{kW,i,j}$ = pre-retrofit connected load for measure i and customer j

$POST_{kW,i,j}$ = post-retrofit connected load for measure i and customer j

$T_{i,j}$ = number of signals installed for measure i and customer j

i = unique measure identifier

j = unique customer identifier

Each of the parameters listed above are developed as follows:

$PEAK\_DC_i$ - The peak duty cycle is derived from end use metered data by the Power Saving Partners Program on 160 signals in 29 intersections. The value represents the fraction of an hour, on average, that the signal is on during the Summer On-Peak period (May 1 to Oct. 31 12:00 PM to 6:00 PM Weekdays).

$PRE_{kW,i,j}$ - The pre-retrofit connected load of the incandescent lamp that was replaced by the LED. This data was obtained from the telephone surveys and was found for the most part to be an industry standard.

$POST_{kW,i,j}$ - The post-retrofit connected load of the LED traffic signal head. This data was obtained from the telephone surveys whenever possible. Often times, the wattage was unknown, but the manufacturer and/or model number was available. In these cases, wattage from manufacturer's specifications was accepted as accurate. If neither the wattage nor the manufacturer or model was available, then the default wattage supplied in PG&E's advice filing was accepted.

$T_{i,j}$ - The number of LED traffic signals retrofit by customer for each measure. For this analysis, a customer is defined as a collection of intersections that were rebated under the same application; typically a city, county, or other municipality.

i – A unique measure identifier. There are currently four different measures for LED traffic signals.

j – A unique customer identifier. Customers are identified as a city, county, or business center such that all accounts (intersections) are billed to the same address.

In order to calculate the annual energy impacts associated with the measure, the above equation is modified to incorporate the average duty cycle as well as the hours per year that the signal is in operation. The resulting equation is detailed below.

$$UEI_{kWh,i,j} = AVG\_DC_i * (PRE_{kW,i,j} - POST_{kW,i,j}) * T_{i,j} * 8760$$

Where,

$UEI_{kWh,i,j}$ = annual unadjusted energy impacts for each measure i and customer j

AVG_DC_i = average percent of hour that signal is lit for measure i

$PRE_{kW,i,j}$ = pre-retrofit connected load for measure i and customer j

$POST_{kW,i,j}$ = post-retrofit connected load for measure i and customer j

$T_{i,j}$ = number of signals installed for measure i and customer j

8760 = number of hours per year that traffic signal is in operation

i = unique measure identifier

j = unique customer identifier

Each of the parameters listed above are developed as follows:

Avg_DC_i - The average duty cycle is derived from end use metered data by the Power Saving Partners Program on 160 signals in 29 intersections. The value represents the fraction of an hour, on average, that the signal is on during all operating periods.

$PRE_{kW,i,j}$ - The pre-retrofit connected load of the incandescent lamp that was replaced by the LED. This data was obtained from the telephone surveys and was found for the most part to be an industry standard.

$POST_{kW,i,j}$ - The post-retrofit connected load of the LED traffic signal head. This data was obtained from the telephone surveys whenever possible. Often times, the wattage was unknown, but the manufacturer and/or model number was available. In these cases, wattage from manufacturer's specifications was accepted as accurate. If neither the wattage nor the manufacturer or model was available, then the default wattage supplied in PG&E's advice filing was accepted.

$T_{i,j}$ - The number of LED traffic signals retrofit by customer for each measure. For this analysis, a customer is defined as a collection of intersections that were rebated under the same application; typically a city, county, or other municipality.

8760 - The annual hours of operation for traffic signals. As traffic signals are always operating, this number is simply the number of hours in a year.

i – A unique measure identifier. There are currently four different measures for LED traffic signals.

j – A unique customer identifier. Customers are identified as a city, county, or business center such that all accounts (intersections) are billed to the same address.

The engineering demand 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.

3.3 BILLING REGRESSION ANALYSIS

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

3.3.1 Overview

The primary objective of the billing analysis is to determine the first-year program energy impacts. A statistical analysis is employed to model the differences in 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.

The population of potential customers for LED traffic signals include cities, counties, and business parks. There are 54 participants and 131 nonparticipants in PG&E's service territory.

As discussed in detail below, the billing regression analysis was conducted at the intersection level, for a sample of telephone-surveyed participants and nonparticipants.

3.3.2 Data Sources for Billing Regression Analysis

The billing regression analysis for the Lighting Evaluation uses data from four primary data sources: PG&E's Marketing Decision Support System (MDSS) tracking database, the billing database, the telephone survey data, and the engineering estimates of changes in usage between the pre- and post-installation periods. 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 Efficiency Options (REO) Program is maintained as part of the MDSS. It contains program applications, rebate and technical information about installed measures; including measure descriptions, quantities installed, rebated amounts, and ex ante demand, energy and therm savings estimates. The MDSS database is linked to the billing database and other program databases through PG&E's intersection specific control number.

PG&E Billing Data

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

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

Telephone Survey Data

As stated above, there are 54 participants and 131 nonparticipants in PG&E's service territory. Telephone surveys were conducted in 1999 with 48 LED participants, and 51 nonparticipants. These surveys collected detailed information regarding changes that have occurred at the intersections within each respondent's service territory. This telephone sample contains information regarding 1,690 nonparticipant intersections, and 2,078 retrofitted participant intersections. Program retrofit information was also available at the intersection level.

The data collected in the telephone survey supplies information on energy-related changes at each intersection for the billing period covered by the billing regression analysis. For a detailed discussion of the telephone survey and the final sample disposition, see Attachment 5. 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 2,078 retrofitted participant intersections. Estimates of energy savings were calculated for each of the four measures installed under the LED Traffic Control Signal Program. The engineering estimates were calculated based on expected savings from the pre-installation technology to the post-installation technology. 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

The participant tracking system described above enabled measures installed under the Program to be associated with specific intersections. Intersections were associated with customers through unique billing contact information. As detailed above, telephone surveys and billing data also provided information at the intersection level. These data sources together, enabled the billing analysis to be performed at the intersection level. PG&E's control number, which is the finest level of aggregation, is unique to a particular intersection and was used as the unique identifier for each record in the analysis dataset. All of the data elements mentioned were linked to the final analysis database by control number.

3.3.4 Analysis Periods

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

In accordance with the Protocols, participants are defined by the "paid date" instead of "installation date." Therefore, all customers paid in 1998 could have actually installed measures in either 1997 or 1998. However, an investigation of the distribution of installation dates revealed that the vast majority occurred between October of 1997 and September of 1998. The following paragraphs detail these findings.

Billing data were available from January 1993 through September 1999. To maximize the number of post installation months in the regression model, a post period of October 1998 through September 1999 was used. Only 2.5 percent of the installations occurred after September 1998, and these were all in October.

Based on the selection of post period, there are only two feasible pre-periods that could have been used: October 1995 through September 1996 (a 1996 pre-period), and October 1996 through September 1997 (a 1997 pre-period). No installation dates were prior to October of 1997. Overall, approximately 97 percent of installation dates occurred between October of 1997 and September of 1998. Given this distribution, the best choice for the pre-period was clearly October 1996 through September 1997.

3.3.5 Data Censoring

Three types of data censoring screens were applied to the billing analysis sample frame to remove customers: those with missing billing data, those with extreme changes in energy use, and those whose installed measures are inconsistent with the intersection size. For customers to be included in the final billing analysis, each had to have billing data that met the following criteria:

Missing Bills

The first reason for excluding customers from the analysis was missing bills. Both the pre-period and post-period had to include at least eight non-missing monthly bills. Bills of less than 100 kWh, representing less than the energy consumption of one 150 watt bulb over 30 days, were considered missing. If there were more than four monthly bills missing in either the pre-period or the post-period, the customer was removed from the analysis. If there were between one and four monthly bills missing and the customer was not removed from the analysis, the remaining months were prorated to an annual estimate.

Extreme Changes in Energy Usage

The second reason for excluding customers from the analysis was for extreme changes in energy use. That is, customers whose pre-period and post-period energy use were radically and inexplicably disparate were censured. The ratio of pre-installation usage to post-installation usage was examined for participants and nonparticipants. We examined this separately for groups of customers that were expected to have an increase in usage, a decrease in usage, and to stay the same. For each comparable group, the bottom 1 percent and top 1 percent were censured. These outliers represent a very small portion of the total population and have billing data that is inconsistent with others' with similar intersection changes.

Installed Measures Inconsistent with Intersection Size

The third and final reason for excluding customers from the analysis was for installation data that was contradictory with the size of the intersection as reflected in the billing data. In particular, customers for whom the components reportedly installed under the program comprised an unreasonable portion of the intersection's total energy use were censured. Recall that only red LEDs were rebated by the program, and red lamps alone should account for only a fraction of total energy usage in an intersection. Intersections where the expected pre-retrofit energy consumption of the components associated with the retrofit exceeded a threshold portion of the pre-retrofit total energy consumption for the intersection were censured.

The method for determining that the installed measures were inconsistent with the intersection size was as follows: First, expected pre-retrofit annual energy consumption of components associated with the retrofit was calculated for each participant intersection. Next, the ratio of this expected energy use to the intersection's total pre-retrofit annual energy use was calculated. This distribution was examined and intersections falling into the top 1 percent were censured. The results of this method produced a limit for the ratio of 1.33. That is, intersections where the expected energy use of the components installed through the program comprised 133 percent of the intersection's total pre-retrofit energy use were censured. We feel this is very conservative limit to impose. As stated above, only red components were rebated, and red components should compose a fraction of an intersection's total energy use. In these cases, the installation data was determined to be inconsistent with the size of the intersection as indicated by the pre-installation billing data.

Exhibit 3-5 presents the number of participant and nonparticipant intersections that were deleted for each of the above criteria. More nonparticipants were censured than participants, and most of the those were due to missing billing data.

Exhibit 3-5
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria

Participant or Nonparticipant	More than 4 Missing Bills	Extreme Usage Change	Inconsistent Installation	Number Removed from Analysis
NP	NO	YES	NO	32
NP	YES	NO	NO	134
NP	YES	YES	NO	69
Total				235
P	NO	NO	YES	19
P	NO	YES	NO	39
P	NO	YES	YES	3
P	YES	NO	NO	28
P	YES	NO	YES	6
P	YES	YES	NO	22
P	YES	YES	YES	7
Total				124

In summary, out of the original sample frame of 1,690 nonparticipant intersections, 235 were removed for bad billing data. Of the original sample of 2,078 LED program participant intersections, 124 were removed because of bad billing, or measure installation data that was inconsistent with the size of the intersection. The remaining 1,455 nonparticipant and 1,954 participant intersections were used in the analysis.

3.3.6 Model Specification

The billing regression analysis for the LED Traffic Control Signal Program Evaluation used two different multivariate regression models under an integrated framework of providing unbiased and robust model estimates. 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 intersection 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, 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:

$$kWh_{post,i} = \beta kWh_{pre,i} + \Sigma_k \eta_k NChg_{i,k} kWh_{pre,i} + \varepsilon_i$$

Where,

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

$NChg_{i,k}$ are the nonparticipant intersection self-reported change variables from the survey data, including adding or replacing traffic signal lights with LEDs, or making any changes that would increase usage;

β and η are the estimated slopes on their respective independent variables; and,

ε is the random error term of the model.

For each intersection in the analysis dataset (participants and nonparticipants), a post-installation predicted usage value is calculated using the parameters of the baseline model estimated for the 1997 to 1999 analysis period:

$$\hat{kWh}_{post,i} = \hat{\beta} kWh_{pre,i}$$

It should be noted that the predicted post installation usage is an estimate of what post-period usage would be in the absence of ***any*** changes, retrofit or other. The second stage of the model, as discussed below, will control for the effects of all changes as appropriate.

Exhibit 3-6 summarizes the final baseline model results that were estimated using 1,455 nonparticipant intersections, as discussed in the *Data Censoring* section.

Exhibit 3-6
Billing Regression Analysis Final Baseline Model Outputs

Parameter Description	Analysis Variable Name	Units	Parameter Estimate	T-Statistic
Pre-Period Usage	kWh_{97}	kWh	1.00	187.08
Increase in Usage * Pre-Period Usage	$INC*kWh_{97}$	kWh	0.67	3.85
LED installation * Pre-Period Usage	$LED*kWh_{97}$	kWh	-0.37	40.82

Exhibit 3-6 above summarizes the independent variables used in the baseline model, together with the t-statistics for each parameter estimate. The final functional relation is estimated as follows:

Baseline Model (1997 to 1999):

$$k\hat{W}h_{99,i} = 1.00 * kWh_{97,i}$$

SAE Model

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

$$kWh_{99,i} - k\hat{W}h_{99,i} = \beta_1\ Eng_i + (\beta_2 LEDp_i + \beta_3 LEDnp_i + \beta_4 INC_i) * kWh_{97,i} + \mu_i$$

Where,

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

$k\hat{W}h_{99,i}$ is intersection i's predicted annualized energy usage for the post- installation period;

Eng_i are the participant engineering impacts for intersection i;

$LEDp_i$ is a binary indicator variable that takes a value of one if intersection i is a participant intersection, and survey data indicates there was a retrofit of LED lights outside of the Pre-1998 CEEI Program.

$LEDnp_i$ is a binary indicator variable that takes a value of one if intersection i is a nonparticipant intersection, and survey data indicates there was a retrofit of LED lights outside the Pre-1998 CEEI Program Carry-Over.

INC_i is a binary indicator variable that takes a value of one if survey data indicates that a change took place at intersection i that would increase energy use.

The difference between predicted and actual usage in 1998 was used as the dependent variable in the SAE model. The 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 the comparison group only to forecast the 1999 usage as a function of 1997 usage. 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.

The effect of outside-the-program changes are captured in the three change variables, LEDp LEDnp and INC. The first two capture outside the program LED additions or retrofits. One such variable is included for participants, and one for nonparticipants. The reason for using separate variables for participants and nonparticipants is that participants have already retrofitted intersection with LED lights, while nonparticipants may or may not have installed any LED lights prior to 1998. For this reason, the outside the program changes made by participants are likely to be less substantial than those made by nonparticipants. Finally, INC is included to capture the effects of changes that would increase energy use. These are not expected to be systematically different for participants and nonparticipants, so a single variable is used. All three change indicator variabes, LEDp, LEDnp, and INC are interacted with pre-period annualized energy use to normalize variations in the impacts of changes over different sized intersections. The resulting estimated coefficients for these change variables represent a percentage change due to an outside-the-program LED installation or a change that increases energy use.

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. Exhibit 3-7 summarizes the final SAE model results that were estimated using 3,409 intersections (1,954 participant and 1,455 nonparticipant), as discussed in the *Data Censoring* section above. The exhibit illustrates the independent variables used in the SAE model, together with the t-statistics.

Exhibit 3-7
Gross Billing Regression Analysis Final Model Outputs

Parameter Description	Analysis Variable Name	Units	Parameter Estimate	T-Statistic
Engineering Estimate	ENG	kWh	-1.02	-117.42
Increase in Usage * Pre-Period Usage	$INC*kWh_{97}$	kWh	0.16	1.82
LED installation * Pre-Period Usage - Parts	$LEDp*kWh_{97}$	kWh	-0.09	-7.87
LED installation * Pre-Period Usage - NP	$LEDnp*kWh_{97}$	kWh	-0.36	-44.01

The dependent variable is the difference between the actual and predicted 1999 usage using the 1997 baseline model. All of the coefficients have the expected sign and are within the commonly accepted 90 percent confidence boundary. An SAE coefficient of 1.02 is calculated for the four LED measures combined. The coefficient is highly statistically significant, easily exceeding the 95 percent confidence level (t-statistics greater than 1.96). As expected, the impact of an outside-the-program LED installation was much larger for nonparticipants than for participants, 36 percent versus 9 percent, respectively. Finally, the effect of a change increasing the energy usage at an intersection was estimates to be 16 percent.

Relative Precision Calculation

Relative precision at 90 percent and 80 percent confidence levels for the adjusted gross energy impact estimates are calculated for the SAE analysis. Relative precision can be estimated for the 90 percent and 80 percent confidence levels were calculated as:

$$RP = \frac{t}{\text{T - Statistic for SAE Coefficient}}$$

Where 't' equals 1.645 and 1.282 for the 90 percent and 80 percent confidence levels, respectively. Therefore, the relative precision on the impact estimate is 1.4 percent at the 90 percent confidence level and 1.1 percent at the 80 percent confidence level.

3.3.8 Net Billing Analysis

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

The net billing regression analysis approach is identical to the gross billing model approach described above, with one important exception. Specifically, non-rebated LED installations are not controlled for in either stage of the model regression. In this way, nonparticipant changes in energy use due to non-rebated LEDs are considered 'natural conservation,' and are used to infer participant free ridership. Further, impacts of participant non-rebated LED installations are used to infer CEEI program spillover. However, this approach does not incorporate a mechanism for capturing nonparticipant spillover, making it a somewhat conservative approach.

Net Baseline Model

Similar to the gross baseline model, the net 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. Consumption is forecasted as a function of pre-period usage only.

In the net model, the predicted consumption or 'baseline consumption' is designed to incorporate reductions in energy use due to non-rebated LED installations. This is accomplished by *not* controlling for the installation of non-rebated LEDs in the baseline model specification. As a result, the effects of the non-rebated LED installations are incorporated into the coefficient on pre-period usage in the baseline model. In this way, participants' predicted post-period consumption is adjusted downward by the level of non-rebated LED installations found in the nonparticipant sample. Specifically, the baseline net model has the following functional form

$$kWh_{post,i} = \beta kWh_{pre,i} + \Sigma_k \eta_k NChg_{i,k} kWh_{pre,i} + \varepsilon_i$$

Where,

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

$NChg_{i,k}$ are the nonparticipant intersection self-reported change variables from the survey data, including the installation of ***rebated*** LEDs, or making any changes that would increase usage;

β and η are the estimated slopes on their respective independent variables; and,

ε is the random error term of the model.

As in the gross model, for each intersection in the analysis dataset (participants and nonparticipants), a post-installation predicted usage value is calculated using the parameters of the baseline model estimated for the 1997 to 1999 analysis period.

$$k\hat{W}h_{post,i} = \hat{\beta}\, kWh_{pre,i}$$

Exhibit 3-8 summarizes the final baseline net model results that were estimated using the same 1455 nonparticipant intersections used in the gross baseline model. As discussed above, the major difference between the gross and net models is that the estimated coefficient $\hat{\beta}$ will be smaller in the net model due to the impacts of non-rebated LED installations.

Exhibit 3-8
Net Billing Regression Analysis Final Baseline Model Outputs

Parameter Description	Analysis Variable Name	Units	Parameter Estimate	T-Statistic
Pre-Period Usage	kWh_{97}	kWh	0.98	182.39
Increase in Usage * Pre-Period Usage	$INC*kWh_{97}$	kWh	0.69	3.79
LED installation * Pre-Period Usage	$LED*kWh_{97}$	kWh	-0.37	-37.03

Exhibit 3-8 above summarizes the independent variables used in the net baseline model, together with the t-statistics for each parameter estimate. As expected the coefficient for pre-period usage is somewhat smaller than in the gross baseline model, .98 versus 1.00. The final functional relation is estimated as follows:

Baseline Model (1997 to 1999):

$$k\hat{W}h_{99,i} = 0.98 * kWh_{97,i}$$

Net SAE Model

Using the predicted post-installation usage values estimated in the baseline model, a simultaneous equation model is specified to estimate the net SAE coefficients on energy impact. The net SAE simultaneous system is identical to the gross SAE simultaneous system, except in the definition of independent variables LEDp and LEDnp. The net SAE simultaneous system can be described as follows:

$$kWh_{99,i} - k\hat{W}h_{99,i} = \beta_1 \ Eng_i + (\beta_2 LEDp_i + \beta_3 LEDnp_i + \beta_4 INC_i) * kWh_{97,i} + \mu_i$$

Where,

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

$k\hat{W}h_{99,i}$ is intersection i's predicted annualized energy usage for the post- installation period;

Eng_i are the participant engineering impacts for intersection i;

$LEDp_i$ Is a binary indicator variable that takes a value of one if intersection i is a participant intersection, and survey data indicates there was a ***rebated*** LED installation outside of the Pre-1998 CEEI Program.

$LEDnp_i$ Is a binary indicator variable that takes a value of one if intersection i is a nonparticipant intersection, and survey data indicates there was a ***rebated*** LED installation outside the Pre-1998 CEEI Program.

INC_i is a binary variable that takes a value of one if survey data indicates that a change took place at intersection i that would increase energy use.

As in the gross model, the difference between predicted and actual usage in 1999 was used as the dependent variable in the net SAE model. The engineering estimates and change variables were used to explain the deviation of the actual usage from the predicted usage. The independent variables used in the model are also similar to the gross SAE model, with the exception that non-rebated LED installations are excluded from the LEDp and LEDnp variables.

The predicted 1998 usage in the net SAE model will be smaller than the predicted usage results from the gross SAE model because of the baselines model's smaller estimated coefficient for pre-period usage. This difference will tend to produce a lower coefficient for the engineering estimate, β_1. At the same time, because there is no explanatory variable that controls for participant non-rebated LED installations, the impact of these installations puts upward pressure on the net SAE coefficient, β_1.

Net Billing Regression Analysis Results

Exhibit 3-9 summarizes the final net SAE model results that were estimated using the same 3,409 intersections (1,954 participant and 1,455 nonparticipant) that were used in the gross model. The exhibit illustrates the independent variables used in the net SAE model, together with the t-statistics and the sample sizes available for each parameter estimate. As one might expect, there were not any participant intersections with rebated out-of-program LED installations. This resulted in an estimated coefficient for the independent variable LEDp of zero.

Exhibit 3-9
Net Billing Regression Analysis Final Model Outputs

Parameter Description	Analysis Variable Name	Units	Parameter Estimate	T-Statistic
Engineering Estimate	ENG	kWh	-1.00	-118.48
Increase in Usage * Pre-Period Usage	$INC*kWh_{97}$	kWh	0.18	-1.99
LED installation * Pre-Period Usage - Parts	$LEDp*kWh_{97}$	kWh	0.00	-
LED installation * Pre-Period Usage - NP	$LEDnp*kWh_{97}$	kWh	-0.37	-39.81

The dependent variable is the difference between the actual and predicted 1999 usage using the 1997 baseline model. All of the coefficients have the expected sign and are within the commonly accepted 90 percent confidence boundary. A net SAE coefficient of 1.00 is calculated for all four LED measures combined. This is only 2 percent lower than the gross model SAE coefficient, 1.02. The net SAE coefficient is highly statistically significant, easily exceeding the 95 percent confidence level (t-statistics greater than 1.96). The other coefficients are also statistically significant, and similar to the results of the gross SAE model.

The net-to-gross ratio based on this approach can be estimated as the ratio of the SAE coefficients for the gross and net billing models. The net-to-gross ratio is 0.97 based on the net billing model.

3.3.9 Difference of Differences Analysis

A second LIRM methodology was also employed to estimate first year net load impacts. The method implemented was the difference of differences approach, which is an approved methodology noted in Table 5 of the Protocols. Net impacts can be estimated using this method in two ways:

(1) NETkwh = (PREpart – POSTpart) – (PREnp – POSTnp)

Or,

(2) NETkwh = (PREpart * (POSTnp / PREnp)) – POSTpart

Where,

NETkwh = Mean net program kWh impact

PREpart = Mean pre-period participant kWh usage

POSTpart = Mean post-period participant kWh usage

PREnp = Mean pre-period nonparticipant kWh usage

POSTnp = Mean post-period nonparticipant kWh usage

This first method is a straight difference of differences: the change in usage observed between the pre and post period among participants is adjusted by subtracting the difference in pre and post usage among nonparticipants. This approach assumes that the change in usage observed by the nonparticipants is what would have occurred among the participants in the absence of the program.

The second method first adjusts the participants pre usage by the ratio of post to pre usage observed in the nonparticipant control group. This can be considered an estimate of what usage would have been in the absence of the program. This adjusted usage is then subtracted from the participants post period usage to estimate the program's net impact. This second method is considered more advantageous when the nonparticipant control group is expected to have a different magnitude of average usage, but the relevant change in usage from the pre to post usage is expected to be representative of the participants in the absence of the program.

These difference of differences LIRM approaches require certain assumptions to be met in order to produce an unbiased estimate of net impacts. Primarily, the difference of differences LIRM approach assumes that the comparison group load impact is equivalent to the load impact that would have occurred within the participant group had the program not existed. If, for example, all of the comparison group load impact was attributable to the program (nonparticipant spillover), and there was little or no free ridership among participants, then the net load impacts would be underestimated. Conversely, if there was no comparison group load impact, and if there was a significant amount of free ridership, then the net load impacts would be overestimated.

Difference of Differences Analysis Results

The analysis was conducted on the same set of 1,954 participant intersections and 1,455 nonparticipant intersections that were used in the net billing analysis, with one exception. All intersections that had rebated traffic control signals (outside of the pre-1998 program carry-over) were removed from the analysis. This was done because these actions are not indicative of what would have occurred in the absence of the program. In total, 392 nonparticipant intersections were removed, resulting in an available sample of 1,954 participant and 1,063 nonparticipant intersections. The results of this analysis were as follows:

Exhibit 3-10
Mean Pre- and Post-Period Usage
Differences and Adjusted Pre-Period Participant Usage

	n	Mean Annual kWh Pre-Period	Post-Period	Differences	Adjusted Pre-Period Kwh
Participants	1954	18,914	9,858	9,056	18,565
Nonparticipants	1063	16,547	16,242	306	n/a

Among nonparticiants, pre- and post-usage were nearly identical, as expected, given the previous billing regression results. Participant usage, on the other hand, was cut nearly in half due to the program measures. Pre-period usage among participants was slightly greater than nonparticipant usage, indicating that the second difference of differences approach relying on adjusting the participant pre-preiod usage, may be more reliable.

Exhibit 3-11 provides the mean net impact estimates using each of the two methods.

Exhibit 3-11
Mean Pre- and Post-Period Usage
Differences and Adjusted Pre-Period Participant Usage

Net Impact Approach	Annual Net Impact	Annual Gross Impact	NTG
Difference of Differences	8,750	8,598	1.02
Adjusted Pre-Usage Difference	8,706	8,598	1.01

The two methods provide nearly the same net impact result. The mean annual gross impact estimate for this sample was 8,598 kWh. The net-to-gross ratio was estimated to be 1.02 for the straight difference of differences approach, and 1.01 for the adjusted pre-usage difference method. These results are very close to the net billing model result of 0.97.

As stated above, the results of these models are likely to be biased. In fact, since there was little comparison group load impact, and from the self-report analysis, there was a significant amount of free ridership, we would expect that the net load impacts would be overestimated based on the difference of differences approach.

3.4 NET-TO-GROSS ANALYSIS

An important step in estimating total impacts from the LED Traffic Control Signal 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 LED Traffic Control Signal (LED) 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 presented.

3.4.1 Data Sources

The primary data sources used in the net-to-gross analysis include the 48 LED participant surveys, and 51 nonparticipant telephone surveys collected in 1999. Other data used in this analysis include the MDSS and CIS databases, and information from the Advice Filings.

3.4.2 Free Ridership

The population of potential customers for LED traffic signals include cities, counties, and business parks. There were a total of 54 LED Traffic Control Signal participants and 131 nonparticipants in PG&E's service territory. Due to the limited available sample size, only self report techniques were used to ascertain net-to-gross ratios. This approach is consistent with the Evaluation Research Plan submitted in July of 1999.

On May 20, 1999 the CADMAC approved a waiver that allows the use of self -report based algorithms to estimate free ridership and spillover effects in the event LIRM models fail to produce statistically reliable results. The approved waiver is presented in Attachment 1.

Method for Scoring Free Ridership

The following discussion explains the methods employed to calculate free ridership amongst program participants. As stated above, this method uses "self report" techniques, rather than statistical modeling techniques, because of the limited sample size available. Definitions used for free ridership and net participation among the participant population are presented. Specific scoring algorithms and questions used to identify free riders in the participant survey are also discussed.

<u>Overview of Methodology</u>

LED traffic signal program participants 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 LED traffic signal equipment

2. In the absence of the CEEI program, the participant would have installed fewer LED traffic control signals.

3. In the absence of the CEEI program, the participant would have installed the same number of LED traffic control period, but would have installed them over a period extending over more than one year.

4. In the absence of the CEEI program, the participant would have installed the same number of LED traffic control signals at the same time (within the year)

Customers who fall into the first category can be considered net program participants. Customers who fall into the second and third category should be considered partial free riders, because in these cases the program resulted in LED installations in 1998 that would not have occurred otherwise. Customers falling into the fourth category should be considered free riders. Estimates of LED program participant free ridership were based on these four categories. Data used to calculate the free ridership estimates was collected as part of a comprehensive telephone survey of LED traffic signal program participants. The survey collected information on the participants' likely LED traffic signal retrofit behavior, with regards to the CEEI program. Responses consistent with category 1 were counted towards net participation. Responses consistent with categories 2 and 3 were counted as partial free ridership, as detailed below. Responses consistent with category 4 were considered free riders.

The questions used to classify responses directly reflect the definitions of net participation, free ridership, and partial 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 LED traffic signal equipment, and when they would have installed that equipment. Generally, the answers to both of these questions allowed the responses to be classified based on the categories described above. To assign a partial free ridership value, questions regarding the portion of the retrofit that would have been completed in 1998 were used. Specific scoring algorithms and the exact text of the corresponding questions are presented below.

Raw results from the free ridership estimates were weighted by the avoided cost associated with a given respondent. There is no reason to expect customers' likely retrofit behavior in the absence of the program would vary by the type of LED traffic signal installed. Thus, the results of the weighted self-report free ridership estimates are presented in a single category.

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

Responses were initially scored based on the following questions:

Q28	*Which of the following statements best describes actions your firm would have undertaken had the LED traffic signal program NOT existed...* 1 = We would not have changed our traffic signals to LED 2 = We would have installed LED traffic signals anyway, but fewer of them 3 = We would have installed the same number of LED traffic signals in the absence of the program 8 = (Refused) 9 = (Don't Know)

Q29	*What percent of the LED signals that were installed through the program would you have installed in the absence of the program?*
Q31	*Which of the following statements best describes your citiy's plans to install LED traffic signals had the program NOT existed…* *1= We would have installed LED traffic signals at the same time we did it through the program* *2= We would have installed LED traffic signals within the year* *3= We would have installed LED traffic signals, but not within the year* *4= We would have installed LED traffic signals over the course of several years* *5= We wouldn't have installed LED traffic signals at all* *8= (Refused)* *9= (Don't Know)*
Q32a	*How many years would it have taken to complete the project?*

A response counted towards **net participation** (consistent with category 1) if:

Q28 = 1

or

Q28 = (2 or 3) AND Q31 = 3

Under the first condition, the respondent indicated that, in the absence of the program, they would not have installed LED traffic signals. Under the second condition, the respondent indicated that, had the program not existed, they would have installed fewer LED traffic signals. However, these participants also indicated that no LED signals would have been installed within the year in the absence of the program.

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

Q28=3 AND Q31 = (1 or 2)

Under this condition the respondent indicated that, in the absence of the program, they would have installed the same number of LED traffic singals, and would have installed them at the same time, or within the year.

Partial free ridership scores were assigned on a percentage scale, with scores between, but not equal to 0% and 100%. The larger the score, the closer the respondent was to a free rider. A response was counted as partial free ridership if

If Q28 = 2 AND Q31 = (1 or 2) Then
Partial Free Ridership = Q29

If Q28 = 3 AND Q31 = 4 Then
Partial Free Ridership = 1/Q32A

If Q28 = 2 AND Q31 = 4 Then
Partial Free Ridership = Q29*1/Q32A

Under the first condition, the respondent stated that they would have installed fewer LED traffic signals had the program not existed, and that these LED signals would have been installed within the year. Under this condition the free ridership score was equal to the portion stated in response to Q29. That is, the percent of the LED signals that were installed through the program that would have been installed in the absence of the program.

Under the second condition the respondent stated that they would have installed the same number of LED traffic signals in the absence of the program. In addition, these signals would have been installed over the course of several years. Under this condition the free ridership score was calculated as 1 divided by the number of years over which the LED would have been installed without the program, as stated in response to question Q32A. This method assigns a free ridership score equal to the portion of the total retrofit that would have occurred in 1998 in the absence of the program, assuming the retrofit would have taken place at a constant rate over the period stated by the respondent.

Under the third condition, the respondent stated both that they would have installed fewer LED traffic signals and that they would have been installed over the course of several years. Under this condition the free ridership score was calculated by evenly allocating the portion of the total retrofit that would have occurred in the absence of the program over the number of years that it would have taken to complete. This is calculated by taking the product of 1 divided by the response to Q32A and Q29.

In the event the participant was unable to provide answers to questions Q28, Q29, Q31, and Q32A sufficient to categorize them in one of the categories as described above, the data was considered inconclusive. In this event, a second set of questions was examined to determine free ridership:

Q33	*Before you knew about the Program, which of the following statements best describes your (city or county)'s plans to install LED traffic fixtures? (READ RESPONSES).* 1 = You hadn't even considered installing LED traffic signals 2 = You were interested in installing LED traffic signals, but had no firm plans to install them 3 = You had already decided to install LED traffic signals, but probably not within the year 4 = You had already decided to install LED traffic signals within the year. 8 = (Refused) 9 = (Don't Know)

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

Q33 = 1 or 3

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

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

Q33 = 4

Under this condition, the respondent indicated that, before they knew about the program, they had already decided to install LED signals within the year. A response of 2 or a refused/don't know response was considered inconclusive. A response of 2 is not a clear indication of what their behavior would have been in the absence of the program. No partial free ridership scores were assigned based upon question Q33.

In the event the response to question Q33 was inconclusive, a third set of questions was used to establish free ridership:

Q34	*If you had not installed LED signals under the program, how long would you have waited to install them?* 1 = Install at the same time 2 = Install within one year 3 = Install after more than one year 4 = Not install at all 8 = (Refused) 9 = (Don't Know)

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

Q34 = 3 or 4

In other words, the respondent indicated that, if they had not installed LED signals under the program, they would have replaced it at least a year later, or not at all.

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

Q34 = 1 or 2

In this case, the respondent indicated that, had they not installed LED traffic signal equipment under the program, they would have installed LED equipment at the same time, or within the year. No partial free ridership scores were assigned based upon the response to question Q34.

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 would not have installed LED signals were counted as net participants. Those who indicated they would have installed fewer LED signals or would have installed them over the course of several years were counted as partial free riders. Partial free ridership scores were assigned accordance with the portion of the retrofit that would have occurred in 1998 in the absence of the program. Customers who fit the fourth classification; those who, in the absence of the program, would have installed the same number of LED traffic signal within one year, were counted as free riders.

If the initial combination of questions (Q28, Q29, Q31, Q32A), could not classify a response because of contradictory, or "don't know" or "refusal" responses, then the responses to the additional questions were used. Question Q33 made similar distinctions as the initial questions. In question Q33 the respondent was asked what they intended to do "before they knew about the retrofit program," as opposed to what they would have done "in the absence of the program." The Q34 question determined when those responding to the additional classification questions would have made the LED retrofit. Partial free rider scores were not assigned based on responses to Q33 or Q34.

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 48 completed telephone surveys of CEEI LED traffic signal program participants. The surveys were conducted between June and August of 1999 as part of a comprehensive telephone survey of CEEI program participants.

Results

The free ridership result from applying the above-described method is presented in this section. All of the equipment adoptions rebated under the LED traffic signal program are of the same technology. Therefore the free ridership results are presented for all the participants in one technology group. There is no reason to expect the free ridership rate would differ across different types of LED traffic signal lamps. The overall free ridership rate was developed by weighting individual free ridership scores by the avoided cost associated with the LED retrofit.

Exhibit 3-12
Weighted Self-report Estimate of Free Ridership for LED Traffic Signal Technology Groups in the Pre-1998 CEEI Program Carry-Over

Technology Group	Sample	Free Ridership
LED Traffic Signals - Wtd by Av Cost	48	23.1%

Exploration of Further Free Ridership Evidence

Introduction

In order to validate the free ridership results presented above, the distribution of other relevant survey questions were explored. In addition, these questions provide detailed information about customers' attitudes and the factors that determined their decision to retrofit traffic signals with LED lights. These distributions are presented to provide detailed supporting evidence of the free ridership scoring method, and do not have any direct bearing on the free ridership results. There are seven such questions presented below. Overall, we found the responses to these questions were highly corroborative of the free ridership scoring algorithm.

As described in the preceeding section, respondents were assigned a value between 0% and 100% for free ridership. Those receiving 100% are considered complete free riders, those receiving a 0% are considered complete net participants. Many scores were in-between, indicating partial free ridership. For the sake of illustration, partial free riders were divided into "net participant" and "free rider" categories. Specifically, those with a free ridership score greater than or equal to 50% were are displayed as free riders, and those with a score under 50% were displayed as net participants.

The first survey question examined was the response to question Q35, "Did the Retrofit Program rebate at all influence your decision to retrofit traffic signals with LED fixtures?" This question was designed to better understand the factors determining the respondents' decision to retrofit traffic signals. All of the net participants stated the rebate influenced their decision to retrofit traffic signal, while only two-thirds of the free riders made such a claim.

Exhibit 3-13
Q35: "Did the Retrofit Program rebate at all influence your decision to retrofit traffic signals?"

	Influenced	Not Influenced
Net Participant	100.0%	0.0%
Freerider	66.7%	33.3%

Similar to the question Q35, question Q36 explored the factors determining the respondents' decision to retrofit traffic signals. The text for question Q36 was, "Independent of the rebate, did the fact that PG&E was backing LED traffic signal technology at all influence your decision to retrofit traffic signals?" In general, the responses to this question indicated that PG&E backing LED technology was not a significant factor in the decision to retrofit traffic signals. However, one-third of the free riders and nearly 40% of the net participants claimed the sponsorship did have some influence. The response pattern to this question does not clearly distinguish net participants from free riders. This may be a result of the imprecise nature of the relationship between the program and the endorsement. That is, the endorsement of LED technology may not have been construed as an integral part of the program.

Exhibit 3-14

Q36: "Independent of the rebate, did the fact that PG&E was backing LED technology influence your decision to retrofit traffic signals?"

	Influenced	Not Influenced
Net Participant	39.0%	61.0%
Freerider	33.3%	66.7%

The next question explored was Q37, which was designed to identify the primary barriers to retrofitting traffic signals with LED lights. The text for this question read, "Prior to participating in the program, what was the primary reason your city had not retrofitted traffic signals with LED lights?" The most common response to this question from net participants was "lack of available funds," while free riders were more likely to state that "waiting for state approval" was the primary reason for not retrofitting traffic signals. This result is supportive of the free ridership scoring algorithm because it shows that financial barriers were more important to net participants.

Exhibit 3-15

Q37: "Prior to participating in the program, what was the primary reason your city had not retrofitted traffic signals with LED lights?"

	Lack of Available Funds	Waiting for State Approval	Lack of Confidence in Technology	Lack of Knowledge/ Awareness of Technology	Other
Net Participant	46.3%	26.8%	12.2%	9.8%	4.9%
Freerider	33.3%	50.0%	0.0%	16.7%	0.0%

The survey question Q38, "Did the Retrofit Program help you overcome this barrier?" provided another perspective on program effectiveness and influence. Here, respondents were asked to state whether the program had been effective in reducing the most important barriers to performing LED traffic signal retrofits. Nearly 70% of the net participants stated that the program was helpful in overcoming their primary barrier. In contrast, 50% of the free riders stated the program was helpful in overcoming these barriers. The discrepancy between the responses of the free riders and the net participants is consistent with their free ridership categorization.

Exhibit 3-16
Q38: "Did the Retrofit Program help you overcome this barrier?"

	Program Helped Overcome Barrier	Program Did Not Help Overcome Barrier
Net Participant	65.9%	34.1%
Freerider	50.0%	50.0%

Many respondents were required to get approval from either their city council or other governing board before proceeding with the retrofit. This introduced another layer into the decision-making process and another opportunity to explore program influence. The remaining questions were asked only of respondents that were required to get approval from the City Council or other governing Board. A significant portion of both net participants and free riders required council or board approval, 83% and 67% respectively.

The first of these questions is Q40, "Do you feel the program rebate at all influenced the City Council (or other governing Board) to approve the project?" This question prompted for respondents' perceptions of the program rebate influence over the decision-making council or board. The vast majority of net participants that required board approval felt the rebate did have influence over the council or board. In contrast, only a minority of free riders stated the program had influence over the council or board. This result strongly supports the categorization of free riders and net participants.

Exhibit 3-17
Q40: "Do you feel the program rebate at influenced the City Council (or other governing Board) to approve the project?"

	Program Did Influence City Council	Program Did Not Influence City Council	Percent Requiring Council or Board Approval
Net Participant	94.1%	5.9%	83.3%
Freerider	25.0%	75.0%	66.7%

Survey question Q41 explores the possible influence that PG&E's endorsement of LED traffic signal technology might have had on the city council or other governing board. The text for this question was, "Independent of the rebate, do you feel that PG&E's backing of LED traffic signal technology at all influenced the City Council (or other Board) to approve the project?" The responses to this question indicate that PG&E's endorsement of LED traffic signals was an influencing factor for the city council or other governing board in about 50 percent of the cases. Recall the earlier discussion of question Q36, which asked nearly the same question, except was directed at the traffic engineer or other professional responding to the survey instead of the city council or board. Similar to the response patterns for question Q36, responses to question Q41 did not draw a clear distinction between net participants and free riders, with both types of customers responding in nearly a 50-50 distribution. Again, this may be explained by the imprecise nature of the relationship between the program and the endorsement.

Exhibit 3-18

Q41: "Independent of the rebate, do you feel that PG&E's backing of LED traffic signal technology at all influenced the City Council (or other Board) to approve the project?"

	PG&E Backing Did Influence City Council	PG&E Backing Did Not Influence City Council	Percent Requiring Council or Board Approval
Net Participant	51.6%	48.4%	83.3%
Freerider	50.0%	50.0%	66.7%

The final question explored was Q42, which read "If the program did not exist, what is the likelihood the City Council or other governing Board would have approved the project?" This question determined whether the program had pivotal influence on the city council or other governing board and speaks directly to the issue of free ridership. While all those who state that the council or board "would not have approved the project in the absence of the program" should be considered net participants, those who state they would have approved anyway are not necessarily free riders. The traffic control engineer or other professional who responded to the survey is likely to also have had decision-making authority, and may or may not have been influenced by the program to endorse the retrofit project. Responses to this question support this logic. All of the free riders claimed the city council or other board would "probably" or "definitely" have approved the project without the program. In contrast, only one-third of the net participants made this claim, with two-thirds stating that there was "no chance" or "maybe, with some convincing" that the board would have approved anyway.

Exhibit 3-19
Q42: "If the program did not exist, what is the likelihood the City Council or other governing Board would have approved the project?"

	No Chance' or 'Maybe'	Probably' or 'Definitely'	Percent Requiring Council or Board Approval
Net Participant	66.7%	33.3%	83.3%
Freerider	0.0%	100.0%	66.7%

Summary

In sum, the questions discussed in this section explored different aspects of free ridership and net participation. In general, the response patterns to these questions were strongly supportive of the free ridership scoring results obtained with the "self report" algorithm presented in the previous section. In addition, they indicate that the rebate was the most important influencing factor of the program, although other aspects were also influential. Most of the net participants cited "lack of available funds" as the primary reason for not retrofitting traffic signals prior to their participation in the program. Also, 100 percent of the net participants claimed the rebate influenced their decision to retrofit traffic signals. Furthermore, approximately 94 percent of net participants that required council or board approval for the retrofit believed the rebate influenced the council or board's decision to approve the project.

However, the rebate was not the only influencing factor of the program. PG&E's endorsement of LED technology was found to have had some influence. The degree of this influence did not distinguish free riders from net participants. Between one-third and one-half of both net participants and free riders indicated that PG&E's endorsement was an influencing factor on their decision to retrofit or on the council or board's decision to approve the project. This may be explained by the inexact nature of the relationship between the program and the endorsement, although it is impossible to tell with any certainty. A little over 10 percent of respondents indicated that lack of knowledge or awareness of LED technology was the primary reason they had not retrofitted traffic signals prior to participating in the program. All of these respondents also indicated that the program was helpful in overcoming this barrier. Eighty percent of these respondents were categorized as net participants.

3.4.3 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. The following discussion explains the methods employed to calculate estimates of spillover amongst LED traffic signal program participants and nonparticipants. The population of potential customers for LED traffic signals include cities, counties, and business parks. In 1998 there were 54 program participants and 131 nonparticipants in PG&E's service territory. Because of this limited available sample, the methods for measuring spillover described below use a "self-report" approach, as opposed to statistical modeling. Definitions used for spillover and net participation among the participant and nonparticipant population are also presented below. Specific scoring algorithms, and questions used to identify spillover in the participant and nonparticipant surveys are discussed and the final calculation of these impacts is also described.

Overview of Methodology

The self-report methodology is composed of three steps:

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

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

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

Participant Spillover:

NTGpart_spill = SP_RATEpart * POPpart*IMPACTpart_spill/IMPACTpop

Where,

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

SP_RATEpart = the participant spillover rate

POPpart = the participant population, in number of sites

IMPACTpart_spill = the per participant site impact associated with spillover

IMPACTpop = the total CEEI Program impact

Nonparticipant Spillover:

NTGnp_spill = SP_RATEnp * POPnp*IMPACTnp_spill/IMPACTpop

Where,

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

SP_RATEnp = the nonparticipant spillover rate

POPnp = the nonparticipant population, in number of sites

IMPACTnp_spill = the per nonparticipant site impact associated with spillover

IMPACTpop = the total CEEI program impact

Identification of the Spillover Rate

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

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

1. the adoption involved the installation of **LED traffic control signals**
2. the respondent was **aware** of the program **before** making the decision to install LED traffic control signals
3. the adoption was **not rebated** as part of the program
4. the respondent stated that the adoption occurred as a result of the **CEEI program's influence**

In other words, the respondent's knowledge of, awareness of, or participation in the CEEI program encouraged them to install LED traffic signal 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:

Question Q44 was used to determine whether non-rebated LED traffic signals had been installed since January of 1997. The question text for Q44 is as follows:

Q44	*Since January 1997, have you installed any LED signals that were not rebated through a PG&E program?*

For Condition 2:

Question Q56 and Q57 were used to verify that the out-of-program LED traffic signal adoption occurred after the respondent became aware of the Retrofit Program. The question text is as follows:

Q56	*Were these changes made after you participated in the Retrofit Program?*
Q57	*Did you become aware of the Retrofit Program before or after you made the decision to install these LED traffic signals outside the program?*

For Condition 3:

Question Q58 was used to determine whether or not additional participant LED signal installations were rebated. The question text for Q58 was as follows:

Q58	*Was your firm paid a rebate by PG&E for these changes in your traffic signals?*

For Condition 4:

The fourth condition, whether or not the program influenced the respondent's equipment selection, was tested with question Q59. Only those respondents who installed non-rebated LED traffic signal equipment after they had become aware of the program were asked the final spillover question. Because of this design, an occurrence of spillover could be identified based on the response to question Q59 alone. The question text for Q59 was as follows:

Q59	*Was the Retrofit Program at all influential in your decision to install LED traffic signals?* 1= Not at all influential 2= Slightly influential 3= Moderately influencial 4= Very influential R= Refused D=Don't know

Participant Spillover Scoring Algorithm

The final scoring algorithm for participant spillover was based on question Q59. This question was used because, as explained above, it was only asked of participants who made a **non-rebated** adoption **after** they had become aware of the program. The scoring algorithm is as follows:

If Q59 = 2,3 or 4 **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 48 LED traffic signal program participants surveyed, a total of 15 respondents met all of the spillover criteria. Nearly one-third of the surveyed participants had been influenced by the program to install additional non-rebated LED traffic signals. This results in a participant spillover rate of 31.3 percent. Because there were a total of 53 participants, this is equivalent to a total of 16.6 participant spillover LED actions.

Identifying Nonparticipant Spillover Actions

For Condition 1:

As with the participant spillover, question Q44 was used to determine whether or not non-rebated LED traffic signal equipment was installed. The text can be found in the explanation of the participant spillover methodology given in the preceding section.

For Condition 2:

Questions Is005, and Q57 were used to verify that the respondent was aware of the program before the LED signal technology was adopted. The text for these questions was as follows:

Is005	*Have you heard of PG&E's Retrofit Efficiency Options programs?*
Q57	*Did you become aware of the Retrofit Program before or after you made the decision to install these LED traffic signals?*

For Condition 3:

Question Q58 was used to determine whether or not the LED traffic signal installation was 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 Q59. Only those respondents who were aware of the program before making the decision to purchase new LED traffic signal equipment, and did not receive a rebate for this purchase were asked Q59. Because of this design, spillover could be calculated based on the response to question Q59. The question text for Q59 was as follows:

Q59	*Was the Retrofit Program at all influential in your decision to install LED traffic signal lights?* 1= Not at all influential 2= Slightly influential 3= Moderately Influential 4= Very Influential R= Refused D=Don't Know

Nonparticipant Spillover Scoring Algorithm

The final scoring algorithm for nonparticipant spillover was based on question Q59. Again, only respondents who stated that they were aware of the program before making the decision to purchase new LED traffic signal equipment, and were not rebated for this purchase, were asked question Q59. Thus, the final spillover scoring algorithm was as follows:

If Q59 = 2,3, or 4

then spillover = 1,

else spillover = 0

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

Nonparticipant Self-report Spillover Results

Of the 51 nonparticipants surveyed, there were 2 respondents who met all of the spillover criteria excluding efficiency. Nonparticipants' reported LED signal adoptions spanned approximately a 30-month period (from January 1997 through approximately June 1999). In order to calculate the 1998 spillover rate, a constant adoption rate over the period was assumed. Thus, the portion of total adoptions captured in the survey assumed to occur in 1998 was calculated by dividing the 12 months in 1998 by the 30 months spanning the entire period, resulting in 40 percent. Thus 40 percent of the 2 spillover adoptions were assumed to occur in 1998, resulting in a spillover rate for 1998 of 1.6 percent.

The approach to distributing the spillover across the 30-month analysis period is conservative relative to alternative allocation methods. Both of the spillover adoptions identified in the survey occurred in 1998, and so could be assigned

As stated earlier, potential customers in PG&E's service territory for LED traffic signals include cities, counties and business parks. From PG&E's 1998 CIS, there were 184 such sites identified, resulting in a total of 131 nonparticipant sites less the 53 participants. Therefore, because there were 131 nonparticipant sites, the spillover rate of 1.6 percent is equivalent to a total of 2 nonparticipant spillover LED adoptions.

Calculation of Impacts Associated With Spillover

Self reported installation information and the MDSS database were used to calculate the impacts associated with spillover. For each spillover adoption, respondents were asked what type of LED traffic control signals were installed and how many of each type. Respondents were also asked how many intersections were effected by the changes. The text for these questions was as follows:

Q47	*Did these installations include Red LEDs?...Yellow LEDs?...Green LEDs? [SELECT ALL THAT APPLY]* 1= Red LEDs 2= Yellow LEDs 3= Green LEDs R= Refused D=Don't Know
Q48	*Which of the following LED components did you install?* 1 = 8" Red Balls 2 = 12" Red Balls 3 = Red Arrows 4 = Orange Pedestrian Crossing Signals 5 = 8" Green Balls 6 = 12" Green Balls 7 = Green Arrows 8 = Green Pedestrian Crossing Signals 9 = 8" Yellow Balls 10 = 12" Yellow Balls 11 = Yellow Arrows 88 = Refused 99 = Don't Know
Q48A	*How many of each were installed?*
Q49	*How many intersections were effected by these LED traffic light installations?*

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 a spillover adoption could be calculated.

Participant Spillover Impact Calculation

Telephone surveys were conducted with almost all of the LED traffic signal program participants: 48 out of 53. Thus, the total spillover impact should be very nearly the impact of the spillover adoptions captured in the survey. The approach that was used is consistent with this objective. To calculate the impacts associated with spillover, avoided cost was used as a proxy for impact. The MDSS was used to determine the average avoided cost per unit installed for each equipment type.

Although there were a couple of spillover adoptions of green and yellow LEDs, the impact of these installations was excluded. This was done because the LED program did not provide rebates for the installation of yellow or green LEDs. In a strict sense, these adoptions were not program qualifying adoptions. We consider this to be a conservative choice, however, because an argument could easily be made that they should be included. These installations of yellow and green LEDs increased energy efficiency and occurred as a direct result of program influence.

Thirteen of the fifteen spillover respondents were able to provide the total number of each type of LED components that were installed. The MDSS was used to determine the average avoided cost per component for each equipment type. Total avoided cost for these 13 installations was estimated by multiplying the average avoided cost per component from the MDSS by the number installed as reported in the surveys.

The two remaining spillover respondents were able to answer questions Q47 and Q49, but not Q48 and Q48A. That is, they were able to state the color of the LED lights installed and the number of intersections effected by the installation, but could not state which components were installed or exactly how many. For these two installations, avoided cost was estimated by multiplying the average avoided cost per intersection by the number of intersections effected by the two retrofits.

The average impact per intersection was calculated from the 13 installations for which complete installation information was provided. The average impact per intersection among these 13 installations was $3,757. To test the reasonability of this estimate, a similar estimate was calculated for all of the retrofitted intersections in the MDSS database. The average avoided cost per intersection in the MDSS was calculated to be $3,391, which is consistent with the participant survey result. This method resulted in a total avoided cost for each of the reported spillover installations.

Exhibit 3-20 below, presents the avoided cost per participant spillover adoption. As stated above, avoided cost data from the MDSS was used as a proxy for impact. For the two cases where detailed installation information was not available, average impact per effected intersection was multiplied by the number of effected intersections to estimate impact. Most of the spillover adoptions involved a minimal number of intersections. Thirteen of the 15 spillover adoptions effected 10 or fewer intersections; five involved only 1 intersection. The impacts associated with these adoptions ranged from a low of $2,311 to a high of $80,894, with all but two at less than $40,000. Overall, the average impact per spillover adoption was estimated at $22,598.

Exhibit 3-20
Avoided Cost of Participant Out-of-Program Adoptions

		Avoided Cost					
	Number of Intersections Effected	Per Intersection	8" Red Balls	12" Red Balls	Red Arrows	Orange Ped Crossing	Total
	1	$2,391	$0	$1,720	$671	$0	$2,391
	1	$2,311	$328	$1,474	$0	$509	$2,311
	4	$6,809	$0	$13,760	$8,050	$5,427	$27,237
	10	$3,757	-	-	-	-	$37,571
	2	$3,494	$0	$2,949	$2,683	$1,357	$6,989
	4	$6,470	$0	$13,760	$8,050	$4,070	$25,880
	10	$1,208	$4,369	$3,686	$4,025	$0	$12,080
	5	$5,926	$1,748	$8,354	$12,746	$6,784	$29,632
	8	$3,315	$0	$20,149	$6,373	$0	$26,522
	1	$4,411	$0	$1,720	$2,013	$678	$4,411
	82	$987	$0	$0	$0	$80,894	$80,894
	1	$3,814	$0	$2,457	$0	$1,357	$3,814
	1	$3,806	$0	$2,457	$671	$678	$3,806
	2	$3,900	$655	$3,440	$2,348	$1,357	$7,800
	18	$3,757	-	-	-	-	$67,628
Average	10						$22,598

Nonparticipant Spillover Impact Calculation

Two nonparticipants were identified as contributing to spillover. Rather than using these 2 installations to calculate an average spillover impact, the survey sample of non-rebated LED traffic signal installations was used. There were a total of 17 such installations for which valid responses were obtained for number of components installed and intersections effected. These 17 installations were used to estimate the average nonparticipant impact associated with spillover. To calculate the impacts associated with spillover, avoided cost was used as a proxy for impact. The MDSS was used to determine the average avoided cost per unit installed for each equipment type.

The 17 non-rebated nonparticipant installations were used to determine the average impact per nonparticipant adoption. Twelve of these 17 installations had valid data for the number of each type of red LED component installed. (Installations of yellow and green LEDs were disregarded because they were not program qualifying adoptions.) For these 12 installations, the impact was calculated by multiplying the number of components installed by the component's avoided cost.

Of the remaining 5 installations, 4 respondents were able to provide the number of intersections effected and the type of components installed. For these installations, the average number of components per intersection from the 12 installations with complete installation information was used. This data was combined with the number of intersections effected to calculate total avoided cost.

For the last remaining installation, the respondent was able to provide the number of intersections effected by the retrofit. The average impact per intersection calculated from the other 16 installations was used as an estimator of the impact per retrofitted intersection for this last respondent. This average impact was calculated to be $4,778. Thus, a total impact result was obtained for each of the 17 non-rebated nonparticipant installations.

Exhibit 3-21 below, presents the impact for each nonparticipant installation. The exhibit also shows the impact per intersection for each adoption, and the average impact per nonparticipant adoption. The average impact per adoption was calculated to be $31,460.

Exhibit 3-21
Avoided Cost of Nonparticipant Non-Rebated Adoptions

	Number of Intersections Effected	Avoided Cost					
		Per Intersection	8" Red Balls	12" Red Balls	Red Arrows	Orange Ped Crossing	Total
	5	$4,305	$0	$14,743	$0	$6,784	$21,527
	5	$2,958	$3,714	$5,651	$0	$5,427	$14,792
	3	$4,683	$0	$9,337	$3,354	$1,357	$14,048
	7	$4,778 -	-	-	-		$33,444
	4	$4,134	$0	$9,829	$6,708	$0	$16,537
	2	$5,632	$0	$5,897	$5,367	$0	$11,264
	2	$2,637	$0	$3,931	$1,342	$0	$5,273
	4	$5,372	$0	$14,743	$3,354	$3,392	$21,489
	3	$4,825	$2,391	$7,415	$4,668	$0	$14,475
	9	$4,825	$7,174	$22,245	$14,005	$0	$43,424
	2	$4,966	$0	$5,897	$2,013	$2,023	$9,933
	2	$4,528	$0	$4,669	$2,013	$2,374	$9,055
	3	$6,310	$0	$8,846	$8,050	$2,035	$18,931
	34	$4,141	$28,947	$32,926	$40,586	$38,327	$140,787
	22	$5,836	$17,536	$54,376	$34,234	$22,252	$128,399
	5	$5,039	$0	$12,358	$7,781	$5,057	$25,196
	1	$6,252	$0	$2,211	$2,683	$1,357	$6,252
Average	7						$31,460

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 avoided cost associated with spillover

AV_COSTpop = the total avoided cost for the CEEI LED traffic control signal 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 avoided cost associated with spillover

AV_COSTpop = the total avoided cost for the CEEI LED traffic control signal program

These equations are identical to those presented earlier, with the exception of using avoided cost as a proxy for impact. Each of the components to calculating the contribution to participant and nonparticipant spillover have been identified and are discussed above, except for the total avoided cost. The total avoided cost as reported in the MDSS is $7,518,055 for LED traffic controls signals.

Participant Spillover NTG Calculation

Exhibit 3-22 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 4.98 percent.

Exhibit 3-22
Participant Spillover Estimate

Avoided Cost per Participant	$	22,598
Spillover rate		31.25%
Number of Participants		53
Number Contributing to Spillover		16.56
Spillover Avoided Cost	$	374,276
LED Avoided Cost	$	7,518,055
NTG Contribution from Participant Spillover		**4.98%**

Nonparticipant Spillover NTG Calculation

Exhibit 3-23 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 0.86 percent.

Exhibit 3-23
Nonparticipant Spillover Estimate

Avoided Cost per Nonparticipant	$ 31,460
Spillover rate	1.57%
Number of Nonparticipants	131
Number Contributing to Spillover	2.05
Spillover Avoided Cost	$ 64,648
LED Avoided Cost	$ 7,518,055
NTG Contribution from Nonparticipant Spillover	0.86%

3.4.4 Final Net-to-Gross Ratios

As mentioned previously, three separate models were implemented to estimate the components of the net-to-gross ratio (free ridership and spillover). The first methodology relied on self-reported estimates of free ridership, participant spillover, and nonparticipant spillover to estimate the net-to-gross ratios. The second approach relied on a net billing regression analysis model, which resulted in estimates of free ridership and participant spillover only. The final approach relied on a difference of differences approach, which also resulted in estimates of free ridership and participant spillover only. Furthermore, both the net billing and difference of differences models only estimate a component of participant spillover: only spillover associated with intersections affected by the rebated LEDS are included. Nonrebated participant intersection spillover is not included, because these intersections are not included in the analyses.

Both LIRM methods (net billing and difference of differences) are potentially biased because the underlying models assume that the level of nonparticipant adoptions of LED nonrebated retrofits is equivalent to what the participants would have done in the absence of the program (or free ridership). Because we found there to be a significant amount of free ridership in the self report analysis, and few nonparticipant nonrebated adoptions, we feel that the LIRM models may have overestimated the net-to-gross ratio.

For this reason, we have selected the self-report results as our final estimate of the net-to-gross ratio. Exhibit 3-24 summarizes the results of each method, as well indicating the estimates for each component of the net-to-gross ratio (free ridership, participant spillover, and nonparticipant spillover). Note that free ridership is not explicitly estimated for the LIRM models. Furthermore, nonparticipant spillover is not included in the net-to-gross estimate for the LIRM models. Finally, as discussed above, only a fraction of the participant spillover is estimated for the two LIRM models.

Exhibit 3-24
Summary of Net-to-Gross Ratios

	Self-Report Method	Net Billing Model	Difference of Differences Approach	Final Result (Self-Report)
Components of NTG				
1-FR	0.77	INCLUDED	INCLUDED	0.77
Part Spill	0.05	PARTIAL	PARTIAL	0.05
NP Spill	0.01	N/A	N/A	0.01
Final NTG Estimate	0.83	0.97	1.01	0.83

4. EVALUATION RESULTS

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

Results are presented by technology group. As stated previously, the Pre-1998 Traffic Signal Program Carry-Over had only Retrofit Efficiency Options participants. Thus, only Retrofit Efficiency Options data is presented. All results are aggregated to the total program level.

4.1 EX POST GROSS IMPACT RESULTS

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

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

Exhibit 4-1
Ex Post Gross Energy Impacts by Technology Group
For Traffic Signal Applications

Program and Technology Group		kWh
REO	12 " Red Ball Signal	7,529,239
	12" Red Arrow Signal	6,071,253
	8 " Red Ball Signal	2,989,573
	Orange Pedestrian Walk Signal	2,672,036
Total		**19,262,102**

Exhibit 4-2
Ex Post Gross Demand Impacts by Technology Group
For Traffic Signal Applications

Program and Technology Group		kW
REO	12 " Red Ball Signal	923
	12" Red Arrow Signal	647
	8 " Red Ball Signal	367
	Orange Pedestrian Walk Signal	385
Total		**2,321**

High Impact Technologies – The technologies that made the largest contributions to impacts were the replacement of standard-efficiency incandescent lamps with LED traffic signals for both 12-inch Red Ball Signals and 12-inch Red Arrow Signals. These two technologies represent approximately 70 percent of the REO program energy impacts and 68 percent of the demand impacts. 12-inch Red Ball Signals alone account for almost 40 percent of the gross energy and demand impacts. The large impacts attributable to these technologies are driven by the large per-signal change in connected load and high participation levels for the 12-inch Red Ball signals.

Low Impact Technologies – The lowest energy impacts were contributed by the Orange Pedestrian Walk Signals, due to the combination of relatively low connected load change, low duty cycle and low participation.

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 4-3 presents the NTG values, separating out the effects of free ridership and spillover (note that due to rounding, values may not sum properly). For this Traffic Signal Evaluation, the results from the self report analysis were used, as discussed in more detail in Section 3.4.

Exhibit 4-3
NTG Adjustments

	Final Result (Self-Report)
Components of NTG	
1-FR	0.77
Part Spill	0.05
NP Spill	0.01
Final NTG Estimate	0.83

The overall NTG ratio is 0.83 based on both energy and demand savings. For energy and demand impacts, free ridership and spillover were approximately 23 and 6 percent, respectively.

4.3 EX POST NET IMPACTS

Exhibits 4-4 and 4-5 present the ex post net energy and demand impacts, for the Pre-1998 Traffic Signal Program Carry-Over.

These exhibits show decreases of 17 percent in ex post program energy impacts and demand impacts (when compared to Exhibits 4-1 and 4-2, gross impacts). The decreases are a result of the application of the NTG adjustments presented in Exhibit 4-3. 12-inch Red Ball and Red Arrow Signals still dominate the savings, representing 70 percent of the energy impacts and nearly 70 percent of the demand impacts.

Exhibit 4-4
Ex Post Net Energy Impacts by Technology Group
For Traffic Signal Applications

Program and Technology Group		Misc.
REO	12 " Red Ball Signal	6,232,704
	12" Red Arrow Signal	5,025,783
	8 " Red Ball Signal	2,474,769
	Orange Pedestrian Walk Signal	2,211,912
Total		**15,945,168**

Exhibit 4-5
Ex Post Net Demand Impacts by Technology Group
For Traffic Signal Applications

Program and Technology Group		kW
REO	12 " Red Ball Signal	764
	12" Red Arrow Signal	535
	8 " Red Ball Signal	303
	Orange Pedestrian Walk Signal	318
Total		**1,921**

4.4 REALIZATION RATES

Exhibits 4-6 through 4-9 present the gross and net realization rates for energy and demand impacts for the Pre-1998 Traffic Signal Program Carry-Over. Exhibit 4-10, at the end of this section, summarizes the gross and net ex ante impacts, ex post impacts, and realization rates.

4.4.1 Gross Realization Rates for Energy Impacts

The gross energy realization rates are presented in Exhibit 4-6. These values represent, by technology, 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 impacts, before taking into account customer behavior effects, both inside and outside the rebate program. These results vary slightly across technology; from 0.83 to 1.15. The overall result, 0.93 is very close to one.

Exhibit 4-6
Gross Energy Impact Realization Rates by Technology Group
For Traffic Signal Applications

Program and Technology Group		RR
REO	12 " Red Ball Signal	0.84
	12" Red Arrow Signal	1.15
	8 " Red Ball Signal	0.94
	Orange Pedestrian Walk Signal	0.83
Total		**0.93**

The only technology group with a gross realization rate greater than one was 12-inch Red Arrow Signals at 1.15. The technology group with the smallest realization rate was Orange Pedestrian Walk Signals, at 0.83. These results are discussed below using information from the review of the ex ante estimates in conjunction with the billing analysis results.

12-inch Red Arrow Signals - The relatively high realization rates for 12-inch Red Arrow Signal technologies are due to the difference between ex ante and ex post duty cycle estimates. The ex post duty cycle estimate is 18 percent higher than the ex ante estimate. The ex post change in connected load is slightly lower than the ex ante, which helps to offset the difference in the duty cycle estimates. The high realization rates for 12-inch Red Arrow Signals have a significant effect on the overall traffic signal end-use realization rate because the energy impact of this technology accounts for almost one third of the traffic signal program's total.

Orange Pedestrian Walk Signals – Overall, ex post energy impacts differ from ex ante energy impact by about 17 percent. The low realization rate is entirely due to the difference between the ex ante and ex post duty cycle estimates. The ex post connected load estimate was slightly lower than the ex ante connected load estimate, but not enough to make a significant impact. The ex post duty cycle estimate, however, is almost 17 percent lower than the ex ante estimate. QC believes that the ex ante duty cycle estimates for the Orange Pedestrian Walk Signals and the 12-inch Red Arrows were inverted. This also helps to explain the high realization rate of the 12-inch Red Arrow Signals.

4.4.2 Gross Realization Rates for Demand Impacts

Gross demand realization rates are presented in Exhibit 4-7. These values represent, by technology, 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 impacts, before taking into account customers' actions within the traffic signal market. Refer to Exhibit 4-10 for an individual presentation of both the ex ante and ex post impacts. Overall, the gross demand estimates are only 1 percent lower than the ex ante values, as illustrated below.

Exhibit 4-7
Gross Demand Impact Realization Rates by Technology Group
For Traffic Signal Applications

Program and Technology Group		RR
REO	12 " Red Ball Signal	0.90
	12" Red Arrow Signal	1.08
	8 " Red Ball Signal	1.01
	Orange Pedestrian Walk Signal	1.05
Total		**0.99**

The technology that differed the most from ex ante estimates was 12-inch Red Ball Signals. Specific comments and justifications for these results are as follows:

12-inch Red Ball Signals - The low realization rate for 12-inch Red Ball Signal technologies results from ex ante estimates for this technology, which are based on an assumed average duty cycle instead of a peak period duty cycle. Ex ante estimates also assume almost a slightly larger change in connected load than the ex post estimates.

12-inch Red Arrow Signals - The ex post estimated impacts for 12-inch Red Arrows are high due to the ex ante duty cycle estimate, which was most likely switched with the Orange Pedestrian Walk Signal 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 technology are presented in Exhibit 4-8, with the net demand realization rates illustrated in Exhibit 4-9. These values represent, by technology, 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 impacts, after taking into account customers' actions within the traffic signal market.

Many of the results presented in Exhibits 4-8 and 4-9 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.

Exhibit 4-8
Net Energy Impact Realization Rates by Technology Group
For Traffic Signal Applications

Program and Technology Group		RR
REO	12 " Red Ball Signal	0.77
	12" Red Arrow Signal	1.06
	8 " Red Ball Signal	0.86
	Orange Pedestrian Walk Signal	0.77
Total		**0.86**

Exhibit 4-9
Net Demand Impact Realization Rates by Technology Group
For Traffic Signal Applications

Program and Technology Group		RR
REO	12 " Red Ball Signal	0.83
	12" Red Arrow Signal	0.99
	8 " Red Ball Signal	0.93
	Orange Pedestrian Walk Signal	0.97
Total		**0.91**

4.5 OVERVIEW OF REALIZATION RATES

The net ex post energy impact is 14 percent lower than the net ex ante impact estimates. This difference is explained primarily by the fact that the free-ridership is high for the Traffic Signal Program, at 23 percent. The unadjusted gross ex post engineering estimates are only 8.5 percent lower than the ex ante estimates. This difference combined with a program-level SAE coefficient of 102 percent resulted in a gross realization rate of 93 percent. A lower ex post net-to-gross adjustment relative to ex ante brought the net realization rate even lower to 86 percent.

The net ex post realization rate for demand impacts is 91 percent. The ex post gross demand impacts are 99 percent of ex ante gross demand impacts. Again, the lower ex post net-to-gross adjustment relative to ex ante resulted in a lower net realization rate relative to gross, at 91 percent.

Exhibit 4-10 summarizes all of the gross and net energy and demand impacts discussed above. Results are also presented for the net-to-gross adjustments and the realization rates.

Exhibit 4-10
Traffic Signal Impact Summary
By Technology Group

Program and Technology Group		Gross Program Impact		NTG Adjustment*		Net Program Impac	
		kWh	kW	(1-FR)	Spillover	kWh	kW
			EX ANTE				
REO	12 " Red Ball Signal	8,954,938	1,025	0.80	0.10	8,059,444	922
	12" Red Arrow Signal	5,258,720	600	0.80	0.10	4,732,848	540
	8 " Red Ball Signal	3,188,400	361	0.80	0.10	2,869,560	325
	Orange Pedestrian Walk Signal	3,205,245	365	0.80	0.10	2,884,720	329
	Total	20,607,303	2,351	0.80	0.10	18,546,573	2,116
			EX POST				
REO	12 " Red Ball Signal	7,529,239	923	0.77	0.06	6,232,704	764
	12" Red Arrow Signal	6,071,253	647	0.77	0.06	5,025,783	535
	8 " Red Ball Signal	2,989,573	367	0.77	0.06	2,474,769	303
	Orange Pedestrian Walk Signal	2,672,036	385	0.77	0.06	2,211,912	318
	Total	19,262,102	2,321	0.77	0.06	15,945,168	1,921
			REALIZATION RATES				
REO	12 " Red Ball Signal	0.84	0.90	-	-	0.77	0.83
	12" Red Arrow Signal	1.15	1.08	-	-	1.06	0.99
	8 " Red Ball Signal	0.94	1.01	-	-	0.86	0.93
	Orange Pedestrian Walk Signal	0.83	1.05	-	-	0.77	0.97
	Total	0.93	0.99	-	-	0.86	0.91

* Weighted by ex-post Gross Energy impact

Attachments

Attachment 1
Waivers

PACIFIC GAS & ELECTRIC COMPANY
REQUEST FOR RETROACTIVE WAIVER FOR
PRE-1998 CEEI PROGRAM CARRY-OVER:
TRAFFIC CONTROL SIGNALS END USE
Study ID # 404d
Date Approved: 5/20/99

Program Background

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

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

Pre-1998 Program Carry-Over Summary: Traffic Management End Use

Technology	Unique Applications	Avoided Cost	Percentage of Avoided Cost
12 " Red Ball Signal	51	3,269,504	43.5%
12" Red Arrow Signal	47	1,918,629	25.5%
8 " Red Ball Signal	45	1,160,947	15.4%
Orange Pedestrian Walk Signal	38	1,168,976	15.5%
TOTAL (Unique Sites)	54	7,518,056	100.0%

Proposed Waiver

The purpose of this waiver is to state PG&E's methodology for conducting the pre-1998 Commercial Sector EEI Evaluation of the Traffic Control Signal End Use (Traffic Control Signal Program). Because the Traffic Control Signal End Use is not explicitly covered under the Protocols[1], PG&E seeks the California DSM Measurement Advisory Committee's (CADMAC's) approval to use the methodology described below for estimating the load impacts for the Traffic Control Signal Program.

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

In general, we will follow Table C-4 of the Protocols, which was developed primarily for the lighting and HVAC end uses.

Sample Sizes
Although 2,217 intersections were retrofitted with LED Traffic Control Signals, only 54 unique customers participated in the program. A customer is generally defined as a city or county. Table 5 of the Protocols defines participants as "those who received financial assistance to install a measure of group of measures during the program year," which is consistent with our definition. Because the number of participants is less than 350, we will conduct a census on these customers. Furthermore, we will attempt to obtain an equal number of nonparticipant completes, which will also have a severely limited sample frame (less than 150).

Gross Demand Impacts
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 Power Savings Partners evaluation of traffic management systems. The calibrated engineering algorithm that will be used is:

Eng_Est(kW) = DC_peak*(Pre_kW – Post_kW)

DC_peak = peak duty cycle
Pre_kW = pre-retrofit wattage
Post_kW = post-retrofit wattage

As a default, the pre- and post-retrofit wattages for the traffic control signals will utilize standard installed wattages used in PG&E's advice filing. We are attempting to survey all 54 participating traffic engineers, with an objective of obtaining from them the pre- and post-retrofit wattages of the retrofitted control signals. Customer specific pre-and post-retrofit wattages will be used when collected, otherwise the default values will be used.

The peak duty cycles will be obtained from the Power Savings Partners evaluation of traffic management systems. These duty cycles were estimated based on end-use monitored data of traffic control signals.

Gross Energy Impacts
For the estimation of first year electric energy impacts, a load impact regression model (LIRM) will be performed. The LIRM will be conducted on the set of surveyed participants and nonparticipants. The LIRM model will incorporate an engineering estimate of energy savings, which will be calculated as:

Eng_Est(kWh) = 8760*DC_ave*(Pre_kW – Post_kW)

DC_ave = average duty cycle
Pre_kW = pre-retrofit wattage
Post_kW = post-retrofit wattage

The peak duty cycles will be obtained from the Power Savings Partners evaluation of traffic management systems. The customer-specific pre- and post-retrofit wattages will be identical to those used in the demand analysis.

Net-to-Gross Analysis
Two methods will be used to estimate first year net impacts: a LIRM, and a self-report analysis. The LIRM model will effectively be a difference of differences approach. If the results of the LIRM model are found to be unreliable, we will use self-report based algorithms to estimate free ridership and spillover effects.

DUOM
We will define the designated unit of measure for the traffic control signal end use to be load impacts per 1000 hours of operation.

Rationale

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

Sample Sizes
For the development of participant and nonparticipant survey samples, a census will be conducted on the 54 participants, and an equivalent number of nonparticipants will be surveyed (or a census). As stated in Table 5 of the Protocols, "if the number of participants is less than 350 for nonresidential programs . . . a census will be attempted".

Gross Demand Impacts
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 Power Savings Partners evaluation of traffic management systems to estimate peak duty cycles. Furthermore, pre- and post-retrofit wattages will be based on customer self-reports obtained through participant surveys. 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 duty cycles based on end-use load data developed from the Power Savings Partners evaluation of traffic management systems.

Gross Energy Impacts
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.

Net-to-Gross Analysis
For the estimation of first year net load impacts, we propose using a LIRM. If the LIRM is found to be unreliable, we propose using self-report based algorithms to estimate free ridership and spillover effects. Table 5 of the Protocols approves the use of a difference of differences approach: "Net load impacts = Participant Group Load Impacts minus Comparison Group Load Impacts." We will follow the Protocol Table 5 in implementing the LIRM.

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 LIRM, 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.

There are two primary reasons why we feel the LIRM may produce reliable results. First of all, we are working with billing accounts that are tied to traffic control signals, as opposed to a building's energy consumption, which is more standard for this type of analysis. Therefore, we may not obtain statistically significant results from the LIRM. 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. The prevailing criterion for assessing this decision would be that a verification study or peer review would lead to a similar conclusion.

Secondly, the difference of differences LIRM approach requires certain assumptions to be met in order to produce an unbiased estimate of net impacts. Primarily, the difference of differences LIRM approach assumes that the comparison group load impact is equivalent to the load impact that would have occurred within the participant group had the program not existed. If, for example, all of the comparison group load impact was attributable to the program (nonparticipant spillover), and there was little or no free ridership among participants, then the net load impacts would be underestimated. Conversely, if there was no comparison group load impact, and if there was a significant amount of free ridership, then the net load impacts would be overestimated.

For the difference of differences approach to produce an unbiased estimate of net impacts, there would have to be no nonparticipant spillover. In this special case, the nonparticipant load impact (i.e., nonparticipant natural conservation) would equal participant free ridership.[2] If we find from the self-report analysis that (1) there is a significant level of nonparticipant spillover, or (2) that free ridership and the nonparticipant load impact are significantly different, we would deem the LIRM results to be unreliable, and resort to the self-report estimate of net impacts. Therefore, the ideal circumstances for applying the difference of differences approach would be when there is no measured self-report spillover or free ridership, and the nonparticipant impact is near zero. Again, the prevailing criterion for assessing this decision would be that a verification study or peer review would lead to a similar conclusion.

DUOM
We will define the designated unit of measure for the traffic control signal end use to be load impacts per 1000 hours of operation. Table C-4 of the Protocols defines the DUOM for the lighting end use to be load impacts per affected square foot per 1000 hours of operation. Because traffic control signals do not have an associated affected square footage, we feel that 1000 hours of operation is the best unit of measure.

Conclusion

[2] A more complex comparison is when there is nonparticipant spillover. In that case, the difference of differences approach holds true only when free ridership is equivalent to two times nonparticipant spillover plus nonparticipant natural conservation.

PG&E is seeking a waiver to clearly define, in advance, acceptable methods for performing the 1998 Commercial Traffic Control Signal Program evaluation. Recommendations in this waiver are designed to maximize the quality and value of evaluation results. The waiver allowing the use of the proposed methodology 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 Traffic Management Ex Ante Gross Energy Impacts
By Technology Group

Program and Technology Group		kWh
REO	12 " Red Ball Signal	8,954,938
	12" Red Arrow Signal	5,258,720
	8 " Red Ball Signal	3,188,400
	Orange Pedestrian Walk Signal	3,205,245
Total		**20,607,303**

Attachment 2-2
Commercial Traffic Management Ex Ante Net Energy Impacts
By Technology Group

Program and Technology Group		kWh
REO	12 " Red Ball Signal	8,059,444
	12" Red Arrow Signal	4,732,848
	8 " Red Ball Signal	2,869,560
	Orange Pedestrian Walk Signal	2,884,720
Total		**18,546,573**

Attachment 2-3
Commercial Traffic Management Unadjusted Engineering Energy Impacts
By Technology Group

Program and Technology Group		kWh
REO	12 " Red Ball Signal	7,365,943
	12" Red Arrow Signal	5,939,579
	8 " Red Ball Signal	2,924,735
	Orange Pedestrian Walk Signal	2,614,085
Total		**18,844,341**

Attachment 2-4
Commercial Traffic Management Gross Energy SAE Coefficients
By Technology Group

Program and Technology Group		SAE
REO	12 " Red Ball Signal	1.02
	12" Red Arrow Signal	1.02
	8 " Red Ball Signal	1.02
	Orange Pedestrian Walk Signal	1.02
Total		1.02

Attachment 2-5
Commercial Traffic Management Ex Post Gross Energy Impacts
By Technology Group

Program and Technology Group		kWh
REO	12 " Red Ball Signal	7,529,239
	12" Red Arrow Signal	6,071,253
	8 " Red Ball Signal	2,989,573
	Orange Pedestrian Walk Signal	2,672,036
Total		**19,262,102**

Attachment 2-6
Commercial Traffic Management Gross Energy Impact Realization Rates
By Technology Group

Program and Technology Group		RR
REO	12 " Red Ball Signal	0.84
	12" Red Arrow Signal	1.15
	8 " Red Ball Signal	0.94
	Orange Pedestrian Walk Signal	0.83
Total		**0.93**

Attachment 2-7
Commercial Traffic Management Net-to-Gross Adjustments
By Technology Group

Program and Technology Group		NTG
REO	12 " Red Ball Signal	0.83
	12" Red Arrow Signal	0.83
	8 " Red Ball Signal	0.83
	Orange Pedestrian Walk Signal	0.83
Total		**0.83**

Attachment 2-8
Commercial Traffic Management Ex Post Net Energy Impacts
By Technology Group

Program and Technology Group		Misc.
REO	12 " Red Ball Signal	6,232,704
	12" Red Arrow Signal	5,025,783
	8 " Red Ball Signal	2,474,769
	Orange Pedestrian Walk Signal	2,211,912
Total		**15,945,168**

Attachment 2-9
Commercial Traffic Management Net Energy Impact Realization Rates
By Technology Group

Program and Technology Group		RR
REO	12 " Red Ball Signal	0.77
	12" Red Arrow Signal	1.06
	8 " Red Ball Signal	0.86
	Orange Pedestrian Walk Signal	0.77
Total		**0.86**

Attachment 2-10
Commercial Traffic Management Ex Ante Gross Demand Impacts By Technology Group

Program and Technology Group		kW
REO	12 " Red Ball Signal	1,025
	12" Red Arrow Signal	600
	8 " Red Ball Signal	361
	Orange Pedestrian Walk Signal	365
Total		**2,351**

Attachment 2-11
Commercial Traffic Management Ex Ante Net Demand Impacts By Technology Group

Program and Technology Group		kW
REO	12 " Red Ball Signal	922
	12" Red Arrow Signal	540
	8 " Red Ball Signal	325
	Orange Pedestrian Walk Signal	329
Total		**2,116**

Attachment 2-12
Commercial Traffic Management Unadjusted Engineering Demand Impacts By Technology Group

Program and Technology Group		Misc.
REO	12 " Red Ball Signal	923
	12" Red Arrow Signal	647
	8 " Red Ball Signal	367
	Orange Pedestrian Walk Signal	385
Total		**2,321**

Attachment 2-13
Commercial Traffic Management Ex Post Gross Demand Impacts
By Technology Group

Program and Technology Group		kW
REO	12 " Red Ball Signal	923
	12" Red Arrow Signal	647
	8 " Red Ball Signal	367
	Orange Pedestrian Walk Signal	385
Total		**2,321**

Attachment 2-14
Commercial Traffic Management Gross Demand Impact Realization Rates
By Technology Group

Program and Technology Group		RR
REO	12 " Red Ball Signal	0.90
	12" Red Arrow Signal	1.08
	8 " Red Ball Signal	1.01
	Orange Pedestrian Walk Signal	1.05
Total		**0.99**

Attachment 2-15
Commercial Traffic Management Net-to-Gross Adjustments for Demand Impacts
By Technology Group

Program and Technology Group		NTG
REO	12 " Red Ball Signal	0.83
	12" Red Arrow Signal	0.83
	8 " Red Ball Signal	0.83
	Orange Pedestrian Walk Signal	0.83
Total		0.83

Attachment 2-16
Commercial Traffic Management Ex Post Net Demand Impacts
By Technology Group

Program and Technology Group		kW
REO	12 " Red Ball Signal	764
	12" Red Arrow Signal	535
	8 " Red Ball Signal	303
	Orange Pedestrian Walk Signal	318
Total		**1,921**

Attachment 2-17
Commercial Traffic Management Net Demand Impact Realization Rates
By Technology Group

Program and Technology Group		RR
REO	12 " Red Ball Signal	0.83
	12" Red Arrow Signal	0.99
	8 " Red Ball Signal	0.93
	Orange Pedestrian Walk Signal	0.97
Total		**0.91**

Attachment 2-18
Commercial Traffic Management
Mapping of Technology to PG&E's Measure Code

Business Type / **Program and Technology Group**	**PG&E Measure Classification** / **Measure Code**
Retrofit Express Option	
12 " Red Ball Signal	L161
12" Red Arrow Signal	L162
8 " Red Ball Signal	L163
Orange Pedestrian Walk Signal	L164

Attachment 2-19
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	0.0896
Summer Partial Peak: **May 1 to Oct. 31** **8:30 AM - 12:00 PM &** **6:00 PM - 9:30 PM Weekdays**	0.9955	0.1044
Summer Off-Peak: **May to Oct. 31** **9:30 PM - 8:30 AM**	0.9755	0.3101
Winter Partial Peak: **Nov. 1 to April 31** **8:30 AM - 9:30 PM Weekdays**	0.9661	0.1865
Winter Off-Peak: **Nov. 1 to April 31** **9:30 PM - 8:30 AM Other**	0.9950	0.3094

Attachment 3

Power Saving Partners Report

Pacific Gas and Electric Company

PowerSaving Partners
Mail Code H28L
P.O. Box 770000
San Francisco, CA 94177
Phone (415) 973-0014
Fax (415) 973-0054

November 16, 1999

Mr. Jay Raggio
Electro-Test Inc.
1320 El Capitan Drive, 4th Floor
Danville, CA 94526

Re: PowerSaving Partners Program ID#95PSP105
CalTrans – Traffic Signal Retrofit

Subjects: Acceptance of Duty Cycle Monitoring Results

Dear Jay:

We have completed our review of the monitoring results that was submitted for CalTrans-traffic signals retrofit project. We conducted an independent analysis of the data submitted and found our results are in close agreement of the results calculated by ETI (see enclosed report). Table 1 lists the approved operating hours. Note that the approved hours are rounded to the nearest integer. These hours are to be used to true up the payments for the completed phases and to be used for payments for the next phases.

Table 1: Approved Hours for CalTrans-Traffic Signals Retrofit

Group	Summer Peak	Summer Part-Part	Summer Off-Peak	Winter Part-Peak	Winter Off-Peak	Annual Total
PED	760	887	2,709	1,584	2,702	8,642
RMS	441	510	1,442	914	1,439	4,746
RTC	664	785	2,468	1,392	2,462	7,771

Sincerely,

Charles Maroon

Charles Maroon
Program Manager

AD:jyy

cc: Terrance Pang
Schiller Associates
File

Enclosure

Review of ETI's Duty Cycle Monitoring Results for CalTrans

Introduction

Electro-test, Inc. (ETI) submitted monitoring results for the CalTrans-traffic signal retrofit project under the PowerSaving Partners (PSP) program. This is the complete monitoring for the project. Preliminary monitoring results were submitted and approved in the Measurement and Verification (M&V) Plan. The monitoring results reviewed in this report will be used for all districts and divisions included in the CalTrans-traffic signal retrofit project. The results will also be used as estimated hours and benchmark for other traffic signal retrofit projects submitted by ETI.

Analysis Methodology

Because traffic signals have short switching cycles, capturing each On/Off status requires tremendous amount of data storage space and computing resource. An alternative monitoring strategy was developed to measure the operating hours of traffic signals. The following procedures were used for determining the operating hours:

1) Measure the operating voltage or amperage draw of the traffic signal when it is turned on. This is done prior to the installation of monitoring equipment and will serve as a reference point for the logger readings.
2) Monitor the traffic signal voltage or amperage for a period of three weeks. Average voltage or amperage readings are recorded at 15-minutes intervals.
3) Retrieve data after three weeks of monitoring. Operating voltage or amperage may be measured again (same as #1) to verify the reference point.
4) For each reading, calculate duty cycle by dividing the measured 15-minutes average reading by the operating voltage or amperage.
5) The overall duty cycle for a group is the average duty cycle calculated from all readings and all loggers.

Results

Simple sampling plan was approved for this project. ETI submitted all monitoring data as well as the operating measurements for review. Schiller Associates analyzed the data for average duty cycle. Table 1 summarizes the monitoring results and the difference relative to ETI's results. The average annual hours were found to be in close agreement with ETI's results; therefore, hours for each of the Time of Use (TOU) period were not analyzed in Schiller Associates' analysis. Table 2 lists the monitoring statistics assuming an infinite population. CalTrans project is still being completed and the total population of the project is not known yet. See Appendix for details of the analysis.

Table 1: Monitoring Results for CalTrans Traffic Signal Retrofit, Schiller Associates

Signal Type	Intersections Metered	Samples Metered	Average Duty Cycle	Schiller Hours	ETI Hours	% Diff.
Main Signal	29	96	0.511	4479	4745	-6.4%
Turn Signal	24	41	0.886	7759	7771	0.3%
Ped. Hand	17	23	0.966	8458	8641	-2.0%
Totals	**70**	**160**				

Table 2: Monitoring Statistics for CalTran Traffic Signal Retrofit, Schiller Associates

Signal Type	Sample Taken	Default cv(y)	Required Sample*	Number Under-sampled	Measured cv(y)	Measured Precision **
Main Signal	96	0.5	68	0	0.60	10.1%
Turn Signal	41	0.4	44	3	0.13	3.2%
Ped Hand	23	0.25	17	0	0.18	6.1%
Totals	**160**		**129**	**3**		

* Assumed an infinite population.

** At 90% confidence level and assumed an infinite population.

Conclusion

Results calculated by ETI are in agreement with those calculated by Schiller Associates and will be approved as submitted. The measured precision met the required precision for all groups. No monitoring will be required for subsequent contract years per approved M&V Plan.

Appendix: Monitoring data analysis for CalTrans traffic signal retrofit

Table 1: Maximum readings from spot measurements

File	Lookup ID	Van	Vbn	Vcn	Ia	Ib	Ic	In
128Kcombined	128Kmart	122.1	122.5	122.2	1.674	1.136	1.21	12.82
1ST&LASP	1st&lasp	120.4	119.0	119.5	2.9	2.5	3.7	0.6
1STMAPL2	1st&Maple	115.5	114.5	114.3	3.261	2.298	1.877	1.848
1ST&NLIVcombined	1st&Nliv	121.1	119.2	120.1	1.084	2.237	2.252	1.896
1STOLD1Scombined	1st&old1st	112.3	112.3	112.1	0.973	0.712	2.358	0.721
1ST&SOFR	1st&sofr	119.1	119.2	118.9	0.948	6.05	0.981	4.74
205GRANT	205grant	117.3	117.1	117.1	3.342	1.422	1.409	1.398
238_spr_oct97_combined	238&spr	122	120.6	121.5	1.746	2.167	0.777	1.175
299_5_ combined	299&5	118.7	118.8	119.3	0.799	0	0	0
5801STN2	5801stN	117.4	115.7	115.8	18.23	1.539	7.33	0.716
5801STS2	5801stS	122.1	120.4	3.9	14.86	2.48	0.841	2.027
CVB_580	580CVB	120.2	118.8	118.8	5.2	2.031	2.104	2.502
80&LEISU_combined	80&leisu	123	121.7	121.7	1.671	1.707	1.921	1.002
880&LEW_Combined	880&lew	121.2	119.7	120	14.75	1.018	1.746	0
880_wash2	880&wash	118.8	117.3	116.9	2.739	6.94	4.01	2.378
E14&HAMP	E14&hamp	118.2	118.6	119.6	2.444	1.888	1.913	0.797
E14THMAT_combined	E14&mat	118.9	119.1	120.1	2.72	1.907	2.038	0.778
ECR25TH_combined	ECR&25th	116.2	115.3	1.8	0.005	0.27	0.304	0.084
ECRSAN&_Combined	ECR&san	122.9	122	122.2	0.36	0.456	1.957	0.057
H1KMART_Combined	H1Kmart	119.7	119.4	120	2.869	1.428	1.428	13.39
hacienda_combined	hacienda	118.9	119.4	119.6	0	0	0	1.125
LAKE_combined	Lake	119.6	119.5	119.3	2.321	1.843	2.56	2.499
MCCULLEN_combined	McCullen	118.2	117.8	118.1	2.581	2.352	2.336	1.43
NSTREET_combined	Nst	117	117	117	117	117	117	117
OLDOREGO_combined	Oldoreego	121.8	121.6	121.9	2.397	0	0	0
OUTLETMALL_Combined	Outletmall	121	120.4	121.2	3.775	0	0	0
PINION_combined	pinion	120.6	120.3	120.6	0.974	3.357	0.704	1.393
SBayshore_combined	Sbayshore	121.3	121.4	121.1	1.427	2.664	1.411	21.33
SOQUEL_combined	soquel	118.8	118.9	119	1.969	2.645	1.474	0.896
TASSAJ_combined	tassaj	115.4	115.6	115.2	0	0	0	0
TH&CABRI_combined	th&cabri	119.9	119.5	119.8	1.104	1.742	1.255	0.555
TH&CO&CC	th&co&cc	119.2	119.2	119	2.439	1.015	1.53	1.512
TH_CORO2	th&coro	119.2	118	117.9	1.342	1.185	0.939	3.678
V&16TH7	V&16th	115.7	115.9	116.2	2.804	0.966	1.796	0.808
WILLOWUN_combined	willowun	122.3	120.9	120.9	0.542	3.419	1.455	2.629

Table 2: Average readings from logger files

File	Intersection	Van	Vbn	Vcn	Ia	Ib	Ic	In	Note
128KMART	128Kmart	17.9	105.4	112.6	0.3	1.1	1.2	10.1	
16TH&V	V&16th	96.9	87.0	104.6	1.5	0.9	0.9	0.8	
1ST&LASP	1st&lasp	119.5	44.7	109.4	2.3	2.2	3.3	0.6	
1ST&LIV	1st&Nliv	120.4	97.4	51.8	1.0	1.9	0.9	1.7	
1STMAPLE	1st&Maple	113.8	86.5	89.3	1.1	0.8	1.8	1.7	
238SP6F.LOG	238&spr	119.2	114.1	5.1	1.0	1.5	0.2	0.2	
238SPR7_.LOG		119.3	114.1	5.2	1.0	1.5	0.2	0.2	
580_1STN.LOG	5801stN	116.0	83.3	35.5	17.2	1.5	5.2	0.0	
580_1STS	5801stS	120.9	91.6	24.2	8.6	2.0	0.8	0.5	
580_CVB1.LOG	580CVB	119.4	117.3	61.4	1.0	0.0	1.0	1.3	
580_CVB2.LOG	580CVB	120.4	118.7	43.1	1.4	0.0	1.0	0.9	
80&LEI2.LOG	80&leisu	119.8	99.8	65.8	1.3	1.1	1.5	0.9	
880&LEW2.LOG	880&lew	120.4	44.8	80.8	14.0	1.0	1.5	0.0	
880_WASH.LOG	880&wash	118.7	81.8	38.2	2.3	3.1	2.8	0.8	
DUM_WI16.LOG	willowun	120.5	7.7	112.6	0.5	1.0	1.4	2.0	
E14&HAMPcombine	E14&hamp	35.3	113.5	119.6	2.1	1.7	1.7	0.3	
ECR&25TH.LOG	ECR&25th	118.4	53.9	1.9	0.3	0.2	0.2	0.1	
ECR&SANA.LOG	ECR&san	121.4	67.1	2.7	0.2	0.3	1.7	0.0	
ECSANT16.LOG	ECR&san	122.4	68.8	90.1	0.2	0.3	1.7	0.0	
H1KMARTE.LOG	H1Kmart	111.9	14.2	114.3	0.1	1.4	1.4	12.8	
HAC7_1.LOG	hacienda	93.8	30.5	31.7	0.0	0.0	0.0	1.1	
I5_299.LOG	299&5	26.0	26.2	96.1	1.3	0.0	0.0	0.0	
LAKE.LOG	Lake	102.9	62.0	103.4	1.8	1.6	1.3	1.8	
LEISURE1.LOG	80&leisu	119.7	100.3	68.0	1.3	1.1	1.5	0.9	
MALLS.LOG	Sbayshore	16.8	112.8	23.6	1.4	0.0	1.4	13.8	
MCCULLEN.LOG	McCullen	114.3	17.1	117.4	0.3	2.1	2.1	1.4	
naglee.log	205grant	37.9	108.7	45.8	2.4	1.4	1.4	1.4	
NORTHST.LOG	Nst	113.3	42.2	103.0	1.5	0.8	1.4	0.7	
OLD1ST.LOG	1st&old1st	104.4	23.7	93.1	0.8	0.2	2.0	0.7	
OREGON.LOG	Oldoreego	115.6	29.3	102.5	0.4	0.0	0.0	0.0	
PINION2.LOG	pinion	119.1	19.3	105.5	0.9	0.9	0.6	1.4	
RONDA2.LOG	Outletmall	118.1	8.6	8.5	3.6	0.0	0.0	0.0	
SANANT63.LOG	ECR&san	123.0	69.2	2.7	0.2	0.3	1.7	0.0	
SFRONT81.LOG	1st&sofr	38.4	109.8	25.8	0.9	5.4	1.0	4.1	
SLIV817		107.3	97.4	57.5	1.8	1.6	1.1	2.0	remeter of 1st&liv
SOQUEL.LOG	soquel	116.9	43.2	108.5	0.9	1.5	1.3	0.9	
TASSAJ2.LOG		120.4	97.4	51.8	1.0	1.9	0.9	1.7	
TASSAJ6F.LOG	tassaj	81.8	43.7	42.8	0.0	0.0	0.0	0.0	
TH&CAB71.LOG	th&cabri	117.4	12.0	108.4	0.8	0.7	1.1	0.5	
TH_CORO.LOG	th&coro	120.6	16.4	111.4	1.2	1.1	0.9	2.4	
THC&CCF.LOG	th&co&cc	37.7	43.3	108.4	2.4	1.0	1.1	1.1	
THCABX.LOG		111.7	15.4	99.2	0.8	0.7	1.0	0.5	
WILL&DUM.LOG	willowun	120.7	7.6	113.0	0.5	0.9	1.4	2.0	

Table 3: Duty Cycle calculations for each group

		Group Information							Duty Cycle						
File	**Intersection**	**Van**	**Vbn**	**Vcn**	**Ia**	**Ib**	**Ic**	**In**	**Van**	**Vbn**	**Vcn**	**Ia**	**Ib**	**Ic**	**In**
128KMART	128Kmart	m	t	m	m	p	p		0.147	0.860	0.921	0.207	0.984	0.989	
1ST&LASP	1st&lasp		m	t	t	m	m	p		0.376	0.915	0.789	0.872	0.886	0.961
1ST&LIV	1st&Nliv	t	m	m	m	t	m	p	0.994	0.817	0.431	0.913	0.828	0.401	0.883
OLD1ST.LOG	1st&old1st	t	m	m	t	m	m	p	0.930	0.211	0.830	0.873	0.251	0.834	0.930
SFRONT81.LOG	1st&sofr	m	t	m	p	m	p	m	0.323	0.921	0.217	0.962	0.897	0.984	0.874
naglee.log	205grant	m	m	t	m	p	p	p	0.323	0.928	0.391	0.715	0.984	0.988	0.976
238SP6F.LOG	238&spr		m	m	p	p	m	m		0.946	0.042	0.583	0.698	0.253	0.145
I5_299.LOG	299&5	m	m	m	p				0.219	0.220	0.805	1.603			
80&LEI2.LOG	80&leisu		m	m	m	m	t	t		0.820	0.541	0.784	0.635	0.786	0.904
880&LEW2.LOG	880&lew		m	m		p	p			0.374	0.673		0.990	0.847	
E14&HAMPcombined.l	E14&hamp		t	m	m	m	t	m		0.957	1.000	0.839	0.899	0.894	0.358
ECR&25TH.LOG	ECR&25th		m		m	m	m	t		0.468			0.726	0.496	0.829
ECR&SANA.LOG	ECR&san		m		m	m	t	t		0.550		0.520	0.705	0.868	0.730
H1KMARTE.LOG	H1Kmart	t	m	m	m				0.935	0.119	0.952	0.051			
HAC7_1.LOG	hacienda	m	m	m					0.789	0.255	0.265				
LAKE.LOG	Lake	t	m	t	m	t	m	m	0.861	0.519	0.866	0.768	0.853	0.517	0.738
MCCULLEN.LOG	McCullen	t	m	t	m	m	m	p	0.967	0.145	0.994	0.114	0.897	0.898	0.983
NORTHST.LOG	Nst	t	m	t	m	m	m	p	0.968	0.360	0.880	0.013	0.007	0.012	0.006
OREGON.LOG	Oldoreego	t	m	m	m				0.949	0.241	0.840	0.187			
RONDA2.LOG	Outletmall	t	m	m	m				0.976	0.071	0.070	0.948			
PINION2.LOG	pinion	t	m	m	t	m			0.988	0.161	0.875	0.898	0.257		
MALLS.LOG	Sbayshore	m	t	m	p		p		0.138	0.929	0.195	0.980		0.987	
SOQUEL.LOG	soquel	t	m	t	m	m	m	p	0.984	0.363	0.912	0.432	0.574	0.859	1.007
TASSAJ6F.LOG	tassaj	m	m	m					0.709	0.378	0.372				
TH&CAB71.LOG	th&cabri	t	m	m	t	m	m		0.979	0.100	0.905	0.699	0.393	0.906	
THC&CCF.LOG	th&co&cc	m	m	t	t	p		m	0.316	0.363	0.911	0.966	0.970		0.703
TH_CORO.LOG	th&coro		m	t	m	m	p	t		0.139	0.945	0.899	0.898	0.978	0.658
16TH&V	V&16th	m	m	t	m	t	m	p	0.838	0.751	0.900	0.542	0.916	0.514	0.961
WILL&DUM.LOG	willowun		m	t	t	m	p			0.063	0.934	0.975	0.276	0.984	

* Duty Cycle = (Average readings from Table 2) / (Maximum readings from Table 1)

Table 4: Caltrans Duty Cycle Summary

	# of Intersection	Sample	Average Duty Cycle	Standard Deviation	cv(y)	Schiller Hrs	ETI DC	ETI Hrs	% Diff.
Main Signal	29	96	0.511	0.308	0.60	4479	0.542	4745	-5.6%
Turn Signal	24	41	0.886	0.112	0.13	7759	0.887	7771	-0.2%
Ped Hand	17	23	0.966	0.172	0.18	8458	0.986	8641	-2.1%
Totals	70	160							

Table 5: Monitoring Statistics (Simple Plan)

	Population	Sample Taken	Default cv(y)	inf. Popul. Sample	Required Sample	Under-sample	Measured cv(y)	Measured Precision
Main Signal		96	0.5	68	68	0	0.60	10.1%
Turn Signal		41	0.4	43	44	3	0.13	3.2%
Ped Hand		23	0.25	17	17	0	0.18	6.1%
Totals		**160**		**128**	**129**	**3**		

Attachment 4

Protocol Tables 6 & 7

PROTOCOL TABLES 6 AND 7

PRE-1998 COMMERCIAL EEI PROGRAM CARRY-OVER EVALUATION OF TRAFFIC CONTROL SIGNAL TECHNOLOGIES

PG&E STUDY ID #404D

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 Traffic Control Signal 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 Protocols do not specify the designated unit of measure for Traffic Control Signals. Therefore, to calculate the per-unit gross and net impacts required by the Protocols, the designated unit of measure was defined as:
  - Number of unique intersections affected by the retrofits.
- Items 6 and 7: The number of measures reported are the purchased number in the MDSS.

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 Traffic Control Signal Study ID #404D

Item Number	Table Item: Description	Estimate	Relative Precision: 90% Confidence	80% Confidence
1.A†	Pre-installation usage, Base usage, and Base usage per designated unit of measurement.	N/A	N/A	N/A
1.B†	Impact Year usage, Impact year usage per designated unit of measurement.	N/A	N/A	N/A
2.A	Gross Peak kW (Demand) Impacts	2,321	6%	4%
	Gross kWh (Energy) Impacts	19,262,102	1%	1%
	Gross thm (Therm) Impacts	N/A	N/A	N/A
	Net Peak kW (Demand) Impacts	1,921	14%	11%
	Net kWh (Energy) Impacts	15,945,168	13%	10%
	Net thm (Therm) Impacts	N/A	N/A	N/A
2.B	Per designated unit* Gross Demand (kW) Impacts	1.07	6%	4%
	Per designated unit* Gross Energy (kWh) Impacts	8901.16	1%	1%
	Per designated unit Gross Therm Impacts	N/A	N/A	N/A
	Per designated unit* Net Demand (kW) Impacts	0.89	14%	11%
	Per designated unit* Net Energy (kWh) Impacts	7368.38	13%	10%
	Per designated unit Net Therm Impacts	N/A	N/A	N/A
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	0.990	6%	4%
	Gross Energy Realization Rate	0.930	1%	1%
	Gross Therm Realization Rate §	N/A	N/A	N/A
	Net Demand Realization Rate	0.910	14%	11%
	Net Energy Realization Rate	0.860	13%	10%
	Net Therm Realization Rate §	N/A	N/A	N/A
3.A	Net-to-Gross ratio based on Avg. Load Impacts	0.828	13%	10%
3.B	Net-to-Gross ratio based on Avg. Load Impacts per designated unit* of measurement.	0.828	13%	10%
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)			
	Pre-installation Avg. (mean) Sq. Foot (comparison group)			
	Pre-installation Avg. Hours of Operation¥ (participant group)			
	Pre-installation Avg. Hours of Operation¥ (comparison group)			
4.B	Post-installation Avg. (mean) Sq. Foot (participant group)			
	Post-installation Avg. (mean) Sq. Foot (comparison group)			
	Post-installation Avg. Hours of Operation¥ (participant group)			
	Post-installation Avg. Hours of Operation¥ (comparison group)			

† The change model estimates of impact did not require an evaluation of base usage.

* The per designated unit used is per intersection.

¥ 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: Traffic Control Signal Measure Count Data
Traffic Control Signal Study ID #404D

Program and Technology Group Description	Number of Measures Paid in 1998		
	All Participants (Item 6.B)	Participant Sample (Item 6.A)	Comparison Group (Item 6.C)
Retrofit Efficiency Option Program			
12 " Red Ball Signal	13,037	905	460
12" Red Arrow Signal	5,616	1,130	851
8 " Red Ball Signal	10,496	4,877	409
Orange Pedestrian Walk Signal	6,789	6,483	544
TOTAL:	**35,938**	**13,395**	**2,264**

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

Business Type	Indoor Lighting	
	# of Part.	**% of Part.**
Traffic Management	54	100%
TOTAL:	**54**	**100%**

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

Industry (3-Digit SIC Code)	Lighting	
	# of Part.	% of Part.
9225	53	98.1%
9226	1	1.9%
TOTAL	**54**	**100.0%**

PROTOCOL TABLE 7

PRE-1998 COMMERCIAL EEI PROGRAM CARRY-OVER
EVALUATION OF TRAFFIC SIGNAL TECHNOLOGIES
PG&E STUDY ID #404D

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

A. OVERVIEW INFORMATION

1. Study Title and Study ID Number

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

Study ID Number: 404D

2. Program, Program Year and Program Description

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

Program Year: Rebates Received in the 1998 Calendar Year.

Program Description:

The Commercial Energy Efficiency Incentives Program for Traffic Signal technologies offered by PG&E has only one component: the Retrofit Efficiency Options (REO) Program.

The REO Program offers fixed rebates to PG&E's customers that install specific LED Traffic Signals in their jurisdictions. The Program covers 8- and 12-inch Red Ball Signals, 12-inch Red Arrow Signals, and Orange Pedestrian Walk Signals. To receive a rebate, the customer is required to submit proof of purchase along with the application. The REO Program is primarily marketed to city and county traffic departments and business centers that contain traffic signals ("TC-1" accounts and "STL" segment codes). The maximum total rebate amount of the REO Program is $100,000 per account.

3. End Uses and/or Measures Covered

End Use Covered: Traffic Signal Technologies.

Measures Covered: For the list of Program measures covered in this evaluation, see Attachment 2, Exhibit 2-18.

4. Methods and Models Used

The PG&E Commercial Traffic Signal 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)

Gross Impact -- Gross impact is computed as the change in energy consumption for a particular Traffic Signal technology relative to a baseline, typically defined as the pre-retrofit incandescent lamps. A detailed discussion of the Traffic Signal impact calculations can be found in *Section 3.2*.

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 duty cycle estimates. 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. Three approaches were used to capture the NTG effect: (1) two difference of differences models were used to estimate free ridership and spillover effects, (2) a net billing, or LIRM model, and (3) the NTG ratio calculation based on survey self report using a representative nonparticipant sample to account for naturally occurring conservation. The NTG analysis approaches are presented in detail in *Sections 3.3* and *3.4*.

5. Participant and Comparison Group Definition

Participant

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

Comparison Group

The comparison group for this study is defined as a group of PG&E commercial customers who did not receive any Traffic Signal end-use rebates in the 1998 calendar year under the CEEI Program, and who share as many characteristics as possible with the participant group in terms of annual usage and jurisdiction type.

6. *Analysis Sample Size*

The final analysis dataset has 99 observations based upon 99 telephone surveys. The distribution of the sample by jurisdiction type is presented in *Section 3.1*.

B. *DATABASE MANAGEMENT*

1. *Data Description and Flow Chart*

All data elements mentioned above were linked to the final analysis database through the unique customer identifier -- the evaluation 'tm_id' variable. For this evaluation, the analysis database served as a centralized tracking system for each customer's billing history, program participation, and sampling status, which helped to reduce data problems such as account mis-match, double counting, or repeated customer contacts.

2. *Key Data Elements and Sources*

A complete list of data elements and their sources can be found in *Section 3.1*. The key analysis data elements and their sources are listed below:

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

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

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

Telephone Survey Data. Two telephone survey samples (48 participants and 51 comparison group customers) were collected as part of this evaluation. They were designed to be representative of the population of each jurisdiction type. The telephone survey supplies information on customer decision-making, equipment operating characteristics, and energy-related changes at each site for the billing period covered by the statistical billing analysis.

Duty Cycle Data. The duty cycle data collected from the Power Saving Partners (PSP) evaluation of traffic signal logger results provided operating information for Traffic Signal measures.

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

Other data elements include PG&E program marketing data, 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, and telephone survey 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 ensure that all energy usage data used in analysis and all telephone survey data collected was of high quality and would prove useful in later analysis. The stages of data validation undertaken and the methods employed are detailed below:

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

Survey Data Collection. Survey data collection was performed by QC's Analysts. Utilizing qualified Analysts allowed for more in-depth interviews and the ability to prompt the contact for more details as deemed necessary. The accuracy of survey responses was greatly increased.

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

5. *Unused Data Elements*

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

C. *SAMPLING*

1. *Sampling Procedures and Protocols*

Program participants who were paid a rebate in 1998 were in most part carryover applicants. Their projects were initiated prior to 1997 but they only applied or received a rebate in 1998 when their projects reached the final implementation stage. There were a total of 54 Traffic Signal sites, 46 from city and 8 from county jurisdictions, that received a rebate from PG&E in 1998. A complete census of the population was needed to meet the Protocol requirements of the telephone survey.

The primary objective of the nonparticipant telephone sample is to provide a control group for the net and gross billing analyses. The final comparison group sample frame consists of 131municipal customers, 106 from city and 25 from county jurisdictions. From this limited sample frame, a census of the nonparticipant population was also performed. The following screening rules were also used:

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

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

Finally, the achieved samples and their distributions can be found in *Section 3.1*. 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 *Attachment* 5.

3. *Statistical Descriptions*

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 regression analysis is presented in *Section* 3.3. The statistical billing model described in this section incorporates analysis for the Traffic Signal Program. Specific procedures and modeling issues are discussed below.

1. *Outliers and Missing Data*

Section 3.3 of the report discuses in detail all of the data screening processes that were implemented.

Note that out of 1,690 nonparticipant intersections, 235 were deleted, whereas only 124 out of 2,078 participant intersections were deleted. This is due to the fact that both the nonparticipants and participants were surveyed using a census. This eliminated the opportunity to pre-screenfor relatively valid billing data prior to being selected into the survey sample frame.

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 3.3* 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*

All relevant regression statistics are presented in *Section 3.3*.

5. *Model Specification*

The model specifications are presented in *Section 3.3*. Specific model specification issues are further discussed 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 the 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.

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.

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, 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, as well as using only experienced analysts to conduct the survey.

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.

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:

---

[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.

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

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

- Finally, the relative precision net demand impacts were calculated using a scaled version of the relative precision for the net energy impact. The sample sizes of the on-site logger data collected as part of the PSP evaluation, 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.

E. DATA INTERPRETATION AND APPLICATION

The program net-to-gross analysis was conducted based 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. 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. These results yielded the lowest estimates of net participation, and were used in all circumstances.

Attachment 5

Survey Instruments

1. This is &INTERVIEWER_. I'm with Quantum Consulting, a management consulting firm based in Berkeley, California. We're assisting PG&E in evaluating its Retrofit Efficiency Options program. We'd like to ask questions about your city's participation in the program. Are you the best person to answer questions about the traffic signals in &CITY?

READ ONLY WHEN PROMPTED:

WHY ARE YOU DOING A SURVEY?

Quantum consulting is helping PG&E improve its energy efficiency programs to make them more attractive. We'd like to ask you a few questions about your city's traffic signal equipment. This is a fact-finding survey – We are not interested in selling you anything.

WHO ARE YOU TRYING TO REACH?

We'd like to speak with the head traffic engineer or the person most knowledgeable about recent changes to traffic signal equipment in &servcity_.

1	Person answering phone is best contact	**2**
2	Transferred to Technical Contact	
3	Given Technical Contact name and phone	*ENTER NAME AND PHONE*

2. The survey will take between 10 and 15 minutes.

1	Yes	**4**
2	Set Call Back Time	*ENTER CALL-BACK TIME*
88	Refused	*THANK & TERM*

4. Do you recall having LED traffic signals installed in &SERVCITY and receiving a rebate as part of PG&Es Retrofit Program?

1	Yes	**5**
2	No	*Thank & Terminate*
88	Refused	
99	Don't Know	

5. I'd like to confirm some information in PG&E's program database. Our records show that &SERVCITY_ had the following equipment installed through PG&E's Retrofit Program.

12" Red Balls ______ Quantity1 ____________

12" Red Arrows Quantity2 ____________

8" Red Balls ______ Quantity3 ____________

Don't Walk Signs ______ Quantity4 ____________

Can you confirm these technologies?

1	Yes	**6**
2	No	
88	Refused	
99	Don't Know	

6. ***DO NOT READ***

If respondent's descriptions are **radically** different than our descriptions, thank and terminate, otherwise, continue…

1	Continue	**7**
2	Radically Different	*Thank & Terminate*

7. What year and month was the installation of your new LED traffic signal equipment completed?

[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	1992	**8**
2	1993	
3	1995	
4	1996	
5	1997	
6	1998	
7	1999	
88	Refused	**9**
99	Don't know	

8.

[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	January	**9**
2	February	
3	March	
4	April	
5	May	
6	June	
7	July	
8	August	
9	September	
10	October	
11	November	
12	December	
13	All Year	
88	Refused	
99	Don't know	

9. What year and month did the installation of your new LED traffic signal equipment **begin**?

[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	1992	**10.**
2	1993	
3	1995	
4	1996	
5	1997	
6	1998	
7	1999	
88	Refused	**11**
99	Don't know	

10.

[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	January	**12**
2	February	
3	March	
4	April	
5	May	
6	June	
7	July	
8	August	
9	September	
10	October	
11	November	
12	December	
13	All Year	
88	Refused	
99	Don't know	

[ASK IF INSTALLED 8" RED BALLS, ELSE SKIP TO 15]

12. What was the wattage of the incandescent 8" red balls that were REMOVED and replaced with LED lights?

(Standard is 127 (CHK) watts)

	Enter Wattage	**13.**
8	Refused	
9	Don't Know	

13. What was the wattage of the LED 8" red balls that were INSTALLED?

(Standard 8" balls include 8, 10, 12,15 watt)

	Wattage	**15**
8	Refused	**14**
9	Don't Know	

14. Do you know what manufacturer you purchased the LED 8" red balls from?

	Manufacturer Name	
8	Refused	
9	Don't Know	**15**

[ASK IF INSTALLED 12" RED BALLS, ELSE SKIP TO 18]

15. What was the wattage of the incandescent 12" red balls that were REMOVED and replaced with LED lights?

(Standard is 150 Watts.)

	Wattage	**16**
8	Refused	
9	Don't Know	

16. What was the wattage of the LED 12" red balls that were INSTALLED?
(Standard 12" balls include 8, 9, 10 and 13 watt)

	Wattage	**18**
8	Refused	**17**
9	Don't Know	

17. Do you know what manufacturer you purchased the LED 12" red balls from?

	Manufacturer Name	
8	Refused	
9	Don't Know	**18**

[ASK IF INSTALLED RED ARROWS, ELSE SKIP TO 21]

18. What was the wattage of the incandescent red arrows that were REMOVED and replaced with LED lights? **(Standard is 150)**

	Wattage	**19**
8	Refused	
9	Don't Know	

19. What was the wattage of the LED red arrows that were INSTALLED?

(Standards for 12" red arrow: 8, 9, 10, and 13 watt)

	Wattage	**21**
8	Refused	**20**
9	Don't Know	

20. Do you know what manufacturer you purchased the LED red arrows from?

	Manufacturer Name	**21**
8	Refused	
9	Don't Know	

[ASK IF INSTALLED PED XING, ELSE SKIP TO 23]

21. What was the wattage of the incandescent Don't Walk signs that were removed and replaced with LED lights? **(Standard is 67 Watts)**

	Wattage	**22**
8	Refused	
9	Don't Know	

22. What was the wattage of the LED Don't Walk signs that were INSTALLED? **(Standard includes 7, 8, 10, and 12)**

	Wattage	**24**
8	Refused	**23**
9	Don't Know	

23. Do you know what manufacturer you purchased the LED don't walk signs from?

	Manufacturer Name	**24**
8	Refused	
9	Don't Know	

[ASK ALL]

24. How many signaled intersections are there in your service area?

[IF DK, ASK FOR BEST GUESS.]

	Enter value	**24a**
8	Refused	
9	Don't Know	

[ASK ALL]

24a. Please estimate what PERCENTAGE of all intersections in your service area were affected by the retrofit?

	Percentage	**24b**
8	Refused	
9	Don't Know	

24b. Have you done any studies to determine the duty cycles for your traffic signal equipment? In other words, have you done studies to determine what percent of the time is an average signal is lit?

1	Yes	**25**
2	No	**28**
8	Refused	
9	Don't Know	

25. During the day, what is the duty cycle for the red traffic signal balls? In other words, during the day what percent of the time is an average red ball lit?

	Percentage	**26**
8	Refused	
9	Don't Know	

26. During the day, what is the duty cycle for the red signal arrows? In other words, during the day what percent of the time is an average red arrow lit?

	Percentage	**27**
8	Refused	
9	Don't Know	

27. During the day, what is the duty cycle for the lighted Don't Walk Signs? In other words, during the day what percent of the time is a Don't Walk Sign lit?

	Percentage	**28**
8	Refused	
9	Don't Know	

28. Which of the following statements best describes the actions your city would have undertaken had the LED traffic signal program NOT existed…

[READ RESPONSES]

1	We would not have changed our traffic signals to LED	**35**
2	We would have installed LED traffic signals anyway, but fewer of them	**29**
3	We would have installed the same number of LED traffic signals in the absence of the program	**31**
8	Refused	**33**
9	Don't Know	

29. What percent of the LED signals that were installed through the program would you have installed in the absence of the program?

	Percent that would have been installed in the absence of the program	**31**
88	Refused	**30**
99	Don't Know	

30. Can you say that it would be…

1	Less than 25%	**31**
2	Between 25% and 50%	
3	Between 50% and 75%	
4	Between 75% and 100%	
8	Refused	
9	Don't Know	

31. Which of the following statements best describes your city's plans to install LED traffic signals had the program NOT existed...

1	We would have installed LED traffic signals at the same time we did it through the program	**35**
2	We would have installed LED traffic signals within the year	
3	We would have installed LED traffic signals, but not within the year	**32**
4	We would have installed LED traffic signals over the course of several years	**32a**
5	We wouldn't have installed LED traffic signals at all	**33**
8	Refused	
9	Don't Know	

32. How many years would you have waited before installing LED signals if the program had not existed?

	Number of Years	**35**
88	Refused	
99	Don't Know	

32a. How many years would it have taken to complete the project?

	Number of Years	**35**
88	Refused	
99	Don't Know	

33. Before you knew about the Program, which of the following statements best describes your city's plans to install LED traffic signals?

[READ RESPONSES]

1	You hadn't even considered installing LED traffic signals	**35**
2	You were interested in installing LED traffic signals, but had no firm plans to install them	**34**
3	You had already decided to install LED signals, but probably not within the year.	**35**
4	You had already decided to install LED traffic signals within the year.	
8	Refused	**34**
9	Don't Know	

34. If you had not installed LED signals under the program, how long would you have waited to install them?

1	Install at same time	**35**
2	Install within the year	
3	Install after more than one year	
4	Not install at all	
8	Refused	
9	Don't Know	

[ASK ALL]

35. Did the Retrofit Program **rebate** at all influence your decision to retrofit traffic signals with LED fixtures?

1	No Influence at all	**36**
2	Slightly Influential	
3	Moderately Influential	
4	Very Influential	
8	Refused	
9	Don't Know	

36. Independent of the rebate, did the fact that PG&E was backing LED traffic signal technology at all influence your decision to retrofit traffic signals?

1	No Influence at all	37
2	Slightly Influential	
3	Moderately Influential	
4	Very Influential	
8	Refused	
9	Don't Know	

37. Prior to participating in the program, what was the primary reason your city had not retrofitted traffic signals with LED lights?

[DO NOT READ]

1	Lack of available funds	38
2	Lack of confidence in the LED traffic signal technology	
3	Waiting for state approval	
4	Lack of support from City Council or other governing Board	
5	Other (SPECIFY)	
8	Refused	39
9	Don't Know	

38. Did the Retrofit Program help you overcome this barrier? Would you say…

1	Yes, very much	39
2	Helped somewhat	
3	No, not at all	
88	Refused	
99	Don't Know	

39. Were you required to get approval from the City Council or other governing Board in order to perform the traffic signal retrofits?

1	Yes	**40**
2	No	**44**
8	Refused	
9	Don't Know	

40. Do you feel the program rebate at all influenced the City Council (or other Board) to approve the project?

1	No Influence at all	**41**
2	Slightly Influential	
3	Moderately Influential	
4	Very Influential	
88	Refused	
99	Don't Know	

41. Independent of the rebate, do you feel that PG&E's backing of LED traffic signal technology at all influenced the City Council (or other Board) to approve the project?

1	No Influence at all	**42**
2	Slightly Influential	
3	Moderately Influential	
4	Very Influential	
88	Refused	
99	Don't Know	

42. If the program did not exist, what is the likelihood the City Council or other governing Board would have approved the project?

1	No chance they would have approved	44
2	Maybe, with some convincing	
3	Probably would have approved anyway	
4	Definitely would have approved anyway	
88	Refused	
99	Don't Know	

[ASK ALL]

44. Since January 1997, have you installed any LED signals, other than those installed under the program?

1	Yes	45
2	No	60
8	Refused	
9	Don't Know	

45. Were these installed as part of new traffic signals, or retrofits of existing signals?

1	New signals	47
2	Retrofits	
3	Both	46
88	Refused	47
99	Don't Know	

46. Of all the LED installations performed outside the program, what percent were retrofits of existing signals (versus new signals)?

	Percent	47
8	Refused	
9	Don't Know	

47. Did these installations include Red LEDs?...Yellow LEDs?...Green LEDs?
[CIRCLE ALL THAT APPLY]

1	Installed Red LEDs	**48**
2	Installed Yellow LEDs	
3	Installed Green LEDs	
88	Refused	**49**
99	Don't Know	

48. Which of the following LED components did you install?

48a. How many &COMPONENT did you install?

[IF DK, ASK FOR BEST GUESS]

		ENTER NUMBER	
1	8" Red Balls		**49**
2	12" Red Balls		
3	Red arrows		**48b**
4	Red Pedestrian Crossing		**49**
5	8" Green Balls		
6	12" Green Balls		
7	Green Arrows		
8	Green Pedestrian Crossing		
9	8" Yellow Balls		
10	12" Yellow Balls		
11	Yellow Arrows		
88	Refused		
99	Don't Know		

48b. Were these red arrows 8 inch or 12 inch?

1	8 inch arrows only	**49**
2	12 inch arrows only	**49**
3	Both, 8 inch and 12 inch arrows	**48c**
88	Refused	**49**
99	Don't Know	

48c. Please estimate what percent of the red arrows installed were 12 inch?

	Percent that were 12 inch	**49**
88	Refused	
99	Don't Know	

49. How many intersections were effected by these LED signal installations, **[IF DK, ASK FOR BEST GUESS]**

[IF NECESSARY]
We are still talking about LED traffic light installations made since January 1997, other than those made through the program.

	Number of Intersections effected	**52**
88	Refused	**50**
99	Don't Know	

50. Approximately what percent of the intersections in your service area were effected by these changes?

	Percent of Intersections effected	**52**
88	Refused	**51**
99	Don't Know	

51. Approximately what percent of the heads in your service area were effected by these changes?

	Percent of Heads effected	**52**
88	Refused	
99	Don't Know	

52. What year were these LED traffic light installations completed?
[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	1992	53
2	1993	
3	1995	
4	1996	
5	1997	
6	1998	
7	1999	
88	Refused	54
99	Don't know	

53. What month were these installations completed?
[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	January	54
2	February	
3	March	
4	April	
5	May	
6	June	
7	July	
8	August	
9	September	
10	October	
11	November	
12	December	
13	All Year	
88	Refused	
99	Don't know	

54. In what year and month did the installation of these LED traffic signals **begin**?

[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	1992	**55**
2	1993	
3	1995	
4	1996	
5	1997	
6	1998	
7	1999	
88	Refused	**56**
99	Don't know	

55.

[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	January	**56**
2	February	
3	March	
4	April	
5	May	
6	June	
7	July	
8	August	
9	September	
10	October	
11	November	
12	December	
13	All Year	
88	Refused	
99	Don't know	

56. Were these changes made after you participated in the Retrofit Program?

1	Yes	**58**
2	No	**57**
88	Refused	
99	Don't Know	

57. Did you become aware of the Retrofit Program BEFORE or AFTER you made the decision to install these LED traffic signals outside the program?

1	Before	58
2	After	
3	At the same time	
88	Refused	
99	Don't Know	

58. Was your city paid a rebate by PG&E for these changes in your traffic signals?

1	Yes	59
2	No	
88	Refused	
99	Don't Know	

59. Was the Retrofit Program at all influential in your decision to install LED traffic signals?

1	Not at all influential	60
2	Slightly influential	
3	Moderately influential	
4	Very influential	
88	Refused	
99	Don't Know	

[ASK ALL]

60. Besides the changes we've already discussed, since January 1, 1997, have any **other changes** occurred that would **increase** any intersection's energy consumption by 10% or more? For example, the addition of traffic signals, lit street signs, flashing yellow lights, or programming changes?

1	Yes	61
2	No	63
88	Refused	
99	Don't Know	

61. How many intersections were effected by these changes?
[IF DK, ASK FOR BEST GUESS]

	Number of Intersections	**63**
88	Refused	**62**
99	Don't Know	

62. About what percent of the intersections in your service area were effected by these change?

	Percent	**63**
88	Refused	
99	Don't Know	

[ASK ALL]

63. Besides the changes we have already discussed, since January 1, 1997, have any **other changes** occurred that would **decrease** any intersection's energy consumption by 10% or more? For example, the removal of traffic signals, low wattage lamp retrofits, or programming changes.

1	Yes	**64**
2	No	**66**
88	Refused	
99	Don't Know	

64. How many intersections were effected by this change?
[IF DK, ASK FOR BEST GUESS]

	Number of Intersections	**66**
88	Refused	**65**
99	Don't Know	

65. About what percent of the intersections in your service area were effected by these change?

	Percent	**66**
88	Refused	
99	Don't Know	

[ASK IF OUTSIDE PROGRAM CHANGES OCCURRED]

66. You mentioned that you have made some changes to your intersections, other than those completed through the LED traffic signal program. We are very interested in identifying the exact intersections at which these changes occurred. We would like to fax or e-mail you a list of all the intersections in your service territory and have you indicate which one had these changes. If you would be willing to fill this out for us, we will reimburse you $20 for your time.

I can send you the form by fax or by email, which do you prefer?

May I please have your fax number/email address?

		Fax number/email address
1	Yes, fax me form	
2	Yes, e-mail me form	
3	No, I refuse to complete the form	

GOODBYE.

Those are all the questions I have for you today. On behalf of Pacific Gas and Electric, thank you very much for your time and cooperation.

1. This is &INTERVIEWER_. I'm with Quantum Consulting, a management consulting firm based in Berkeley, California. We're assisting PG&E in evaluating its traffic signal program. Are you the best person to answer questions about the traffic signals in &CITY?

READ ONLY WHEN PROMPTED:

WHY ARE YOU DOING A SURVEY?

Quantum consulting is helping PG&E improve its energy efficiency programs to make them more attractive. We'd like to ask you a few questions about your city's traffic signal equipment. This is a fact-finding survey – We are not interested in selling you anything.

WHO ARE YOU TRYING TO REACH?

We'd like to speak with the head traffic engineer or the person most knowledgeable about recent changes to traffic signal equipment in &servcity_.

1	Person answering phone is best contact	**2**
2	Transferred to Technical Contact	
3	Given Technical Contact name and phone	*ENTER NAME AND PHONE*

2. The survey will take between 10 and 15 minutes.

1	Yes	**4**
2	Set Call Back Time	*ENTER CALL-BACK TIME*
88	Refused	*THANK & TERM*

4. Our records indicate that you did not participate in PG&E's Retrofit Efficiency Options program in 1998. Is this correct?

1	Yes	**5**
2	No	*Thank & Terminate*
88	Refused	
99	Don't Know	

23. How many signaled intersections are there in your service area?

[IF DK, ASK FOR BEST GUESS.]

	Enter value	**24b**
8	Refused	
9	Don't Know	

24b. Have you done any studies to determine the duty cycles for your traffic signal equipment? In other words, have you done studies to determine what percent of the time an average signal is lit?

1	Yes	**25**
2	No	**ls005**
8	Refused	
9	Don't Know	

25. During the day, what is the duty cycle for the red traffic signal balls? In other words, during the day what percent of the time is an average red ball lit?

	Percentage	**26**
8	Refused	
9	Don't Know	

26. During the day, what is the duty cycle for the red signal arrows? In other words, during the day what percent of the time is an average red arrow lit?

	Percentage	**27**
8	Refused	
9	Don't Know	

27. During the day, what is the duty cycle for the lighted Don't Walk Signs? In other words, during the day what percent of the time is a Don't Walk Sign lit?

	Percentage	**IS005**
8	Refused	
9	Don't Know	

IS005. Have you heard of PG&E's Retrofit Efficiency Options programs?

1	Yes	**Is051**
2	No	**44**
8	Refused	
9	Don't Know	

IS051. Are you aware that LED traffic signal lights were covered by the Retrofit Program?

1	Yes	**44**
2	No	
8	Refused	
9	Don't Know	

44. Since January 1997, have you installed any LED traffic signal lights that were not rebated through a PG&E program?

1	Yes	**45**
2	No	**60**
8	Refused	
9	Don't Know	

45. Were these installed as part of new traffic signals, or retrofits of existing signals?

1	New signals	**47**
2	Retrofits	
3	Both	**46**
88	Refused	**47**
99	Don't Know	

46. What percent of the LED installations were retrofits of existing signals (versus new signals)?

	Percent	**47**
8	Refused	
9	Don't Know	

47. Did these installations include Red LEDs?...Yellow LEDs?...Green LEDs? **[CIRCLE ALL THAT APPLY]**

1	Installed Red LEDs	**48**
2	Installed Yellow LEDs	
3	Installed Green LEDs	
88	Refused	**49**
99	Don't Know	

48. Which of the following LED components did you install?

48a. How many &COMPONENT did you install?

[IF DK, ASK FOR BEST GUESS]

<table>
<tr><th></th><th></th><th>ENTER NUMBER</th><th></th></tr>
<tr><td>1</td><td>8" Red Balls</td><td></td><td rowspan="2">49</td></tr>
<tr><td>2</td><td>12" Red Balls</td><td></td></tr>
<tr><td>3</td><td>Red arrows</td><td></td><td>48b</td></tr>
<tr><td>4</td><td>Red Pedestrian Crossing</td><td></td><td rowspan="10">49</td></tr>
<tr><td>5</td><td>8" Green Balls</td><td></td></tr>
<tr><td>6</td><td>12" Green Balls</td><td></td></tr>
<tr><td>7</td><td>Green Arrows</td><td></td></tr>
<tr><td>8</td><td>Green Pedestrian Crossing</td><td></td></tr>
<tr><td>9</td><td>8" Yellow Balls</td><td></td></tr>
<tr><td>10</td><td>12" Yellow Balls</td><td></td></tr>
<tr><td>11</td><td>Yellow Arrows</td><td></td></tr>
<tr><td>88</td><td>Refused</td><td></td></tr>
<tr><td>99</td><td>Don't Know</td><td></td></tr>
</table>

48b. Were the red arrows 8 inch or 12 inch?

1	8 inch arrows only	**49**
2	12 inch arrows only	**49**
3	Both, 8 inch and 12 inch arrows	**48c**
88	Refused	**49**
99	Don't Know	

48c. Please estimate what percent of the red arrows installed were 12 inch?

	Percent that were 12 inch	**49**
88	Refused	
99	Don't Know	

49. How many intersections were effected by these LED traffic light installations, **[IF DK, ASK FOR BEST GUESS]**

[IF NECESSARY]

	Number of Intersections effected	**52**
88	Refused	**50**
99	Don't Know	

50. Approximately what percent of the intersections in your service area were effected by these changes?

	Percent of Intersections effected	**52**
88	Refused	**51**
99	Don't Know	

51. Approximately what percent of the heads in your service area were effected by these changes?

	Percent of Heads effected	**52**
88	Refused	
99	Don't Know	

52. What year and month were these LED traffic light installations completed?
[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	1992	**53**
2	1993	
3	1995	
4	1996	
5	1997	
6	1998	
7	1999	
88	Refused	**54**
99	Don't know	

53.

[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	January	**54**
2	February	
3	March	
4	April	
5	May	
6	June	
7	July	
8	August	
9	September	
10	October	
11	November	
12	December	
13	All Year	
88	Refused	
99	Don't know	

54. In what year and month did the installation of these LED traffic signal lights **begin**?

[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	1992	**55**
2	1993	
3	1995	
4	1996	
5	1997	
6	1998	
7	1999	
88	Refused	**57**
99	Don't know	

55.

[IF DON'T KNOW, ASK FOR BEST GUESS.]

1	January	**57**
2	February	
3	March	
4	April	
5	May	
6	June	
7	July	
8	August	
9	September	
10	October	
11	November	
12	December	
13	All Year	
88	Refused	
99	Don't know	

[Ask if is005=1 and is051=1]

57. Did you become aware of the Retrofit Program BEFORE or AFTER you made the decision to install these LED traffic lights?

1	Before	**58**
2	After	
3	At the same time	
88	Refused	
99	Don't Know	

58. Was your city paid a rebate by PG&E for these changes in your traffic signals?

1	Yes	**59**
2	No	
88	Refused	
99	Don't Know	

59. Was the Retrofit Program at all influential in your decision to install LED traffic signal lights?

1	Not at all influential	**60**
2	Slightly influential	
3	Moderately influential	
4	Very influential	
88	Refused	
99	Don't Know	

[ASK ALL]

60. [Besides the changes we've already discussed,] since January 1, 1997, have any **[other changes]** occurred that would **increase** any intersection's energy consumption by 10% or more? For example, the addition of traffic signals, lit street signs, flashing yellow lights, or programming changes?

1	Yes	**61**
2	No	**63**
88	Refused	
99	Don't Know	

61. How many intersections were effected by these changes?
[IF DK, ASK FOR BEST GUESS]

	Number of Intersections	**63**
88	Refused	**62**
99	Don't Know	

62. About what percent of the intersections in your service area were effected by these changes?

	Percent	**63**
88	Refused	
99	Don't Know	

[ASK ALL]

63. [Besides the changes we have already discussed,] since January 1, 1997, have any **[other] changes** occurred that would **decrease** any intersection's energy consumption by 10% or more? For example, the removal of traffic signals, low wattage lamp retrofits, or programming changes.

1	Yes	**64**
2	No	**66**
88	Refused	
99	Don't Know	

64. How many intersections were effected by this change?
[IF DK, ASK FOR BEST GUESS]

	Number of Intersections	**66**
88	Refused	**65**
99	Don't Know	

65. About what percent of the intersections in your service area were effected by these change?

	Percent	**66**
88	Refused	
99	Don't Know	

[ASK IF CHANGES OCCURRED]

66. You mentioned that you have made some changes to your intersections. We are very interested in identifying the exact intersections at which these changes occurred. We would like to fax or e-mail you a list of all the intersections in your service territory and have you indicate which one had these changes. If you would be willing to fill this out for us, we will reimburse you $20 for your time.

I can send you the form by fax or by email, which do you prefer?

May I please have your fax number/email address?

		Fax number/email address
1	Yes, fax me form	
2	Yes, e-mail me form	
3	No, I refuse to complete the form	

GOODBYE.

Those are all the questions I have for you today. On behalf of Pacific Gas and Electric, thank you very much for your time and cooperation.