Customer Energy Efficiency Program
Measurement and Evaluation Program

EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1995 NONRESIDENTIAL ENERGY EFFICIENCY INCENTIVES PROGRAM FOR COMMERCIAL SECTOR HVAC TECHNOLOGIES

PG&E Study ID number: 326

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FINAL REPORT

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1. EXECUTIVE SUMMARY

This section presents a summary of the impact results for the commercial Heating, Ventilating and Air-Conditioning (HVAC) technologies offered under the Pacific Gas & Electric Company's (PG&E's) 1995 Nonresidential Energy Efficiency Incentives (EEI) Programs. This evaluation covers HVAC technologies retrofits that were performed at PG&E customer facilities, for all rebates paid in 1995. These retrofits were performed under three different PG&E programs, the Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customized Incentives Programs. The results are presented in three sections: evaluation results summary (covering the numerical results of the study), major findings, and major recommendations.

1.1 EVALUATION SUMMARY

The evaluation results are summarized in terms of energy savings (kWh), demand savings (kW), therms impacts, and realization rates, the ratio of the evaluation results (ex post) to the program design estimates (ex ante). These results are presented on a gross and net basis (i.e., before and after accounting for customer actions outside the program). Exhibit 1-1 presents the gross energy, demand, and therm savings results, together with the gross realization rates.

Exhibit 1-1
Summary of Gross Evaluation Results
Commercial HVAC Applications

	Gross Impacts								
	Energy			Demand			Therm		
Program and Technology Group	Ex Ante (kWh)	Ex Post (kWh)	Realization Rate	Ex Ante (kW)	Ex Post (kW)	Realization Rate	Ex Ante (Therm)	Ex Post (Therm)	Realization Rate
Retrofit Express	14,033,280	18,745,534	1.34	3,178	2,088	0.66	0	0	NA
Retrofit Efficiency Options	6,688,386	4,934,528	0.74	1,581	758	0.48	0	0	NA
Customized Incentives	31,168,215	27,196,121	0.87	2,417	1,292	0.53	2,057,723	2,056,662	1.00
Total	51,889,884	50,876,182	0.98	7,176	4,138	0.58	2,057,723	2,056,662	1.00

The ex ante numbers presented above in Exhibit 1-1 and below in Exhibits 1-2, 1-3 and 1-4 were obtained from PG&E's Management Decision Support System (MDSS), PG&E's 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 in 1995 and 1996, revised in December 1996.

These results illustrate the following key points about the gross commercial HVAC impacts:

More than half of program energy savings and all of the program therm savings are from HVAC technologies installed through the Customized Incentives Program. The RE program accounted for the largest share of demand impacts, however. This apparent disproportionate distribution of energy and demand impacts between the two programs is a direct result of the measures offered and the associated operation of these measures. For example, Energy Management Systems (EMS), offered through the Customized program have tremendous energy impacts, but virtually all off peak.

Overall ex post gross impacts were only slightly lower than the ex ante gross estimates for energy and therms, but were more than 40 percent lower for demand. This is primarily the result of adjustments to operating conditions for measures that were assumed in the ex ante analysis to have large peak period demand impacts.

Of the programs and impacts evaluated, only energy impacts for the RE program were found to be substantially greater than assumed ex ante. Higher-than-predicted savings observed in the statistical analysis of billing data for variable speed drive (VSD) HVAC fan motors were largely responsible for this high realization rate. Savings estimates for this measure were based on DOE-2.1E Models calibrated to end-use metered data collected for installed measures. Coupled with the knowledge that the impacts were based on calibrated models, the high realization rate indicates that the additional savings is most likely due to assumptions of the existing case, mainly the size of the existing fan. In Section 5 a recommendation is made to explore this with future evaluation activities.

Evaluation of therm impacts was limited to the Customized Incentives Program; for these measures, gross therm impacts very closely matched the ex ante estimates.

Exhibits 1-2, 1-3, and 1-4 present the net energy, demand, and therm impact results, together with the net realization rates, at the same levels presented in Exhibit 1-1. These results reflect the gross realization rates as well as the ex ante and ex post net-to-gross (NTG) ratios for HVAC measures in the RE, REO, and Customized Incentives programs. While the NTG adjustments apply equally to energy and demand impacts, their overall effect depends on the relative contribution of impact of the measures to which they are applied.

Exhibit 1-2
Summary of Net Evaluation Energy Results
Commercial HVAC Applications

Technology Group	Gross (kWh)	Net-to-Gross Adjustments: Free Ridership (1-FR)	Net-to-Gross Adjustments: Spillover	Net-to-Gross Adjustments: NTG Ratio (Unitless)	Net (kWh)
		EX ANTE			
Retrofit Express	14,033,280	0.57	0.10	0.67	9,402,355
Retrofit Efficiency Options	6,688,386	0.57	0.10	0.67	4,481,217
Customized Incentives	31,168,215	0.65	0.10	0.75	23,376,167
Total	51,889,884	0.62	0.10	0.72	37,259,739
		EX POST			
Retrofit Express	18,745,534	0.85	0.00	0.85	15,986,522
Retrofit Efficiency Options	4,934,528	0.80	0.00	0.80	3,970,487
Customized Incentives	27,196,121	0.85	0.00	0.85	23,225,487
Total	50,876,182	0.85	0.00	0.85	43,182,496
		REALIZATION RATES (Ex Post/Ex Ante)			
Retrofit Express	1.34	NA	NA	NA	1.70
Retrofit Efficiency Options	0.74	NA	NA	NA	0.89
Customized Incentives	0.87	NA	NA	NA	0.99
Total	0.98	NA	NA	NA	1.16

For energy, the ex post net impacts exceed the ex ante design estimates by 16 percent. The following points apply:

- The ex ante NTG ratio was 0.67 for the RE and REO programs and 0.75 for the Customized Incentives Program.
- The ex post NTG ratio—for both the RE and Customized Incentives programs as well as for all HVAC measures—averaged 0.85, which is larger than the corresponding ex ante value of 0.72. For the RE program, which also had high ex post energy impacts, this led to a net realization rate of almost 1.7. As previously discussed, this was driven by the high impacts associated with the VSD measures.
- While both the REO and the Customized Incentives measures had net realization rates of less than 1.0, the high gross and net realization rates for the RE program led to higher-than-anticipated program-wide net impacts.

Exhibit 1-3
Summary of Net Evaluation Demand Results
Commercial HVAC Applications

Technology Group	Gross (kW)	Net-to-Gross Adjustments			Net (kW)
		Free Ridership (1-FR)	Spillover	NTG Ratio (Unitless)	
		EX ANTE			
Retrofit Express	3,178	0.57	0.10	0.67	2,129
Retrofit Efficiency Options	1,581	0.57	0.10	0.67	1,059
Customized Incentives	2,417	0.65	0.10	0.75	1,813
Total	7,176	0.60	0.10	0.70	5,001
		EX POST			
Retrofit Express	2,088	0.81	0.00	0.81	1,700
Retrofit Efficiency Options	758	0.75	0.00	0.75	572
Customized Incentives	1,292	0.85	0.00	0.85	1,103
Total	4,138	0.82	0.00	0.82	3,376
		REALIZATION RATES (Ex Post/Ex Ante)			
Retrofit Express	0.66	NA	NA	NA	0.80
Retrofit Efficiency Options	0.48	NA	NA	NA	0.54
Customized Incentives	0.53	NA	NA	NA	0.61
Total	0.58	NA	NA	NA	0.68

For demand, the higher ex post NTG ratio across all programs is not sufficient to offset the low (0.58) gross realization rate. As noted previously, the evaluation results found that ex ante estimates overstated demand impacts for several HVAC measures, particularly those installed through the Customized Incentives Program.

Exhibit 1-4
Summary of Net Evaluation Therm Results
Commercial HVAC Applications

Program	Gross (therm)	Net-to-Gross Adjustments: Free Ridership (1-FR)	Spillover	NTG Ratio (Unitless)	Net (therm)
		EX ANTE			
Retrofit Express	0	NA	NA	NA	0
Retrofit Efficiency Options	0	NA	NA	NA	0
Customized Incentives	2,057,723	0.65	0.10	0.75	1,543,292
Total	2,057,723	0.65	0.10	0.75	1,543,292
		EX POST			
Retrofit Express	0	NA	NA	NA	0
Retrofit Efficiency Options	0	NA	NA	NA	0
Customized Incentives	2,056,662	0.85	0.00	0.85	1,756,389
Total	2,056,662	0.85	0.00	0.85	1,756,389
		REALIZATION RATES (Ex Post/Ex Ante)			
Retrofit Express	NA	NA	NA	NA	NA
Retrofit Efficiency Options	NA	NA	NA	NA	NA
Customized Incentives	1.00	NA	NA	NA	1.14
Total	1.00	NA	NA	NA	1.14

Since ex post gross therm impacts are almost exactly equal to the ex ante estimate, the net therm realization rate is due entirely to the difference between the ex post and ex ante NTG ratios for Customized Incentives measure.

Detailed presentation and discussion of the above findings can be found in *Section 4.*

1.2 MAJOR FINDINGS

Overall, PG&E's ex ante estimates for the commercial HVAC technologies paid under the 1995 programs understated energy impacts for RE measures, but overstated them for REO and Customized Incentives measures. A single HVAC measure—VSDs for HVAC fan motors—was found to account for most of the higher-than-expected energy impact for the RE program. In addition, both gross and net ex post demand impacts attributable to the installation of HVAC measures were substantially lower than predicted.

Because of the complexity of the application forms and the process for estimating net impacts for Customized Incentives measures, substantial differences were found between the ex ante and net gross impacts for a number of sites. While the more extreme variations tended to cancel each other out, the overall result was to lower ex post impacts.

1.3 MAJOR RECOMMENDATIONS

Recommendations that would enhance future program performance and evaluation are summarized below, and are presented in more detail in *Section 5.*

Energy Management Systems (EMS) are an effective means of reducing energy consumption, but require a knowledgeable operator to achieve those savings. EMSs used to monitor and control complicated HVAC plants require significant operator input, ideas, and operational decisions to achieve savings. EMSs cannot be expected to save energy without adequate system commissioning. PG&E should require commissioning for these systems (or other complicated measures) and offer incentives based on a performance contract. On-site investigations conducted as part of this evaluation effort have shown that performance contracts are an effective means of ensuring savings from installation of a particular system.

Application Engineering Review is a necessary component of the submittal process, and can be used to effectively screen applications that have significant analysis errors. In some instances, large errors were observed in the Customized Incentives applications submitted, resulting in inaccurate reporting of project impacts. Since applications submitted for the Customized Incentives Program (or other current programs like Nonresidential New Construction and Advanced Performance Options) can result in relatively large incentives (often based on impact achieved), it is recommended that a more intensive application review be used to capture these anomalies.

Analysis of Reasonableness of Savings should be another method used to assess errors in the application savings estimates. For example, the Customized Incentives application includes this type of comparison information within Attachment 7, where measure savings are compared against both the baseline quantity used and also against total billing records for the site. However, in some instances, these valuable data do not appear to be used in an effort to reject claimed savings.

Rebates Offered for Infrequently Operated Systems - Measures are sometimes installed that are either redundant systems (in case the primary system fails or requires repair), or are strictly peaking systems (coming on-line only on rare occasions). Due to the potentially low impacts for such retrofits, PG&E should consider rejecting rebates for equipment that meet these criteria.

Demand Impact information for VSD measures - Very large impacts were observed for the Variable Speed Drive measures installed under the program. For both the ex ante and engineering estimates, the assumption is made that at peak loads there is zero demand impact since the VSD is operating at 100 percent load. If the existing fans are oversized, there will indeed be a demand impact since the VSD will only operate the fan at the level required to meet space conditioning needs. This would also result in greater predicted energy savings since the VSD is operating below the curve it was calibrated to. Future evaluation activities should include the collection of frequency as well as demand data to better determine the peak level ofd VSD operation.

2. INTRODUCTION

This report summarizes the impact evaluation of Pacific Gas & Electric Company's (PG&E's) Nonresidential Energy Efficiency Incentives (EEI) Program for commercial sector HVAC technologies (the HVAC Evaluation). These technologies are covered by three separate program options: the Retrofit Express (RE), Retrofit Efficiency Options (REO), and the Customized Incentives Programs. The evaluation effort covers customers who were paid rebates under these programs in 1995. The programs are summarized below.

2.1 THE RETROFIT EXPRESS PROGRAM

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

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

- High-efficiency central air-conditioning units in various capacity ranges
- Variable speed drive HVAC fans
- High-efficiency package terminal air-conditioning units
- Programmable thermostats, bypass timers and electronic timeclocks
- Reflective window film
- Water chillers of various capacity ranges
- Direct evaporative cooler units, evaporative condensers and evaporative cooling towers

2.2 THE RETROFIT EFFICIENCY OPTIONS PROGRAM

The REO program included nine HVAC technologies, which can be summarized in the four bullets below:

- Variable frequency drive supply fans
- Installation of high efficiency water chillers
- Variable air volume supply systems, which replace constant air volume supply systems
- Evaporative cooling towers

The REO program targeted commercial, industrial, agricultural, and multifamily market segments most likely to benefit from these selected measures. Customers were required to submit calculations for the projected first-year energy savings along with their application prior to installation of the high efficiency equipment. PG&E representatives worked with customers to identify cost-effective improvements, with special emphasis on operational and maintenance measures at the customers' facilities. Marketing efforts were coordinated among PG&E Divisions, emphasizing local planning areas with high marginal electric costs to maximize program benefits.

2.3 THE CUSTOMIZED INCENTIVES PROGRAM

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

The following Customized Incentives technologies were analyzed as part of the evaluation:

- HVAC variable speed drive
- High efficiency chiller
- Energy management systems (EMS)
- Other miscellaneous Customized Incentives measures which included
  - Installation of various energy efficient motors
  - Installation of various HVAC controls
  - Various technologies (i.e., precoolers, economizers and pipe insulation) added to increase system efficiency

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

2.4 EVALUATION OVERVIEW

The impact evaluation described in this report covers all HVAC technologies installed at commercial accounts, as determined by the Management Decision Support System (MDSS) sector code, that were included under the RE, REO, and Customized Incentives programs and for which rebates were *paid* during calendar year 1995. As a result, the evaluation includes measures offered under PG&E programs filed in program years from 1992 through 1995.

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

2.4.1 Objectives

The objectives of the evaluation were originally stated in the Request for Proposals (RFP), refined during the project initiation meeting, and documented in the evaluation research plan. These research objectives are as follows:

- Determine first-year net energy, demand, and therm impacts by business type and technology group for RE, REO and Customized Incentives HVAC technologies paid in 1995, and overall impacts for the commercial sector as required by the California Public Utilities Commission (CPUC) protocols.
- Compare evaluation results 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.
- Provide recommendations to strengthen the RE and REO programs.
- Create an impact sample subset of participants for future retention monitoring as required by the CPUC protocols.
- Complete tables 6, 7, and 11 of the Protocols.

Results are segmented by technology and building type. Technologies are defined by measures offered by the RE, REO, and Customized Incentives programs. Building types for the commercial market sector, as defined by PG&E, are office, retail, college and university, schools, grocery, restaurant, health care, hotel/motel, warehouse, personal service, customer service, and miscellaneous.

The difference between gross and net impacts is the behavior that affected customers' participation. Adjustments were made to the gross estimate of savings for customers that would have installed energy-efficient measures anyway, despite the program (free-riders). Spillover rates, defined as energy-efficient measures installed outside the program (as a result of the presence of the program), were also estimated, but were not used to adjust the program impacts.

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

2.4.2 Timing

The 1995 Commercial HVAC Impact Evaluation began in December 1995, completed the planning stage in December 1996, executed data collection between mid-March and early November 1996, and completed the analysis and reporting phase in January 1997.

2.4.3 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.

2.5 REPORT LAYOUT

This report presents the results of the above evaluation. It is divided into five sections, plus appendices. *Sections 1 and 2* are the *Executive Summary* and the *Introduction*. *Section 3* presents the *Methodology* of the evaluation. It is supported in detail by *Appendices A* through *D*. *Section 4* presents detailed results and discussion and is supported by *Appendix E*. *Section 5* presents recommendations for improving the evaluation, the program measures, the program tracking system, and the CPUC Protocols. *Appendix F* provides impacts by Time-of-Use costing periods. The survey appendices provide the survey and on-site data collection instruments, and the survey call dispositions, frequencies, and refusal comments.

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

3. METHODOLOGY

In this section, the methods used to conduct the 1995 Pacific Gas & Electric Company (PG&E) Commercial HVAC Technologies Evaluation (the HVAC Evaluation) are presented. This section begins with an overview of the evaluation approach. This is followed by more detailed discussions of the specific engineering, billing regression, and net-to-gross (NTG) analysis approaches used in the evaluation. Additional detail on these three approaches is supplied in *Appendices B, C* and *D*, respectively.

3.1 INTEGRATED EVALUATION APPROACH

This overview of the integrated evaluation approach begins by presenting the data sources and the sample design approach used for the HVAC 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.

3.1.1 Data Sources

The HVAC Evaluation used data supplied by PG&E to develop a nested sample design plan for the collection of additional data required in each analysis.

Existing Data

All available data supplied by PG&E were used in the analysis of the HVAC program. Of particular importance were PG&E's historical billing data, program participant data (Management Decision Support System [MDSS]), paper copies of Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customized Incentives applications, other program-related data, and industry standards information. Each of the existing data sources is described briefly below.

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

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

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

PG&E 1995 Customer Energy Efficiency Programs Advice Filing[1] - This report documents the ex ante earnings claims, including specific information on the derivation of per-unit ex ante savings estimates and the assumptions that go into those estimates. This documentation often includes assumptions such as operating hours and operating factors, by fixture type. This document supplies the best information available on ex ante estimates and assumptions, thus facilitating knowledge-based comparisons to ex post estimates.

State and Industry Standards/Information - In order to establish baseline levels and new equipment performance levels, State and industry standards information from the California Energy Commission and organizations such as the American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) and American National Standards Institute (ANSI) was used, together with information from manufacturers. For all applicable measures, Title 24 standards were used to define baseline efficiencies.

Copies of RE, REO and Customized Incentives Paper Application Files - QC requested and received complete copies of application files for a random 50 RE participants and all REO and Customized Incentives participants. The RE files were used to verify the entries in the MDSS electronic files and to identify additional information that could be extracted from the file to improve the analysis. The REO applications provided additional information not found in the MDSS, predominantly on attached equipment invoices. Customized Incentives files associated with sites selected for On-Site surveys provided detailed information on how the application estimate was computed. These applications were assessed to determine what information needed to be collected or verified during the On-Site survey.

Nested Sample Plan Design

The impact analysis plan is based upon a nested sample design approach. In the integrated evaluation approach, a core HVAC end-use metered (EUM) sample is leveraged to a larger audit sample, which in turn, is leveraged to a less expensive telephone survey sample. The MDSS database program application information is then used to leverage results to the entire participant population. This approach, as shown in Exhibit 3-1, results in the efficient use of information contributing to the final impact results.[2]

HVAC EUM data (represented by the innermost circle in Exhibit 3-1) supply the most accurate source of data used to calibrate the engineering estimates. For variable speed drives, EUM data is the most important source of calibration information, due to a wide range of operating scenarios.

The on-site audit sample (represented by the band around the innermost circle in Exhibit 3-1) is designed to support the telephone sample for the largest participation segments. This sample contributes equipment details that are site-specific, and better estimates of operating hours, operating factors and other technical factors that are difficult to collect over the telephone. The on-site sample itself is not designed to be statistically representative, but rather to support the estimate of detailed engineering parameters collected within the segments with the highest projected impact.

A significantly larger telephone survey sample (represented in Exhibit 3-1 by the second band from the core circle), is designed to be representative of the participant population by technology and

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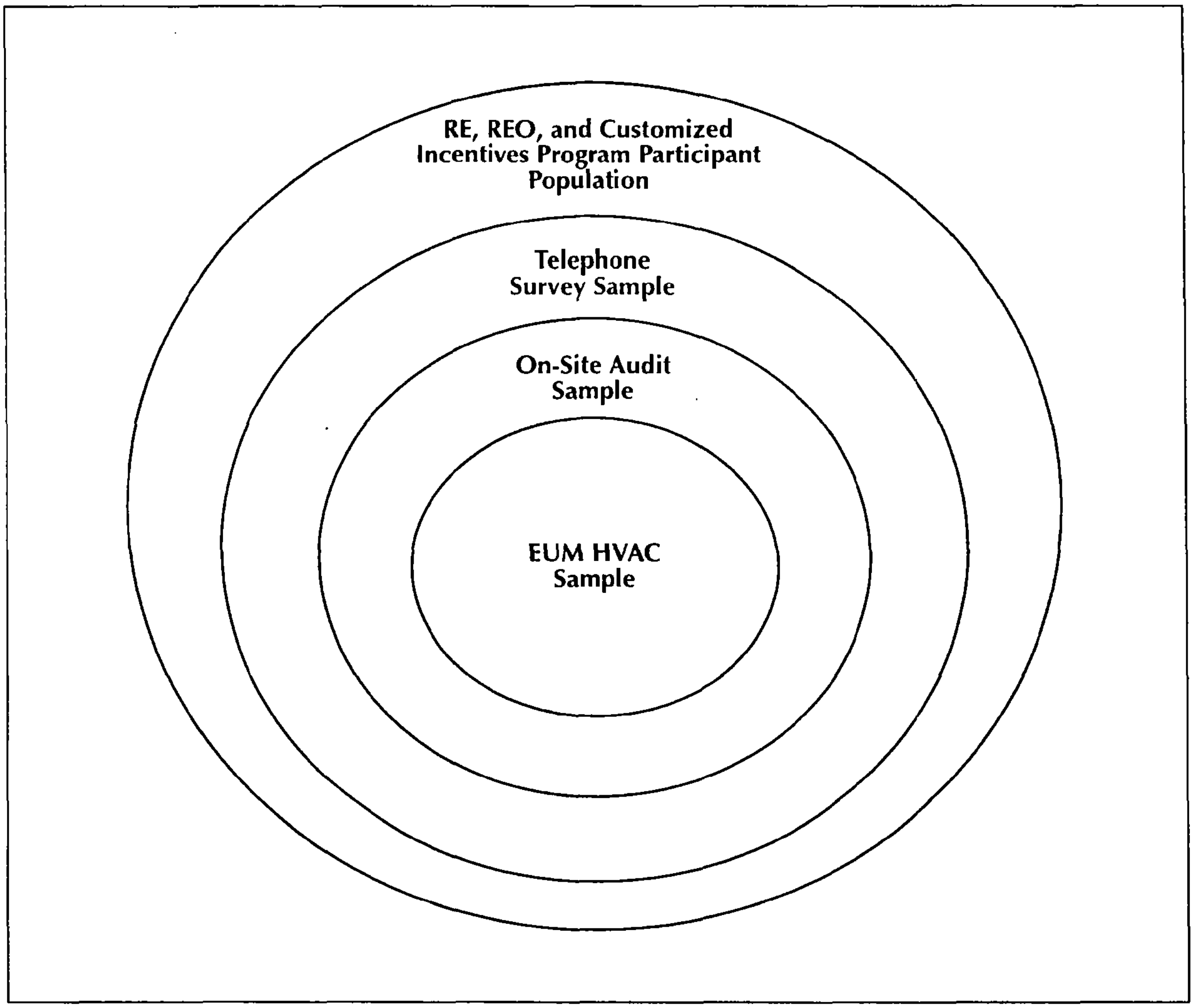
[1] PG&E 1995 Customer Energy Efficiency Programs Advice Letter No. 1867-G/1481-E, filed October 1994.

[2] For a detailed description of the allocation of each of these sample types by technology and building type refer to Appendix A.

business type. The telephone survey supplies information on participant decision-making, energy-related changes at each site for the billing period covered by the billing analysis, and data for estimating the NTG adjustments.

The participant population (represented by the outermost circle in Exhibit 3-1), is based upon information in the MDSS, and provides information needed to generalize estimated per-unit impact estimates for the telephone-surveyed sample (to the entire population of program participants). Using the population to leverage impact estimates corrects for potential bias in the sample selection process, especially in terms of the actual distribution of installed measures.

Exhibit 3-1
Nested Sample Design



Primary Collected Data

Data was collected from both participant and nonparticipant samples in order to support the integrated evaluation approach. The sample design developed for the data collection plan complies with the Protocols and meets the program evaluation objectives. In this evaluation, the sampling unit is a customer site, which defines a unique service address. The final sample sizes for the telephone, on-site, lighting logger, and EUM are summarized in Exhibit 3-2 by end-use element.

Exhibit 3-2
Commercial Sector Data Collection
For the Indoor HVAC End Use

Program	End Use	Commercial				
		Telephone Surveys	On-Site Audits	End-Use Metering	Time-of-Use (TOU) Loggers	Combination
Custom	Lighting	18	1	0	0	0
	HVAC	58	32	0	0	0
	Refrigeration	7	16	0	1	1
Retrofit	Lighting	600	227	5	108	112
	HVAC	434	107	20	13	31
	Refrigeration	235	16	0	1	1
Total	Lighting	614	228	5	108	112
	HVAC	487	137	20	13	31
	Refrigeration	241	18	0	2	2
Total Participants (Unique Sites)		1,217	380	20	108	126
Total Nonparticipants (Unique Sites)		808	36	0	0	0
Total (Unique Sites)		2,025	416	20	108	126

Telephone Survey Sample - For each segment, the retrofit program sample design allocated the sample in proportion to the program-avoided cost by segment. This sample design yields analysis data that are concentrated with the segments with the highest impact, in order to obtain the best estimate of impact for the largest portion of the population.

In addition, a census was attempted for the largest customers. This sample allocation, combined with the random sampling techniques used in other segments, produces a stratified random telephone survey sample representing the program-participant population (paid in 1995). Annual energy consumption values were used to group customers into five usage/size strata based upon a Dalenius-Hodges procedure. The comparison group customers are then selected to mirror the underlying distribution of the participant target population by size and business type. (For the customers in the largest size strata, a census was attempted both for among participants and nonparticipants.) A nonparticipant sample was developed based upon on the business type and usage strata distribution that resulted from the participant sample allocation.

Telephone surveys were collected for a total of 2,025 customers, 487 of which were HVAC participants. There were 808 customers in the comparison group (451 as the original lighting and HVAC comparison group, 201 as the supplemental refrigeration comparison group, and 156 outside the program retrofitters found through the canvass survey).

On-Site Audit Sample - Similar to the telephone survey sample, this sample was also structured to be approximately proportional to the program segment-level avoided costs. A total of 416 on-site surveys were conducted in the commercial sector, with 380 participants and 36 comparison group customers.

End-Use Metering - This sample is not intended to be a random sample, nor strictly proportional to the program-avoided cost. A total of 20 participant sites were end-use metered to provide load data for Central Air-Conditioner (CAC) and Variable Speed Drive (VSD) installations.

3.1.2 Gross Impact Estimates

Per participant gross energy, demand, and therm impacts were developed for specified time-of-use (TOU) costing periods, using engineering and statistically adjusted engineering (SAE) estimates. Steps detailed in this section are displayed in Exhibit 3-3.

Gross Energy Estimates

Gross energy estimates were developed using two distinct analysis steps. Engineering estimates were first developed for each participant. These estimates were then adjusted using billing data-derived SAE coefficients.

Gross, unadjusted engineering impacts were developed for each retrofit measure. The engineering methods used are described in greater detail in *Section 3.2*. Gross impacts were developed for CAC and VSD using calibrated DOE-2.1E simulations. These simulations were carried out for Office and Retail business types and then leveraged to additional business types using telephone survey data and MDSS information. Ideally, estimates for all business types and measures would be generated based on calibrated models, given sufficient resources. Given the resources for this project, the optimal solution was to leverage the calibrated models from the Office and Retail business types to all other business types and adjust the results with the SAE analysis.

In addition, site specific engineering impact estimates were generated for 32 selected applications and 47 associated MDSS line items. For all other measures, such as Reflective Window Film and Evaporative Coolers, the algorithms used to generate the ex ante estimates were extensively reviewed and modified to include new and more accurate information. A complete evaluation of each of these algorithms and the associated new algorithms are included in Appendix B, Standard Measures. These modified algorithms were then used to produce participant specific estimates of impact.

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 program energy savings.

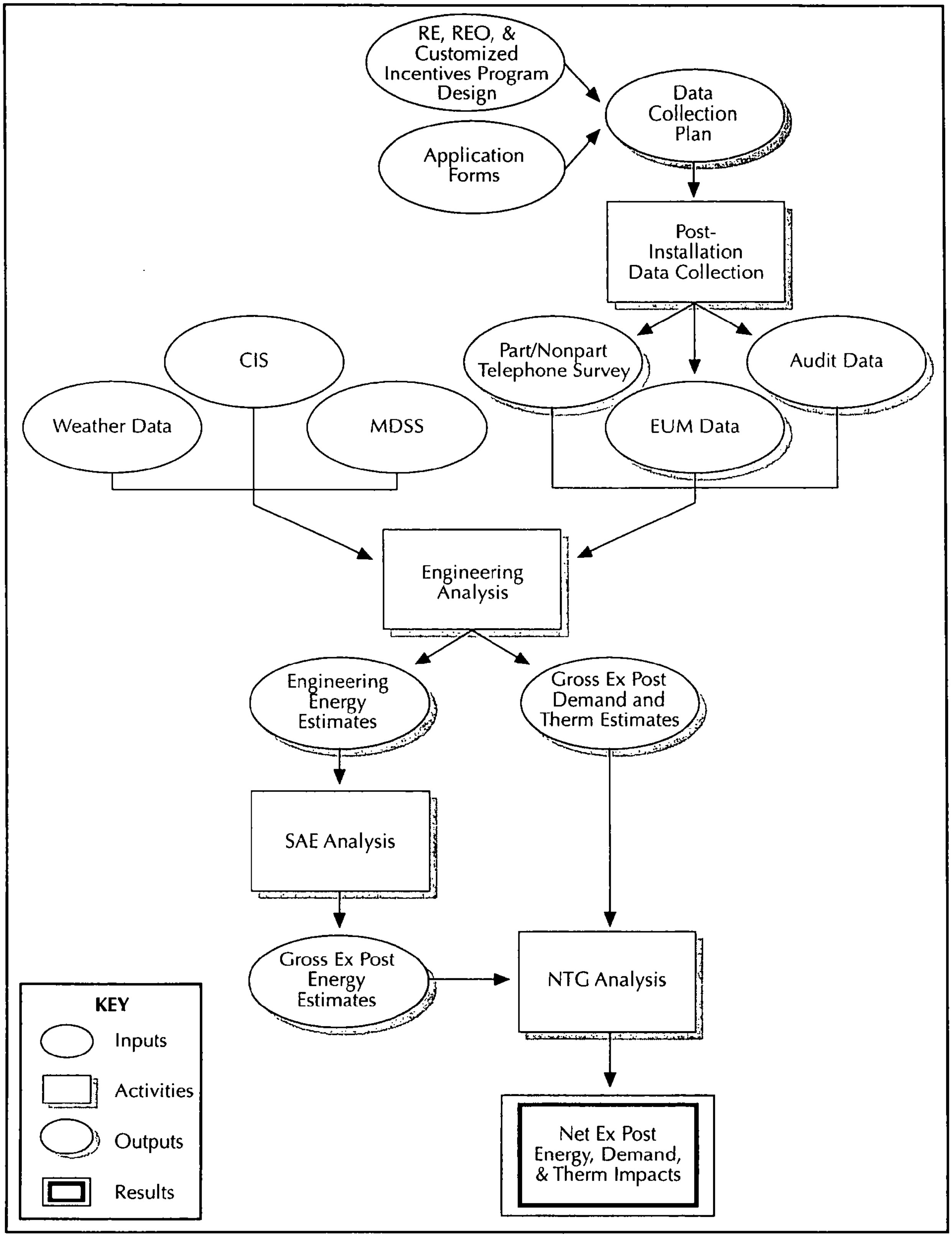
Gross Demand Estimates

Gross demand estimates are based solely upon unadjusted hourly engineering estimates. Whenever possible, engineering demand estimates were developed using EUM or site survey data in conjunction with the methods used for the gross energy estimates.

Gross Therm Estimates

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

Exhibit 3-3
Method for Estimating Impacts



3.1.3 *Net-to-Gross Estimates*

The NTG analysis is designed to adjust gross program impacts for free-ridership and the actions taken by PG&E customers outside the HVAC program. Self-reported data were 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. This self-reported estimate of program NTG was not adjusted for the effects of program spillover, where energy efficiency actions taken outside the program are claimed

Application of the final NTG adjustments, by technology, yields net program impacts. Each step is taken to achieve final net results is explained in the remainder of this section, starting with the engineering analysis.

3.2 *ENGINEERING METHODS*

The engineering approach that supports realized gross impacts in the HVAC evaluation is presented in this section. This presentation summarizes the more detailed discussion of engineering methods in Appendix B, and specific section within that appendix are cited as appropriate in the remainder of this section. The following topics are discussed:

- First, an overview of the engineering approach is presented.
- Then, details surrounding the development of impacts for central air-conditioners and variable speed drive fan motors are discussed, as well as a brief discussion of the methods used for high efficiency chillers.
- An overview of the methods used and the engineering estimates developed for other RE and REO measures is then presented.
- Next, the methods used and the engineering estimates developed for the Customized Incentives Program are summarized.

3.2.1 *Overview of the Evaluation Approach*

The Commercial HVAC engineering analysis consisted of the analysis of three separate PG&E programs: Retrofit Express (RE), Retrofit Efficiency Options (REO) and Customized Incentives. Where measures offered in different programs are similar (such as variable speed drives), identical analysis methods were applied across all programs.

Listed below are various RE and REO measures and an overview of the evaluation approach used for each:

Central Air-Conditioners - Estimates were derived using computer energy use simulations (DOE-2.1 E) which were calibrated to billing data (see *Section B.3*).

Variable Speed Drives for HVAC Fans - This measure was offered in all of the PG&E programs. However, a single method was used to develop estimates, using DOE-2.1E simulations which were calibrated to EUM data (see *Section B.3*).

Water Chillers - Impacts were developed using data gathered from on-site audits, application data, and DOE-2 simulations (see *Section B.3*).

Cooling Towers - The analysis method used data gathered from on-site audits, along with ex ante calculations, to develop engineering estimates.

Other Measures - A detailed review of the algorithms used to develop ex ante impacts was performed for the other RE/REO measures.

As a result of program design, many of the measures installed in the Customized Incentives Program were similar to or the same as those for the RE and REO programs, but were installed in larger and more complex projects. For this reason, many of the analysis methods used are similar to those employed in the RE and REO program evaluations. Additionally, on-site audits and detailed application reviews were performed for a select number of Customized Incentives applications.

3.2.2 Evaluation Approach: Variable Speed Drives and Central Air Conditioning

Demand and energy savings for the program measures associated with Central Air Conditioners (CAC) and Variable Speed Drives (VSDs) for supply fans were determined on a per unit basis using the DOE-2 building energy simulation program. The analysis combines detailed on-site audit data with information from telephone surveys to supply reliable engineering estimates. These estimates are then used as input to a statistically-adjusted engineering (SAE) regression model using billing data.

The engineering estimates for CAC and VSD were developed as follows:

- Develop DOE-2 models
- Calibrate DOE-2 models
- Create undiversified and diversified energy models
- Calculate CAC energy savings
- Calculate VSD energy savings
- Calculate water chiller energy savings
- Compute energy and demand impacts

On-site audit data were used to develop DOE-2 models of offices and retail facilities that participated in the program. These models were then calibrated using end-use-metered (EUM) and billing data in conjunction with California Energy Commission (CEC) weather data adjusted for local conditions[3]. The resulting hourly estimates were diversified and leveraged to additional business types using telephone survey data of operating hours. Finally, the DOE-2.1E model estimates were regenerated using current CEC approved weather data and Title 24 baseline equipment efficiencies to compute program impacts.

Develop DOE-2 Models

Audit and billing data were analyzed to determine the number of DOE-2.1E prototypes needed to represent typical participating office and retail facilities. The primary variables reviewed were conditioned square footage and the ratio of summer usage[4] to conditioned square footage.

[3] This approach is consistent with the approach used for the 1994 HVAC program year evaluation.

[4] Total premise kWh for the months of June, July and August, 1996.

Across business types, the VSD measure was clearly installed in larger facilities compared to the CAC measure. Within measures, only CACs in retail facilities need to be divided into categories, large and small. The small prototype typically represents a single owner operated business, while the larger prototype represents a larger chain store such as a Target K-Mart. Key characteristics for each of the five resulting prototypes are detailed in Exhibit 3-4.

Exhibit 3-4
Key Characteristics for DOE-2.1E Prototypes

File	Office VSD	Retail VSD	Office CAC	Small Retail CAC	Large Retail CAC
Sample Size	5	8	31	9	8
Total Sq Ft	40,948	80,745	12,477	4,201	80,745
Slab	21,224	65,693	9,045	4,034	65,693
Total Wall	17,680	20,532	7,324	4,236	20,532
Frame	28%	0%	34%	5%	0%
Block	72%	100%	66%	95%	100%
Frame Insulation	R-13	-	R-11	R-7	-
Block Insulation	R-7	R-0	R-11	R-0	R-0
Roof Area	21,224	65,693	9,045	4,034	65,693
Roof	R-19	R-19	R-11	R-11	R-19
Ceiling Height	8	16	9	14	16
Window	5,284	437	1,496	389	437
Window Type	Single Clear	Single Clear	Single Clear	Single Clear	Single Clear
Cooling BTUH	N/A	N/A	403128	135046	2595841
Occupants	160	906	86	57	906
Cool Thermostat	72	73	73	75	73

Calibrate DOE-2 Models

To ensure that the modeled results were accurate and reasonable, models were calibrated to EUM and billing data. Lighting loads and schedules were incorporated into the models based on audit data and schedule data gathered through phone surveys. Calibration was performed by comparing DOE-2.1E simulation output run using the adjusted weather data from with the EUM and billing data.

Create Undiversified and Diversified Energy Models

Using the calibrated DOE-2.1E prototypes discussed above, undiversified energy usage estimates were created by setting the HVAC system to operate 24 hours a day. Other operational aspects of the building, such as lighting and miscellaneous equipment schedules, were based on audit data and information calculated in the lighting analysis. For both CAC and VSD, the calibrated DOE-2 models were run using the adjusted CEC weather data in each climate zone. The weather data covered October 1, 1995, through September 30, 1996, the post-retrofit period used in the SAE model.

The DOE-2 models provide simulated annual energy used, at an hourly level, for Retail and Office sites in all climate zones with program participation. All other business types are mapped to either the Office, Small Retail, or Large Retail prototype as shown in Exhibit 3-5.

Exhibit 3-5
Business Type Mapping

OFFICE	SMALL RETAIL[5]	LARGE RETAIL
Office	Small Retail	Large Retail
Community Service	Personal Service	Grocery
Health Care Hospital	Restaurant	Warehouse
Hotel/Motel	Miscellaneous Commercial	-
College/University	-	-
School	-	-

The simulated undiversified cooling and fan energy use was diversified for each business type by hourly operating factors (the percentage of HVAC systems operating during a specified time) gathered through telephone surveys. For the School business type, the diversified load was multiplied by 27percent for June, July, and August to reflect the large reduction in occupancy in schools during those months.

Calculate CAC Energy Savings

The diversified CAC energy model produced an annual equivalent full load hour (EFLH) estimate for each business type and climate zone, where EFLH is defined as the total annual usage, divided by the connected load for the CAC unit. Energy savings estimates for each site in the SAE sample were calculated using estimated EFLH, total tons retrofit, post retrofit EER and an assumed existing EER. Energy savings were computed for each participant in the SAE sample using the equation in Exhibit 3-6.

Calculate VSD Energy Savings

The diversified VSD energy model results were used to produce an estimate of annual kWh usage per installed horsepower by business type and climate zone. This was accomplished for each of the three equipment types (constant volume, inlet vane, and variable speed drive). Energy savings estimates were computed as the difference of the diversified constant-volume and inlet-vane cases to the diversified VSD case.

Based on previous analysis, constant-volume fans were assumed to make up 70 percent of the pre-retrofit conditions while the remaining sites were assumed to be Inlet-vane systems. This was computed based on the advice filing, which states a 19 percent reduction in savings for the constant volume case, due to the presence of existing inlet vane fan systems.

Energy savings estimates for each site in the SAE sample were calculated using estimated per horsepower usage and total retrofit horsepower for each fan system. For the majority of the participants, the existing fan type was not known, so the assumed distribution of 70 percent constant volume and 30 percent inlet vane was used. The energy savings were computed for each participant in the SAE sample using the equation in Exhibit 3-7. For all other participants the existing fan type was used and the appropriate baseline usage of either 100 percent constant volume or 100 percent inlet vanes was used.

[5] This classification was used for CAC sites only. These business types were mapped to the Large Retail model in the case of VSDs.

Exhibit 3-6
Engineering Estimates of CAC Energy Savings

$kWh_{sav,i}$	$= U * \{EFLH_j * T * 12 * (1/EER_1 - 1/EER_{MDSS})\}$
Where	
$kWh_{sav,i}$	= Annual energy impact for participant "i" (kWh/yr.)
U	= Number of units installed
$EFLH_j$	= Diversified Equivalent Full Load Hours for business type j
T	= Number of tons installed per unit
12	= Conversion of tons to kBtuh
EER_1	= Pre-retrofit EER
EER_{MDSS}	= Post-retrofit EER

Exhibit 3-7
Engineering Estimates of VSD Energy Savings

$kWh_{sav,i}$	=	$U * [kWh_j - \{(kWh_{j,cv} * 0.30) + (kWh_{j,iv} * 0.70)\}]$
Where		
$kWh_{sav,i}$	=	Annual energy impact for participant "i" (kWh/yr.)
U	=	Number of retrofit Horsepower
kWh_j	=	Annual diversified energy use per horsepower for business type j (kWh/yr.) for fans with variable speed drives
$kWh_{j,iv}$	=	Annual diversified energy use per horsepower for business type j (kWh/yr.) for inlet vane fans
$kWh_{j,cv}$	=	Annual diversified energy use per horsepower for business type j (kWh/yr.) for constant volume fans

Compute Energy and Demand Impacts

The final step in the analysis of CAC and VSD measures was the calculation of energy and demand impacts for each. The energy savings estimates described above were based on weather data for dates between October 1, 1995, through September 30, 1996, and were used as inputs to the SAE analysis. The following steps were taken to convert the energy *savings* estimates to *impact* estimates:

- Current CEC weather data[6] were used to generate the calibrated DOE-2.1E energy estimates, instead of actual adjusted CEC weather data.
- CAC impact estimates were computed using minimum efficiencies defined by Title 24, rather than the existing equipment efficiencies.

Peak demand impacts were calculated for CAC only, since VSD impacts are assumed to be zero under peak conditions. CAC peak demand impacts were based on an undiversified peak duty cycle calculated from EUM data. For each metered CAC unit, the five highest weekday duty cycles occurring between 3:00 PM and 4:00 PM were selected as representing peak duty cycles. The average of these duty cycles across all metered CAC units was 88.7 percent.

Except for Schools, Coincident Diversity Factors (CDF) were computed as the product of the peak duty cycle and the weekday 3:00 PM to 4:00 PM operating factor used in the energy analysis. For schools, the telephone survey reported peak operating factor of 27 percent was used to compute the CDF .

Exhibit 3-8
Equation for Estimating CAC Demand Savings

$kW_{sav,i}$	=	$U * \{CDF_i * T * 12 * (1/EER_1 - 1/EER_{MDSS})\}$
Where		
$kW_{sav,i}$	=	Peak demand impact for participant "i"
U	=	Number of units installed
CDF_i	=	Coincident Diversity Factor, computed as 0.887 times the hour 3-4 PM operating Factor
T	=	Number of tons per installed unit
EER_1	=	Baseline EER
EER_{MDSS}	=	Post-retrofit EER

3.2.3 Calculate RE and REO High-Efficiency Chiller Impacts

Savings and impact estimates associated with high efficiency chillers were computed by leveraging off of the CAC program estimates. This approach was used since it would produce consistent, reasonably accurate estimates of change in energy consumption to be adjusted by the SAE analysis.

[6] Approved for use with the 1992 and 1995 Energy Efficiency Standards for Residential and Nonresidential Buildings. Referred to on magnetic media as CZxxRV2.WY2, where xx indicates the climate zone.

Energy estimates of savings were then computed by leveraging on the Office EFLH values from the chiller and CAC simulations. This was accomplished by calculating the ratio of chiller EFLH to Office CAC EFLH values for each climate zone with participation. This ratio was then used in conjunction with the method developed for CAC estimates (See *Section B-3*).

3.2.4 Evaluation Approach: Retrofit Express and Retrofit Efficiency Options

For RE and REO measures other than CAC and VSDs, the evaluation approach was based on an assessment, adjustment and recalculation of the algorithms and input assumptions used to develop the ex ante impacts. Since many of the same measures were offered in both the RE and REO programs, the adjusted methods developed for evaluating a measure in one program were applied to other programs. The aim of the evaluation was to either confirm or correct the methods and inputs used in the ex ante estimates.

When applicable, the engineering algorithms used by PG&E to develop ex ante impacts for RE measures were reviewed thoroughly (algorithms were taken from the 1995 Advice Filing[7]). Ex ante impacts were re-calculated using methods and inputs listed in the Advice Filing. This involved an assessment of the method used and the associated input data. Any numeric or logic errors were identified and corrected during the process of re-calculation. For several measures, such as direct Evaporative coolers, a new method was used in place of the method in Advice Filing.

Evaluation impacts were then generated using the adjusted method or new method. When possible, inputs and methods were verified using either sources referenced in the Advice Filing or alternate sources. For all of the measures reviewed, a complete assessment, including the identification of errors, the recommendations for correcting theses errors or the new method developed are detailed in *Appendix B, Section B.6*.

3.2.5 Evaluation Approach: Customized Incentives

The evaluation of Customized Incentives applications focused on sites which claimed the highest avoided cost under the program. The following describe the steps used in the evaluation process:

- Applications were first ranked according to the total claimed avoided cost for the facility.
- On-site audits were performed for 28 of the sites with the highest avoided cost.
- A comparison was made between on-site audit data and data found in the MDSS.
- If there was a discrepancy found between the audit data and the ex ante impacts then one or all of the following were developed:
  - DOE-2.1 E simulations
  - Temperature bin models
  - Spreadsheet-based algorithms

See *Section B.7* for detailed information regarding the development of impacts for each Customized Incentives participant.

[7] PG&E 1995 Customer Energy Efficiency Programs Advice Letter No. 1867-G/1481-E, filed October 1994.

3.3 *BILLING REGRESSION ANALYSIS*

The key objective of the billing analysis is to determine the first-year program energy impacts. A statistical analysis is employed to model the differences in customers' energy usage between pre- and post-installation periods. The model is specified using actual customer billing data and independent variables that explain changes in customers' energy usage including engineering estimates of 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 engineering impact estimates. Realized impacts represent the fractions of the engineering estimates actually "observed" or "detected" in the statistical analysis of actual billing data. The SAE coefficients estimated in the billing analysis regression models are relative to the results of the evaluation-based engineering estimates, not the PG&E Program ex ante estimates. The SAE coefficients are then used to estimate program impacts and realization rates relative to the ex ante estimates.

As discussed below, the billing regression analysis was conducted on a sample of telephone surveyed participants and nonparticipants. Because many Commercial Program participants installed measures under multiple end uses, one integrated billing analysis approach was used to model the Lighting, HVAC and Refrigeration end uses. *Appendix C* discusses the billing regression analysis in more detail.

3.3.1 Data Sources for Billing Regression Analysis

The billing regression analysis for the 1995 Commercial Program Evaluation used data from five primary data sources: the PG&E Management Decision Support System (MDSS) tracking database, the billing database, the telephone survey data, the engineering estimates of changes of usage between the pre- and post-installation periods, and the weather data tapes from PG&E's load research weather sites. A summary of the data elements used in the regression analysis are presented below.

Program Participant Tracking System

The participant tracking system for the Retrofit Express (RE), Retrofit Efficiency Options (REO) and Customized Incentives Programs was maintained as part of the MDSS. It contains program applications, rebate and technical information about installed measures, including measure description, quantity, rebate amount, and ex ante demand, and energy and therm savings estimates. The MDSS database is linked to the billing database and other program databases through PG&E's customers control numbers.

PG&E Billing Data

For this evaluation, the PG&E billing data were obtained from two different data sources within PG&E. 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 *Appendix A*. The billing histories contained in this data base only run through September 1995.

The second billing dataset, which consists only of customer accounts in the surveyed dataset, was later obtained from PG&E Load Data Services. This billing dataset contains bill readings that run through September 1996. 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, from January 1992 to September 1996.

Weather Data

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

Telephone Survey Data

All available telephone surveys (except for the Canvass surveys, which do not collect detailed information regarding changes that have occurred at the premise) collected as part of the evaluation for the Commercial Sector Program were used in the billing regression. Four telephone survey samples totaling 1,217 participants and 652 nonparticipants were collected for the Commercial Sector Evaluation. The 1,217 participant surveys included 487 HVAC participants, 614 Lighting participants, and 241 Refrigeration participants. Because of the significant levels of cross-over among participants across the Commercial Program end uses, one integrated billing regression model was developed to evaluate all three Commercial Program end uses.

The data collected in the telephone survey supplies information on energy-related changes at each site for the billing period covered by the billing regression analysis. For a detailed discussion of the telephone survey sample design and the final sample distribution, see *Appendix A*.

Engineering Estimates

Engineering estimates of savings were estimated for all 487 HVAC participants. Separate estimates were calculated for every measure installed under the Commercial Sector Program. The engineering estimates were calculated based on expected savings from the pre-installation technology to the post-installation technology. For some technologies, such as Central A/Cs installed in the HVAC Program, the savings estimates will differ from the impact estimates. Impacts are calculated relative to a baseline efficiency, while the savings estimates are based on a pre-existing unit's efficiency. *Appendix B* discusses in greater detail the calculation of the savings estimates used in the billing analysis.

For all measures, customer-specific engineering estimates were used in the SAE billing regression model, except for some Customized Incentives measures. For customers with EMS and "Other HVAC" Customized Incentives measures who were not on-site audited, the impact estimates supporting the application were used as the engineering estimates for the SAE analysis. From the engineering analysis based on the on-site audited measures, it was determined that the application's energy estimate was reasonable and accurate for all EMS applications used in the SAE analysis.

For the "Other HVAC" Customized Incentives measures, the measures can be so unique and the impact estimates so dependent on building characteristics and other equipment installed at the facility, that it is very difficult to estimate an impact without performing an on-site audit. However, the level of documentation provided along with the applications was sufficient to allow for an assessment of the quality of the impact calculations made. A review of the applications associated with the "Other HVAC" Customized Incentives measures indicated that the applications provided the best data for use in the SAE analysis.

3.3.2 Data Aggregation and Analysis Dataset Development

Because many measures installed under the Commercial Program affected multiple customer accounts within a unique site, the billing analysis had to be performed at the site level. Therefore, all account level data had to be aggregated up to the site level. A unique Site ID was created based on a combination of the PG&E service address, premise number and corporation number in the billing system to serve as the key variable for aggregating and linking data.

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

The engineering estimates of change were also aggregated to the Site ID level. However, prior to aggregating to the Site ID level, the installation dates for each individual measure were analyzed to ensure that only the impacts occurring within the billing analysis periods were being aggregated. The selection of analysis periods is discussed in the next section.

All data elements mentioned above were linked to the final analysis database by Site ID.

3.3.3 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 actually installed measures in 1992, 1993, 1994 or 1995, with 1995 installations accounting for approximately two-thirds of total installations. *Appendix C* discusses in detail how the selection of an installation date was estimated, since the installation date is not always provided in the MDSS. In summary, the application received date was used as a proxy for the installation date, unless a valid self-reported installation date was provided by the customer through the telephone survey, in which case the self-report date was used.

Billing data were available from January 1992 through September 1996. To maximize the number of post installation months, a post period of October 1995 through September 1996 was used. Because the majority of installations occurred during 1995, the only feasible pre-periods were October 1992 through September 1993 and October 1993 through September 1994. Survey data gathered change information dating back from the beginning of 1993. Therefore, both pre-installation periods could be used. However, the further back the pre-installation period is chosen, the more likely there are to be changes that have occurred at the site. To minimize the number of changes that have occurred outside the program between the pre- and post-installation periods (and to minimize the errors associated with self-reported changes and dates the changes occurred), the October 1993 through September 1994 pre-installation period was selected.

3.3.4 Data Censoring

Prior to implementing the billing analysis models, the customer sample was screened for invalid data and potential outliers. The data screening was applied to the entire participant and nonparticipant billing analysis sample frame. Three primary screening criteria were applied to remove customers that have invalid billing data, that may not have had their bill properly aggregated to the Site ID level, or that were extremely large users which could not be adequately controlled for in the billing analysis model. *Appendix C* described in detail the criteria that were used to remove customers from the billing regression analysis.

Exhibits 3-9 and 3-10 present the final sample sizes used in the billing analysis by business type and technology for participants and by business type for nonparticipants.

Exhibit 3-9
Billing Analysis Sample Used
Post-Censoring
HVAC End-Use Technologies

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	75	26	-	24	4	10	20	3	8	4	19	5	198
Variable Speed Drive HVAC Fan	12	10	-	2	-	-	-	-	-	-	-	1	25
Package Terminal A/C	2	-	-	7	-	2	-	13	-	-	-	-	24
Programmable Thermostat	36	10	-	13	-	6	7	2	2	2	10	1	89
Reflective Window Film	34	9	-	3	3	2	7	3	3	2	8	2	76
Water Chiller	-	1	-	1	-	-	-	-	-	-	2	-	4
Other RE Measures	-	1	-	-	1	1	-	-	-	-	-	-	3
Retrofit Express Total	131	45	-	41	8	17	27	19	11	7	30	7	343
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	1	-	-	-	-	-	-	-	-	1
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	1	-	-	-	-	-	-	-	-	1
Retrofit Efficiency Options Total	-	-	-	1	-	-	-	-	-	-	-	-	1
Customized Incentives Program													
HVAC Variable Speed Drive	1	-	-	-	1	-	-	-	-	-	-	-	2
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	4	-	-	14	1	-	-	-	1	-	-	-	20
Other CI Measures	2	-	1	1	-	-	-	-	1	-	-	-	5
Customized Incentives Total	7	-	1	15	2	-	-	-	1	-	-	-	26
Total	138	45	1	55	10	17	27	19	12	7	30	7	368

Exhibit 3-10
Billing Analysis Sample Used
Post-Censoring
Nonparticipants

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Total	74	124	1	26	185	34	27	15	53	6	31	44	620

3.3.5 Model Specification

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

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

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

Baseline Model

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

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

Where

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

ΔCDD_i and ΔHDD_i are the annual change of cooling and heating degree days (base 65°F) between the post-installation year and pre-installation year;

$Elec_i$ is an indicator variable (0/1) for the ith customer, which equals 1 if the customer has electric heating;

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

α_j is the indicator variable (0/1) for the jth business type, which equals 1 if the customer is in that business type and 0 otherwise;

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

ε is the random error term of the model.

For each customer in the analysis dataset, a post-installation predicted usage value is calculated using the parameters of the baseline models estimated for the 1994 to 1996 analysis period. They both take the same functional form with different segment-level intercept series (α_j) and slopes (β, γ and ϕ):

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

The final functional relation, based on all 620 nonparticipants used in the baseline model, is estimated as follows:

Baseline Model (1994 to 1996):

$$\begin{aligned} k\hat{W}h_{96,i} = & -40834 * OFF\_LG + 1349 * OFF\_SM - 19849 * RET\_LG - 120 * RET\_SM \\ & +942 * SCHOOLS + 5378 * GROCERY + 8461 * SUPERMKT + 4756 * REST \\ & +10964 * HEALTH + 2403 * HOTEL + 4167 * WAREHOUS + 675 * PERSONAL \\ & +4795 * COMMUN + 37895 * MISCBT \\ & +1.13 * OFF\_LG4 + 0.91 * OFF\_SM4 + 0.99 * RET\_LG4 + 1.00 * RET\_SM4 \\ & +1.00 * SCHOOLS4 + 0.98 * GROCERY4 + 0.98 * SUPERMKT4 + 0.99 * REST4 \\ & +0.99 * COLLEGE4 + 0.94 * HEALTH4 + 1.02 * HOTEL4 + 1.04 * WAREHOUS4 \\ & +0.94 * PERSONAL4 + 0.95 * COMMUN4 + 0.95 * MISCBT4 \\ & +0.0000456 * CDD_{96-94,i} * kWh_{94,i} + 0.0000324 * HDD_{96-94,i} * kWh_{94,i} \end{aligned}$$

SAE Model

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

$$kWh_{96,i} - F_{94}(kWh_{94}, \Delta CDD \ \Delta HDD) = \sum_m \beta_m' Eng_m + \sum_k \eta_k' Chg_{i,k} + \mu_i$$

The difference between predicted and actual usage in 1996 was used as the dependent variable in a SAE model. Based upon the estimated participation month, the pro-rated engineering estimates and change variables were used to explain the deviation in actual usage from the predicted usage.

As discussed above, the predicted usage is estimated using only the comparison group to forecast the 1996 usage as a function of 1994 usage and change of cooling and heating degree days from 1994 to 1996. This usage prediction presents what would have happened in the absence of the program.

3.3.6 Billing Regression Analysis Results

The coefficients of the engineering impact, termed the SAE coefficients, are used to calculate the ex post gross energy impacts. Independent realization rates are estimated to provide PG&E with business type and technology group level results. Exhibit 3-11 below summarizes the final SAE model results that were estimated using 935 participants (including 368 HVAC participants), as discussed in the Data Censoring section. Also, summarized below are the independent variables used in the SAE model, together with the t-statistics and the sample sizes available for each parameter estimate.

The dependent variable is the difference between the actual and predicted 1996 usage using the 1994 baseline model.

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

All but three of the SAE coefficients are significant at the 95 percent confidence level (t-statistics greater than 1.96). In addition, all of the statistically significant SAE coefficients were the correct sign, and therefore used in the calculation of the final ex post energy calculations. The three SAE coefficients that were not significant at the 95 percent confidence interval (HIDs in warehouses and schools, and thermostats in offices) were not used in the final ex post energy calculations. Because each of the insignificant SAE coefficients were also the wrong sign, they were set to zero. Therefore, no energy impacts are being claimed for these three segments, which is a conservative approach.

All the of the HVAC technologies are represented in the SAE billing analysis, except for REO Variable Frequency Drives (VFD), REO CAV to VAV, and Customized Incentives Chillers, as shown in Exhibit C-12. Although these measures represent only ten percent of the energy impact, an approach needed to be developed for adjusting the engineering energy impact estimate for these measures.

The REO VFD measure is very similar to those installed under the RE and Customized Incentives programs, and the engineering estimate is calculated using the same approach. Therefore, engineering energy impact estimate for the REO VFD measure was adjusted by the SAE coefficient estimated for the RE and Customized Incentives measures.

Three approaches were considered for adjusting the engineering energy impact estimate for the REO CAV to VAV measure: (1) applying the Other RE HVAC SAE coefficient, (2) applying the Other Custom HVAC SAE coefficient, or (3) leaving the engineering estimate unadjusted. Because the REO CAV to VAV measure is usually installed in large businesses, typical of those installing Customized Incentives measures, the Other Custom HVAC SAE coefficient was used to adjust the engineering energy impact estimate for the REO CAV to VAV measure. This is also the most conservative approach since the SAE coefficient is only 0.65.

Exhibit 3-11
Billing Regression Final Model Outputs

Parameter Descriptions	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients				
HVAC End Use				
Central A/Cs	kWh	-2.07	3.67	184
ASDs	kWh	-1.90	6.75	27
Chillers	kWh	-1.58	2.39	5
EMS	kWh	-1.03	8.38	20
Other Custom HVAC	kWh	-0.65	4.76	5
Office Thermostats	kWh	0.05	1.06	36
Other RE/REO HVAC	kWh	-0.90	2.89	153
Lighting End Use				
Office Flourescents	kWh	-1.00	14.67	116
Other Flourescents	kWh	-0.68	7.41	261
Controls	kWh	-1.38	2.09	57
Warehouse HIDs	kWh	0.02	0.07	10
School HIDS	kWh	0.11	0.30	10
Other RE Lighting	kWh	-1.26	2.15	119
Custom Lighting	kWh	-0.51	3.07	15
Refrigeration				
Custom Refrigeration	kWh	-0.75	2.00	3
RE/REO Refrigeration	kWh	-0.53	1.98	181
Other End Uses	kWh			
Other	kWh	-1.71	2.90	62
Change Variables	kWh			
Cooling System Replacement	(0,1)*kWh	-0.03	0.70	10
Lighting System Replacement	(0,1)*kWh	-0.08	4.17	48
Change in Employees	(±1,0)*kWh	0.01	0.64	57
Square Foot Change	± sqft	4.42	2.37	27
Heating System Replacement	(0,1)*kWh	-0.07	0.04	4
Other Equipment Change	(0,1)*kWh	0.03	1.17	42
Remove Equipment	(0,1)*kWh	0.08	0.64	2
Refrigeration Replacement	(0,1)*kWh	0.00	0.01	3
Add Equipement	(0,1)*kWh	0.11	0.49	11
Other Additions	(0,1)*kWh	0.14	12.41	375

The engineering energy impact for Chillers was estimated differently for Customized Incentives applications than for RE and REO applications, due to the different types of businesses that install these measures. Therefore, the engineering energy impact estimate for Customized Incentives Chillers was left unadjusted, which is conservative compared to the alternative approach of applying the 1.58 SAE coefficient estimated for the RE and REO applications.

The SAE coefficient of 0.65 for "Other" Customized Incentives HVAC measures is based on a sample size of only five sites, compared to the 43 unique sites that installed "Other" Customized Incentives HVAC measures in 1995. In addition, these five sites represent only seven percent of the total ex ante energy impact contributed by these 43 sites. Also, one third of the customers installing "Other" Customized Incentives HVAC measures have usage over 3 million kWh per year, which are not represented in the SAE analysis.

The larger customers (usage over 3 million kWh per year), however, are very well represented in the on-site audit sample, for which calibrated engineering energy impacts were estimated. Sixteen sites, which represent 53 percent of the total ex ante energy impact, were on-site audited, one of which was included in the SAE billing analysis. The ratio of the engineering energy impact estimate to the ex ante estimate is 0.79 for the on-site audit sample. This can be directly compared to the SAE coefficient, because ex ante estimates were used as the engineering energy impact estimates for the billing analysis, as mentioned above.

Three approaches were considered for estimating the ex post gross energy impact for the "Other" Customized Incentives HVAC measures:

- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population.
- The 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate from the on-site audit sample could be applied to the ex ante estimate of gross energy impact for the population.
- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population that is most similar to the SAE sample, and the 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate could be applied to the population most similar to the on-site audit sample.

The approach of applying the SAE coefficient to the ex ante estimate of gross energy impact for the population, which is the most conservative method, was chosen for two reasons. First, the SAE coefficient provides a statistically adjusted result that is significant at the 95 percent confidence level. Second, the 0.79 ratio based on the on-site audit is very sensitive to a few individual on-site results. For example, the ratio of the engineering to ex ante estimate is 1.51 for the site with the largest energy impact. If the engineering estimate was set equal to the ex ante estimate for this customer, the overall ratio for all on-sites would be 0.64. Conversely, if the site with the second largest energy impact, which has a ratio of 0.41, had an engineering estimate set equal to the ex ant estimate, the overall ratio would be 0.95.

The SAE coefficients are multiplied by the evaluation estimates of gross energy impact to calculate the gross ex post energy impacts.

3.3.7 Self-Selection

In addition to conducting a billing analysis to estimate gross energy impacts as described above, a net billing analysis was performed, with the objective of estimating SAE coefficients that could be applied to gross engineering estimates to calculate net energy impact. The net billing analysis model specification differs from the gross billing analysis model, which used two different multivariate regression models (a baseline model using a control group and an SAE model using participants). Instead, the net billing analysis model runs one integrated model combining both the participants and nonparticipants.

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

One solution to this problem is to include an Inverse Mills Ratio in the model to correct for self-selection. This method was developed by Heckman (1976, 1979[8]) and is used by others (Goldberg and Train, 1996[9]) to address the problem of self-selection into energy retrofit programs. The Mills Ratio technique assumes that the unobserved factors that are influencing participation are distributed normally. The influence of these unobserved factors on participation can be approximated by a Mills Ratio which itself is distributed normally. Using the Mills Ratio corrects for the self-selection bias in the net savings regression as the unobserved factors affecting participation are now controlled for in the model. As a result, standard regression techniques should produce unbiased coefficient estimates.

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

To correct for self-selection, a probit model of program participation is estimated. Upon estimation, the parameters of the participation model are then used to calculate an Inverse Mills Ratio for both participants and nonparticipants. This Mills Ratio is then included in the net savings regression that combines both participants and nonparticipants. If the Mills Ratio controls for those unobserved factors that determine participation, and the other model assumptions are met, then the net savings model can then be estimated as if participation in the program is randomly determined.

Using the Inverse Mills Ratio to correct for selection relies on several assumptions. First, the net savings due to the program, whether expressed as naturally occurring savings or a net-to-gross ratio, must be normally distributed. In addition, the Mills Ratio must not be highly correlated with the other independent variables used in the net billing regression. In this application, both of these assumptions are found to be violated. Net savings due to the program is biased upward toward large customers and is not distributed normally. The Mills Ratio term used in the net savings regression is also found to be highly correlated with other independent variables, which introduces multi-collinearity into the model. As a result of these violations, the regression analysis using the Mills Ratio technique does not yield reliable estimates in this application. A description of the methods used for this application are provided in *Appendix C.*

Therefore, self-selection is not treated explicitly in the billing regression analysis. However, because the objective of the billing regression analysis is to estimate the program gross energy impacts, the self-selection bias, if it even exists, has very limited impacts on the outputs of such estimation when both cross-sectional and time series data are used. In addition, the effects of free ridership are explicitly modeled in the net to gross analysis, described in *Section 3.4*.

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

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

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

3.3.8 *Relative Precision Calculation*

Relative precision at 90 percent and 80 percent confidence levels for the adjusted gross energy impact estimates are calculated for each of the SAE analysis segments. As mentioned above, there are a total of sixteen analysis segments that were explicitly modeled and the relative precision estimates based upon the model output are presented in Exhibit 3-12 below. In order to calculate the total program level adjusted gross impact and relative precision, the segment level results were weighted by their unadjusted engineering energy impact estimates in the following equations.

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

Where β_i and Eng_i are the SAE coefficients and unadjusted engineering impact estimates for segment i, respectively. The program level standard error can be estimated as:[10]

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

Where CVi = (std(βi)/βi) is the coefficient of variation in segment i, estimated in the billing regression model. Finally, the relative precision at 90 percent and 80 percent confidence levels were calculated as

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

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

Exhibit 3-12
Relative Precision Calculation

SAE Analysis Level	Engineering Gross Energy Impact Estimate (MWh)	SAE Coefficient	t-Statistic	Relative Precision at 80%	Relative Precision at 90%
HVAC End Use					
Central A/Cs	878	2.07	3.67	35%	45%
ASDs	8,971	1.90	6.75	19%	24%
Chillers	2,966	1.58	2.39	54%	69%
EMS	10,290	1.03	8.38	15%	20%
Other Customized Incentives HVAC	18,668	0.65	4.76	27%	35%
Office Thermostats	1,332	0.00	-	-	-
Other RE/REO HVAC	6,087	0.90	2.89	44%	57%
Total	49,192	1.03		12%	15%

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

3.4 NET-TO-GROSS METHOD

In this section, the methods used to derive net-to-gross (NTG) results for the evaluation of PG&E's 1995 Commercial RE/REO/Customized Incentives Programs is presented. After a brief review of data sources, the approach to estimating free-ridership and spillover from participant self-reports is described. Finally, investigation into the use of more sophisticated discrete choice modeling techniques to estimate program net effects is discussed.

3.4.1 Data Sources

Data used in the NTG analysis include 487 telephone surveys from HVAC end use participants surveyed from April through August 1996, and 451 HVAC end use nonparticipants surveyed from June through August 1996. Other data used in the analysis include 156 telephone surveys from canvass nonparticipants and 634 canvass nonparticipants who were "thanked and terminated" because they had not made an equipment retrofit or installation. The canvass nonparticipants were surveyed from June through July 1996.

3.4.2 Self-Report-Based Estimates of Free-Ridership

The RE/REO/Customized Incentives participants surveyed installed or adopted the following technology groups. (Participants who installed multiple technologies may be included in more than one technology group.)

Technology Group	N
Central Air Conditioner	244
Adjustable Speed Drive	32
HVAC Controls	119
Package Terminal	26
Reflective Window Film	97
Water Chillers	10
Other	11
Custom	58

Because free-ridership often varies by technology, results were calculated for each technology group. However, caution should be employed in interpreting the analysis results, given the small group sizes for some technology groups.

Methods for Scoring Free-Ridership

The method used to score free-ridership uses participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. The complete text of the participant surveys may be found in *Appendix S-1*.

As described in the work plan, a series of questions was posed to program participants. If the customer indicated that he had not been shopping for new HVAC equipment before becoming aware of the program, he was scored initially as a net participant. A customer was then classified as a free-rider if he met the following two conditions: (1) stated that he would have installed high-efficiency equipment within the year and had already selected the equipment; and (2) stated that he would have purchased high-efficiency equipment if the program had not existed.

Free-Ridership Results

NTG results weighted by avoided cost (AC) and calculated by subtracting the free-ridership rates obtained through each of the methods described above are presented in Exhibit 3-13. Results are presented overall and by segment. Technologies classified as "other" include air handlers (2), cooling towers (3), evaporative condensers (5), and constant-to-variable air volume (1).

Exhibit 3-13
NTG Weighted by Avoided Cost

	RE/REO Technology groups								
	Adjustable Speed Drive	HVAC Controls	Water Chiller	Central AC	Reflective Window Film	Package Terminal	Other	Custom	Overall
N	32	119	10	244	97	26	11	58	597
% Avoided Cost	12.37%	11.82%	9.37%	4.13%	3.07%	0.86%	15.02%	31.63%	88.27%
NTG	0.897	0.807	0.700	0.835	0.699	0.943	0.876	0.854	0.843

Overall, weighted NTG results range from a low of 0.7 for chillers to a high of 0.943 for package terminal units. The program-wide NTG ratio, weighted by avoided cost, was 0.843. This result was used as the basis for subsequent adjustment for spillover.

3.4.3 Self-Report-Based Estimates of Spillover

HVAC spillover can be defined as HVAC efficiency improvements implemented outside the program but influenced by the program. Preliminary estimates of HVAC spillover rates were generated by analyzing responses to a combination of questions asked of 487 participants and 1,241 nonparticipants.

Methods for Scoring Spillover

The integrated approach to estimating HVAC spillover is summarized below.

All surveyed respondents were asked if they had installed HVAC equipment outside the program since January 1993. Participants who answered "yes" to the first question were asked if these changes were made after participating in the program. Nonparticipants, and participants who said the changes were made after participation, were asked if they made the equipment changes through a PG&E program.

Participants who passed the first two screening questions and had not changed out HVAC equipment through a PG&E program, and nonparticipants who passed the first two screening questions and were aware of the program at the time of equipment purchase, were asked how influential the program was in their decision. Those who said that the program had influenced their decision[11] were included in the preliminary estimate of program spillover.

Survey-based estimates were applied to the HVAC participant population and the HVAC nonparticipant population along with estimates of impact per site, resulting in a final spillover impact.

It should be noted that this analysis provides a preliminary indication of spillover rates and more in-depth analysis is required to quantify spillover impacts.

Spillover Result— Participants

Forty-five surveyed participants (nine percent of the total participant sample) reported that since January 1993 they had added HVAC equipment. Forty-nine percent of those participants who added equipment (4.5 percent of the total participant sample) added the equipment after participating in the program. Twenty-seven percent (2 percent of the total participant sample) did not install the equipment through the program. Six of these respondents (1 percent of the total participant sample) reported the program influenced their additional HVAC equipment installations. Of these six, two installed additional HVAC equipment in 1995. Two of 489 participants yields an initial unweighted spillover rate of 0.41 percent for 1995.

Spillover Results—Nonparticipants

One hundred twenty-six of 1,241 program nonparticipants reported making HVAC changes outside the program, of which 88 respondents confirmed their installations were not done through the program. Thirteen respondents (1 percent of the total nonparticipant sample) reported they were aware of the program before they purchased the equipment. Of these 13, 3 respondents reported their knowledge of the program was influential on their equipment selection. One of these 3 respondents installed HVAC equipment in 1995. One of 1,241 nonparticipants yields an unweighted spillover estimate of 0.08 percent for 1995.

Because the levels of self-reported spillover are so low and based on such a small number of responses, it was decided not to apply a correction for either participant or nonparticipant spillover. One minus the self-reported rate of free-ridership (0.843) was therefore used as the self-reported NTG ratio for the HVAC program overall, with the corresponding measure-specific NTG ratios used for individual technologies.

3.4.4 Use of Discrete Choice Models to Estimate NTG

In addition to the estimates based on self-reported data, discrete choice modeling techniques were assessed for their practicality in estimating NTG ratios and free ridership rates for HVAC measures. This approach was used successfully to evaluate high-efficiency equipment purchases in PG&E's 1995 Commercial Lighting Energy Efficiency Incentives (EEI) Program.

For the HVAC program, the technologies that are best suited for discrete choice analysis are split and package units. However, these measures account for less than 3 percent of the total energy impact due to the HVAC program. Information is available on the type of measures adopted outside the program, but expensive data resources were not used to determine whether these

[11] "To what extent did participating in the program influence your additional equipment selection?" Values of 2, 3, 4, and 5 (slightly influential to very influential) were considered to demonstrate program influence on the purchase.

measures are standard or high-efficiency. As a result, assumptions must be made regarding the efficiency of these measures in order to specify a model.

Modeling Approach and Results

The approach adopted in this analysis was to explore four different logit model specifications using a variety of assumptions regarding the technology adopted outside the program. These different models provide a range of possible NTG ratios based on whether customers outside the program purchase standard or high-efficiency HVAC equipment. *Appendix D* discusses the modeling approach and results in more detail.

In the logit model, the decision to purchase high-efficiency equipment is explained by the cost and savings of the equipment, any rebate offered by the HVAC program, awareness of the HVAC program, and other customer characteristics. Once estimated, the model is used to determine the probability of purchasing high-efficiency equipment in the absence of the HVAC program. This is simulated by setting program awareness and the rebate amount equal to zero in the logit purchase model. These probabilities both with and in absence of the HVAC program are used to calculate a NTG ratio. With the four models, the estimates for the NTG ratio range from 0.49 to 2.88.

Conclusion

The wide range of NTG ratio estimates illustrates the sensitivity of these models to assumptions made regarding the energy efficiency of HVAC equipment purchased outside the program. Accurate information regarding the energy efficiency of the equipment purchased outside the HVAC program, such as the data collected for the Lighting program, is essential for developing a model that more accurately estimates the NTG ratio for the HVAC program. Because such detailed data were not available, the self-reported NTG ratios were used as the basis for adjusting gross to net impacts in the HVAC evaluation.

4. *EVALUATION RESULTS*

This section contains the results of this 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 for the differences between the ex ante and ex post estimates are discussed in the presentation of program realization rates.

Where segment analysis could be supported, results are presented by technology group and building type. All results are segmented by program: Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customized Incentives. All results are aggregated to the entire commercial sector by program.

4.1 EX POST GROSS IMPACT RESULTS

Ex post gross energy, demand, and therm impacts for the RE, REO, and Customized Incentives programs for HVAC technologies are presented in Exhibits 4-1, 4-2, and 4-3, respectively. The ex post gross energy and demand impacts by PG&E costing period are provided in *Appendix F.*

As shown in Exhibit 4-1, the Customized Incentives Program technologies represent more than 55 percent of the energy impacts, the largest contributor being Other Customized HVAC technologies. Office and retail business types represent about half of the overall energy impacts, with office being the largest single segment, accounting for about 38 percent of energy impacts.

Variable or adjustable speed drives, which were offered through all three programs, contributed more to energy impacts than any other technology, with approximately 17,000 MWh, or about one-third of the total. Energy Management Systems and programmable thermostats (including timeclocks, bypass timers, and setback programmable thermostats), were the second largest contributer, having a total program impact of almost 13,000 MWh, or 25 percent of the total. A variety of "other Customized Incentives measures" together accounted for about 20 percent of this program's total impact. Technologies covered in this category are generally site-specific energy-efficiency measures that do not fit into any of the established measure definitions. High efficiency chillers contributed just over 7 percent of HVAC energy impacts, with the REO and Customized Incentives programs representing more than 90 percent of the total.

Ex post energy impacts were set to zero for programmable thermostats in offices. As explained in more detail in *Appendix C: Billing Regression Analysis*, the SAE coefficients were statistically insignificant and the wrong sign within this particular segment. Therefore, a conservative estimate of zero impact was assigned.

The REO program plays a small role in the overall impact, with just under 10 percent of the energy savings being attributable to this program. Technologies installed through the REO program were most important to the health care and community service business types, representing over 15 percent of energy impacts for these segments.

Exhibit 4-1
Ex Post Gross Energy Impacts
By Business Type and Technology Group
For HVAC Technologies Paid in 1995

Business Type / Program and Technology Group	Commercial HVAC First-Year Energy Impacts (kWh)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	525,642	281,396	40,936	187,548	55,439	162,633	128,079	16,074	49,946	89,327	241,370	38,137	1,816,527
Variable Speed Drive HVAC Fan	2,813,602	5,175,127	965,036	35,644	130,946	-	122,085	140,154	101,000	1,871,764	-	84,959	11,440,318
Package Terminal A/C	7,654	1,566	3,680	42,023	-	13,979	31,857	120,285	408	-	4,690	-	226,144
Programmable Thermostat	0	276,534	9,369	595,792	35,183	129,262	123,984	19,618	217,875	134,030	448,586	56,476	2,046,708
Reflective Window Film	1,532,208	67,385	100,755	37,906	46,846	26,707	182,729	87,769	79,668	71,823	189,158	34,973	2,457,926
Water Chiller	61,742	66,913	-	68,460	-	-	-	-	-	-	25,672	-	222,787
Other RE Measures	127,178	-	-	186,899	23,678	12,192	66,595	61,231	-	8,747	48,603	-	535,124
Retrofit Express Total	5,068,027	5,868,921	1,119,777	1,154,273	292,092	344,772	655,330	445,131	448,897	2,175,692	958,078	214,545	18,745,534
Retrofit Efficiency Options Program													
Variable Frequency Drive	408,297	99,084	494,425	-	-	-	-	-	-	-	-	-	1,001,806
Water Chiller	108,676	590,332	-	-	-	-	928,687	-	-	-	373,211	-	2,000,905
CAV to VAV	1,733,726	-	-	-	-	-	-	-	-	-	-	-	1,733,726
Cooling Tower	27,719	35,316	-	-	-	-	135,056	-	-	-	-	-	198,091
Retrofit Efficiency Options Total	2,278,418	724,732	494,425	0	0	0	1,063,743	0	0	0	373,211	0	4,934,528
Customized Incentives Program													
HVAC Variable Speed Drive	1,615,813	-	-	-	1,435,537	-	684,015	357,401	-	-	523,716	-	4,616,483
High Efficiency Chiller	1,560,525	-	-	-	-	-	-	-	-	-	-	-	1,560,525
Energy Management System	2,504,659	-	1,227,263	3,420,436	746,289	-	1,959,984	602,385	11,680	86,131	-	-	10,558,827
Other Customized Incentives Measures	6,135,731	-	524,908	261,856	-	-	1,628,648	-	229,992	1,514,162	164,988	-	10,460,286
Customized Incentives Total	11,816,728	0	1,752,171	3,682,292	2,181,826	0	4,272,647	959,787	241,672	1,600,293	688,704	0	27,196,121
Total	19,163,174	6,593,652	3,366,373	4,836,565	2,473,918	344,772	5,991,719	1,404,918	690,569	3,775,985	2,019,993	214,545	50,876,182

The results in Exhibits 4-2 illustrate the following findings relative to demand impacts:

In contrast to energy impacts, which were dominated by the Customized Incentives Program, slightly over half of gross ex post demand impacts are attributed to the RE program. Technologies installed through the REO program contributed less than 15 percent. The difference between the distributions of demand and energy impacts are clearly a function of the measures installed. As discussed in energy impacts above, some of the largest contributors to energy impacts are VSDs, EMS and Setback Thermostats, all measures which do not have demand impacts.

Central air conditioners (central ACs) installed through the RE program and water chillers installed through all three programs each account for approximately 25 percent of demand impacts. Among other technologies, other customized incentives measures accounted for about 22 percent and reflective window film contributed 12 percent.

Exhibit 4-2
Ex Post Gross Demand Impacts
By Business Type and Technology Group
For HVAC Technologies Paid in 1995

Business Type / Program and Technology Group	Commercial HVAC First-Year Demand Impacts (kW)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	398	121	19	79	21	55	83	9	28	38	146	19	1,016
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	0
Package Terminal A/C	7	2	2	22	-	10	17	147	1	-	3	-	212
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	0
Reflective Window Film	322	14	19	2	9	6	39	16	15	15	35	7	499
Water Chiller	34	27	-	4	-	-	-	-	-	-	8	-	73
Other RE Measures	131	-	-	27	9	7	76	18	-	3	17	-	288
Retrofit Express Total	893	163	40	134	39	78	214	190	44	56	210	25	2,088
Retrofit Efficiency Options Program	-	-	-	-	-	-	-	-	-	-	-	-	
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	0
Water Chiller	10	149	-	-	-	-	235	-	-	-	127	-	522
CAV to VAV	83	-	-	-	-	-	-	-	-	-	-	-	83
Cooling Tower	23	40	-	-	-	-	90	-	-	-	-	-	153
Retrofit Efficiency Options Total	116	189	0	0	0	0	325	0	0	0	127	0	758
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	0
High Efficiency Chiller	401	-	-	-	-	-	-	-	-	-	-	-	401
Energy Management System	-	-	-	-	-	-	-	-	-	-	-	-	0
Other Customized Incentives Measures	648	-	-	41	-	-	13	-	73	115	-	-	891
Customized Incentives Total	1,049	0	0	41	0	0	13	0	73	115	0	0	1,292
Total	2,059	353	40	175	39	78	553	190	118	171	337	25	4,138

The office segment contributed 50 percent of demand impacts. Among other segments, only health care accounted for more than 10 percent. The sharply lower demand impact (relative to energy) for the retail, grocery, and personal service segments result from these segments' large participation in variable speed drive (VSD) HVAC fans, which have significant energy impacts but are assumed to have no demand impact at system peak when the fan motors are fully loaded.

Therm impacts associated with the installation of HVAC technologies paid in 1995 are presented in Exhibit 4-3.

Exhibit 4-3
Ex Post Gross Therm Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Therm Impacts												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	71,670	-	-	379,573	-	-	597,692	9,327	615	-	-	-	1,058,877
Other Customized Incentives Measures	659,610	-	23,700	28,726	-	-	263,911	-	192	-	13,403	8,243	997,785
Customized Incentives Total	731,280	0	23,700	408,299	0	0	861,603	9,327	807	0	13,403	8,243	2,056,662
Total	731,280	0	23,700	408,299	0	0	861,603	9,327	807	0	13,403	8,243	2,056,662

Gross therm impacts are associated only with program participants who have gas heating. Since accurate fuel type/heating equipment saturation data were not available for program participants in such RE measures as programmable thermostats and reflective window film (which would presumably have negative therm impacts), ex post therm impacts were calculated only for those segments for which ex ante therm impacts were estimated.

Energy management systems and other Customized Incentives measures contributed almost equally to the overall ex post therm impacts. Typically, energy management systems saved energy by eliminating or reducing the use of heating equipment during unoccupied periods.

Therm impacts from energy management systems were concentrated in the health care and, to a lesser extent, schools segments. The office building type accounted for two-thirds of the therm impacts from other Customized Incentives measures.

4.2 NET-TO-GROSS ADJUSTMENTS

Exhibit 4-4 presents the NTG values by technology. While discrete choice analysis was investigated for some segments, NTG results based on self-reported data were ultimately used, as described in detail in *Appendix D*.

In the case of self-reported data, results are presented without participant and nonparticipant spillover. Estimates of 1995 participant and nonparticipant spillover were generated based on self-reported data, but the resulting measures of spillover were very low, less than 1 percent. Therefore, a conservative estimate of the NTG ratio as one minus free-ridership was used for all segments.

Exhibit 4-4
NTG Adjustments by Technology Group

Business Type / Program and Technology Group	Net-to-Gross Adjustments												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	
Variable Speed Drive HVAC Fan	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Package Terminal A/C	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	
Programmable Thermostat	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	
Reflective Window Film	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
Water Chiller	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
Other RE Measures	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	
Retrofit Express Total													
Retrofit Efficiency Options Program													
Variable Frequency Drive	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	
Water Chiller	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	
CAV to VAV	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	
Cooling Tower	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	
Retrofit Efficiency Options Total													
Customized Incentives Program													
HVAC Variable Speed Drive	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
High Efficiency Chiller	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
Energy Management System	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
Other Customized Incentives Measures	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
Customized Incentives Total													
Total													

NTG values based upon self-reported data range from 0.70 for reflective window film to 0.94 for package terminal air conditioners. For Customized Incentives Program participants, a single NTG ratio was applied regardless of the specific technology. For chillers, a single NTG was calculated for the RE and REO program. Chillers installed through the Customized Incentives program, however, were assigned the NTG ratio for the Customized program. This is consistent with the way the SAE coefficients were applied to the engineering estimates of gross energy impact.

The overall program ex post NTG ratio was approximately 15 percent higher than the overall program ex ante NTG ratio for energy and demand, and some 13 percent higher for therms. Exhibit 4-14, at the end of this section, presents all of the ex ante and ex post gross and net energy, demand and therm impacts.

4.3 *EX POST NET IMPACTS*

Exhibits 4-5 and 4-6 present the ex post net energy and demand impacts, respectively, for HVAC technologies paid in 1995 through the RE, REO, and Customized Incentives programs.

Exhibit 4-5
Ex Post Net Energy Impacts
By Business Type and Technology Group
HVAC Technologies Paid in 1995

Business Type / Program and Technology Group	Commercial HVAC First-Year Energy Impacts (kWh)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	438,911	234,966	34,182	156,603	46,292	135,798	106,946	13,422	41,705	74,588	201,544	31,844	1,516,800
Variable Speed Drive HVAC Fan	2,523,801	4,642,089	865,637	31,973	117,458	-	109,510	125,718	90,597	1,678,972	-	76,209	10,261,966
Package Terminal A/C	7,218	1,477	3,470	39,628	-	13,182	30,042	113,429	385	-	4,423	-	213,253
Programmable Thermostat	0	223,163	7,561	480,804	28,393	104,314	100,055	15,832	175,825	108,162	362,009	45,576	1,651,693
Reflective Window Film	1,071,013	47,102	70,428	26,496	32,745	18,668	127,727	61,351	55,688	50,204	132,221	24,446	1,718,090
Water Chiller	43,220	46,839	-	47,922	-	-	-	-	-	-	17,970	-	155,951
Other RE Measures	111,408	-	-	163,724	20,742	10,680	58,338	53,638	-	7,663	42,576	-	468,768
Retrofit Express Total	4,195,571	5,195,635	981,279	947,150	245,630	282,642	532,618	383,389	364,200	1,919,590	760,743	178,075	15,986,522
Retrofit Efficiency Options Program													
Variable Frequency Drive	357,668	86,798	433,116	-	-	-	-	-	-	-	-	-	877,582
Water Chiller	76,073	413,232	-	-	-	-	650,081	-	-	-	261,247	-	1,400,633
CAV to VAV	1,518,744	-	-	-	-	-	-	-	-	-	-	-	1,518,744
Cooling Tower	24,282	30,937	-	-	-	-	118,309	-	-	-	-	-	173,528
Retrofit Efficiency Options Total	1,976,768	530,966	433,116	0	0	0	768,390	0	0	0	261,247	0	3,970,487
Customized Incentives Program													
HVAC Variable Speed Drive	1,379,905	-	-	-	1,225,949	-	584,149	305,221	-	-	447,254	-	3,942,476
High Efficiency Chiller	1,332,688	-	-	-	-	-	-	-	-	-	-	-	1,332,688
Energy Management System	2,138,979	-	1,048,083	2,921,052	637,331	-	1,673,826	514,437	9,974	73,556	-	-	9,017,238
Other Customized Incentives Measures	5,239,914	-	448,272	223,625	-	-	1,390,866	-	196,414	1,293,094	140,900	-	8,933,084
Customized Incentives Total	10,091,486	0	1,496,354	3,144,677	1,863,279	0	3,648,840	819,658	206,388	1,366,651	588,154	0	23,225,487
Total	16,263,825	5,726,602	2,910,749	4,091,827	2,108,909	282,642	4,949,848	1,203,047	570,588	3,286,240	1,610,144	178,075	43,182,496

Exhibit 4-6
Ex Post Net Demand Impacts
By Business Type and Technology Group
HVAC Technologies Paid in 1995

Business Type / Program and Technology Group	Commercial HVAC First-Year Demand Impacts (kW)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	332	101	16	66	17	46	69	8	23	32	122	15	848
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	0
Package Terminal A/C	7	1	2	21	-	10	16	138	1	-	3	-	200
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	0
Reflective Window Film	225	10	13	2	7	4	27	11	11	10	25	5	349
Water Chiller	24	19	-	3	-	-	-	-	-	-	6	-	51
Other RE Measures	115	-	-	23	8	7	66	15	-	3	15	-	252
Retrofit Express Total	704	131	31	115	32	66	178	173	35	45	170	20	1,700
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	0
Water Chiller	7	104	-	-	-	-	165	-	-	-	89	-	365
CAV to VAV	73	-	-	-	-	-	-	-	-	-	-	-	73
Cooling Tower	20	35	-	-	-	-	79	-	-	-	-	-	134
Retrofit Efficiency Options Total	100	140	0	0	0	0	243	0	0	0	89	0	572
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	0
High Efficiency Chiller	342	-	-	-	-	-	-	-	-	-	-	-	342
Energy Management System	-	-	-	-	-	-	-	-	-	-	-	-	0
Other Customized Incentives Measures	554	-	-	35	-	-	11	-	63	98	-	-	761
Customized Incentives Total	896	0	0	35	0	0	11	0	63	98	0	0	1,103
Total	1,700	271	31	150	32	66	433	173	98	143	259	20	3,376

Overall, Exhibits 4-5 and 4-6 show reductions of 15 percent from ex post program energy impacts and 20 percent from demand impacts (when compared to Exhibits 4-1 and 4-2, gross impacts), as a result of the application of the NTG adjustments presented in Exhibit 4-4. Since spillover was not claimed for any segment, all the individual technology/business segment net impacts are less than the corresponding gross impact. Moreover, the relatively narrow range of NTG estimates described above yields a distribution of impacts among segments that is similar to the distribution of gross impacts.

On a net basis, variable speed drives for HVACs are still the dominant measure and offices are still the dominant business segment for energy impacts. The above-average NTG ratio for VSDs helped boost the relative importance of this technology from 32.6 percent to 33.9 percent of total HVAC energy impacts.

For demand, net impacts show a larger reduction compared to gross because of the lack of demand impacts associated with VSD HVAC fans, the technology with the highest NTG ratio. Similarly, two measures that contributed 28 percent of gross demand impacts (RE/REO chillers and reflective window film) had the lowest NTG ratios in the program.

Exhibit 4-7
Ex Post Net Therm Impacts
By Business Type and Technology Group
HVAC Technologies Paid in 1995

Business Type / Program and Technology Group	Commercial HVAC First-Year Therm Impacts												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	61,206	-	-	324,155	-	-	510,429	7,965	525	-	-	-	904,281
Other Customized Incentives Measures	563,307	-	20,240	24,532	-	-	225,380	-	164	-	11,446	7,040	852,108
Customized Incentives Total	624,513	0	20,240	348,687	0	0	735,809	7,965	689	0	11,446	7,040	1,756,389
Total	624,513	0	20,240	348,687	0	0	735,809	7,965	689	0	11,446	7,040	1,756,389

Net therm impacts, summarized in Exhibit 4-7, differ from the gross therm impacts presented in Exhibit 4-3 by 15.6 percent, reflecting the 0.85 NTG ratio applied to all Customized Incentives measures.

4.4 REALIZATION RATES

Exhibits 4-8 through 4-13 present the gross and net realization rates for energy, demand, and therm impacts for the RE, REO, and Customized Incentives HVAC technologies.

4.4.1 Gross Realization Rates for Energy Impacts

The gross energy realization rates are presented in Exhibit 4-8. These values represent, by segment, the ratio of the ex post gross impact evaluation findings to the gross ex ante program design estimates. These realization rates illustrate how well the ex ante estimates predicted energy savings, before taking into account customer behavioral effects, both inside and outside the program.

Exhibit 4-8
Gross Energy Impact Realization Rates
By Business Type and Technology Group
HVAC Technologies Installed in 1995

Business Type / Program and Technology Group	Gross Energy Realization Rates												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	1.07	2.33	1.33	1.06	3.53	1.81	0.68	1.76	4.58	1.59	1.01	1.25	1.24
Variable Speed Drive HVAC Fan	2.41	2.61	2.97	1.58	4.97	-	3.60	6.20	2.68	2.54	-	2.82	2.61
Package Terminal A/C	0.90	1.07	0.82	0.84	-	0.83	0.86	0.86	0.90	-	1.03	-	0.86
Programmable Thermostat	0.00	0.84	2.29	0.67	1.43	1.02	0.87	1.20	1.04	1.17	1.06	0.38	0.48
Reflective Window Film	0.95	0.95	0.99	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.90	0.95	0.94
Water Chiller	6.05	3.98	-	3.30	-	-	-	-	-	-	3.52	-	2.07
Other RE Measures	1.23	-	-	0.53	0.42	0.40	0.51	0.42	-	0.42	0.42	-	0.56
Retrofit Express Total	0.97	2.33	2.41	0.74	1.70	1.18	0.84	1.04	1.31	2.16	0.96	0.87	1.34
Retrofit Efficiency Options Program													
Variable Frequency Drive	0.54	0.53	0.79	-	-	-	-	-	-	-	-	-	0.64
Water Chiller	0.12	1.14	-	-	-	-	1.69	-	-	-	1.60	-	0.91
CAV to VAV	0.65	-	-	-	-	-	-	-	-	-	-	-	0.65
Cooling Tower	1.05	0.79	-	-	-	-	0.73	-	-	-	-	-	0.77
Retrofit Efficiency Options Total	0.52	0.97	0.79	-	-	-	1.44	-	-	-	1.60	-	0.74
Customized Incentives Program													
HVAC Variable Speed Drive	1.60	-	-	-	1.16	-	1.90	1.90	-	-	0.98	-	1.38
High Efficiency Chiller	1.32	-	-	-	-	-	-	-	-	-	-	-	1.32
Energy Management System	1.03	-	1.03	0.93	1.03	-	1.03	1.03	1.03	1.03	-	-	0.99
Other Customized Incentives Measures	0.65	-	0.65	0.65	-	-	0.65	-	0.65	0.65	0.65	-	0.65
Customized Incentives Total	0.84	-	0.88	0.90	1.11	-	0.90	1.24	0.66	0.67	0.87	-	0.87
Total	0.81	2.02	1.09	0.86	1.16	1.18	0.95	1.17	0.98	1.11	1.00	0.87	0.98

Overall, Exhibit 4-8 shows that the ex ante estimates are very close to the ex post gross energy impact estimates for the program overall, but that the realization rate varies across programs. The high realization rate for RE measures can be attributed in part to the 1.9 SAE coefficient estimated for the high-impact VSD HVAC fan segment (the effects of this same realization rate on HVAC VSDs in the Customized Incentives Program were offset by the low SAE coefficient on "Other Customized Incentives measures").

The technology group results presented in Exhibit 4-8 are explained below (using information from the review of the ex ante estimates in conjunction with the impact analysis results.)

Programmable Thermostats - This technology group, which includes time clocks and bypass timers as well as setback programmable thermostats, had the lowest gross energy realization rate of any measure. In addition to using a single climate zone, the ex ante estimates used an incorrect return air value to determine the heating and cooling loads during setback hours (Please see *Appendix B, Section B.6 for more detail*). While the engineering estimate of energy impacts was

15 percent lower than the ex ante savings number, the key to the low realization rate for this technology is the zero SAE coefficient applied to the engineering estimate of savings in the office segment, which accounted for 40 percent of the ex ante energy savings from programmable thermostats. As noted earlier, the SAE coefficient was statistically insignificant and the wrong sign for this technology/business segment combination, so a conservative estimate of zero impact was assigned.

Central Air Conditioners - The gross realization rate of 1.24 for central air conditioners is the result of several changes relative to the ex ante impacts. First, engineering impacts were found to be much lower than the ex ante estimates. This reflected the use of a single climate zone in the ex ante estimates and seven distinct climate zones in the evaluation analysis. (A substantial number of HVAC installations were in the San Francisco Bay area, where cooling requirements are relatively low, thereby reducing energy impacts for these sites.) Conversely, the billing analysis of central air conditioner sites found realized energy impacts that were more than twice the engineering estimates, thereby more than offsetting the engineering reduction. Since the engineering estimate was based on self-reported hours of cooling system operation, it is likely that actual hours of operation exceed those reported by survey respondents. This would explain the high SAE coefficient.

Variable Speed Drives - HVAC applications of VSDs by RE participants showed the highest gross energy realization rate of any technology. The evaluation analysis of VSD impacts used a consistent, per-horsepower approach across programs and applied the multiple climate zones described above. The engineering estimates of impacts for RE VSDs were about 35 percent higher than the ex ante estimates; for VSDs installed through the REO and Customized Incentives programs, energy impacts were 30 and 60 percent, respectively, below the ex ante estimates. Since the RE ex ante VSD impacts were based on DOE-2 simulations that were not available for review, specific reasons for the higher RE engineering estimates could not be identified. In addition, the SAE coefficient for this technology indicates that realized impacts were almost twice as high as the engineering estimates. The most likely explanation for this high SAE coefficient is that many HVAC systems are oversized, and therefore run at less than full load even during peak hours. As a result, they generate greater energy savings than suggested by the engineering estimates, which assume no savings from VSDs during peak hours.

Water Chillers - As with VSDs, the evaluation approach used to generate ex post energy impacts for chillers was applied to this technology in a consistent manner across programs. Seven different climate zones were used (rather than the single climate zone assumed for the ex ante estimate). In addition, ex post impacts were calculated on a per ton basis, using data collected from a review of program applications, rather than per square foot. For REO chillers, the engineering analysis led to sharply lower impacts; for Customized Incentives program chillers, impact increased. In total, engineering estimates were approximately 15 percent below the ex ante energy savings. The SAE analysis showed realized impacts to be 58 percent higher than the engineering estimate for RE and REO chillers, contributing to an overall gross realization rate of 1.09 for all chillers.

Reflective Window Film - As indicated by the gross realization rate, gross ex post energy savings for this measure were 5.5 percent below the ex ante estimates. The ex post impact is lower for two reasons: first, a review of the inputs to the ex ante calculation revealed a discrepancy between the annual solar heat gains listed in ASHRAE and those used in the calculation, which led to engineering estimates that were a few percent higher than the ex ante estimates. Second, the subsequent application of the SAE coefficient of 0.90 reduced the evaluation estimate to its final value.

Energy Management Systems - For energy management systems, a review of individual Customized Incentives Program applications yielded engineering impacts that were 3 percent below the ex ante estimates, as detailed in Appendix B. This reduction was effectively offset by the SAE coefficient of 1.03, resulting in a 0.99 gross realization rate.

Other Customized Incentives Measures - Based on a statistically significant coefficient of 0.65 on the estimated energy savings for a sample of "other Customized measures" sites included in the billing analysis, this SAE coefficient was applied to the savings estimates for all "other Customized" premises. The result is a conservative estimate of gross energy impacts and a gross realization rate that is equal to the SAE coefficient.

4.4.2 Gross Realization Rates for Demand Impacts

Gross demand realization rates are presented in Exhibit 4-9. These values represent, by segment, the ratio of the ex post gross impact evaluation findings to the gross ex ante program design estimate. These realization rates illustrate how well the ex ante estimates predicted demand savings, before taking into account customers' actions within the HVAC market.

Exhibit 4-9
Gross Demand Impact Realization Rates
By Business Type and Technology Group
HVAC Technologies Paid in 1995

Business Type / Program and Technology Group	Gross Demand Realization Rates												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	1.08	1.06	1.00	0.30	1.06	1.06	1.11	0.97	1.02	1.08	0.97	0.97	0.88
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	1.16	1.11	0.89	0.31	-	1.06	1.13	0.97	1.07	-	1.10	-	0.81
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	0.46	0.45	0.43	0.13	0.45	0.46	0.47	0.41	0.43	0.46	0.39	0.42	0.45
Water Chiller	4.49	1.70	-	0.12	-	-	-	-	-	-	1.84	-	0.83
Other RE Measures	1.68	-	-	0.14	0.44	0.61	0.49	0.33	-	0.41	0.37	-	0.52
Retrofit Express Total	0.77	1.01	0.61	0.24	0.64	0.91	0.60	0.75	0.69	0.74	0.72	0.72	0.66
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	0.01	0.44	-	-	-	-	1.17	-	-	-	0.76	-	0.38
CAV to VAV	1.00	-	-	-	-	-	-	-	-	-	-	-	1.00
Cooling Tower	1.27	0.96	-	-	-	-	3.02	-	-	-	-	-	1.70
Retrofit Efficiency Options Total	0.15	0.50	-	-	-	-	1.41	-	-	-	0.76	-	0.48
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	0.86	-	-	-	-	-	-	-	-	-	-	-	0.86
Energy Management System	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Customized Incentives Measures	0.46	-	-	0.52	-	-	0.52	-	0.67	1.00	-	-	0.52
Customized Incentives Total	0.55	-	-	0.32	-	-	0.28	-	0.67	1.00	-	-	0.53
Total	0.54	0.65	0.58	0.25	0.47	0.91	0.87	0.57	0.68	0.90	0.69	0.72	0.58

Overall, the gross demand estimates are 32 percent lower than the ex ante values, as presented in Exhibit 4-9. Demand results are explained using information from review of the ex ante estimates and the evaluation engineering analyses. Specific comments and justifications for the results are as follows:

Central Air Conditioners - For central air conditioners, as well as for package terminal air conditioning units, the evaluation calculated demand impacts based upon the observed peak period duty cycle; that is, the percentage of the time that an operating system was running during the peak hour, as gathered from EUM data. This was multiplied by the self-reported peak hour operating factor for each premise to create a customer-specific CDF that could be multiplied by the connected load. Because this process led to a lower CDF than assumed by the ex ante estimate, the gross realization rates are less than 1.0

Reflective Window Film - the low gross demand realization rate for this measure can be attributed to an error in the calculation of ex ante demand impacts, where peak per-square-foot heat gains were summed rather than averaged. This finding and the revised method used to generate the evaluation impact estimates are detailed in *Appendix B, Section B.6*.

Water Chillers - In the engineering analysis for chillers, data collected during on-site visits were used to determine peak loading factors, which were then multiplied by the site-specific operating factor for the peak hour. The resulting ex post estimates were generally close to the ex ante estimates for RE and Customized Incentives chiller installations, but were much lower for the REO chillers. This was the result of a single installation in the office business segment, where the program chiller had been installed specifically to meet off-peak cooling load and had no impact at the time of peak.

4.4.3 Gross Realization Rates for Therm Impacts

Gross therm realization rates are presented in Exhibit 4-10. The slight difference between the ex ante and ex post values is reflected in the realization rate of 1.00. Based upon the review of Customized Incentives applications, minor changes were made to the impact calculations for "other Customized Incentives measures" installed in the office segment.

Exhibit 4-10
Gross Therm Impact Realization Rates
By Business Type and Technology Group
HVAC Technologies Paid in 1995

Program and Technology Group \ Business Type	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
	Gross Therm Realization Rates												
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	1.00	-	-	1.00	-	-	1.00	1.00	1.00	-	-	-	1.00
Other Customized Incentives Measures	1.00	-	1.00	1.00	-	-	1.00	-	1.00	-	1.00	1.00	1.00
Customized Incentives Total	1.00	-	1.00	1.00	-	-	1.00	1.00	1.00	-	1.00	1.00	1.00
Total	1.00	-	1.00	1.00	-	-	1.00	1.00	1.00	-	1.00	1.00	1.00

4.4.4 Net Realization Rates

Because of the differences between the ex ante and the ex post estimates of the NTG adjustment, the net realization rates are generally 15-20 percent higher than the gross realization rates. The ex ante estimate of NTG was 0.67 for RE and REO measures and 0.75 for Customized Incentives measures. As shown in Exhibit 4-4 above, the ex post NTG estimates vary between 0.70 and 0.94, depending on the technology, resulting in an overall NTG of 0.85 for energy and 0.82 for demand.

The net realization rates by segment are presented for energy in Exhibit 4-11, for demand in Exhibit 4-12, and for therms in Exhibit 4-13. These values represent, by segment, the ratio of net impact evaluation findings to the net ex ante program design estimates. The realization rates illustrate how well the ex ante estimates predict savings, after taking into account customers' actions within the HVAC market. A comparison of ex ante and ex post impacts are presented in Exhibit 4-14 at the end of this section.

Exhibit 4-11
Net Energy Impact Realization Rates
By Business Type and Technology Group

Business Type / Program and Technology Group	Net Energy Realization Rates												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	1.33	2.90	1.65	1.32	4.40	2.25	0.85	2.20	5.71	1.98	1.25	1.56	1.55
Variable Speed Drive HVAC Fan	3.23	3.49	3.98	2.11	6.65	-	4.82	8.31	3.59	3.40	-	3.78	3.49
Package Terminal A/C	1.27	1.51	1.16	1.18	-	1.17	1.21	1.20	1.27	-	1.44	-	1.21
Programmable Thermostat	0.00	1.01	2.76	0.81	1.73	1.23	1.04	1.44	1.25	1.40	1.27	0.46	0.58
Reflective Window Film	0.99	0.99	1.04	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.94	0.99	0.98
Water Chiller	6.32	4.16	-	3.45	-	-	-	-	-	-	3.68	-	2.17
Other RE Measures	1.61	-	-	0.69	0.55	0.53	0.66	0.54	-	0.54	0.55	-	0.73
Retrofit Express Total	1.20	3.07	3.15	0.91	2.13	1.44	1.02	1.34	1.58	2.85	1.13	1.08	1.70
Retrofit Efficiency Options Program													
Variable Frequency Drive	0.70	0.70	1.03	-	-	-	-	-	-	-	-	-	0.83
Water Chiller	0.13	1.19	-	-	-	-	1.76	-	-	-	1.68	-	0.95
CAV to VAV	0.85	-	-	-	-	-	-	-	-	-	-	-	0.85
Cooling Tower	1.37	1.04	-	-	-	-	0.95	-	-	-	-	-	1.01
Retrofit Efficiency Options Total	0.68	1.06	1.03	-	-	-	1.56	-	-	-	1.68	-	0.89
Customized Incentives Program													
HVAC Variable Speed Drive	1.82	-	-	-	1.32	-	2.17	2.17	-	-	1.11	-	1.58
High Efficiency Chiller	1.50	-	-	-	-	-	-	-	-	-	-	-	1.50
Energy Management System	1.17	-	1.17	1.06	1.17	-	1.17	1.17	1.17	1.17	-	-	1.13
Other Customized Incentives Measures	0.74	-	0.74	0.74	-	-	0.74	-	0.74	0.74	0.74	-	0.74
Customized Incentives Total	0.96	-	1.00	1.03	1.26	-	1.02	1.41	0.76	0.76	0.99	-	0.99
Total	0.96	2.61	1.30	1.00	1.33	1.44	1.08	1.39	1.14	1.33	1.13	1.08	1.16

Exhibit 4-12
Net Demand Impact Realization Rates
By Business Type and Technology Group

Business Type / Program and Technology Group	Net Demand Realization Rates												
	Office	**Retail**	**College/ University**	**School**	**Grocery**	**Restaurant**	**Health Care**	**Hotel/Motel**	**Warehouse**	**Personal Service**	**Community Service**	**Misc.**	**Total**
Retrofit Express Program													
Central A/C	1.34	1.33	1.24	0.37	1.32	1.32	1.38	1.20	1.27	1.35	1.21	1.21	1.10
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	1.64	1.56	1.25	0.43	-	1.50	1.59	1.37	1.50	-	1.54	-	1.13
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	0.48	0.47	0.45	0.13	0.46	0.48	0.49	0.43	0.45	0.48	0.41	0.44	0.47
Water Chiller	4.69	1.77	-	0.12	-	-	-	-	-	-	1.93	-	0.87
Other RE Measures	2.19	-	-	0.19	0.58	0.79	0.64	0.43	-	0.54	0.49	-	0.68
Retrofit Express Total	0.91	1.21	0.71	0.30	0.77	1.14	0.75	1.01	0.81	0.89	0.87	0.86	0.80
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	0.02	0.46	-	-	-	-	1.22	-	-	-	0.79	-	0.39
CAV to VAV	1.31	-	-	-	-	-	-	-	-	-	-	-	1.31
Cooling Tower	1.66	1.25	-	-	-	-	3.95	-	-	-	-	-	2.23
Retrofit Efficiency Options Total	0.19	0.55	-	-	-	-	1.57	-	-	-	0.79	-	0.54
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	0.98	-	-	-	-	-	-	-	-	-	-	-	0.98
Energy Management System	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Customized Incentives Measures	0.53	-	-	0.59	-	-	0.59	-	0.76	1.14	-	-	0.59
Customized Incentives Total	0.63	-	-	0.37	-	-	0.32	-	0.76	1.14	-	-	0.61
Total	0.62	0.74	0.67	0.31	0.56	1.14	1.01	0.76	0.78	1.05	0.79	0.86	0.68

Exhibit 4-13
Net Therm Impact Realization Rates
By Business Type and Technology Group

Program and Technology Group \ Business Type	Net Therm Realization Rates												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	1.14	-	-	1.14	-	-	1.14	1.14	1.14	-	-	-	1.14
Other Customized Incentives Measures	1.14	-	1.14	1.14	-	-	1.14	-	1.14	-	1.14	1.14	1.14
Customized Incentives Total	1.14	-	1.14	1.14	-	-	1.14	1.14	1.14	-	1.14	1.14	1.14
Total	1.14	-	1.14	1.14	-	-	1.14	1.14	1.14	-	1.14	1.14	1.14

Overall, given the difference between the ex ante and ex post NTG adjustment factors discussed above, it is not surprising that the net realization rates are greater than the gross realization rates presented earlier.

Most of the results presented in Exhibit 4-11 to 4-13 can be explained using information from the review of the ex ante estimates and the evaluation engineering and billing regression analyses, as discussed under the review of the gross realization rates. Most of the comments discussed in relation to the gross realization rate estimates apply to the net realization rates.

Net Energy Impacts - The net realization rate for HVAC measures overall is 1.16, even though the net realization rate is less than 1.0 for REO and essentially equal to 1.0 for Customized measures. The 1.7 realization rate for the RE program is a result of the very high realization rates (both net and gross) for VSD HVAC fans, which in turn reflect the SAE coefficient of 1.9.

Net Demand Impacts - Despite the higher ex post than ex ante NTG ratios, the demand realization rate is less than 1.0 for all programs. This is because of the low ex post gross demand results discussed earlier.

Net Therm Impacts - The net therm realization rate is simply the result of applying higher ex post NTG ratio than as assumed in the ex ante calculations.

4.5 OVERVIEW OF REALIZATION RATES

In summary, while the ex post demand impacts are lower than predicted because of several measure-specific problems with inputs to or calculations of ex ante impact estimates, the overall net energy impacts are 16 percent higher than predicted by the ex ante net estimates. This realization rate is well documented and supportable based on the information developed during the evaluation. Appendix B presents a more detailed analysis of the engineering computational methods used.

Exhibit 4-14 summarizes all of the gross and net energy, demand and therm impacts discussed above. Results are also presented for the net to gross adjustments and the realization rates.

Exhibit 4-14
Commercial HVAC Impact Summary By Technology Group

Business Type / Program and Technology Group	Gross Program Impact kWh	Gross Program Impact kW	Gross Program Impact Therm	NTG Adjustment (1-FR)	NTG Adjustment Spillover	Net Program Impact kWh	Net Program Impact kW	Net Program Impact Therm
EX ANTE								
Retrofit Express Program								
Central A/C	1,462,731	1,153	-	0.57	0.10	980,030	773	-
Variable Speed Drive HVAC Fan	4,384,022	-	-	0.57	0.10	2,937,294	-	-
Package Terminal A/C	264,071	263	-	0.57	0.10	176,928	176	-
Programmable Thermostat	4,250,762	-	-	0.57	0.10	2,848,009	-	-
Reflective Window Film	2,604,815	1,116	-	0.57	0.10	1,745,225	748	-
Water Chiller	107,456	88	-	0.57	0.10	71,995	59	-
Other RE Measures	959,422	557	-	0.57	0.10	642,874	373	-
Retrofit Express Total	14,033,280	3,178	-	0.57	0.10	9,402,355	2,129	-
Retrofit Efficiency Options Program								
Variable Frequency Drive	1,573,383	23	-	0.57	0.10	1,054,166	15	-
Water Chiller	2,203,943	1,385	-	0.57	0.10	1,476,641	928	-
CAV to VAV	2,654,240	83	-	0.57	0.10	1,778,340	56	-
Cooling Tower	256,821	90	-	0.57	0.10	172,070	60	-
Retrofit Efficiency Options Total	6,688,386	1,581	-	0.57	0.10	4,481,217	1,059	-
Customized Incentives Program								
HVAC Variable Speed Drive	3,334,954	76	-	0.65	0.10	2,501,216	57	-
High Efficiency Chiller	1,185,146	468	-	0.65	0.10	888,860	351	-
Energy Management System	10,633,984	147	1,058,877	0.65	0.10	7,975,490	110	794,158
Other Customized Incentives Measures	16,014,131	1,727	998,846	0.65	0.10	12,010,601	1,295	749,135
Customized Incentives Total	31,168,215	2,417	2,057,723	0.65	0.10	23,376,167	1,813	1,513,292
Total	51,889,884	7,176	2,057,723	0.62	0.10	37,259,739	5,001	1,543,292
EX POST								
Retrofit Express Program								
Central A/C	1,816,527	1,016	-	0.84	0.00	1,516,800	848	-
Variable Speed Drive HVAC Fan	11,440,318	-	-	0.90	0.00	10,261,960	-	-
Package Terminal A/C	226,144	212	-	0.94	0.00	213,253	200	-
Programmable Thermostat	2,046,708	-	-	0.81	0.00	1,651,693	-	-
Reflective Window Film	2,457,926	499	-	0.70	0.00	1,718,090	349	-
Water Chiller	222,787	73	-	0.70	0.00	155,951	51	-
Other RE Measures	535,124	288	-	0.88	0.00	468,766	252	-
Retrofit Express Total	18,745,534	2,088	-	0.85	0.00	15,986,522	1,700	-
Retrofit Efficiency Options Program								
Variable Frequency Drive	1,001,806	0	-	0.88	0.00	877,582	0	-
Water Chiller	2,000,905	522	-	0.70	0.00	1,400,633	365	-
CAV to VAV	1,733,726	83	-	0.88	0.00	1,518,744	73	-
Cooling Tower	198,091	153	-	0.88	0.00	173,528	134	-
Retrofit Efficiency Options Total	4,934,528	758	-	0.80	0.00	3,970,487	572	-
Customized Incentives Program								
HVAC Variable Speed Drive	4,616,483	0	-	0.85	0.00	3,942,476	0	-
High Efficiency Chiller	1,560,525	401	-	0.85	0.00	1,332,688	342	-
Energy Management System	10,558,827	0	1,058,877	0.85	0.00	9,017,238	0	904,281
Other Customized Incentives Measures	10,460,286	891	997,785	0.85	0.00	8,933,084	761	852,108
Customized Incentives Total	27,196,121	1,292	2,056,662	0.85	0.00	23,225,487	1,103	1,756,389
Total	50,876,182	4,138	2,056,662	0.85	0.00	43,182,490	3,376	1,756,389
REALIZATION RATES								
Retrofit Express Program								
Central A/C	1.24	0.88	-	-	-	1.55	1.10	-
Variable Speed Drive HVAC Fan	2.61	-	-	-	-	3.49	-	-
Package Terminal A/C	0.86	0.81	-	-	-	1.21	1.13	-
Programmable Thermostat	0.48	-	-	-	-	0.58	-	-
Reflective Window Film	0.94	0.45	-	-	-	0.98	0.47	-
Water Chiller	2.07	0.83	-	-	-	2.17	0.87	-
Other RE Measures	0.56	0.52	-	-	-	0.73	0.68	-
Retrofit Express Total	1.34	0.66	-	-	-	1.70	0.80	-
Retrofit Efficiency Options Program								
Variable Frequency Drive	0.64	0.00	-	-	-	0.83	0.00	-
Water Chiller	0.91	0.38	-	-	-	0.95	0.39	-
CAV to VAV	0.65	1.00	-	-	-	0.85	1.31	-
Cooling Tower	0.77	1.70	-	-	-	1.01	2.23	-
Retrofit Efficiency Options Total	0.74	0.48	-	-	-	0.89	0.54	-
Customized Incentives Program								
HVAC Variable Speed Drive	1.38	0.00	-	-	-	1.58	0.00	-
High Efficiency Chiller	1.32	0.86	-	-	-	1.50	0.98	-
Energy Management System	0.99	0.00	1.00	-	-	1.13	0.00	1.14
Other Customized Incentives Measures	0.65	0.52	1.00	-	-	0.74	0.59	1.14
Customized Incentives Total	0.87	0.53	1.00	-	-	0.99	0.61	1.14
Total	0.98	0.58	1.00	-	-	1.16	0.68	1.14

5. RECOMMENDATIONS

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

5.1 EVALUATION METHODS

The evaluation team offers the following comments and recommendations regarding methods used in the 1995 evaluation:

Calculation of Ex Ante Impacts - As part of the 1995 HVAC Evaluation, an attempt was made to reproduce the Retrofit Express (RE) Program impacts found in the MDSS. This resulted in several observations where ex ante impact methods were misapplied. Such errors could probably be avoided in the future with a regular and thorough review of the MDSS contents by the program manager or a qualified analyst. MDSS staff who currently review the MDSS records may not be trained in the technology-specific details that are essential to conducting meaningful quality checks.

Revisions to the Ex Ante Impact Methods - All ex ante algorithms for RE and REO HVAC measures paid in 1995 were thoroughly reviewed. Where necessary, these methods were updated using alternate methods or assumptions, as described in detail in *Appendix B*. It is recommended that PG&E carefully review the updates to these algorithms, and apply those updates to future Advice Filings.

Multiple Account Records - Application records are currently stored in the MDSS based on the PG&E control number, which is in turn linked to a particular account. Premises (an entire building or even multiple buildings with a single address) are often retrofit, but records are not available that adequately link each retrofit to the total sample of accounts affected. Billing regression analyses and other calibrated engineering models which incorporate this information may be adversely affected, since the observed usage is inconsistent with the measure and number of units retrofit. PG&E may be able to more thoroughly reconcile each retrofit in the MDSS with all customer accounts.

Demand Impact information for VSD Measures - Very large impacts were observed for the Variable Speed Drive measures installed under the program. For both the ex ante and engineering estimates, the assumption is made that at peak loads there is zero demand impact since the VSD is operating at 100 percent load. If the existing fans are oversized, there will indeed be a demand impact since the VSD will only operate the fan at the level required to meet space conditioning needs. This would also result in greater predicted energy savings since the VSD is operating below the curve it was calibrated to. Future evaluation activities should include the collection of frequency as well as demand data to better determine the peak level ofd VSD operation.

Impact Estimates Based on Conditioned Square Feet - Some ex ante algorithms make use of the facility conditioned square feet to represent the installed system capacity instead of a more reliable engineering figure. This is especially true within the REO program, where chiller retrofits, cooling tower retrofits, air handler variable frequency drive retrofits, and boiler retrofits are all based in part upon the facility square footage. Quality checks using engineering and industry rules, such as tons per square foot, should be implemented to ensure realistic impacts, or a more reliable method of computing impact estimates should be developed.

5.2 *MEASURES OFFERED*

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

Energy Management Systems are an effective means of reducing energy consumption, but require a knowledgeable operator to achieve those savings. EMSs used to monitor and control complicated HVAC plants require significant operator input, ideas, and operational decisions to achieve savings. EMSs cannot be expected to save energy without adequate system commissioning. PG&E should require commissioning for these systems (or other complicated measures) and offer incentives based on a performance contract. On-site investigations conducted as part of this evaluation effort have shown that performance contracts are an effective means of ensuring savings from installation of a particular system.

Application Engineering Review is a necessary component of the submittal process, and can be used to effectively screen applications that have significant analysis errors. In some instances, large errors were observed in the Customized Incentives applications submitted, resulting in inaccurate reporting of project impacts. Since applications submitted for the Customized Incentives Program (or other current programs like Nonresidential New Construction and Advanced Performance Options) can result in relatively large incentives (often based on impact achieved), it is recommended that a more intensive application review be used to capture these anomalies.

Analysis of Reasonableness of Savings should be another method used to assess errors in the application savings estimates. For example, the Customized Incentives application includes this type of comparison information within Attachment 7, where measure savings are compared against both the baseline quantity used and also against total billing records for the site. However, in some instances, these valuable data do not appear to be used in an effort to reject claimed savings.

Rebates Offered for Infrequently Operated Systems - Measures are sometimes installed that are either redundant systems (in case the primary system fails or requires repair), or are strictly peaking systems (coming on-line only on rare occasions). Due to the potentially low impacts for such retrofits, PG&E should consider rejecting rebates for equipment that meet these criteria.

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

Customer Energy Efficiency Program
Measurement and Evaluation Program

EVALUATION OF PACIFIC GAS & ELECTRIC COMPANY'S 1995 NONRESIDENTIAL ENERGY EFFICIENCY INCENTIVES PROGRAM FOR COMMERCIAL SECTOR HVAC TECHNOLOGIES APPENDICES

PG&E Study ID number: 326

March 1, 1997

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EVALUATION OF PG&E'S 1995 NONRESIDENTIAL ENERGY EFFICIENCY INCENTIVES PROGRAM FOR COMMERCIAL SECTOR HVAC TECHNOLOGIES

PG&E STUDY ID#: 326

VOLUME I: ANALYSIS APPENDICES

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Appendix A
Sample Design

A. SAMPLE DESIGN

This appendix presents the sample design for the evaluation of Pacific Gas and Electric Company's (PG&E's) 1995 Nonresidential Energy Efficiency Incentive (EEI) Programs, Commercial Sector (the Commercial program). An integrated sample design was implemented for the Lighting, HVAC, and Refrigeration end uses. First, the sample design approach and resulting sample allocation are presented. This appendix then concludes with a discussion of the California Public Utilities Commission (CPUC) Evaluation and Measurement Protocols (the Protocols) requirements.

A.1 EXISTING DATA SOURCES FOR SAMPLE DESIGN

The participant tracking system for the Retrofit Express (RE), Retrofit Efficiency Options (REO), and Customized Incentives Programs is maintained as part of the PG&E Management Decision Support System (MDSS). Henceforth, the RE and REO program components are referred to as simply Retrofit. The MDSS contains program application, rebate, and technical information regarding installed measures, including measure descriptions, quantities, rebate amounts, and ex ante demand, energy and therm saving estimates. The MDSS extract used in this evaluation is consistent with data used in the PG&E Annual Earning Assessment Proceedings (AEAP) Report.

For the Retrofit and Customized Incentives programs, participation was tracked at both application and measure levels. They are linked by application code and program year. Each application can cover multiple measures and accounts, and each measure is linked to a PG&E electrical or gas service location where the measures are supposed to be installed. The account location is identified 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.

QC's existing PG&E commercial population files, assembled in support of prior evaluations, cover the period from January 1992 to September 1995. The billing series for October 1995 through September 1996 were extended only for customers in the analysis dataset. 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.

A.2 SAMPLE DESIGN OVERVIEW

The objectives of the sample design were to

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

The sample design is based upon a nested sample design approach. This approach consists of nesting samples of customer data so that the most expensive and detailed primary data can be leveraged to the population. The largest customer group includes all of the commercial customers with monthly PG&E billing data and participant tracking data who were rebated for eligible lighting, HVAC and refrigeration technologies in 1995 (the "participant population"). The smallest group is the metered (TOU loggered or end-use metered) participants, who have the most comprehensive information available. These participants have lighting logger (for the Lighting end use) or end-use metering (for the HVAC end use) data, on-site audit data, telephone survey data, participant tracking data, and billing data.

The advantage of a nested sample design is that the overlapping samples of primary data can be used to improve the accuracy of the engineering and statistical analysis for the population, rather than just for the customers for which the data are available. For example, logger and metered data are used to establish accurate measures of operating hours by key business types that are then used to improve the reliability of estimates for all customers in the survey sample.

A.3 SAMPLE SEGMENTATION

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

The first step in the participant segmentation process grouped firms by business type, as defined in the MDSS. There are a total of 12 business types and 34 technology groups, as defined below. Exhibit A-1 presents the distribution of unique customer sites across the business type and technology group segmentation.

Annual energy consumption values were used to group customers into five usage/size strata based upon a Dalenius-Hodges procedure. The comparison group customers are then selected to mirror the underlying distribution of the participant target population by size and business type. (For the customers in the largest size strata, a census was attempted both for among participants and nonparticipants.)

Exhibit A-1
1995 Commercial Segmentation and Distribution of Unique Participant Sites

Technology	Business Type	Commercial												
		Office	Retail	College/Univ	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Serv.	Comm. Serv.	Misc.	Total
Indoor Lighting	Halogen	47	46	8	17	2	26	10	16	9	4	24	8	217
	Compact Fluorescent Lamps	323	106	19	175	38	136	107	136	36	31	156	39	1,301
	Incandescent to Fluorescent Fixture	14	2	2	16	0	12	2	7	2	0	10	5	72
	Exit Signs	175	60	10	107	18	80	35	9	11	9	73	10	596
	Efficient Ballasts Changeouts	33	20	6	26	17	6	10	3	10	2	18	5	156
	T8 Lamps and Electronic Ballasts	728	620	33	345	229	194	187	41	135	152	271	126	3,055
	Delamp Fluorescent Fixtures	280	155	14	106	58	80	42	9	42	39	48	26	898
	High Intensity Discharge	40	42	4	30	11	2	1	2	67	14	34	82	329
	Reduced Wattage Lighting	2	1	0	1	0	0	0	0	1	1	1	0	7
	Controls	113	48	15	80	10	12	29	18	25	12	52	28	442
	Customized Lighting Measures	7	1	1	0	42	0	0	0	6	0	6	1	64
	Indoor Lighting End Use Total	890	726	43	401	294	260	215	158	208	183	379	222	3,968
HVAC	Central A/C	179	65	3	49	13	38	66	7	31	25	71	14	558
	Adjustable Speed Drives	35	27	2	2	12	0	2	2	1	9	2	2	96
	Package Terminal A/C	1	1	2	8	0	2	2	42	1	0	2	0	61
	Set-Back Thermostat	90	32	2	24	3	18	19	3	16	12	39	12	269
	Reflective Window Film	90	23	6	5	11	9	33	5	22	20	25	13	262
	Water Chillers	6	4	0	1	0	0	4	0	0	0	3	0	18
	Customized EMS	10	0	2	30	5	0	7	2	1	1	0	0	58
	Customized Controls	3	0	1	1	0	0	1	0	0	1	2	0	9
	Chiller Optimization	1	0	0	0	0	0	1	0	0	0	0	0	2
	Convert to VAV	3	0	0	1	0	0	2	0	0	0	0	0	6
	Other Customized Equipment	3	0	0	0	0	0	5	0	1	0	0	0	9
	Other HVAC Technologies	19	2	0	10	3	3	8	1	3	1	4	1	55
	HVAC End Use Total	354	123	17	114	43	53	123	59	59	57	116	34	1,149
Refrigeration	Customized Measures	1	0	0	0	61	0	0	0	1	0	0	5	68
	Standardized Measures	13	75	3	4	193	208	2	6	10	1	18	12	545
	Refrigeration End Use Total	14	75	3	4	253	208	2	6	11	1	18	17	612
Misc.	Outdoor Lighting	87	47	12	101	19	22	35	30	35	16	72	42	518
	Energy Efficient Motors	19	4	4	2	3	0	9	1	6	3	6	23	80
	Heat Recovery & Hot Water	0	0	1	0	1	1	0	1	0	1	2	0	7
	AG Pumping	1	0	0	0	0	0	0	0	0	2	1	13	17
	AG Other	0	0	0	0	0	0	0	0	1	0	0	1	2
	Cooking Equipment	4	2	0	12	29	50	1	4	2	0	3	0	107
	Non-Process Boilers	0	0	1	0	0	0	2	0	0	0	2	0	5
	Process Boilers	0	0	0	0	0	1	0	0	1	1	1	0	4
	Process	2	0	0	0	0	0	0	0	2	2	2	15	23
	Misc. End Uses Total	113	53	15	112	52	73	46	36	46	23	88	90	747
Program Total		1,231	869	61	518	544	558	336	218	289	239	528	321	5,694

Data Source: 1995 PG&E Frozen MDSS Database Received on July 25 1996.

A.4 TECHNOLOGY SEGMENTATION

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

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

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

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

The technology segmentation presented in Exhibit A-1 shows the highest level of segmentation, at the measure level for all end uses in the commercial sector. While the engineering analysis was conducted at the measure level, the statistical billing data analysis was conducted at a much coarser level, that is, at the technology-group level or at an even higher level of aggregation.

A.5 SAMPLE FRAME

The first step in sample design is to determine the sampling frame. In general, the sampling frame includes only those customers who are program participants, or likely targets of the program, rather than all customers in the population. It sets the stage for all data collection activities that follow, and determines the availability of billing data for the remainder of the analysis.

In this evaluation, different analyses (e.g., impact analysis, free-rider analysis, and spillover analysis) use different sampling frames, which are defined by analyzing what possible actions a customer in PG&E's service territory could have taken during the study period. This classification provides the basis for the sample design. Without this kind of control, the Statistically Adjusted Engineering (SAE) analysis change model cannot be estimated, since nonprogram-induced changes cannot be separated from changes between periods attributable to other factors, such as weather and economic trends.

A.6 PARTICIPANT SAMPLE FRAME

This section details the reduction of the eligible participant population to a sample frame suitable for impact analysis. None of the criteria used to screen the sample are believed to have adverse impacts on the sample representativeness; therefore, the screening criteria preserve the transferability of the impact results to the population.

The final participant sample frame for the Lighting and HVAC end uses consists of 2,560 commercial customers drawn from the eligible population of 5,694 program participants paid in 1995. In addition, there were 322 pretest and 78 multisite participants that were added to the 2,560 unique sites to form the final fielding sample frame. Criteria considered in the assessment of the quality of participant account billing data are as follows:

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

Quality of usage readings for the customer for the period of January 1993 through September 1995: Customers are required to have non-missing, non-zero usage values for all months spanned by the billing data. Customers are also required to have realistic PG&E revenues for the period. Realistic revenues are defined as revenues of at least $0.03 per kWh, but no greater than $0.25 per kWh.

Cohesion of billing data across years: The original billing data was received by year, i.e., the billing data for each calendar year was stored on a separate data tape. Data from different billing tapes was checked to ensure that the first month on each tape was immediately after the last month of the previous year's tape.

PG&E division representative deletion requests: Lists of customers in the sample frame were sent to the appropriate PG&E division representative for approval. Based upon responses from the representatives, some customers were deleted from the sample frame.

Reasonable usage across years and populated telephone numbers: Accounts are screened to ensure that the mean usage on the account for 1994 and 1995 is no more than twice (or less than half) the mean usage on the account for 1993 and 1994, respectively. Accounts are also screened to ensure they have reasonable phone numbers, and any accounts with no telephone number, or zeros in place of a number, are rejected from the sample frame.

For the Refrigeration end use, the entire participant sample was drawn for the sample frame because only 612 participant sites were available.

A.7 COMPARISON GROUP SAMPLE FRAME

The comparison group sample frame consists of 4,153 commercial customers drawn from the eligible population of 801,561 nonparticipants (Lighting and HVAC end uses) in the Commercial program. Since comparison group surveys were conducted only for customers in the commercial sector, the first step in creation of the sample frame is to limit eligibility to only those accounts having SIC codes representing commercial business activities. Note that similar screen criteria were used:

- Excessive changes in usage between 1993 and 1994 billing years: Accounts are screened to ensure that the mean usage on the account for 1994 and 1995 is no more than twice (or less than half) the mean usage on the account for 1993 and 1994, respectively.

- Geographic location of customers: Accounts are screened to insure that they fall within the geographic regions targeted for comparison group telephone survey and on-site survey data collection.

In drawing the sample frame, targets are established for each business type and usage segment, so that the sample frame distribution, by business type and usage segment, is the same as that of the surveyed program participant population. The drawing is conducted in this manner to ensure sufficient representation of each business type/usage segment combination in the sample frame and allow survey data collection in accordance with the sample design.

For the Refrigeration end use, a supplemental nonparticipant sample frame consisting 836 customers divided among small grocery (574), supermarkets (154), agricultural preparation (65), and refrigerated warehouses (43) was drawn to supplement the Lighting and HVAC comparison group.

Finally, the canvass survey sample frame of 6,000 is drawn randomly from a frame of 172,354 customers based upon geographic targets for this survey.

A.8 SAMPLE ALLOCATION APPROACH

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

The final sample sizes for the telephone, on-site, lighting logger, and end-use metering are summarized in Exhibit A-2 by end-use element.

Exhibit A-2
Data Collected by Program and End Use

Program	End Use	Commercial Telephone Surveys	On-Site Audits	End-Use Metering	Time-of-Use (TOU) Loggers	Combination
Custom	Lighting	18	1	0	0	0
	HVAC	58	32	0	0	0
	Refrigeration	7	16	0	1	1
Retrofit	Lighting	600	227	5	108	112
	HVAC	434	107	20	13	31
	Refrigeration	235	16	0	1	1
Total	Lighting	614	228	5	108	112
	HVAC	487	137	20	13	31
	Refrigeration	241	18	0	2	2
Total Participants (Unique Sites)		1,217	380	20	108	126
Total Nonparticipants (Unique Sites)		808	36	0	0	0
Total (Unique Sites)		2,025	416	20	108	126

Telephone Survey Sample - For each segment, the retrofit program sample design allocated the sample in proportion to the program-avoided cost by segment. This sample design concentrates sample points to segments that represent highest impact, in order to obtain the best estimate of impact for the largest portion of the population. In addition, a census was attempted for the largest customers. This sample allocation, combined with the random sampling techniques within each segment, produces a stratified random telephone survey sample representing the program-participant population (paid in 1995). A nonparticipant sample is developed based upon on the business type and usage strata distribution resulting from the participant sample allocation.

Telephone surveys were collected for a total of 2,025 customers, 1,217 of which are participants, and the remaining 808 are in the comparison group (451 as the original lighting and HVAC comparison group, 201 as the supplemental refrigeration comparison group, and 156 outside the program retrofitters found through the canvass survey).

On-site Audit Sample - Similar to the telephone survey sample, this sample was also structured to be approximately proportional to the program segment-level avoided cost estimates. A total of 416 on-site surveys were conducted for the commercial sector, with 380 participants and 36 comparison group customers.

Lighting Logger and End-Use Metering - This sample is not intended to be a random sample, nor strictly proportional to the program-avoided cost. The sample allocations were manipulated in order to assure adequate sample sizes for calibration of engineering models. A total of 108 and 20 participant sites were loggered or end-use metered.

A.9 RELATIVE PRECISION

Given a sample design, the relative precision, based upon total annual energy use, reflects the uncertainty regarding the extent to which the allocated sample sizes are large enough to control for the population variance in terms of annual energy usage. Precision for the telephone sample is calculated using the following procedure. First, the 1994 annual energy consumption is computed for all participants in the analysis dataset.

Next, five strata are constructed based on customers' annual usage using the Delanius-Hodges procedure. Exhibit A-3 presents the stratum-level sample size, sample weight, sample mean, and estimated standard errors for each end-use element. Note that since a census was attempted for the largest customers, participants with consumption greater than 10,000,000 kWh were excluded from this step. Overall, there were 73 participants in the population with usage at or above this level; 37 were successfully surveyed and included in the analysis dataset. (If these 37 were included in the variance calculation—using the surveyed sample—the oversampling of large customers would explode the variance far beyond that of the true variance in the population.)

Then, the program level mean and standard error are calculated using classic stratified sample techniques. [1] Finally, the relative precision at 90 percent confidence level is calculated as a two-tailed test.

By end-use element, the following relative precisions were achieved:

- For indoor lighting, the relative precision is 4.7 percent based upon a survey sample of 592. For the largest customers, 22 surveys were completed out of a participant population of 49.
- For HVAC, the relative precision is 6.0 percent based upon a survey sample of 473. For the largest customers, 14 surveys were completed out of a participant population of 21.
- For refrigeration, the relative precision is 4.6 percent based upon a survey sample of 240. For the largest customers, 1 survey was completed out of a participant population of 3.

[1] Cochran, W.G., *Sampling Techniques*, Third Edition, John Wiley & Sons, 1977. pp 91-95.

Exhibit A-3
Telephone Sample
Relative Precision Levels

LIGHTING

Weight	n	mean	Standard Error	Relative Prec.
52.8%	205	60,757	4,746	12.8%
24.5%	153	218,522	6,452	4.9%
11.5%	99	575,245	20,564	5.9%
6.9%	78	1,586,348	58,156	6.0%
4.3%	57	4,918,699	287,212	9.6%
100.0%				
TOTAL	592	471,990	13,460	4.7%
Usage > 10,000,000 kWh in 1994			49	
Surveyed			22	
TOTAL Surveyed = 614				

REFRIGERATION

Weight	n	mean	Standard Error	Relative Prec.
59.1%	168	45,814	2,759	9.9%
22.7%	41	227,111	13,980	10.1%
3.9%	13	631,164	50,908	13.3%
12.3%	12	1,533,060	55,581	6.0%
2.0%	6	4,068,986	339,006	13.7%
100.0%				
TOTAL	240	372,375	10,401	4.6%
Usage > 10,000,000 kWh in 1994			3	
Surveyed			1	
TOTAL Surveyed = 241				

HVAC

Weight	n	mean	Standard Error	Relative Prec.
53.9%	231	51,141	3,357	10.8%
19.5%	96	211,135	8,474	6.6%
10.7%	58	610,891	28,876	7.8%
10.1%	51	1,654,388	79,836	7.9%
5.7%	37	4,660,035	327,280	11.6%
100.0%				
TOTAL	473	566,376	20,647	6.0%
Usage > 10,000,000 kWh in 1994			21	
Surveyed			14	
TOTAL Surveyed = 487				

It follows that the 808 surveys that comprise the comparison group sample yield a relative precision of at least that obtained by the corresponding participant samples. Since the expected precision is based upon the annual energy usage, this does not imply that these levels of precision can be obtained for the impact analysis.

A.10 DEMONSTRATION OF PROTOCOL COMPLIANCE

A.10.1 Sampling Procedures Adopted

The sample design follows the rules established by the CPUC in the January 1995 revisions to the "Protocols and Procedures for the Verification of Costs, Benefits and Shareholder Earning from Demand Side Management Programs." Recent revisions to the Protocols—a draft dated 6/27/95—were incorporated wherever appropriate. The purpose of this section of the report is to identify compliance with these Protocols, with respect to the 1995 Commercial Sector Program Evaluation activities.

A.10.2 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.

A.10.3 Overall Sampling Procedures

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

A.10.4 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 450 contributing points in the analysis dataset. *(This was the requirement at the time of the sample design; this requirement was relaxed to 350 subsequent to the completion of the data collection activities conducted for this evaluation.)*

Data collection protocols are met regarding minimum analysis dataset size, if primary site-specific data are collected on-site, as per Table 5, part C, paragraph 4 of the Protocols. Data collection efforts are further strengthened during on-site activities through the installation of lighting loggers. These devices record specific fixture operating profiles during the monitoring period, and serve to calibrate self-reported lighting operating schedules. Data collected in this way follows the participant protocol recommendations set forth in Table C-4, paragraph 1 of the Protocols.

As discussed earlier, the sample collected for the commercial section, all end uses achieve a relative precision of at least 6 percent at a 90 percent confidence level, well below the 10 percent required by the Protocols, Table 5, part C, paragraph 4. Each participant chosen for the telephone sample is required to have at least nine months of post-installation billing data, and 12 months of pre-installation data, as per the Protocols, Table 5, part D, paragraphs 2 and 1, respectively.

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 analysis dataset meets the sample size requirement in Table 5, part C, paragraph 3. The calculated relative precision meets the precision requirement in Table 5, part C, paragraph 4. The commercial comparison group telephone sample is drawn based upon the similar distribution of participant sample, in terms of their business types and annual usage.

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 1991 to September 1996, which ensures an adequate pre- and post-installation billing periods for customers who installed applicable measures between 1993 and 1995.

Appendix B
Engineering Detailed Computational Methods

B. ENGINEERING DETAILED COMPUTATIONAL METHODS

The technical approach and engineering results that support realized gross impacts in the 1995 Pacific Gas and Electric Company (PG&E) Commercial HVAC Technologies Evaluation (Commercial HVAC Evaluation) are presented in this appendix. The purpose of a presentation of the engineering computations is to provide detailed intermediate results that either verify or contradict the methods used to generate program design demand and energy impact estimates. Results are presented to ensure that future program design and evaluation activities will benefit from the engineering parameters generated during the 1995 program evaluation effort.

B.1 APPENDIX B STRUCTURE

The appendix is structured as follows:

- First, an overview of the engineering approach is presented.
- Then, details surrounding the development of impacts for central air conditioners, variable speed drives for fans and high efficiency chillers are discussed.
- An overview of the methods used and the engineering estimates developed for other RE and REO measures is then presented.
- Next, the methods used and the engineering estimates developed for the Customized Incentives program are summarized.
- The final two sections of the appendix contain detailed calculations, assumptions, and analyses used in the development of engineering estimates, first for the RE and REO programs, then for the Customized Incentives program.

B.2 OVERVIEW OF THE EVALUATION APPROACH

The Commercial HVAC Evaluation consisted of the analysis of three separate PG&E programs, Retrofit Express (RE), Retrofit Efficiency Options (REO) and Customized Incentives. Where measures offered in different programs are similar (such as variable speed drives), identical analysis methods were applied across all programs.

Listed below are various RE and REO measures and an overview of the evaluation done for each:

Central Air-Conditioners - Estimates of energy use were derived using the DOE-2.1E building energy simulation model, calibrated to billing data (see *Section B.3*).

Variable Speed Drives for Ventilation Fans - This measure was offered in all of the PG&E programs. However, a single method was used to develop estimates, using DOE-2.1E simulations which were calibrated to end use metered (EUM) data (see *Section B.3*).

Water Chillers - Impacts were developed using data gathered from on-site audits, application data, and DOE-2.1 simulations.

Cooling Towers - The analysis method used data gathered from on-site audits, along with ex ante calculations, to develop engineering estimates.

Other Measures - A detailed review of the algorithms used to develop ex ante impacts was performed for the other RE measures.

As a result of program design, some of the measures installed in the Customized Incentives program were similar to or the same as those for the RE and REO programs, but were installed in larger and more complex projects. For this reason, some of the analysis methods used are similar to those employed in the RE and REO program evaluations. Additionally, on-site audits and detailed application reviews were performed for a select number of Customized Incentives applications.

B.3 EVALUATION APPROACH: CENTRAL AIR-CONDITIONERS, VARIABLE SPEED DRIVES, AND WATER CHILLERS

Demand and energy savings for the program measures associated with Central Air Conditioning (CAC) and Variable Speed Drives (VSDs) for supply fans were determined on a per unit basis using the DOE-2 building energy simulation program.

The engineering analysis combines detailed on-site audit data with information from telephone surveys to supply reliable engineering estimates. These estimates are then used as input to a statistically-adjusted engineering (SAE) regression model using billing data. The primary value of generating engineering estimates of energy and demand savings is that they reduce the standard error of SAE regression estimates.

The engineering estimates for CAC and VSD were developed as follows:

- Develop DOE-2 models
- Calibrate DOE-2 models
- Create undiversified and diversified energy models
- Calculate CAC energy savings
- Calculate VSD energy savings
- Calculate water chiller energy savings
- Compute energy and demand impacts

On-site audit data were used to develop DOE-2 models of offices and retail facilities that participated in the program. These models were then calibrated using end-use-metered (EUM) and billing data in conjunction with California Energy Commission (CEC) weather data adjusted for local temperatures[1]. The resulting hourly estimates were then diversified and leveraged to additional building types using telephone survey data of operating hours. Finally, the DOE-2.1E model estimates were regenerated using long term weather data and CEC baseline equipment efficiencies to compute program impacts.

[1] This approach is consistent with the approach used for the 1994 HVAC program year evaluation

B.3.1 Develop DOE-2 Models

Audit and billing data were analyzed to determine the number of DOE-2.1E prototypes needed to represent typical participating office and retail facilities. The primary variables reviewed were conditioned square footage and the ratio of summer usage[2] to conditioned square footage. Across business types, the VSD measure was clearly installed in larger facilities compared to the CAC measure. Within measures, only CACs in retail facilities need to be divided into categories, large and small. The small prototype typically represents a single owner operated business, while the larger prototype represents a larger chain store such as a Target K-Mart.

- CAC Measures:
  - It was determined that Office participants could be represented by one prototype, since the relationship between energy use and building size appears to be relatively linear.
  - Retail participants were grouped into two categories:
    - -- Small Retail, with summer energy use of less than 100,000 kWh, and
    - -- Large Retail, with summer energy use of 100,000 kWh or more.
- VSD Prototypes:
  - As with CAC, VSD Office participants could be represented by one prototype, since the relationship between energy use and building size also appeared to be linear.
  - All of the Retail VSD sites in the audit sample fit into the classification of Large Retail.

For all prototypes, lighting density was entered based in lighting data collected from the on-site survey. Lighting schedules were based on segment average operating profiles from on-site survey data collected to support the lighting evaluation.

Key characteristics for the five prototypes are detailed in Exhibit B-1.

[2] Total premise kWh for the months of June, July and August, 1996.

Exhibit B-1
Key Characteristics for DOE-2.1E Prototypes

File	Office VSD	Retail VSD	Office CAC	Small Retail CAC	Large Retail CAC
Sample Size	5	8	31	9	8
Total Sq Ft	40948	80745	12477	4201	80745
Slab	21224	65693	9045	4034	65693
Total Wall	17680	20532	7324	4236	20532
Frame	28%	0%	34%	5%	0%
Block	72%	100%	66%	95%	100%
Frame Insulation	R-13	-	R-11	R-7	-
Block Insulation	R-7	R-0	R-11	R-0	R-0
Roof Area	21224	65693	9045	4034	65693
Roof	R-19	R-19	R-11	R-11	R-19
Ceiling Height	8	16	9	14	16
Window	5284	437	1496	389	437
Window Type	Single Clear	Single Clear	Single Clear	Single Clear	Single Clear
Cooling BTUH	N/A	N/A	403128	135046	2595841
Occupants	160	906	86	57	906
Cool Thermostat	72	73	73	75	73

B.3.2 Calibrate DOE-2 Models

To ensure that the modeled results were accurate and reasonable, models were calibrated to EUM and billing data. Calibration was performed by comparing DOE-2 simulations run under weather data from different climate zones with the EUM data.

CAC Model Calibration -Audit data for CAC sites indicated that both Office and Retail HVAC systems were designed with an average sizing of approximately 400 square feet per ton of cooling. This sizing was used for all CAC sites across climate zones. Minimum ventilation, miscellaneous equipment watts per square foot, and economizer control strategies were used in calibrating the model.

Billing data were used to verify the accuracy of the calibration across climate zones. This was accomplished by comparing the annual estimates of HVAC and lighting usage to annual billing data for the sites that contributed to each prototype.

VSD Model Calibration - Using ASHRAE fan curves[3] and the EUM data, hourly air flow provided by VSD fans was computed. As illustrated in Exhibit B-2, percent of full load cubic feet per minute (CFM) was observed to be relatively linear with outdoor temperature. The DOE-2.1E prototypes were calibrated to observed percent CFM delivered at given dry bulb temperatures. Exhibit B-3 shoes the mean, calculated percent CFM, upper and lower bounds computed as 1 standard deviation of the mean EUM data and average DOE-2.1E simulation results. Data were compared at 2 degree temperature bins for typical operating conditions.

The calibration was carried out for weekday hours between 10 AM and 6 PM where outside dry bulb temperature was 70 Degrees Fahrenheit or greater. This was done in order to isolate typical

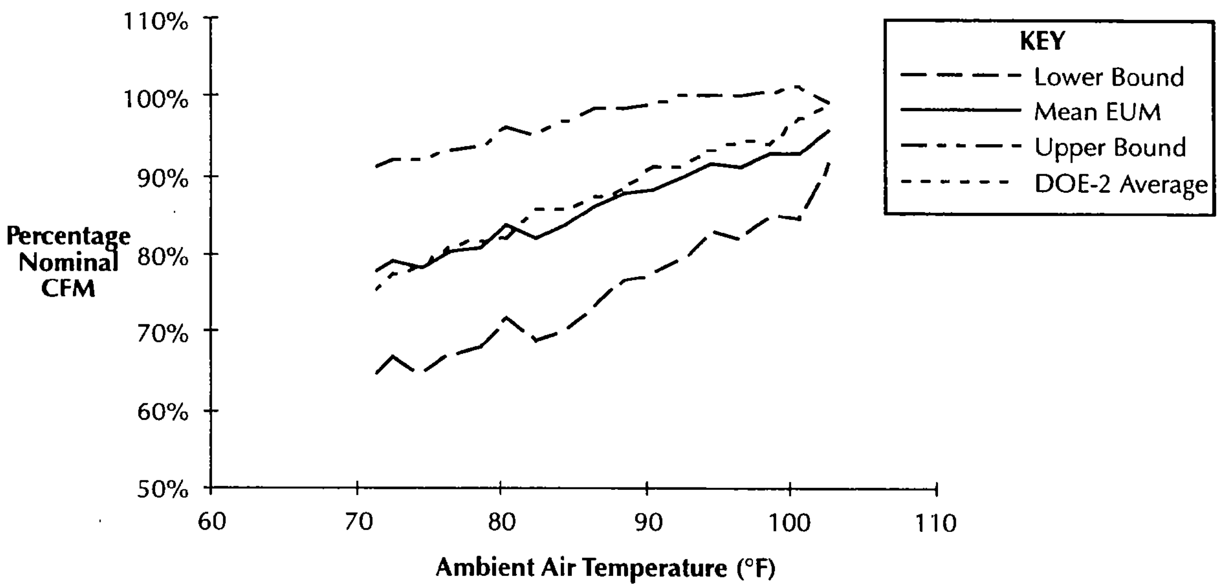
3 ASHRAE/IES Standard 90.1-1989 User's Manual, November 1992. Page 13-48 - 13-49.

cooling operation, where the majority of the VSD impacts take place. Calibration parameters for the model included fan size, minimum outside air and miscellaneous equipment watts per square foot. Calibrating the models in this way allowed for adjustment of the prototypes across climate zones.

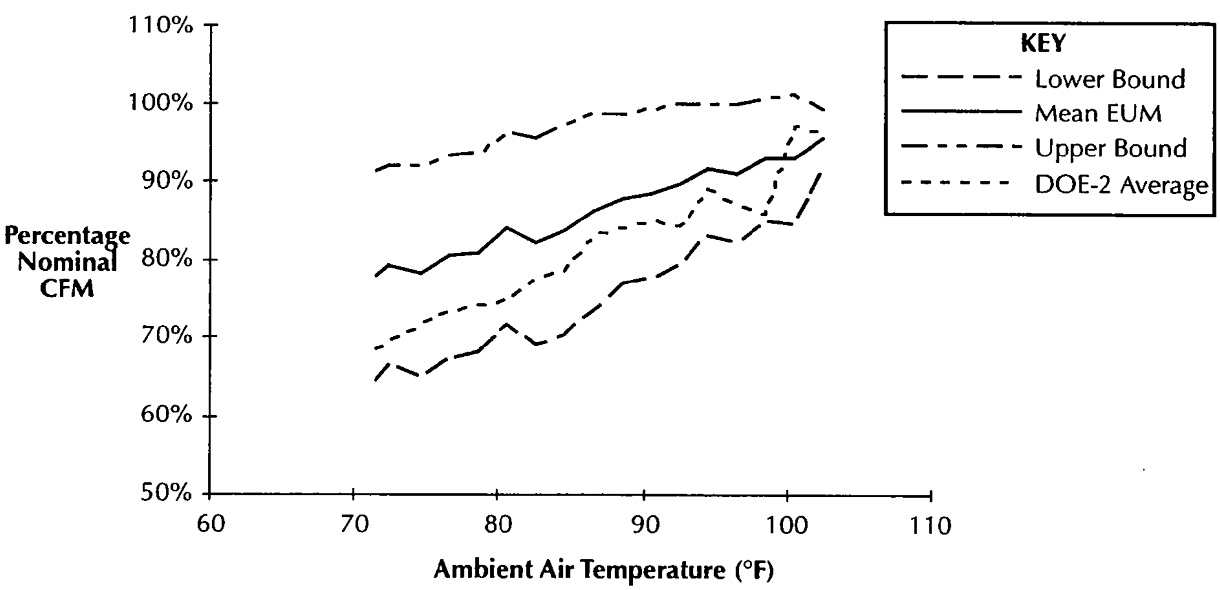
Average, maximum loads from the EUM air handler fans were observed to be approximately 74 percent of rated fan kW during peak periods of operation. It was assumed that this 74 percent represented the operating condition of the existing fan at constant volume.

Exhibit B-2
Percentage CFM vs. Ambient Temperature

Retail EUM and Simulated



DOE-2 and EUM



B.3.3 Create Undiversified and Diversified Energy Estimates

Using the calibrated DOE-2.1E prototypes discussed above, undiversified energy usage estimates were created by setting the HVAC system to operate 24 hours a day. Other operational aspects of the building, such as lighting and miscellaneous equipment schedules, were based on audit data and information calculated in the lighting analysis. For both CAC and VSD, the calibrated DOE-2 models were run using the adjusted CEC weather data in each climate zone. The weather data covered October 1, 1995, through September 30, 1996, the post-retrofit period used in the SAE model.

Undiversified CAC savings estimates were generated using the installed efficiencies of the retrofit equipment taken from the MDSS and estimated existing efficiencies based on the size of the retrofit unit. The existing efficiencies used were based on 1988 Title 24 standards, down graded to reflect a 15 year old CAC system, the assumed equipment life for these types of systems.

Undiversified VSD fan energy usage was determined by running the calibrated DOE-2.1E prototypes for three different fan systems using the adjusted CEC weather data:

VSD Fans - modeled as the post-retrofit case.

Constant-volume fans - modeled as one of the pre-retrofit cases. This fan system assumes 100 percent nominal CFM during fan operation.

Inlet vane fans - modeled as a secondary pre-retrofit case. The inlet vane fan system was modeled by to account for existing variable air volume systems which used inlet vanes as a means of volume control. This case was necessary because participants of the REO program and many of the participants of the Customized Incentives program replaced inlet vane fans with VSD as a means of volume control. For these participants, the inlet vane case represents baseline energy consumption. Further, the advice filing for the ASD measure of the RE program (S22) assumes that 19 percent of the energy consumed by existing fans are inlet vane. This 19 percent figure was used to prorate the constant volume and inlet vane cases for participants with unknown existing conditions.

For both CAC and ASD, the DOE-2.1E prototypes provide simulated annual energy usage, at an hourly level for Retail and Office business types in all climate zones with program participation. All other business types are mapped to the Office and Small or Large Retail prototypes as shown in Exhibit B-3.

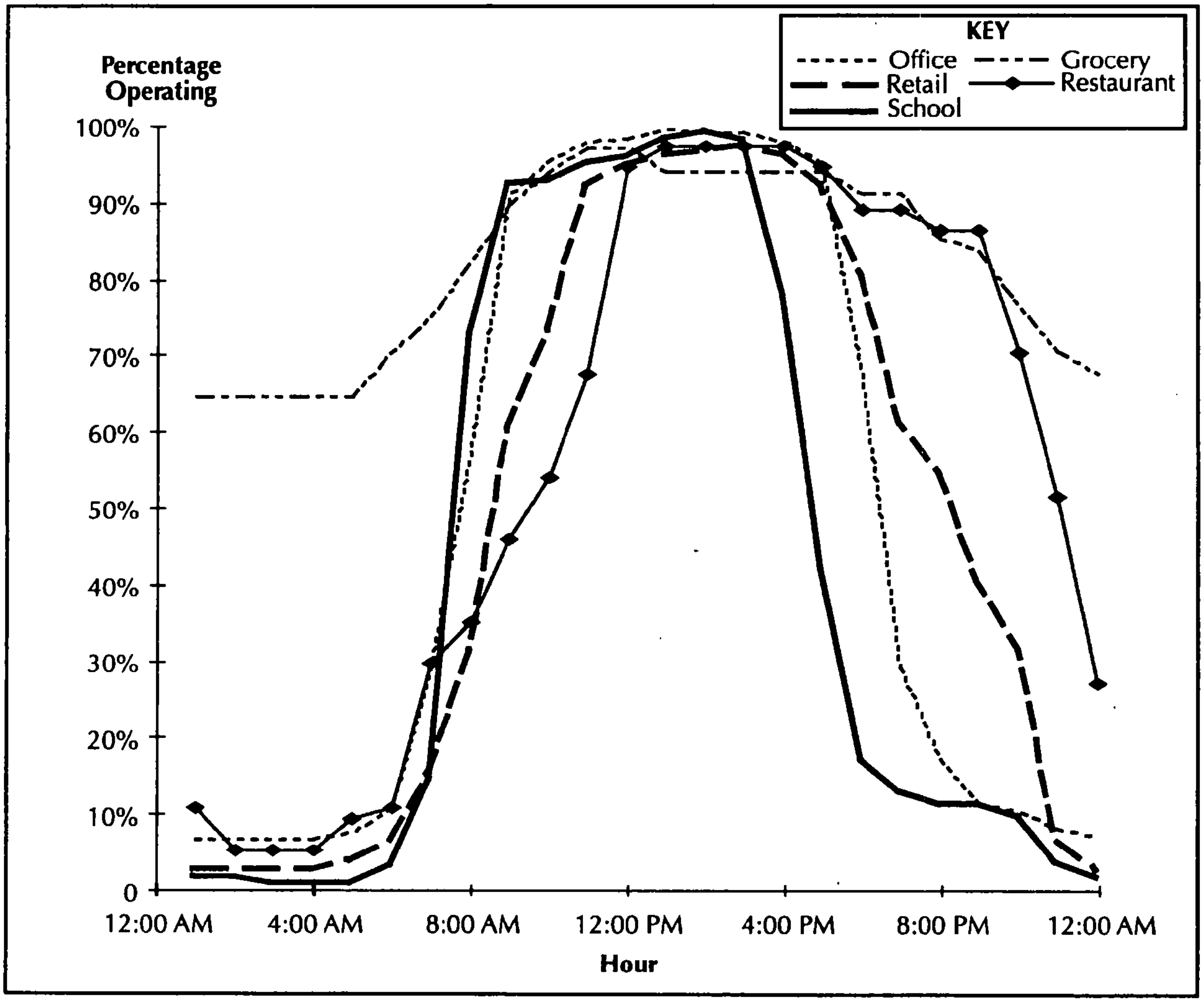
Exhibit B-3
Business Type Mapping

OFFICE	SMALL RETAIL[4]	LARGE RETAIL
Office	Small Retail	Large Retail
Community Service	Personal Service	Grocery
Health Care Hospital	Restaurant	Warehouse
Hotel/Motel	Miscellaneous Commercial	-
College/University	-	-
School	-	-

[4] This classification was used for CAC sites only. These business types were mapped to the Large Retail model in the case of VSDs.

The simulated, hourly cooling and fan energy use was diversified for each business type by hourly self reported operating factors gathered through telephone surveys. The operating factor is defined as the percentage of facilities reporting the availability of space conditioning for a given hour and season. Business type specific hourly operating factors for key business types are illustrated in Exhibit B-4. Note that these are average, annual profiles. The School business type underwent an additional adjustment for the months June, July, and August. For those months, the diversified load was multiplied by 27 percent, which is the telephone survey reported peak operating factor. This additional factor reflects the large reduction in occupancy for schools during the summer months. The result of this step are a series of hourly loads for CAC and fan systems adjusted for the occupancy and operational patterns of participants.

Exhibit B-4
Annual Average HVAC Operating for Key Business Types



B.3.4 Calculate CAC Energy Savings

For all CAC energy usage and saving estimates, a method of calculation incorporating Equivalent Full Load Hours (EFLH) was developed. The EFLH is defined as the total annual cooling energy usage, divided by the connected load for the CAC unit. The diversified CAC energy model produced an annual equivalent full load hour (EFLH) estimate for each business type and climate zone.

Energy savings estimates for each site in the SAE sample were calculated using estimated EFLH, total tons retrofit, post retrofit EER and an assumed existing EER as discussed previously. Energy savings were computed for each participant in the SAE sample using the equation in Exhibit B-5.

Exhibit B-5
Equation for Estimating CAC Energy Savings

$$kWh_{sav,i} = U * \{EFLH_j * T * 12 * (1/EER_1 - 1/EER_{MDSS})\}$$

where:

$kWh_{sav,i}$ = Annual energy savings for participant "j" (kWh/yr.)

U = Number of units installed

$EFLH_j$ = Diversified Equivalent Full Load Hours for business type j

T = Number of tons installed

12 = Conversion of tons to kBtuh

EER_1 = Existing System EER

EER_{MDSS} = Post-retrofit EER

B.3.5 Calculate VSD Energy Savings

The diversified VSD energy model results were used to produce an estimate of annual kWh usage per installed horsepower by business type and climate zone. This was accomplished for each of the three equipment types (constant volume, inlet vane, and variable speed drive). Energy savings estimates were computed as the difference of the diversified constant-volume and inlet-vane cases to the diversified VSD case.

Based on previous analysis, constant-volume fans were assumed to make up 70 percent of the pre-retrofit conditions while the remaining sites were assumed to be Inlet-vane systems. This was computed based on the advice filing, which states a 19 percent reduction in savings for the constant volume case, due to the presence of existing inlet vane fan systems.

Energy savings estimates for each site in the SAE sample were calculated using estimated per horsepower usage and total retrofit horsepower for each fan system. For the majority of the participants, the existing fan type was not known, so the assumed distribution of 70 percent constant volume and 30 percent inlet vane was used. The energy savings were computed for each participant in the SAE sample using the equation in Exhibit B-6. For all other participants the existing fan type was used and the appropriate baseline usage of either 100 percent constant volume or 100 percent inlet vanes was used.

Exhibit B-6
Equation for Estimating VSD Energy Savings

$$kWh_{sav,i} = U * [kWh_j - \{(kWh_{j,cv} * 0.30) + (kWh_{j,iv} * 0.70)\}]$$

where:

$kWh_{sav,i}$	=	Annual energy impact for participant "i" (kWh/yr.)
U	=	Number of retrofit Horsepower
kWh_j	=	Annual diversified energy use per horsepower for business type j (kWh/yr.) for fans with variable speed drives
$kWh_{j,iv}$	=	Annual diversified energy use per horsepower for business type j (kWh/yr.) for inlet vane fans
$kWh_{j,cv}$	=	Annual diversified energy use per horsepower for business type j (kWh/yr.) for constant volume fans

B.3.5 Compute Energy and Demand Impacts

The final step in the analysis of CAC and VSD measures was the calculation of energy and demand impacts for each. The energy savings estimates described above were based on weather data for dates between October 1, 1995, through September 30, 1996, and were used as inputs to the SAE analysis. The following steps were taken to convert the energy *savings* estimates to *impact* estimates:

Current CEC - CEC weather data[5] were used to generate the calibrated DOE-2.1E energy estimates, instead of actual adjusted CEC weather data.

Baseline - CAC savings estimates were adjusted to reflect the difference between post-retrofit conditions and minimum efficiencies defined by Title 24, rather than the pre-retrofit equipment.

Peak demand impacts were calculated for CAC only, since VSD impacts are assumed to be zero under peak conditions. CAC peak demand impacts were based on an undiversified peak duty cycle calculated from EUM data. For each metered CAC unit, the five highest weekday duty cycles

[5] Approved for use with the 1992 and 1995 Energy Efficiency Standards for Residential and Nonresidential Buildings. Referred to on magnetic media as CZxxRV2.WY2, where xx indicates the climate zone.

occurring between 3 and 4 PM were selected as representing peak duty cycles. The average of these duty cycles across all metered CAC units was 88.7 percent.

Except for Schools, Coincident Diversity Factors (CDF) were computed as the product of the peak duty cycle and the weekday 3 to 4 PM operating factor used in the energy analysis. For schools, the telephone survey reported peak operating factor of 27 percent was used to compute the CDF .

Exhibit B-7
Equation for Estimating CAC Demand Savings

$kW_{sav,i}$	=	$U * \{CDF_j * T * 12 * (1/EER_1 - 1/EER_{MDSS})\}$
where:		
$kW_{sav,i}$	=	Peak demand impact for participant "i"
U	=	Number of units installed
CDF_i	=	Coincident Diversity Factor, computed as 0.887 times the hour 3-4 PM operating Factor
T	=	Number of tons per installed unit
EER_1	=	Baseline EER
EER_{MDSS}	=	Post-retrofit EER

B.3.6 Calculate RE and REO High Efficiency Chiller Impacts

Savings and impact estimates associated with high efficiency chillers were computed by leveraging off of the CAC program estimates. This approach was used since it would produce consistent, reasonably accurate estimates of change in energy consumption to be adjusted by the SAE analysis. The following steps were taken to generate the chiller estimates.

An Office DOE-2.1E prototype from QC's library was modified to reflect the lighting and equipment characteristics of the on-site sample. The prototype was simulated with a central plant configured with two chillers in Lead/Lag operation.

Simulations were carried out using the adjusted CEC weather data for each climate zone with participation. Total energy consumption and the full load demand of the chiller were then used to compute EFLH values for the lead chiller.

Energy estimates of savings were then computed by leveraging on the Office EFLH values from the chiller and CAC simulations. This was accomplished by calculating the ratio of chiller EFLH to Office CAC EFLH values for each climate zone with participation. This ratio was then used in conjunction with the method developed for CAC estimates. The equation used is illustrated in Exhibit B-8.

Exhibit B-8
Equation for Estimating Chiller Savings

$kWh_{sav,i}$	=	$U * \{EFLH_j * EFLH_{CH} / EFLH_{OFF} * T * 12 * (kW/Ton_1 - kW/Ton_{MDSS})\}$
where:		
$kWh_{sav,i}$	=	Annual energy savings for participant "i" (kWh/yr.)
U	=	Number of units installed
$EFLH_j$	=	Diversified Equivalent Full Load Hours for business type j
$EFLH_{CH}$	=	Equivalent Full Load Hours for chiller prototype
$EFLH_{Off}$	=	Equivalent Full Load Hours for Office CAC prototype
T	=	Number of tons installed
12	=	Conversion of tons to kBtuh
kW/Ton_1	=	Existing System kW/Ton
kW/Ton_{MDSS}	=	Post-retrofit kW/Ton

Demand estimates for chillers were computed using chiller information from the MDSS or applications, in conjunction with operating and loading information obtained from on-site surveys. On-site survey information indicated that during peak periods participating chillers operate on average at 91 percent of their full load capacity. Therefore, peak demand impacts were computed as the difference in connected load of the retrofit and Title 24 baseline chiller times 0.91. Following are several points regarding chiller impacts.

For chillers installed under the RE program, the Title 24 baseline efficiency is substantially lower then the minimum chiller efficiency required for program participation. All evaluation impacts are computed using Title 24 baselines so the impacts for chillers installed under the RE program reflect this.

Demand impacts for the REO program are computed using the efficiency listed on the application. These efficiencies were computed for the site specific conditions of the retrofit chiller. For this reason, the Title 24 baseline chiller efficiency was modified using the ratio of the Site specific chiller efficiency to the ARI rated efficiency of the retrofit chiller. This was done so that the baseline efficiency used to compute impacts would be consistent with the site specific efficiency for the retrofit chiller.

B.4 *EVALUATION APPROACH: RETROFIT EXPRESS AND RETROFIT EFFICIENCY OPTIONS*

For RE and REO measures other than CAC and VSDs, the evaluation approach was based on a review of the algorithms and input assumptions used to develop the ex ante impacts. Since many of the same measures were offered in both the RE and REO programs, methods developed for evaluating a measure in one program were, for consistency, applied to other programs. The aim of the evaluation was to either confirm or correct the methods and inputs used in the ex ante estimates.

When applicable, the engineering algorithms used by PG&E to develop ex ante impacts for RE measures were reviewed thoroughly (algorithms were taken from the 1995 Advice Filing[6]). For each measure, the following analysis steps were performed in an algorithm review:

- Ex ante impacts were re-calculated using methods and inputs listed in the Advice Filing.
- Evaluation impacts are developed using revised methods and inputs when applicable. When possible, inputs and methods were verified using either sources referenced in the Advice Filing or alternate sources such as ASHRAE, the CEC or ARI.

Estimates were derived for the water chiller measures using a more detailed analysis approach.

An on-site audit was performed for selected sites, in order to gather detailed engineering information. Then, DOE-2.1 E simulations were performed using data from individual applications and on-site audits in order to derive engineering estimates.

Engineering impact estimates for the cooling tower measure were derived using on-site audit data and calculation methods listed in the Advice Filing.

Section B.6 contains detailed information regarding the development of impacts for each RE and REO measure.

B.5 *EVALUATION APPROACH: CUSTOMIZED INCENTIVES*

The evaluation of Customized Incentives applications focused on sites which claimed the highest avoided cost under the program. The following describe the steps used in the evaluation process:

- Applications were first ranked according to the total claimed avoided cost for the facility.
- On-site audits were performed for 28 of the sites with the highest avoided cost.
- A comparison was made between on-site audit data and data found in the MDSS.
- If there was a discrepancy found between the audit data and the ex ante impacts then one or all of the following were developed:
  - DOE-2.1 E simulations
  - Temperature bin models
  - Spreadsheet-based algorithms

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[6] PG&E 1995 Customer Energy Efficiency Programs Advice Letter No. 1867-G/1481-E, filed October 1994.

Section B.7 contains detailed information regarding the development of impacts for each Customized Incentives participant.

B.6 DETAILED METHODS USED TO DEVELOP MEASURE-SPECIFIC RETROFIT EXPRESS AND RETROFIT EFFICIENCY OPTIONS ENGINEERING ESTIMATES

This section contains detailed information regarding the development of impacts for each RE and REO measure, and is presented using the following format:

- For each measure, a written summary provides an overview of the algorithm review.

- Detailed calculations used in the analysis are provided.

Setback Programmable Thermostats

Measure Description: Installation of setback programmable thermostats in spaces with regular occupied and unoccupied periods.

Summary of Advice Filing Calculations: A bin analysis method was employed to create per thermostat energy and therm impacts. Demand impacts were not calculated, as setback thermostats do not affect peak demand.

Comments on Advice Filing Calculations: Program review has shown that the per-unit impacts were applied to each participant with the assumption that each thermostat controlled the conditioning of 5,000 sq ft of office space, regardless of building size or type. These impacts were not adjusted to account for different climate zones.

Comments on Advice Filing Inputs: Incorrect return air values were used to determine the heating and cooling loads during setback hours. Weather data was for San Jose, and thus only represented one climate zone.

Evaluation Process: Energy and therm impacts were developed using modified return air values during setback hours and binned weather data from all 16 California climate zones. A conditioned square footage value was developed for each participant using MDSS, survey, and audit data. Climate zone-specific impacts (leveraged by square footage) were then applied.

Additional Notes: If the ex ante assumptions for a given premise indicated only energy impacts, then no therm impact was developed.

Setback Programmable Thermostat:

1) **Installs setback programmable thermostats in spaces with regular occupied and unoccupied periods.**

2) **Assumptions used in Advice Filing:**

Office hours = 07:00-18:00 M-F
Occupied Hours = 11 hr/day x 5 day/week x 52.14 week/yr
= 2,868
= Listed as 2,870 hr/year
AC size = 10 tons (120,000 Btu)
AC Efficiency = 1.3 kW/ton with out fans
EER = 9.23 Btu/Watt (calculated in spreadsheet "Window Film AF")
Area serviced/ton = 500 sqft/ton
Heating size = 250 kBtu/hr
Heating efficiency = 70%
Area served = 50 Btu/hr-sqft
Total cfm = 5,000
Fan hp = 3
Outside Supply Air = 20%
Location = San Jose, ASHRAE bin weather data

A bin analysis method is used, where:

OSA = outside air temp (F)
Bin = hours per year that temp is in a given range (hr/yr)
% OSA = percent outside air (fixed at 20%)
Ret Air = return air temp (F)
Mix Air = mixed air temperature
= (% OSA x OSA) + [(1 - % OSA) x Ret Air]
67 F = temp at which system switches from cooling to heating
SAT = supply air temp (F)
SAT (cooling) = 67 F + {[67 F - OSA)/5] x 2}
SAT (heating) = 67 F + {[67 F - OSA)/5] x 3}
Heating Loads (kBtu/yr) = [SAT - Mix Air (F)] x Bin (hr/yr) x (1.085 Btu/hr-F-CFM) x Air Flow (CFM)
Cooling Loads (kBtu/yr) = [Mix Air - SAT (F)] x Bin (hr/yr) x (1.085 Btu/hr-F-CFM) x Air Flow (CFM)

Sample Heating and Cooling Load Calculations for San Jose							
Outside Air (F)	Total Bin (hr/yr)	% OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
92	6	20%	74	77.6	57	671	0
87	24	20%	74	76.6	59	2,292	0
82	84	20%	74	75.6	61	6,653	0
77	207	20%	74	74.6	63	13,027	0
72	535	20%	74	73.6	65	24,960	0
67	1,077	20%	74	72.6	67	32,719	0
62	1,756	20%	74	71.6	70	15,242	0
57	1,977	20%	74	70.6	73	0	25,741
52	1,545	20%	74	69.6	76	0	53,642
47	935	20%	74	68.6	79	0	52,753
42	451	20%	74	67.6	82	0	35,232
37	138	20%	74	66.6	85	0	13,775
32	24	20%	74	65.6	88	0	2,916
27	1	20%	74	64.6	91	0	143
Total	8,760				Total	95,564	184,203

Recreated from Advice Filing p.AC-54 (Thermostat Set-back)

Baseline Energy Usage:

Cooing = Cooling Loads (kBtu/yr) x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 95,564 kBtu/yr x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 10,353
= 10,353 kWh/yr for San Jose

Heating = Heating Loads (kBtu/yr) x (1 therm/100 kBtu) x 1/Efficiency
= 184,203 kBtu/yr x (1 therm/100 kBtu) x 1/70%
= 2,631
= 2,631 therm/yr for San Jose

Revised Energy Use 7:00AM - 6:00PM

Sample Heating and Cooling Load Calculations for San Jose							
Outside Air (F)	Total Bin (hr/yr)	% OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
92	4	20%	74	77.6	57	447	0
87	16	20%	74	76.6	59	1,528	0
82	53	20%	74	75.6	61	4,198	0
77	122	20%	74	74.6	63	7,677	0
72	293	20%	74	73.6	65	13,670	0
67	516	20%	74	72.6	67	15,676	0
62	608	20%	74	71.6	70	5,277	0
57	563	20%	74	70.6	73	0	7,330
52	395	20%	74	69.6	76	0	13,714
47	200	20%	74	68.6	79	0	11,284
42	78	20%	74	67.6	82	0	6,093
37	19	20%	74	66.6	85	0	1,897
32	3	20%	74	65.6	88	0	365
27	0	20%	74	64.6	91	0	0
Total	2,870				Total	48,473	40,683

Recreated from Advice Filing p.AC-54 (Thermostat Set-back)

Advice Filing lists total bin as 2,879 hours, but calculations do not support this.

Business Hours Energy Usage:

Cooling = Cooling Loads (kBtu/yr) x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 48,473 kBtu/yr x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 5,251
= 5,251 kWh/yr for San Jose

Heating = Heating Loads (kBtu/yr) x (1 therm/100 kBtu) x 1/Efficiency
= 40,683 kBtu/yr x (1 therm/100 kBtu) x 1/70%
= 581
= 581 therm/yr for San Jose

Revised Energy Use 7:00PM - 6:00AM

Sample Heating and Cooling Load Calculations for San Jose

Outside Air (F)	Total Bin (hr/yr)	% OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
92	2	20%	74	77.6	62.0	169	0
87	8	20%	74	76.6	64.0	547	0
82	31	20%	74	75.6	66.0	1,614	0
77	85	20%	74	74.6	68.0	3,043	0
72	242	20%	74	73.6	73.6	0	0
67	561	20%	74	72.6	72.6	0	0
62	1,148	20%	74	71.6	71.6	0	0
57	1,414	20%	74	70.6	70.6	0	0
52	1,150	20%	74	69.6	71.0	0	8,734
47	735	20%	74	68.6	74.0	0	21,532
42	373	20%	74	67.6	77.0	0	19,021
37	119	20%	74	66.6	80.0	0	8,651
32	21	20%	74	65.6	83.0	0	1,982
27	1	20%	74	64.6	86.0	0	116
Total	5,890				Total	5,374	60,036

Recreated from Advice Filing p.AC-54 (Thermostat Set-back)

Setback Energy Usage:

Cooling = Cooling Loads (kBtu/yr) x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 5,374 kBtu/yr x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 582
= 582 kWh/yr for San Jose

Heating = Heating Loads (kBtu/yr) x (1 therm/100 kBtu) x 1/Efficiency
= 60,036 kBtu/yr x (1 therm/100 kBtu) x 1/70%
= 858
= 858 therm/yr for San Jose

Additional warm-up/cool-down loads:

Cooling = 19 F x (1hr/day x 3 mo/yr x 22 day/mo) x 1.085 Btu/cfm-deg-hr x 5,000 cfm
= 6,802,950
= 6,803 kBtu/yr
Advice filing does not list 5,000 cfm in the equation, but it obviously was used to derive the result.

Heating = 11 F x (1hr/day x 3 mo/yr x 22 day/mo) x 1.085 Btu/cfm-deg-hr x 5,000 cfm
= 3,938,550
= 3,939 kBtu/yr

Total Retrofit Energy Use:

Cooling = 48,473 kBtu/yr + 5,373 kBtu/yr +3,939 kBtu/yr
= 57,785
Adjust to kWh = 57,785 kBtu/yr x (1 ton/12,000 Btu) x (1,000 Btu/kBtu)
= 4,815
= 4,815 ton/yr x 1.3 kW/ton
= 6,260
= 6,260 kWh/yr

Heating = 40,683 kBtu/yr + 60,036 kBtu/yr + 6,803 kBtu/yr
= 107,522
Adjust to Therm = 107,522 kBtu/yr x (1 therm/100,000 Btu) x (1,000 Btu/kBtu)
= 1,075
= 1,075 therm/yr x (1/70%)
= 1,536
= 1,536 therm/yr

Energy Savings:

Cooling = 10,353 kWh/yr - 6,260 kWh/yr
= 4,093
= 4,093 kWh/yr for a 10 ton unit — According to Advice Filing p. AC-57

Heating = 2,631 therms/yr - 1,536 therms/yr
= 1,095
= 1,095 therms/yr for a 250 kBtuh unit — According to Advice Filing p. AC-57

4) Evaluation Estimates:

For Baseline and Business Hours energy usage, see advice filing.

Revised Energy Use 7:00PM - 6:00AM

Sample Heating and Cooling Load Calculations for San Jose							
Outside Air (F)	Total Bin (hr/yr)	% OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
92	2	20%	85	86.4	82.2	46	0
87	8	20%	85	85.4	84.2	52	0
82	31	20%	85	84.4	86.2	0	0
77	85	20%	85	83.4	88.2	0	0
72	242	20%	85	82.4	90.2	0	0
67	561	20%	85	81.4	92.2	0	0
62	1,148	20%	85	80.4	94.2	0	0
57	1,414	20%	85	79.4	101.8	0	0
52	1,150	20%	55	54.4	56.8	0	14,973
47	735	20%	55	53.4	59.8	0	25,519
42	373	20%	55	52.4	62.8	0	21,045
37	119	20%	55	51.4	65.8	0	9,296
32	21	20%	55	50.4	68.8	0	2,096
27	1	20%	55	49.4	71.8	0	122
Total	5,890				Total	98	73,051

Recreated from Advice Filing p.AC-54 (Thermostat Set-back)

Setback Energy Usage:

Cooling = Cooling Loads (kBtu/yr) x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 5,374 kBtu/yr x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 11
= 11 kWh/yr

Heating = Heating Loads (kBtu/yr) x (1 ton-hr/100 kBtu) x 1/Efficiency
= 60,036 kBtu/yr x (1 therm/100 kBtu) x 1/70%
= 1,044
= 1,044 therms/yr

Total Retrofit Energy Use:

Assume same "ramping" used in the Advice Filing.

Cooling = 48,473 kBtu/yr + 98 kBtu/yr +3,939 kBtu/yr
= 52,510

Adjust to kWh = 52510 kBtu/yr x (1 ton/12,000 Btu) x (1,000 Btu/kBtu)
= 4,376
= 4,376 ton/yr x 1.3 kW/ton
= 5,689
= 5,689 kWh/yr

Heating = 40,683 kBtu/yr + 73,051 kBtu/yr + 6,803 kBtu/yr
= 120,537

Adjust to Therm = 120,573 kBtu/yr x (1 therm/100,000 Btu) x (1,000 Btu/kBtu)
= 1,205
= 1,205 therm/yr x (1/70%)
= 1,722
= 1,722 therm/yr

Energy Savings:
Cooling = 10,353 kWh/yr - 5,689 kWh/yr
= 4,664
= 4,664 kWh/yr for a 10 ton unit

Heating = 2,631 therms/yr - 1,722 therms/yr
= 909
= 909 therms/yr for a 250 kBtuh unit

5) Summary of Results:

Impact Type (per 10-ton unit)	Impact		Recommended Source
	Advice Filing	Evaluation	
NC Demand (kW)	-	-	
Coinc. Demand (kW)	-	-	
Annual Energy (kWh)	4,093	4,664	Evaluation

***See following spreadsheet for evauation estimates for Climate Zone 4.**

Climate Zone Specific Impacts:

Climate Zone	kWh/ton
CZ_1	73.4
CZ_2	546.9
CZ_3	253.3
CZ_4*	**559.6**
CZ_5	305.9
CZ_6	597.9
CZ_7	764.2
CZ_8	844.2
CZ_9	942.2
CZ_10	1059.4
CZ_11	1043.7
CZ_12	736.6
CZ_13	1366.5
CZ_14	1307.2
CZ_15	2435.2
CZ_16	489.2

6) Adjust Energy Impacts by Conditioned Area:

Advice Filing Assumptions:
Cooling Energy Savings = 4,664 kWh/yr for a 10 ton unit
= 466.4 kWh/yr-ton
Heating Energy Savings = 909 therms/yr for a 250 kBtuh unit
= 3.636 therms/yr-kBtuh

AC Sizing = 1 ton/500 sqft — According to Advice Filing p. AC-54

Furnace Sizing = 50 Btuh/sqft — According to Advice Filing p. AC-54

Evaluation Energy Estimate:
Cooling = (Conditioned Area) x (1 ton/500 sqft) x 466.4 kWh/yr-ton

Heating = (Conditioned Area) x (50 Btuh/sqft) x (3.636 therms/yr-kBtuh) x (1 kBtuh/1,000 Btuh)

Sample Heating and Cooling Load Calculations for Climate Zone 4							
Outside Air (F)	Total Bin (hr/yr)	% OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
117	0	20%	74	82.6	47.0	0	0
112	0	20%	74	81.6	49.0	0	0
107	0	20%	74	80.6	51.0	0	0
102	0	20%	74	79.6	53.0	0	0
97	10	20%	74	78.6	55.0	1,280	0
92	25	20%	74	77.6	57.0	2,794	0
87	112	20%	74	76.6	59.0	10,694	0
82	296	20%	74	75.6	61.0	23,445	0
77	488	20%	74	74.6	63.0	30,710	0
72	724	20%	74	73.6	65.0	33,778	0
67	853	20%	74	72.6	67.0	25,914	0
62	1,289	20%	74	71.6	70.0	11,189	0
57	1,780	20%	74	70.6	73.0	0	23,176
52	1,370	20%	74	69.6	76.0	0	47,566
47	986	20%	74	68.6	79.0	0	55,630
42	519	20%	74	67.6	82.0	0	40,544
37	243	20%	74	66.6	85.0	0	24,256
32	61	20%	74	65.6	88.0	0	7,413
27	4	20%	74	64.6	91.0	0	573
22	0	20%	74	63.6	94.0	0	0
17	0	20%	74	62.6	97.0	0	0
Total	8,760				Total	139,803	199,158

Revised Energy Use 7:00AM - 6:00PM

Sample Heating and Cooling Load Calculations for Climate Zone 4							
Outside Air (F)	Total Bin (hr/yr)	% OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
117	0	20%	74	82.6	47.0	0	0
112	0	20%	74	81.6	49.0	0	0
107	0	20%	74	80.6	51.0	0	0
102	0	20%	74	79.6	53.0	0	0
97	7	20%	74	78.6	55.0	896	0
92	18	20%	74	77.6	57.0	2,012	0
87	76	20%	74	76.6	59.0	7,256	0
82	205	20%	74	75.6	61.0	16,237	0
77	349	20%	74	74.6	63.0	21,963	0
72	422	20%	74	73.6	65.0	19,688	0
67	381	20%	74	72.6	67.0	11,575	0
62	469	20%	74	71.6	70.0	4,071	0
57	497	20%	74	70.6	73.0	0	6,471
52	262	20%	74	69.6	76.0	0	9,097
47	94	20%	74	68.6	79.0	0	5,303
42	53	20%	74	67.6	82.0	0	4,140
37	21	20%	74	66.6	85.0	0	2,096
32	4	20%	74	65.6	88.0	0	486
27	2	20%	74	64.6	91.0	0	286
22	0	20%	74	63.6	94.0	0	0
17	0	20%	74	62.6	97.0	0	0
Total	2,860				Total	83,698	27,880

Revised Energy Use 7:00PM - 6:00AM

Sample Heating and Cooling Load Calculations for Climate Zone 4

Outside Air (F)	Total Bin (hr/yr)	% OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
117		20%	85	91.4	72.2	0	0
112		20%	85	90.4	74.2	0	0
107		20%	85	89.4	76.2	0	0
102		20%	85	88.4	78.2	0	0
97	3	20%	85	87.4	80.2	117	0
92	7	20%	85	86.4	82.2	159	0
87	36	20%	85	85.4	84.2	234	0
82	91	20%	85	84.4	86.2	0	0
77	139	20%	85	83.4	88.2	0	0
72	302	20%	85	82.4	90.2	0	0
67	472	20%	85	81.4	92.2	0	0
62	820	20%	85	80.4	94.2	0	0
57	1,283	20%	85	79.4	101.8	0	0
52	1,108	20%	55	54.4	56.8	0	14,426
47	892	20%	55	53.4	59.8	0	30,970
42	466	20%	55	52.4	62.8	0	26,292
37	222	20%	55	51.4	65.8	0	17,343
32	57	20%	55	50.4	68.8	0	5,690
27	2	20%	55	49.4	71.8	0	243
22		20%	55	48.4	74.8	0	0
17		20%	55	47.4	77.8	0	0
Total	5,900				Total	511	94,964

	Cooling	Heating
Baseline Loads	139,803	199,158
Retrofit Business Hours Loads	83,698	27,880
Retrofit Setback Hours Loads	511	94,964
Ramping Loads	3,939	6,803
Total Retrofit Loads	88,148	129,647
Baseline Energy Use	15,145	2,845
Retrofit Energy Use	9,549	1,852
Savings	5,596	993
kWh/ton	559.6	
therm/kBtu		3.972

Package Terminal AC Units

Measure Description:	Installation of high efficiency packaged terminal air-conditioners and heat-pumps. This measure provides an incentive to install PTAC and PTHP units that exceed Title20 standards.
Summary of Advice Filing Calculations:	Demand and energy impacts were developed using equivalent full load hours (ELFHs), coincident demand factors (CDFs), and system efficiency.
Comments on Advice Filing Calculations:	Calculation methods cited in the Advice Filing do not accurately model participant specific retrofits. This is due to a generalized assumption regarding typical efficiency and capacity upgrades.
Comments on Advice Filing Inputs:	Sufficient data are not available to verify either the CDF or the EFLH values used in the calculation. ELFHs do not take climate zone variation into account.
Evaluation Process:	Using the change in EER for each site (based upon the MDSS), a revised equation was used in conjunction with Advice Filing EFLH and CDF values, to estimate per participant impacts.
Additional Notes:	

Package Terminal AC

1) **Install high efficiency PTAC and PTHP.**
Units must exceed Title 20 standards.

2) **Ex-ante Assumptions Used in Calculations:**

Equivalent Full Load Cooling Hours

Market Segment	Hours/Year
Schools K-12	500
Hotel/Motel	700
Grocery	600
College	1,200
Warehouse	300
Office	1,000
Hospitals	1,900
Other	1,200
Retail	800
Restaurant	1,300
Process Industry	800
Assembly Industry	2,100

Advice Filing, Table 1, p. AC-3

EER = 10.0 - (0.16 x Capacity Btuh)

3) **Advice Filing Estimates:**

Demand Savings:

Measure Demand Savings = kW Title 20 - kW High Efficiency Unit, according to Advice Filing, p. AC-17

kW = (12,000 Btuh/ton) x (1kW/1,000Watt) x (tons/EER Btuh/Watt) according to Advice Filing, p. AC-17

Measure Demand Savings

Tons	Title 20 EER	Title 20 kW	High Efficiency EER	High Efficiency kW	Demand Savings kW	Demand Savings kW/ton-EER
0.6	8.9	0.809	9.5	0.758	0.051	0.142
0.8	8.6	1.116	9.6	1.000	0.116	0.145
1	8.0	1.500	9.1	1.319	0.181	0.165
1.3	7.6	2.053	9.1	1.714	0.338	0.174
					Average =	0.156

Advice Filing p. AC-17,18

Advice Filing lists 0.157, the diff. is due to rounding

Coincident Demand Savings = Measure Demand Savings x 0.75 CDF
= 1.56 kW/ton-EER x 0.75 CDF
= 1.17
= 1.17 kW/ton-EER   Advice Filing lists 0.118, the diff. is due to rounding

Energy Savings:

Annual Energy Savings = Measure Demand Savings x EFLCH
= 0.156 kW/ton-EER x EFLCH

Coincident Energy Savings

Market Segment	Hours/Year	Annual Energy Savings kWh/ton-EER
Schools K-12	500	78
Hotel/Motel	700	109
Grocery	600	94
College	1,200	187
Warehouse	300	47
Office	1,000	156
Hospitals	1,900	296
Other	1,200	187
Retail	800	125
Restaurant	1,300	203
Process Industry	800	125
Assembly Industry	2,100	328

Advice Filing, p. AC-18

Values are slightly different than Advice Filing, due to using 0.156 kW/ton-EER as opposed to 0.157 kW/ton-EER

4) **Evaluation Estimates:**

Demand Savings:

EER is not linear.

For this reason, calculating an impact using the unit kW/ton-EER is only valid for a very small range of EER values.

Demand estimates are developed at a per unit basis.

Demand Savings = (Capacity, Btuh) x (1/EERtitle20 - 1/EERretrofit) x (1kW/1,000 Watts)

Coincident Demand Savings = Demand Savings x CDF

CDF = varies by climate zone and business type (0.75 used in sample calculations)

Tons	Capacity Btuh	Title 20 EER	High Efficiency EER	Demand Savings kW	Coincident Demand Savings kW
0.6	7,200	8.9	9.5	0.051	0.038
0.8	9,600	8.6	9.6	0.116	0.087
1	12,000	8.0	9.1	0.181	0.136
1.3	15,600	7.6	9.1	0.338	0.254

Energy Savings:

Energy savings are also determined at a per unit level.

= Measure Demand Savings x EFLCH
= Assume 1 ton unit with 1.1 change in EER
= 0.181 kW/ton x EFLCH

Sample Energy Savings Using 0.181 kW/ton

Market Segment	Hours/Year	Annual Energy Savings kWh
Schools K-12	500	91
Hotel/Motel	700	127
Grocery	600	109
College	1,200	217
Warehouse	300	54
Office	1,000	181
Hospitals	1,900	344
Other	1,200	217
Retail	800	145
Restaurant	1,300	235
Process Industry	800	145
Assembly Industry	2,100	380

Reflective Window Film

Measure Description: Provides an incentive for the installation of reflective window film on clear non-North facing glazing.

Summary of Advice Filing Calculations: Cooling loads attributable to solar heat gain were calculated using equation 27.41 of the ASHRAE Fundamentals Handbook (p.27.24). Per square foot energy and demand impacts were estimated for applied reflective film.

Comments on Advice Filing Calculations: Methods used to determine energy and demand impacts are valid.

Comments on Advice Filing Inputs: A review of the inputs from ASHRAE revealed a discrepancy between the annual solar heat gains listed in ASHRAE and those used in Advice Filing calculations.

Evaluation Process: Energy and demand estimates were developed using the correctly applied ASHRAE method.

Additional Notes:

Reflective Window Film

1) **Install reflective film on clear glass, non-North facing exposures.**

2) **Ex-ante Assumptions Used in Calculations:**

Clear glass SC = 0.95 ASHRAE Fundamentals p.27.19 table 11
Glass with reflective coating SC = 0.45 ASHRAE Fundamentals p.27.36 table 28
Solar data based on ASHRAE 1989 Fundamentals, p.27.10,latitude = 40 degrees
Radiation data multiplied by 75% to account for variations in shading and clearness.
Assume 75% fenestration for vertical surfaces.
Average cooling efficiency = 1.3 kW/ton
Conversion of kW/ton to EER:
= 1/[(1.3 kW/ton) x (1 ton/12 kBtu)]
= 9.23
= 9.23 Btu/W (EER)
Sample Building
Height = 30 ft
Footprint = 100 ft x 100 ft
Building Surface Area = 30,000 sqft
While building surface area is not needed for our analysis, the calculation is wrong.
Evaluation Building Surface Area = (4 x 100 ft x 30 ft) + 100 ft x 100 ft
= 22,000
= 22,000 sqft

Solar Load, South = 309 kBtu/sqft-yr
Solar Load, East-West = 241 kBtu/sqft-yr

3) **Advice Filing Estimates:**

Energy Savings:

Assume 2,250 sqft of glazing per orientation.

Orientation	Area (sqft)	Solar Load (kBtu/sqft-yr)	Annual Solar Load (kBtu/yr)
South	2,250	309	695,250
East	2,250	241	542,250
West	2,250	241	542,250
Sum	6,750		1,779,750

Advice Filing table, p.AC-59

Baseline Solar Gain = 0.95 SC x 1,779,750 kBtu/yr
= 1,690,763
= 1,690,763 kBtu/yr
Retrofit Solar Gain = 0.45 SC x 1,779,750 kBtu/yr
= 800,888
= 800,888 kBtu/yr
Annual Energy Savings = (1,690,763 kBtu/yr) - 800,888 kBtu/yr
= 889,875
Adjust to kWh = 889,875 kBtu/yr x 1ton/12,000Btu/hr x 1,000 Btu/kBtu
= 74,156
= 74,156 ton-hr/yr x 1.3 kW/ton
= 96,403
= (96,403 kWh/yr)/6,750 sqft
= 14.28
= 14.28 kWh/sqft-yr

Demand Savings:

Advice Filing estimate:

Orientation	Average Peak Gain (Btu/hr-sqft)
East	216
South	33.3
West	25
Total	274.3
Average	91.43

Advice Filing, p.AC-60

Total Average Peak Gain = 274.3 Btu/sqft x 2,250 sqft
= 617,175

Alternate Calculation:
Total Average Peak Gain = 91.43 Btu/hr-yr x 6,750 sqft
= 617,153

Account for Load Time Delay = 617,175 Btu x 0.65 mass coefficient
= 401,164

Adjusted to kW = 401,164 Btu/hr x 1 ton/12,000 Btu/hr x 1.3 kW/ton
= 43.46
= 43 kW

The Advice Filing does not perform any further calculations.
This is NOT the demand savings.
Demand Savings = 43 kW/6,750 sqft
= 0.0064
= 0.0064 kW/sqft
This would assume a 100% reduction in solar gains during the peak hour.

4) Evaluation Estimates:

Calculate Baseline Solar Gains Using ASHRAE Fundamentals†:

Month	Half Day SHGF East (Btu/hr-sqft)	Half Day SHGF South (Btu/hr-sqft)	Half Day SHGF West (Btu/hr-sqft)	Daily SHGF East-West Btu/sqft-day	Annual SHGF East-West Btu/sqft-yr	Daily SHGF South Btu/sqft-day	Annual SHGF South Btu/sqft-yr
January	452	813	62	514	15,934	1626	50,406
February	648	821	85	733	20,524	1642	45,976
March	832	694	114	946	29,326	1388	43,028
April	957	488	148	1105	33,150	976	29,280
May	1024	358	176	1200	37,200	716	22,196
June	1038	315	188	1226	36,780	630	18,900
July	1008	352	181	1189	36,859	704	21,824
August	928	474	157	1085	33,635	948	29,388
September	787	672	119	906	27,180	1344	40,320
October	623	791	89	712	22,072	1582	49,042
November	445	798	63	508	15,240	1596	47,880
December	374	775	53	427	13,237	1550	48,050
					Sum = 321,137		Sum = 446,290

ASHRAE Fundamentals† Table 27-8, p.27.10

East-West Solar Gain = 321,137 Btu/sqft-yr x .75 shading factor
= 241
= 241 kBtu/sqft-yr

South Solar Gain = 446,290 Btu/sqft-yr x .75 shading factor
= 335
= 335 kBtu/sqft-yr

Advice Filing calculates 309 kBtu/sqft-yr for South solar gain, which is not consistent with the Evaluation estimate.
Application of a 75% shading factor renders this a conservative estimate.
Potential loads on unshaded surfaces could be as high as 100% of those estimated.

Calculate Baseline Peak Solar Gains Using ASHRAE Fundamentals†:

	Peak Hour Solar Gains (Btu/hr-sqft)		
	8:00 AM, 4:00 PM	9:00 AM, 3:00 PM	10:00 AM, 2:00 PM
June (ave)	90.67	89.67	83.00
East	216	192	145
South	29	45	69
West	27	32	35
July (ave)	90.67	92.00	87.33
East	216	193	146
South	30	52	81
West	26	31	35
August (ave)	93.33	101.67	99.33
East	216	197	150
South	41	80	116
West	23	28	32
Average	91.56	94.44	89.89
East	**216**	194	147
South	**33.3**	59	88.7
West	**25.3**	30.3	34

ASHRAE Fundamentals† p.27.10, Table 8

Peak solar gains occur during the 9:00 AM or 3:00 PM hour.
Advice Filing uses values from the 8:00 AM or 4:00 PM hour (in bold).

Energy Savings:
Assume 2,250 sqft of glazing per orientation.

Orientation	Area (sqft)	Solar Load (kBtu/sqft-yr)	Annual Solar Load (kBtu/yr)
South	2,250	335	753,750
East	2,250	241	542,250
West	2,250	241	542,250
Sum	6,750		1,838,250

Advice Filing table, p.AC-59

Baseline Solar Gain = 0.95 SC x 1,838,250 kBtu/yr
= 1,746,338
= 1,746,338 kBtu/yr
Retrofit Solar Gain = 0.45 SC x 1,838,250 kBtu/yr
= 827,213
= 827,213 kBtu/yr
Annual Energy Savings = (1,746,338 kBtu/yr) - 827,213 kBtu/yr
= 919,125
Adjust to kWh = 919,125 kBtu/yr x 1ton/12,000Btu/hr x 1,000 Btu/kBtu
= 76,594
= 76,594 ton-hr/yr x 1.3 kW/ton
= 99,572
= (977,527 kWh/yr)/6,750 sqft
= 14.74
= 14.74 kWh/sqft-yr

Demand Savings:

Baseline Peak Gain = (216 Btu/sqft + 33.3 Btu/sqft +25.3 Btu/sqft) x 2,250 sqft
= 617,850
= 617,850 Btu x 0.95 SC
= 586,958

Adjust for Load Time Delay = 586,958 Btu x 0.65 mass coefficient factor
= 381,522
= 381,522 Btu

Retrofit Peak Gain = 617,850 Btu x 0.45 SC
= 278,033

Adjust for Load Time Delay = 278,033 Btu x 0.65 mass coefficient factor
= 180,721
= 180,721 Btu

Demand Savings = 381,522 Btu - 180,721 Btu
= 200,801

Adjusted to kW/sqft = (200,801 Btu x 1 ton/12,000 Btu/hr x 1.3 kW/ton)/6,750 sqft
= 0.0032
= 0.0032 kW/sqft

Coincident Demand Savings = 0.0032 kW/sqft x 0.75 CDF
= 0.0024
= 0.0024 kW/sqft

5) Summary of Results:

Impact Type (per sqft of film)	Impact		Recommended Source
	Advice Filing	Evaluation	
Coinc. Demand (kW)	0.0064	0.0024	Evaluation
Annual Energy (kWh)	14.28	14.74	Evaluation

6) Sources

† ASHRAE Handbook, "Fundamentals"; American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA, 1989

Direct Evaporative Coolers

Measure Description: Provides an incentive for the replacement of an existing AC unit with an equally sized direct evaporative cooler system. Measure participation is restricted to certain climate zones.

Summary of Advice Filing Calculations: Used HVAC manufactures' software to develop demand and energy impacts.

Comments on Advice Filing Calculations: No documentation is provided for the method used. Additionally, final impacts are greater than baseline demand and energy usage, which is theoretically impossible. (See Additional Notes)

Comments on Advice Filing Inputs: The inputs used in the calculations are not substantiated.

Evaluation Process: Demand and energy savings were determined using climate zone-specific cooling degree hours, fan motor horsepower and the efficiency of the existing AC unit (see Additional Notes). Impacts were developed using motor efficiency values listed in the baseline assumptions for the RE Motors program.

Additional Notes: In the interim between the 1994 Advice Filing and the current evaluation, PG&E revised substantially the methods used to determine impacts. The evaluation effort concentrated on the revised algorithms, and used (with slight modifications) the current methods developed by PG&E for the 1996 Advice Filing.

Direct Evaporative Cooler

1) Replace an existing AC unit with an equally sized direct evaporative cooler.

2) Ex-ante calculation assumptions:

1994 Advice Filing Assumptions

Air Flow = assumed to be 5,000 CFM
Air Heat Capacity = 1.085 Btu/hr-F-CFM
Cooling Efficiency = 8.8 Btu/Watt-hr (EER) or 1.3 kW/ton
Furnace Efficiency = 70%

1996 Advice Filing Assumptions

High comfort occupancy has an internal requirement of 76 F, 60% RH.

For a 5 F Δt between entering DB and interior design DB, the outside WB temp must be 64 F or lower.

Low comfort occupancy has an internal requirement of 84 F, 60% RH.

For a 5 F Δt between entering DB and interior design DB, the outside WB temp must be 72 F or lower.

4 hp of fan energy is required to move 12,000 cfm at 0.5 in static pressure.

This is consistent with manufactures' data.

Conventional HVAC system efficiency is 1.3 kW/ton.

To convert from hp to kW use 0.746 kW/hp.

The heat capacity of air is 1.08 Btu/hr-F-cfm.

3) 1994 Advice Filing Estimates:

Demand Savings for a 10 ton unit (kW/yr)

Market Segment	CEC Climate Zone								
	1	2	3	4	5	11	12	13	16
Warehouse	N/A	8.1	N/A	6.1	5.1	10.1	9.1	9.1	6.1
Hotel/Motel	N/A	7.1	N/A	5.1	4.1	9.1	8.1	8.1	5.1
Retail	N/A	16.1	N/A	14.1	12.1	19.1	18.1	19.1	13.1
Restaurant	N/A	27.2	N/A	23.2	19.2	31.2	31.2	32.2	18.2
Average	N/A	14.6	N/A	12.1	10.1	17.4	16.6	17.1	10.6

Advice Filing p.AC-44

Assuming that a 10 ton unit at 1.3 kW/ton (8.8 EER) has a power draw of 13 kW, many of these estimates are unreasonable.

Virtually all of the retail and restaurant estimates are greater than the connected load of the baseline unit.

Energy Savings for a 10 ton unit (kWh/yr)

Market Segment	CEC Climate Zone								
	1	2	3	4	5	11	12	13	16
Warehouse	N/A	8,436	N/A	650	1,805	13,593	9,549	13,302	5,054
Hotel/Motel	N/A	29,014	N/A	23,202	22,758	37,998	32,611	37,284	26,093
Retail	N/A	17,685	N/A	2,960	4,163	25,662	19,651	26,306	9,720
Restaurant	N/A	48,378	N/A	36,800	28,485	60,599	54,631	63,090	32,258
Average	N/A	25,878	N/A	15,903	14,303	34,463	29,111	34,996	18,281

Advice Filing p.AC-44

4) 1996 Advice Filing Estimates:

In the interim between the 1994 Advice Filing and the current evaluation, PG&E significantly revised the methods used to develop impacts. The following estimates were developed by PG&E for the 1996 Advice Filing†.

Evaporative Capacity:

$$Q = cfm \times \Delta t \times 1.08 \text{ Btu/hr-F-cfm}$$

where:
Q = evaporative capacity (Btu/hr)
cfm =j cubic feet per minute
Δt = temperature differential between indoor design conditions and supply air temperature that can be generated without exceeding the moisture ratio of the design conditions.
= indoor design temp - (DB design temp - [70% effectiveness x (DB design temp - WB design temp)])

Climate Zone	DB Design temp (F)	WB Design temp (F)	Exit temp from evap.	Evaluation Δt (F)	Advice Filing Δt (F)	Capacity (Btu/hr)	Capacity (tons)
2	90	65	72.5	11.5	11.5	149,040	12.42
4	83	71	74.6	8.0	8.0	103,680	8.64
5	77	65	68.6	15.4	15.4	199,584	16.63
11	96	66	75	9.0	9.0	116,640	9.72
12	93	68	75.5	8.5	8.5	110,160	9.18
13	99	71	79.4	4.6	4.6	59,616	4.97
16	99	63	73.8	10.2	10.2	132,192	11.02

Evaporator Fan Demand:

A 4 hp fan can move 12,000 cfm
= 4 hp x 0.746 kW/hp
= 2.984
= 2.984 kW

Demand Savings:

= baseline demand (kW/ton) - [fan demand (kW)/evaporator capacity (tons)]
= 1.3 kW/ton - 2.984 kW/capacity (tons)

Energy Savings:

= demand savings (kW/ton) x cooling degree hours (CDH)

Climate Zone	Demand Impacts (kW/ton)	AF Dem. Impacts (kW/ton)	CDH (hours)	Energy Impacts (kWh/ton)	AF Energy Imp. (kWh/ton)
2	1.06	1.04	1,003	1,063	1,043
4	0.95	0.93	861	822	801
5	1.12	1.11	493	552	547
11	0.99	0.97	1,729	1,717	1,677
12	0.97	0.95	1,331	1,298	1,264
13	0.70	0.65	2,252	1,575	1,464
16	1.03	1.01	720	741	727

5) Evaluation Estimates:

Use method described in the RE Motors program, (Advice Filing, p.MT-8).
Baseline efficiency for a 4 hp motor = 83%, according to Advice Filing p.MT-7
Load factor is assumed to be 80%, according to Advice Filing p.NRR-64

Fan Demand Savings:

= kW/hp x hp x 1/eff x % load
= 0.746 kW x 4 hp x (1/83% eff) x 80% load
= 2.876
= 2.876 kW/12,000 cfm

Coincident Demand Savings:

= [baseline demand (kW/ton) x CDF] - [fan demand (kW)/evaporator capacity (tons)]
= [(1.3 kW/ton) x 75%] - 2.876 kW/capacity (tons)

Energy Savings:

= demand savings (kW) x cooling degree hours (CDH)

6) Summary of Results:

Climate Zone	Demand Impacts		Cooling Degree	Energy Impacts	
	Evaluation (kW/ton)	1996 Advice Filing (kW/ton)	Hours (hours)	Evaluation (kWh/ton)	1996 Advice Filing (kWh/ton)
2	0.74	1.04	1,003	1,072	1,043
4	0.64	0.93	861	833	801
5	0.80	1.11	493	556	547
11	0.68	0.97	1,729	1,736	1,677
12	0.66	0.95	1,331	1,313	1,265
13	0.40	0.65	2,252	1,624	1,464
16	0.71	1.01	720	748	727

7) Sources

† PG&E, "1997 Customer Energy Efficiency Programs, Advice Letter No. 1978-G/1608-E Workpapers"; pp. AC-23 to AC-25

Bypass Timer

Measure Description:	Installation of a bypass timer to control the fans of a space which is intermittently occupied after hours when the space conditioning system is off.
Summary of Advice Filing Calculations:	Using fan motor horsepower, assumed hours of operation and a fan load/efficiency value, energy savings were developed. No demand savings are estimated since bypass timers do not affect the peak demand.
Comments on Advice Filing Calculations:	The percent a fan is loaded is generally independent from efficiency.
Comments on Advice Filing Inputs:	The fan load/efficiency value is not substantiated with documentation. Assumed hours of operation are poorly documented.
Evaluation Process:	Energy impacts were developed using fan load and motor efficiency values listed in the baseline assumptions for RE HVAC measures and the RE Motors program, respectively.
Additional Notes:	

Bypass Timer

1) Install a bypass timer for a zone intermittently occupied after hours when conditioning is scheduled off.

Timer controls the fans of a central AC system.

2) Ex-ante calculation assumptions:

Average occupancy of zone is 2 hours per night.
Existing fan power = 1.0 hp.
Fans operate at 80% load/efficiency.
This value appears to be a combination of fan load and fan efficiency.
These two variables are independent of each other, and so should not be combined.
To convert from hp to kW use 0.746 kW/hp.
Baseline assumes fans are on for 11 hours a day, 260 days a year after business hours.
According to the Setback Programmable Thermostat measure, business hours are from 7:00 AM to 6:00 PM (11 hrs).
This implies that the system would be off for 13 hours (24 hr - 11 hr).
Retrofit assumes fans are on for 2 hours a day, 5 days a week after business hours.
Savings associated with the compressor are ignored, as night cooling loads are small due to low occupancy and low ambient temperatures.
Heating savings are not determined.

3) Advice Filing Estimates:

Baseline Energy Use:

= 1 hp x 0.746 kW/hp x 80% load/eff x 11 hrs/day x 260 days/yr
= 1,707
= 1,707 kWh/yr
Advice Filing lists 1,797 kWh/yr (AC-78)

Energy Savings:

= 1 hp x 0.746 kW/hp x 80% eff. x (11 - 2 hrs/day) x 260 days/yr
= 1,397
= 1,397 kWh/yr
This is 82% of the baseline. 82%
Advice Filing also lists 82% (p.AC-78) which indicates that the 1,797 kWh/yr value was typed incorrectly.

NC Demand Savings:

= 1 hp x 0.746 kW/hp
= 0.746 kW

Cycle Peak Coincident Demand Savings:

= 0.746 kW x 0.82 x 0.75 CDF
= 0.459
= 0.459 kW
Demand savings is counted towards off-peak and partial-peak savings only, and is not applied to the MDSS.

5) Evaluation Estimates:

Use method described in the RE Motors proggram, (Advice Filing, p.MT-8).
Baseline efficiency for a 1 hp motor = 77%, according to Advice Filing p.MT-7
Load factor is assumed to be 80%, according to Advice Filing p.NRR-64

Baseline Energy Use:

= 1 hp x 0.746 kW/hp x (1/77% eff.) x 80% load x 11 hrs/day x 260 days/yr 0.9375
= 2,217
= 2,217 kWh/yr

Energy Savings:

= 1 hp x 0.746 kW/hp x (1/77% eff.) x 80% load x (11 - 2 hrs/day) x 260 days/yr
= 1,814
= 1,814 kWh/yr
This is 82% of the baseline. 82%

NC Demand Savings:

= kW x 1/eff x % load x (impact hours/baseline hours)
= 0.746 kW x (1/77% eff) x 80% load x (9 hrs/11 hrs)
= 0.634
= 0.634 kW

Coincident Demand Savings:

Since fans are assumed to run continuously during the peak period, the coincident demand savings are zero.

6) Summary of Results:

Impact Type (per timer)	Impact		Recommended Source
	Advice Filing	Evaluation	
Coinc. Demand (kW)	0	0	
Annual Energy (kWh)	1,397	1,814	Evaluation

Timeclock

Measure Description:	Installation of timeclocks, which regulate HVAC usage in spaces with regular occupied and unoccupied periods.
Summary of Advice Filing Calculations:	A bin analysis method was employed to create per timeclock energy impacts. Demand impacts were not calculated, as timeclocks do not affect peak demand.
Comments on Advice Filing Calculations:	Program review has shown that the per-unit impacts were applied to each participant with the assumption that each timeclock controlled the conditioning of 5,000 sq ft of office space, regardless of building size or type. These impacts were not adjusted to account for different climate zones.
Comments on Advice Filing Inputs:	Weather data was for San Jose, and thus only represented one climate zone.
Evaluation Process:	Energy and therm impacts were developed using modified return air values during setback hours and binned weather data from all 16 California climate zones. A conditioned square footage value was developed for each participant using MDSS data. Climate zone-specific impacts (leveraged by square footage) were then applied.
Additional Notes:	If the ex ante assumptions for a given premise indicated only energy impacts, then no therm impact was developed.

Timeclock - Electronic:

1) **Installs electronic timeclocks in spaces with regular occupied and unoccupied periods.**

2) **Assumptions used in Advice Filing:**

Office hours = 07:00-18:00 M-F
Occupied Hours = 11 hr/day x 5 day/week x 52.14 week/yr
= 2,868
= Listed as 2,870 hr/year
AC size = 10 tons (120,000 Btu)
AC Efficiency = 1.3 kW/ton with out fans
EER = 9.23 Btu/Watt (calculated in spreadsheet "Window Film AF")
Area serviced/ton = 500 sqft/ton
Heating size = 250 kBtu/hr
Heating efficiency = 70%
Area served = 50 Btu/hr-sqft
Total cfm = 5,000
Fan hp = 3
Outside Supply Air = 20%
Location = San Jose, ASHRAE bin weather data

A bin analysis method is used, where:

OSA = outside air temp (F)
Bin = hours per year that temp is in a given range (hr/yr)
% OSA = percent outside air (fixed at 20%)
Ret Air = return air temp (F)
Mix Air = mixed air temperature
= (% OSA x OSA) + [(1 - % OSA) x Ret Air]
67 F = temp at which system switches from cooling to heating
SAT = supply air temp (F)
SAT (cooling) = 67 F + {[67 F - OSA)/5] x 2}
SAT (heating) = 67 F + {[67 F - OSA)/5] x 3}
Heating Loads (kBtu/yr) = [SAT - Mix Air (F)] x Bin (hr/yr) x (1.085 Btu/hr-F-CFM) x Air Flow (CFM)
Cooling Loads (kBtu/yr) = [Mix Air - SAT (F)] x Bin (hr/yr) x (1.085 Btu/hr-F-CFM) x Air Flow (CFM)

Sample Heating and Cooling Load Calculations for San Jose							
Outside Air (F)	Total Bin (hr/yr)	% OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
92	6	20%	74	77.6	57	671	0
87	24	20%	74	76.6	59	2,292	0
82	84	20%	74	75.6	61	6,653	0
77	207	20%	74	74.6	63	13,027	0
72	535	20%	74	73.6	65	24,960	0
67	1,077	20%	74	72.6	67	32,719	0
62	1,756	20%	74	71.6	70	15,242	0
57	1,977	20%	74	70.6	73	0	25,741
52	1,545	20%	74	69.6	76	0	53,642
47	935	20%	74	68.6	79	0	52,753
42	451	20%	74	67.6	82	0	35,232
37	138	20%	74	66.6	85	0	13,775
32	24	20%	74	65.6	88	0	2,916
27	1	20%	74	64.6	91	0	143
Total	8,760				Total	95,564	184,203

Recreated from Advice Filing p.AC-54 (Thermostat Set-back)

Baseline Energy Usage:

Cooing = Cooling Loads (kBtu/yr) x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 95,564 kBtu/yr x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 10,353
= 10,353 kWh/yr for San Jose

Heating = Heating Loads (kBtu/yr) x (1 therm/100 kBtu) x 1/Efficiency
= 184,203 kBtu/yr x (1 therm/100 kBtu) x 1/70%
= 2,631
= 2,631 therm/yr for San Jose

Revised Energy Use 7:00AM - 6:00PM

Sample Heating and Cooling Load Calculations for San Jose							
Outside Air (F)	Total Bin (hr/yr)	% OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
92	4	20%	74	77.6	57	447	0
87	16	20%	74	76.6	59	1,528	0
82	53	20%	74	75.6	61	4,198	0
77	122	20%	74	74.6	63	7,677	0
72	293	20%	74	73.6	65	13,670	0
67	516	20%	74	72.6	67	15,676	0
62	608	20%	74	71.6	70	5,277	0
57	563	20%	74	70.6	73	0	7,330
52	395	20%	74	69.6	76	0	13,714
47	200	20%	74	68.6	79	0	11,284
42	78	20%	74	67.6	82	0	6,093
37	19	20%	74	66.6	85	0	1,897
32	3	20%	74	65.6	88	0	365
27	0	20%	74	64.6	91	0	0
Total	2,870				Total	48,473	40,683

Advice Filing lists total bin as 2,879 hours, but calculations do not support this.

Recreated from Advice Filing p.AC-54 (Thermostat Set-back)

Business Hours Energy Usage:

Cooling = Cooling Loads (kBtu/yr) x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 48,473 kBtu/yr x (1 ton-hr/12 kBtu) x 1.3 kW/ton
= 5,251
= 5,251 kWh/yr for San Jose

Heating = Heating Loads (kBtu/yr) x (1 therm/100 kBtu) x 1/Efficiency
= 40,683 kBtu/yr x (1 therm/100 kBtu) x 1/70%
= 581
= 581 therm/yr for San Jose

Additional warm-up/cool-down loads:

Cooling = 16 F x (1.5 hr/day x 3 mo/yr x 22 day/mo) x 1.085 Btu/cfm-deg-hr x 5,000 cfm
= 8,593,200
= 8,593 kBtu/yr
Advice filing does not list 5,000 cfm in the equation, but it obviously was used to derive the result.

Heating = 24 F x (1.5 hr/day x 3 mo/yr x 22 day/mo) x 1.085 Btu/cfm-deg-hr x 5,000 cfm
= 12,889,800
= 12,890 kBtu/yr

Total Retrofit Energy Use:

Cooling = 48,473 kBtu/yr + 8,593 kBtu/yr
= 57,066
Adjust to kWh = 57,066 kBtu/yr x (1 ton/12,000 Btu) x (1,000 Btu/kBtu)
= 4,756
= 4,756 ton/yr x 1.3 kW/ton
= 6,182
= 6,182 kWh/yr

Heating = 40,683 kBtu/yr + 12,890 kBtu/yr
= 53,573
Adjust to Therm = 53,573 kBtu/yr x (1 therm/100,000 Btu) x (1,000 Btu/kBtu)
= 536
= 536 therm/yr x (1/70%)
= 765
= 765 therm/yr

Energy Savings:

Cooling = 10,353 kWh/yr - 6,221 kWh/yr
= 4,171
= 4,171 kWh/yr for a 10 ton unit — According to Advice Filing p. AC-52

Heating = 2,631 therms/yr - 765 therms/yr
= 1,866
= 1,866 therms/yr for a 250 kBtuh unit — According to Advice Filing p. AC-52

4) **Evaluation Estimates:**

See Advice Filing impacts.
Impacts developed for all climate zones:

5) **Summary of Results:**

Impact Type (per 10-ton unit)	Impact		Recommended Source
	Advice Filing	Evaluation	
NC Demand (kW)	-	-	
Coinc. Demand (kW)	-	-	
Annual Energy (kWh)	4,171	4,171	Evaluation

Climate Zone Specific Impacts:

Climate Zone	kWh/ton
CZ_1	22.9
CZ_2	523.4
CZ_3	202.9
CZ_4*	**514.7**
CZ_5	255.7
CZ_6	547.6
CZ_7	714.4
CZ_8	807.3
CZ_9	913.1
CZ_10	1071.0
CZ_11	1060.5
CZ_12	722.5
CZ_13	1407.9
CZ_14	1364.6
CZ_15	2731.7
CZ_16	460.1

***See following spreadsheet for evaluation estimates for Climate Zone 4.**

6) **Adjust Energy Impacts by Conditioned Area:**

Advice Filing Assumptions:
Cooling Energy Savings = 4,171 kWh/yr for a 10 ton unit
= 417.1 kWh/yr-ton
Heating Energy Savings = 1,866 therms/yr for a 250 kBtuh unit
= 7.464 therms/yr-kBtuh

AC Sizing = 1 ton/500 sqft According to Advice Filing p. AC-54

Furnace Sizing = 50 Btuh/sqft According to Advice Filing p. AC-54

Evaluation Energy Estimate:
Cooling = (Conditioned Area) x (1 ton/500 sqft) x 417.1 kWh/yr-ton

Heating = (Conditioned Area) x (50 Btuh/sqft) x (7.464 therms/yr-kBtuh) x (1 kBtuh/1,000 Btuh)

Outside Air (F)	Total Bin (hr/yr)	%OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
Sample Heating and Cooling Load Calculations for Climate Zone 4							
117	0	20%	74	82.6	47.0	0	0
112	0	20%	74	81.6	49.0	0	0
107	0	20%	74	80.6	51.0	0	0
102	0	20%	74	79.6	53.0	0	0
97	10	20%	74	78.6	55.0	1,280	0
92	25	20%	74	77.6	57.0	2,794	0
87	112	20%	74	76.6	59.0	10,694	0
82	296	20%	74	75.6	61.0	23,445	0
77	488	20%	74	74.6	63.0	30,710	0
72	724	20%	74	73.6	65.0	33,778	0
67	853	20%	74	72.6	67.0	25,914	0
62	1,289	20%	74	71.6	70.0	11,189	0
57	1,780	20%	74	70.6	73.0	0	23,176
52	1,370	20%	74	69.6	76.0	0	47,566
47	986	20%	74	68.6	79.0	0	55,630
42	519	20%	74	67.6	82.0	0	40,544
37	243	20%	74	66.6	85.0	0	24,256
32	61	20%	74	65.6	88.0	0	7,413
27	4	20%	74	64.6	91.0	0	573
22	0	20%	74	63.6	94.0	0	0
17	0	20%	74	62.6	97.0	0	0
Total	8,760				Total	139,803	199,158

Revised Energy Use 7:00AM - 6:00PM

Outside Air (F)	Total Bin (hr/yr)	%OSA	Return Air (F)	Mixed Air (F)	Supply Air (F)	Cooling (kBtu/yr)	Heating (kBtu/yr)
Sample Heating and Cooling Load Calculations for Climate Zone 4							
117	0	20%	74	82.6	47.0	0	0
112	0	20%	74	81.6	49.0	0	0
107	0	20%	74	80.6	51.0	0	0
102	0	20%	74	79.6	53.0	0	0
97	7	20%	74	78.6	55.0	896	0
92	18	20%	74	77.6	57.0	2,012	0
87	76	20%	74	76.6	59.0	7,256	0
82	205	20%	74	75.6	61.0	16,237	0
77	349	20%	74	74.6	63.0	21,963	0
72	422	20%	74	73.6	65.0	19,688	0
67	381	20%	74	72.6	67.0	11,575	0
62	469	20%	74	71.6	70.0	4,071	0
57	497	20%	74	70.6	73.0	0	6,471
52	262	20%	74	69.6	76.0	0	9,097
47	94	20%	74	68.6	79.0	0	5,303
42	53	20%	74	67.6	82.0	0	4,140
37	21	20%	74	66.6	85.0	0	2,096
32	4	20%	74	65.6	88.0	0	486
27	2	20%	74	64.6	91.0	0	286
22	0	20%	74	63.6	94.0	0	0
17	0	20%	74	62.6	97.0	0	0
Total	2,860				Total	83,698	27,880

	Cooling	Heating
Baseline Loads	139,803	199,158
Retrofit Business Hours Loads	83,698	27,880
Ramping Loads	8,593	12,890
Total Retrofit Loads	92,291	40,770
Baseline Energy Use	15,145	2,845
Retrofit Energy Use	9,998	582
Savings	5,147	2,263
kWh/ton	514.7	
therm/kBtu		9.051

Water and Evaporative Cooled Single Package AC Unit

(≥ 135,000 Btu/hr)

Remote Condensing Unit (RCU); Air-Cooled

(≥ 135,000 Btu/hr)

Remote Condensing Unit (RCU); Water- and Evaporative- Cooled (≥ 135,000 Btu/hr)

Measure Description:	All three measures involve the replacement of an existing standard-efficiency AC unit with a high-efficiency unit that exceeds Title20 specifications.
Summary of Advice Filing Calculations:	Demand and energy impacts were developed using equivalent full load hours (ELFHs), coincident demand factors (CDFs), and system efficiency.
Comments on Advice Filing Calculations:	Calculation methods cited in the Advice Filing do not accurately model participant specific retrofits. This is due to a generalized assumption regarding typical efficiency and capacity upgrades.
Comments on Advice Filing Inputs:	Baseline efficiencies are consistent with Title20 standards. Sufficient data are not available to verify either the CDF or the EFLH values used in the calculation. ELFHs do not take climate zone variation into account.
Evaluation Process:	Using the change in EER for each site (based upon the MDSS), a revised equation was used in conjunction with EFLHs (developed as part of the evaluation of the RE Central AC measures), to estimate per participant impacts.

Water and Evaporative Cooled Single-Package AC Unit
Remote Condensing Unit (RCU); Air-Cooled
Remote Condensing Unit (RCU); Water and Evaporative Cooled

1) Installation of high-efficiency AC units using the different technologies described.
Units must exceed Title 20 standards

2) Ex-ante Assumptions Used in Calculations:
Baseline Title20 Efficiencies:
Evap Single-Package AC = 9.6 EER
RCU Air-cooled = 9.9 EER
RCU Evap-cooled = 12.9 EER
These values were verified using CEC documentation.

Equivalent Full Load Cooling Hours

Market Segment	Hours/Year
Schools K-12	500
Hotel/Motel	700
Grocery	600
College	1,200
Warehouse	300
Office	1,000
Hospitals	1,900
Other	1,200
Retail	800
Restaurant	1,300
Process Industry	800
Assembly Industry	2,100

Advice Filing. Table 1. p. AC-3

3) Advice Filing Estimates:

Demand Savings:
Measure Demand Savings = kW Title 20 - kW High Efficiency Unit, according to Advice Filing, p. AC-15

kW = (12,000 Btuh/ton) x (1kW/1,000Watt) x (tons/EER Btuh/Watt) according to Advice Filing, p. AC-15
Coincident Demand Savings = Measure Demand Savings x 0.75 CDF

Demand Savings

Program	Tons	Title 20 EER	Title 20 kW	High Efficiency EER	High Efficiency kW	Demand Savings kW	Demand Savings kW/ton-EER	Coinc kW Savings kW/ton-EER
Evap. Cooled SPAC	80	9.6	100.000	10.5	91.429	8.571	0.119	
	80	9.6	100.000	11.5	83.478	16.522	0.109	
						Average	**0.114**	**0.085**
Air-Cooled RCU	30	9.9	36.364	10.2	35.294	1.070	0.119	
	60	9.9	72.727	10.5	68.571	4.156	0.115	
						Average	**0.117**	**0.088**
Evap-Cooled RCU	80	12.9	74.419	13.5	71.111	3.307	0.069	
	120	12.9	111.628	14	102.857	8.771	0.066	
						Average	**0.068**	**0.051**

Advice Filing p. AC-15-22
Values may vary slightly due to rounding.

Energy Savings:

Annual Energy Savings = Measure Demand Savings x EFLCH

Coincident Energy Savings

Market Segment	Hours/Year	Evap. Cooled SPAC Annual Energy Savings kWh/ton-EER	Air-Cooled RCU Annual Energy Savings kWh/ton-EER	Evap-Cooled RCU Annual Energy Savings kWh/ton-EER
Schools K-12	500	57	59	34
Hotel/Motel	700	80	82	47
Grocery	600	68	70	41
College	1,200	137	141	81
Warehouse	300	34	35	20
Office	1,000	114	117	68
Hospitals	1,900	216	223	129
Other	1,200	137	141	81
Retail	800	91	94	54
Restaurant	1,300	148	152	88
Process Industry	800	91	94	54
Assembly Industry	2,100	239	246	142

Advice Filing p. AC-15-22

Values may vary slightly due to rounding.

4) Evaluation Estimates:

Demand Savings:

EER is not linear.

For this reason, calculating an impact using the unit kW/ton-EER is only valid for a very small range of EER values

Demand estimates are developed at a per unit basis.

Demand Savings = (Capacity, Btuh) x (1/EERtitle20 - 1/EERretrofit) x (1kW/1,000 Watts)

Coincident Demand Savings = Demand Savings x CDF

CDF = varies by climate zone and business type

Energy Savings:

Use EFLH's and CDF's developed for the CAC measures for each climate zone.

Energy Savings = Demand Savings x EFLH (climate zone specific)

No efficiency value recorded in the MDSS for the single participant in the RCU Evap-cooled measure.

Using the baseline efficiencies and the kW and kWh impacts, the retrofit efficiency was determined through back-calculations.

Back-calculated Efficiency.

3.723 kW = 0.068 kW/ton-ΔEER x 36.5 tons x (EER - 12.9 EER) x 0.75 CDF

EER = [3.723 kW/(0.068 kW/ton-ΔEER x 36.5 tons x 0.75 CDF)] + 12.9

= 14.9

= 14.9 EER according to kW impacts

3,416.4 kWh = 34 kWh/ton-ΔEER x 36.5 tons x (EER - 12.9 EER)

EER = 15.65

= 15.65 EER according to kWh impacts

Average EER = 15.28

B.7 DETAILED METHODS USED TO DEVELOP PREMISE-SPECIFIC CUSTOMIZED INCENTIVES ENGINEERING ESTIMATES

This section contains detailed information regarding the development of impacts for each Customized Incentives application, and is presented using the following format:

- For each application, a written summary provides a synopsis of the application review process.
- Detailed calculations used in the analysis are provided.

Customized Incentives VSD

Customized rebates for variable speed drives were distributed between 24 records in MDSS. Of these records, 20 were associated with VSDs on supply fans. Other records were associated with VSDs on pumps, chillers, and cooling tower fans. Rebates for the Customized program are based on the demand and energy reductions computed specifically for individual applications.

Program	Customized Rebates
Measure	Variable Speed Drives

Summary of Rebate Calculations

In the case of VSDs on supply fans, savings were based on energy estimates from the Retrofit Express VSD analysis. Site specific adjustments were made to reflect operating schedules and fan size.

All other uses of VSDs were reviewed individually to verify accuracy of calculations.

Comments on Calculations

Impacts and calculation methods are detailed in the applications. For the most part, the calculations are based on temperature bin models, associating a fan load with a given outside air dry bulb temperature. Energy impacts from these calculations agree with the project summary and the MDSS records.

Evaluation Process

Energy estimates from the Retrofit Express VSD analysis represent hourly fan loads based on 24 hour operating schedules. Estimates were computed by using long term (TMY) weather data specific to the climate zone. These figures were diversified to site specific loads based on evaluation of the applications.

Applications were reviewed to gather horsepower of fans, fan schedules, and basecase fan type.

Operating schedules were used to diversify the per-horsepower energy estimates for both pre- and post-retrofit conditions. Dependent on data from the application, a base case of a Constant-volume fan, or Inlet vane system was used.

Baseline and post-retrofit energy use were compared to determine per-horsepower savings.

Additional Notes

All VSD measures on non-supply fans were reviewed and determined to be reasonable estimates.

Impact Results

	kW	kWh	Therm
MDSS	76	3,335	0
Adjusted Engineering	0	2,428	0
Engineering Realization Rate	0.0	0.73	NA

EMS Systems in District Schools

Program	Customized Rebates
Measure	EMS
Site Description	School District

Measure Description

Install a central energy management system to automate equipment scheduling for several schools within the district. Twenty-two applications were submitted for a total of 24 schools.

Summary of Rebate Calculations

Savings claimed within the applications were accepted.

Comments on Calculations

Energy saving calculations were based on bin models which represented loading of the heating and cooling systems before and after installation of the EMS. Heating equivalent full load hours (EFLH) are projected to decrease from 456 to 227. Cooling EFLH are projected to decrease from 706 to 389. Connected loads were based on detailed audits of the facilities.

Evaluation Process

Site visits were performed on five schools representing 43% of the total energy savings for all participating schools. Connected load data was verified through visual inspection of equipment. Operating hours were verified by school personnel.

It was found that the connected load data was very accurate. There were a few minor discrepancies with small motors, but these were deemed to be insignificant to the overall savings calculations. It was assumed that the level of accuracy exhibited in the on-sites was maintained throughout the applications, therefore connected loads were not adjusted.

Bin model analysis of full load hour reduction was accepted as an accurate representation of pre- and post-retrofit conditions.

Additional Notes

Impact Results

	kW	kWh	Therm
MDSS	0	2,016,177	228,057
Adjusted Engineering	0	2,016,177	228,057
Engineering Realization Rate	NA	1.00	1.00

Site ID #	150
Control#	0348858
Check #	59427
Program	Customized Rebates
Measure(s)	EMS, Return Air Ductwork, Low Leakage Dampers, VAV conversion.
Site Description	Large Secondary School

Measure Description:

Four measures were installed at this site: A central EMS system, Return air ducts for 100% outside air units, low leakage dampers for outside air and conversion from packaged constant volume to variable air volume.

Summery of Rebate Calculations:

The rebate calculations were performed using the HAP simulation program from the Carrier Corporation. Sequential simulations were performed for each of the measures installed. Summary output from the simulation, by month, are provided at the building level. Estimates of end use consumption are provided only on an annual basis. Simulations appear to have been conducted using weather data for Oakland, California.

Comments on Calculations

Input files used for the simulations were not available for review. Based on the application information, it appears that the simulations were based on detailed site information collected over a long period of time. As detailed in the application, energy use at this site is much higher then other similar schools in the same area. A critical assumption made by the preparer is that this additional energy use is attributable to a poor HVAC system and mode of operation. This assumption is then used as the basis to calibrate the HAP model. Another point made in the application is that a complete lighting retrofit was carried out previously, resulting in a lighting density of 0.82 Watts per square foot of conditioned space. This value is relatively low, even for sites that have been completely retrofit with high efficiency lighting.

Evaluation Process

After a review of the application information, an on-site survey was conducted. The primary objective of the Survey was to verify the HVAC equipment and operating characteristics. All of HVAC units at the site are packaged, gas heating, electric cooling systems.

The number, type and capacity of the packaged HVAC systems described in the application were verified during the on-site survey. Also verified were the presence of adjustable speed drives on all multi-zone systems. During the on-site survey it was noticed that several of the HVAC units were appeared functional but not operating, indicating that the ventilation fans cycle with the compressor or furnace. Also verified were the operating hours and months of the equipment. This information was consistent with the hours and months stated in application in Exhibit M.

To confirm the operation of the installed measures, monthly HAP output from the application was plotted against billing data. Recall that the HAP data is at the building level and there is very little information available to disaggregate end-use values from this data. Monthly HAP data were available for a base or calibration run and then each of the subsequent measure savings estimate runs.

The calibration simulation agreed reasonably well with the billing data, recall however that the assumption had been made that the HVAC usage at this site was much larger than other schools in the same district.

It appears that the simulation representing the post installation case of the EMS system assumes greatly reduced HVAC usage in the summer months of June, July and August. This is contrary to both the stated hours of operation from Exhibit M and the available billing data. Since the HAP input files used to generate these data were not available, a DOE-2 model was developed to explore the effect of various operating assumptions.

After several parametric simulations, a model was completed which more reasonably agreed with post installation billing data. In order to calibrate the model, following assumptions were implemented:

- HVAC operation was available for the stated operating hours for all 12 months of the year.
- Supply and return fans were allowed to cycle with the furnace and compressor rather than run continuously.
- The model was simulated with climate zone 12 data (Sacramento) rather than climate zone 3 data (Oakland). Walnut Creek is located in climate zone 12. Based on ASHRAE weather and cooling degree day data, it was determined that climate zone 12 was a more representative climate zone. Note that all other campus's that participated in this program were modeled with climate zone 3 weather data.

The return air ductwork and low leakage dampers were then modeled by adjusting assumptions of the amount of outdoor air for particular zones. The VAV measure was not modeled explicitly using DOE-2 due to the level of site data necessary to accurately model a VAV system. Instead the application estimate for this measure was verified by adding the incremental savings for this measure to the estimates from the

DOE-2 simulations and comparing to billing data. Since these two values agreed well, the application estimates was accepted as accurate.

Additional Notes

Impact Results

	kW	kWh	Therm
MDSS	0	1,007,592	19,082
Adjusted Engineering	0	651,835	19,082
Engineering Realization Rate	N/A	0.65	1.00

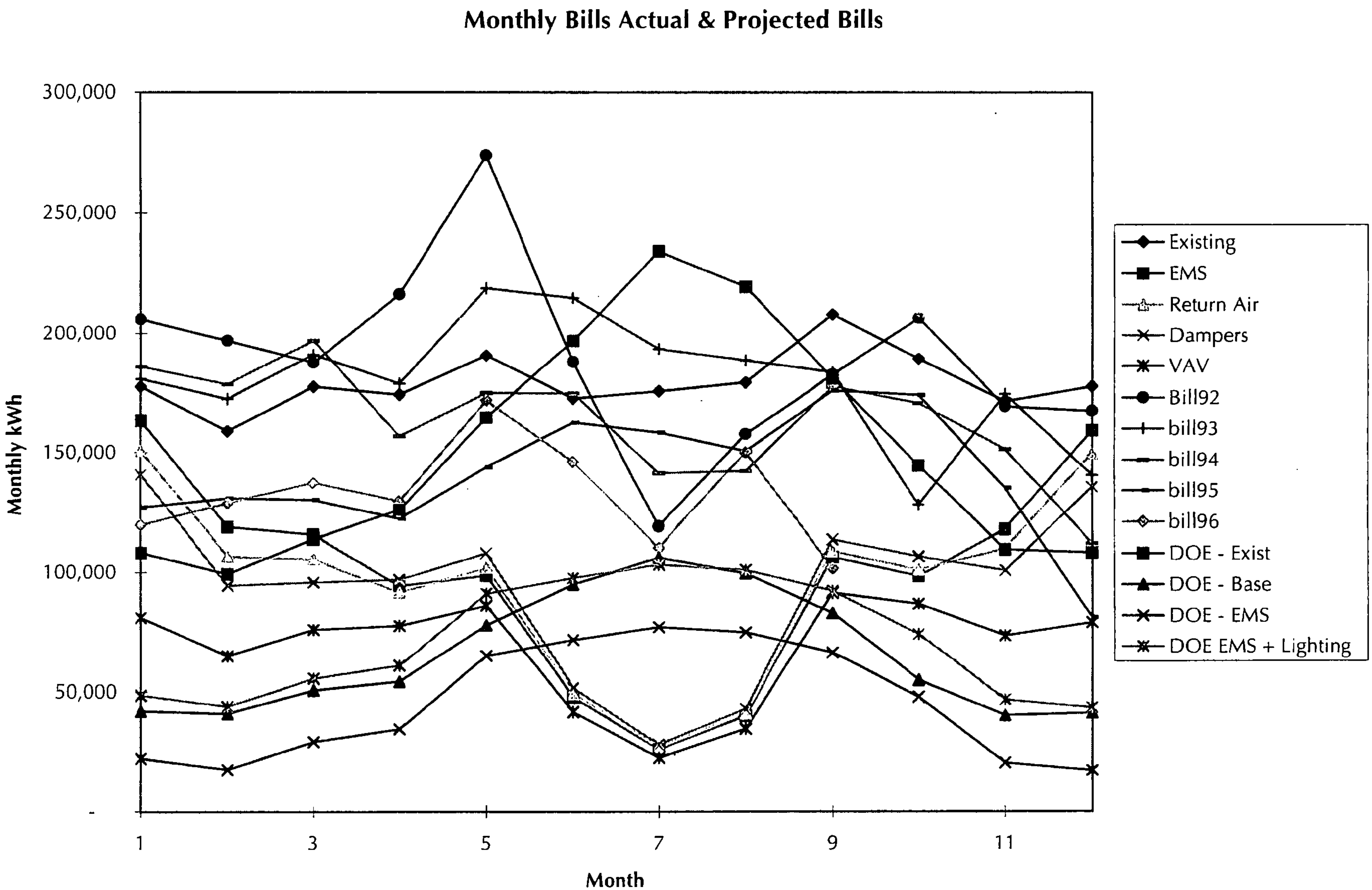
School	Sq. Footage	12 Month Bill	Measured Lighting kW (Pre Retrofit)	Measured Lighting kW (Post Retrofit)	Lighting kWh/Yr	Misc Usage	HVAC	Bill kWh/Sq Ft	Est. HVAC kWh/SqFT-Yr	Est. Lighting kWh/SqFT-Yr	Lighting W/Sq-Ft (Pre Retrofit)	Lighting W/Sq-Ft (Post Retrofit)	New/Old Lighting Watts
Comparison Information From Application													
Clayton Valley	163,391	601,920	195.48	163.2	406,598		168,236	3.68	1.03	2.49	1.20	1.00	0.83
College Park	138,872	929,040	208.6	143.1	433,888		453,345	6.69	3.26	3.12	1.50	1.03	0.69
Concord High	143,513	749,640	202.37	156.8	420,930		294,978	5.22	2.06	2.93	1.41	1.09	0.77
Mt. Diablo	180,151	821,200	223.8	154.7	465,504		318,742	4.56	1.77	2.58	1.24	0.86	0.69
Ygnacio Valley	159,080	1,148,160	245.62	211.3	510,890		585,604	7.22	3.68	3.21	1.54	1.33	0.86
Northgate	167,800	2,128,800	138.3	138.3	313,320		1,719,684	12.69	10.25	1.87	-	0.82	
Northgate TARGET					**403,722**	1,329,069	**396,009**						
Average for schools other than Northgate:								**5.47**	**2.36**	2.87	**1.38**	**1.06**	
									43%	52%			
Analysis Approach:													
1) This information is provided in the application for comparison to Northgate HS													
2) Assume that the HVAC and Lighting usage for schools other than Northgate have been computed reasonably													
2a) Assume that the HVAC usage estimate of 80% of an already large bill unreasonable													
3) Assume that it is not reasonable for Northgate to save 20% more on a lighting retrofit than other schools. Use other school retrofit average													
4) Compute "Target" energy usage for HVAC and lighting to calibrate DOE-2													
5) Simulate the Calibrated DOE-2 model with EMS controling the HVAC systems and compare to Post retrofit billing data													
6) Assess reasonableness of results													

Model 48DF	24	34	44	54	64
Tons	20	30	40	50	60
Standard HP	7.5	10	15	20	25
Alternate HP	7.5	15	20	25	30
Nominal CFM	8,000	12,000	16,000	20,000	24,000
CFM/HP	1,067	1,200	1,067	1,000	960
CFM/Ton	400	400	400	400	400
Model 48DJ	24	34	44	54	64
Tons	20	30	40	50	60
Standard HP		7.5	15	15	20
Alternate HP					
Nominal CFM		10,500	14,000	17,500	21,000
CFM/HP		1,400	933	1,167	1,050
CFM/Ton		350	350	350	350
Ave. CFM/HP		1,300	1,000	1,083	1,005

	Parameter	Value	Source
Physical			
	Cond. Sq. Footage	167,800	Application
	Lighting w/Sqft	1.06	Average from other retrofit schools. Is more reasonable than 0.80 on application
System			
	Capacity(Tons)	606.75	On-site Audit
	Supply Fan HP	170	On-site Audit
	Supply kW	104.44	Calculated: Assume 90% loading (about 0.6 In static).
	CFM	227,531	Calculated Using Carrier data average @ 350 CFM/Ton
	Supply Watts/CFM	0.459	
	Return Fan HP	68	On-site Audit
	Return kW	35.81	Calculated: Assume 90% loading (about 0.6 In static).
	CFM	182,025	Calculated Using 10% Exhaust to account for ventilation
	Watts/CFM	0.197	
	Post-Vent(% Flow)	24%	From Application
	Pre-Vent(% Flow)	5%	From Application

MBH	# Units	Supply CFM (From Applic)	Total BTUH	Tons	Supply HP	Return HP	CFM / TOn	Type	cfm/HP
645	1	19,130	645,000	53.8	15	5	356	SZ	1275
645	1	17,375	645,000	53.8	15	5	323	SZ	1158
155	1	3,585	155,000	12.9	2		278	MZ	1793
		8,525	-	-	10			MZ	853
325	1	4,855	325,000	27.1	7.5	3	179	MZ	647
221	1	6,710	221,000	18.4	7.5	2	364	MZ	895
504	1	11,959	504,000	42.0	15	3	285	MZ	797
608	1	12,680	608,000	50.7	10	1	250	MZ	1268
199	1	5,795	199,000	16.6	3	2	349	MZ	1932
427	1	13,285	427,000	35.6	15	5	373	SZ	886
352	1	11,405	352,000	29.3	7.5	3	389	MZ	1521
455	1	11,300	455,000	37.9	7.5	3	298	MZ	1507
725	1	11,265	725,000	60.4	10	3	186	MZ	1127
395	1	11,230	395,000	32.9	10	7.5	341	MZ	1123
366	1	11,568	366,000	30.5	10	7.5	379	MZ	1157
391	1	11,124	391,000	32.6	10	7.5	341	MZ	1112
368	1	11,855	368,000	30.7	10	7.5	387	MZ	1186
500	1	9,830	500,000	41.7	5	3	236	MZ	1966
								0.415039	
		193,476	43.39	606.75	132.5	55			1233
		242,700	Estimated CFM @ 400 CFM/Ton						1831.698
			The 193,476 "Measured" CFM value 193,476						
		227,531	Use this value computed as 375 CFM/TON from average data from Carrier						

	Existing	EMS	Return Air	Dampers	VAV	Bill92	bill93	bill94	bill95	bill96	App. Lighti	DOE-2 HV	EMS
January	177,544	163,328	150,856	140,830	81064	205,948	180,703	185,840	126,869	119,368	26,110	23348.11	21430.45
February	158,930	118,732	106,635	94,497	64889	196,813	172,525	178,493	130,731	128,770	26,110	30120.61	26400.73
March	177,544	115,638	105,478	95,929	76058	187,414	190,835	196,789	130,110	137,449	26,110	44984.44	38193.03
April	174,229	94,347	91,581	97,098	77677	216,213	178,709	156,892	122,083	129,599	26,110	52475.51	42287.76
May	190,422	98,721	101,956	107,988	86057	273,932	218,831	174,999	143,942	171,747	26,110	65686.45	55845.74
June	172,575	47,896	49,253	51,797	41822	187,705	214,765	174,747	162,509	146,042	26,110	70932.48	53267.76
July	175,596	26,327	27,001	28,285	22862	118,790	193,209	141,367	158,401	110,115	26,110	75072.71	54265.68
August	179,157	40,179	41,207	43,185	34871	157,660	188,326	142,259	150,582	150,124	26,110	74457.03	57864.5
September	207,890	106,247	108,695	113,593	91416	182,328	183,375	177,551	175,879	101,587	26,110	77234.81	64924.64
October	188,865	98,381	101,042	106,567	86838	206,262	127,770	170,676	173,993		26,110	64735.99	55735.59
November	171,339	117,808	109,757	100,779	73431	169,189	174,402	151,307	135,033		26,110	38617.71	34281.71
December	177,544	159,095	149,503	135,274	78925	167,321	140,453	111,879	81,067		26,110	18323.2	16961.28
Sum	2,151,635	1,186,699	1,142,964	1,115,822	815,910	2,269,574	2,163,903	1,962,800	1,691,200		313,320	635,989	521,459


Monthly Bills Actual & Projected Bills
300,000
250,000
200,000
150,000
100,000
50,000
-
Monthly kWh
1
3
5
7
9
11
Month
Existing
EMS
Return Air
Dampers
VAV
Bill92
bill93
bill94
bill95
bill96
DOE - Exist
DOE - Base
DOE - EMS
DOE EMS + Lighting

Assumed Lig	Exist		Base		EMS		Low Leakage Dampers		DOE - Exist	DOE - Base	DOE - EMS	Low Leakag	DOE EMS +
	Cooling	Ventilation	Cooling	Ventilation	Cooling	Ventilation	Cooling	Ventilation	HVAC	HVAC	HVAC	HVAC	VAC + lighti
26110	47	108,117	3,889	38,230	1,992	20,588	1,759	17,458	108,163	42,119	22,580	19,216	48,690
26110	1,676	97,654	8,215	32,901	5,690	12,266	5,825	10,473	99,330	41,116	17,956	16,297	44,066
26110	5,643	108,117	18,093	32,741	17,412	11,997	18,059	11,882	113,760	50,834	29,409	29,941	55,519
26110	21,133	104,629	31,079	23,216	26,310	8,485	27,535	8,518	125,762	54,295	34,795	36,053	60,905
26110	56,585	108,117	60,617	17,259	50,385	14,637	51,291	14,644	164,702	77,876	65,022	65,936	91,132
26110	92,079	104,629	74,994	19,887	56,482	15,117	56,513	15,117	196,708	94,882	71,599	71,630	97,709
26110	126,006	108,117	84,105	21,929	61,260	15,827	59,605	15,784	234,123	106,034	77,087	75,389	103,197
26110	111,283	108,117	78,943	20,629	58,962	15,860	57,932	15,844	219,400	99,572	74,823	73,777	100,933
26110	76,194	104,629	65,330	17,570	52,171	14,013	52,183	14,014	180,823	82,900	66,184	66,197	92,294
26110	36,442	108,117	42,689	12,282	37,160	10,778	37,986	10,813	144,558	54,971	47,937	48,799	74,047
26110	4,749	104,629	14,525	25,887	11,979	8,713	11,149	7,719	109,378	40,411	20,692	18,868	46,802
26110	60	108,117	3,356	37,981	1,736	15,658	1,506	12,668	108,177	41,337	17,394	14,173	43,504
	531,898	1,272,985	485,836	300,511	381,538	163,939	381,343	154,933	1,804,883	786,347	545,477	536,276	545,477
							250,070			1,018,537	342,723	9,201	Savings for
												299911	
							0.9					651,835	

Site ID#:	1230
Check #	61487
Measure	Install heat exchanger between tower water and building loop

Measure Description: A "free cooling" heat exchange system was installed, that allows the building supply water loop to bypass of the central plant chiller, when ambient weather conditions drop below 60 °F. The heat exchanger installed allows for a direct exchange of heat between the tower water loop and the building loop. The building cooling load is either met entirely using the free cooling system or the chiller system, never both simultaneously. MDSS records list this as HVAC - Other; action code 299.

Summary of Calculations in the Original Application: The calculations use a balance point bin model to estimate chiller loads in the pre-retrofit condition. This bin model assumes a maximum chiller demand of 282 kW at 107 °F outdoor dry bulb and 5 kW at 42 °F outdoor dry bulb.

In the post-retrofit condition it is assumed that the chillers are locked out below 60°F, and that all chiller loads are met using the free cooling system.

Peak demand impacts are assumed to be zero because free cooling is obtained during the early morning and late at night, and during periods with low outdoor temperatures.

Comments on Calculations: This retrofit included the installation of a new evaporative cooling tower. The tower retrofit was, however, applied for under a separate application (refer to check number 60361).

Evaluation Process: The chiller loads assumed in this application were verified using chiller logs maintained at the site.

Logs were also available surrounding the operation of the free cooling system. Outdoor temperatures recorded on this log support the application assumption of free cooling below 60 °F. Of the eighty one records obtained for free cooling, just four observations were recorded where the outdoor temperature was in excess of 60 °F.

In contrast, however, chiller logs for the period December 1995 and January 1996 showed chiller operation below 60 °F. This suggests that the reported chiller lockout at 60 °F is not always applicable (the on-site contact stated that the chiller lockout occurs at an even higher outdoor temperature of 63 °F in the post-retrofit condition, though the logs do not support this position).

In general, on-site documented records are consistent with the application assumptions. Following several verification steps, application estimates were adopted.

Additional Notes: An on-site inspection of this facility was conducted on November 19, 1996 with Lee Wilson.

Impact Results for Site ID# 1230

	kW	kWh	Therm
MDSS	0	216,028	0
Evaluation Estimates	0	216,028	0
Engineering Realization Rate	NA	1.0	NA

Input - Chiller #1 Records

Chiller #1 Data							
Observation No.	Outside Temperature	Compressor Amps	Both Running?	Average Compressor Amps	Probability of Both Running	Number of Observations Contributing	Bin
1	49	100	0	100	0.00	1	47
5	50	85	0				
6	50	85	0				
8	50	105	0				
9	52	105	0				
10	52	110	0				
11	52	100	0				
12	52	105	0				
13	52	95	0				
4	54	95	0				
14	54	90	0	98	0.00	10	52
2	55	85	0				
7	55	120	0				
3	56	90	0	98	0.00	3	57
74	64	195	0	195	0.00	1	62
23	65	175	1				
106	65	130	0				
35	66	180	1				
44	66	165	0				
52	66	195	0				
66	66	185	1				
71	66	150	1				
104	66	174	1				
119	66	165	0				
122	66	170	0				
20	67	120	1				
22	67	110	1				
111	67	168	0				

Input - Chiller #1 Records

18	68	125	0				
45	68	180	0				
78	68	190	1				
84	68	195	0				
98	68	185	0				
105	68	170	0				
110	68	176	0				
114	68	162	0				
118	68	170	0				
58	69	186	0				
112	69	175	0	167	0.33	24	67
34	70	170	0				
59	70	190	0				
92	70	180	0				
93	70	180	0				
117	70	175	0				
120	70	170	0				
121	71	170	0				
21	72	120	1				
115	72	171	0				
116	72	170	0				
109	73	183	0				
30	74	195	0				
65	74	190	0				
107	74	185	0	175	0.07	14	72
15	75	200	1				
75	75	190	0				
113	75	177	0				
19	76	100	1				
64	76	190	0				
76	76	180	1				
83	76	175	0				
100	76	150	1				

108	76	185	0				
29	78	200	0				
46	78	195	0				
51	78	194	0				
91	78	180	0	178	0.31	13	77
43	80	195	0				
101	80	184	1				
103	80	176	1				
24	81	195	0				
16	82	115	0				
17	82	105	1				
77	82	175	1				
82	82	185	1				
33	84	195	0				
36	84	195	0				
57	84	189	0				
90	84	165	1				
102	84	166	1	172	0.54	13	82
99	85	190	1				
53	86	195	0				
63	86	180	1				
72	86	145	1				
94	87	185	1				
28	88	185	1				
40	88	200	0				
79	88	170	1				
85	88	190	0	182	0.67	9	87
25	90	180	0				
48	90	185	1				
49	90	186	1				
32	92	195	0				
37	92	180	1				
38	92	175	0				

39	92	196	0				
47	92	185	1				
80	92	160	1				
89	92	180	1				
26	94	175	1				
50	94	188	1				
73	94	145	1				
86	94	190	1	180	0.71	14	92
42	96	185	1				
56	96	184	1				
67	96	180	1				
41	98	180	1				
54	98	180	1				
55	98	186	1				
87	98	190	1	184	1.00	7	97
27	100	200	0				
31	100	190	0				
69	100	187	1				
70	100	184	1				
95	100	185	1				
97	100	186	1				
68	102	185	1				
81	102	190	1				
96	102	189	1				
62	104	180	1	188	0.80	10	102
60	106	180	1	180	1.00	1	107
88	110	175	1	175	1.00	1	112
61	118	180	1	180	1.00	1	117

Input - Chiller #2 Records

Chiller #2 Data							
Observation No.	Outside Temperature	Compressor Amps	Both Running?	Average Compressor Amps	Probability of Both Running	Number of Observations Contributing	Bin
7	48	160	0	160	0.00	1	47
1	50	110	0				
6	50	140	0				
18	50	140	0				
2	51	170	0				
19	51	110	0				
13	51.3	149	0				
17	52	140	0				
21	52	115	0				
22	52	110	0				
5	54	145	0				
8	54	145	0				
20	54	115	0				
11	54.4	148	0	134	0.00	13	52
23	55	120	0				
3	56	150	0				
16	56	140	0				
12	56.8	146	0	139	0.00	4	57
4	60	145	0				
15	60	145	0				
29	60	145	0				
10	60.5	150	0				
14	60.5	147	0				
187	62	175	0				
189	62	170	0				
9	63	152	0				
36	64	180	0				
38	64	185	0				

Input - Chiller #2 Records

148	64	180	0				
180	64	180	0				
197	64	185	0	165	0.00	13	62
24	65	155	0				
34	65	170	0				
51	65	185	0				
89	65	150	0				
112	65	185	0				
123	65	175	0				
145	65	185	0				
159	65	180	0				
25	66	160	0				
33	66	156	0				
47	66	185	0				
67	66	180	0				
69	66	185	1				
75	66	185	1				
86	66	180	0				
94	66	160	0				
96	66	185	0				
100	66	189	0				
105	66	190	0				
111	66	190	0				
158	66	180	0				
165	66	185	1				
171	66	190	0				
175	66	180	0				
179	66	180	0				
185	66	185	0				
200	66	180	0				
201	66	180	0				
26	67	165	0				
182	67	182	0				

192	67	184	0				
35	68	167	0				
42	68	180	0				
61	68	80	0				
99	68	191	0				
106	68	186	0				
108	68	185	0				
129	68	180	0				
152	68	182	0				
157	68	180	0				
164	68	185	0				
170	68	185	0				
184	68	180	0				
186	68	180	0				
196	68	180	0				
56	69	180	0				
117	69	185	0				
183	69	180	0				
193	69	184	0	177	0.06	49	67
43	70	185	0				
46	70	185	0				
107	70	185	0				
116	70	190	0				
122	70	190	0				
138	70	190	0				
30	71	155	0				
39	71	185	0				
153	71	186	0				
172	71	185	0				
181	71	180	0				
27	72	160	0				
28	72	165	0				
88	72	175	0				

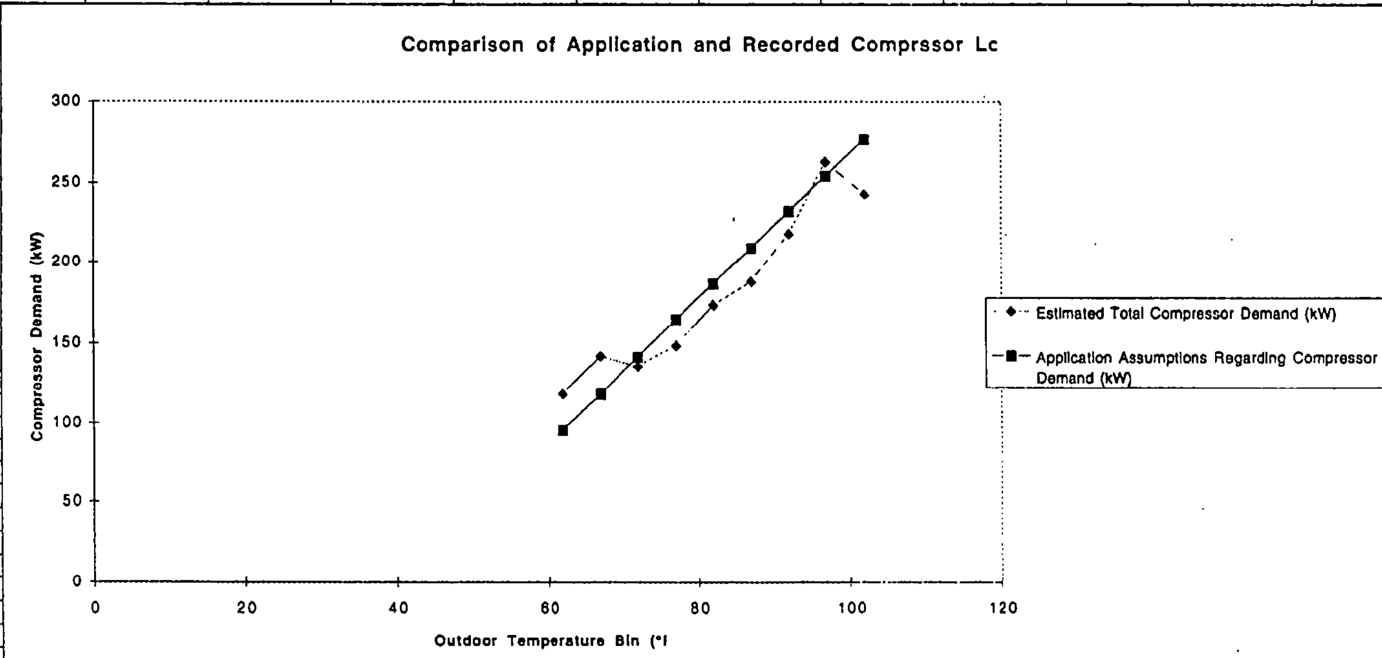
173	72	185	0				
176	72	185	0				
188	72	180	0				
198	72	180	0				
37	73	185	0				
160	73	185	0				
166	73	185	0				
190	73	180	0				
50	74	190	0				
52	74	185	0				
55	74	185	0				
62	74	195	0				
90	74	150	1				
104	74	190	0				
109	74	190	0				
146	74	200	1				
163	74	185	0				
174	74	185	0				
195	74	180	0				
199	74	180	0	182	0.06	34	72
31	75	160	0				
97	75	190	0				
101	75	189	0				
113	75	190	0				
70	76	185	0				
93	76	195	0				
121	76	185	0				
144	76	187	1				
151	76	184	0				
154	76	187	0				
177	76	180	0				
191	77	181	0				
32	78	172	0				

40	78	190	0				
41	78	185	0				
48	78	185	0				
114	78	190	0				
155	78	185	0				
178	78	185	0				
194	78	181	0	184	0.05	20	77
44	80	185	0				
118	80	190	0				
124	80	195	0				
149	80	166	1				
150	80	168	1				
161	80	185	0				
167	80	185	0				
168	80	180	0				
169	80	185	0				
68	82	180	1				
74	82	184	0				
127	82	179	0				
133	82	185	1				
139	82	190	0				
57	83	184	0				
58	83	186	0				
59	83	186					
130	83	182	0				
49	84	185	0				
53	84	190	0				
71	84	180	1				
110	84	185	0				
115	84	190	0				
119	84	190	0				
137	84	190	1				
147	84	170	1				

162	84	185	0	184	0.27	26	82
63	85	174	0				
72	85	186	1				
73	85	184	1				
98	85	193	0				
143	85	189	1				
45	86	185	0				
54	86	190	0				
91	86	190	0				
95	86	195	0				
102	86	190	0				
103	86	190	0				
156	86	180	0				
76	88	180	1				
87	88	180	1				
125	88	177	0				
126	88	179	0	185	0.31	16	87
77	90	178	1				
78	90	185	1				
131	91	178	0				
60	92	81	1				
92	92	180	1				
136	92	190	1				
140	92	190	1				
64	94	181	1				
65	94	175	1				
66	94	182	1				
79	94	180	1				
120	94	190	0				
128	94	179	0	175	0.77	13	92
83	96	189	1				
80	98	186	1				
81	98	187	1				

82	98	189	1				
134	98	190	1				
142	98	191	1	189	1.00	6	97
132	102	185	1				
141	102	187	1	186	1.00	2	102
84	106	190	1	190	1.00	1	107
135	110	190	1	190	1.00	1	112
85	118	190	1	190	1.00	1	117

	Compressor #1			Compressor #2			Combined Analysis				
Bin	Average Compressor Amps	Probability of Both Running	Number of Observations Contributing	Average Compressor Amps	Probability of Both Running	Number of Observations Contributing	Weighted Average Compressor Amps	Weighted Average Probability of Both Running	Total Compressor Load (amps)	Estimated Total Compressor Demand (kW)	Application Assumptions Regarding Compressor Demand (kW)
47	100	0.00	1	160	0.00	1	130	0.00	130	92	27
52	98	0.00	10	134	0.00	13	118	0.00	118	83	50
57	98	0.00	3	139	0.00	4	122	0.00	122	86	73
62	195	0.00	1	165	0.00	13	167	0.00	167	118	95
67	167	0.33	24	177	0.06	49	174	0.15	200	141	118
72	175	0.07	14	182	0.06	34	180	0.06	191	135	141
77	178	0.31	13	184	0.05	20	182	0.15	209	148	164
82	172	0.54	13	184	0.27	26	180	0.36	244	173	186
87	182	0.67	9	185	0.31	16	184	0.44	265	187	209
92	180	0.71	14	175	0.77	13	177	0.74	309	218	232
97	184	1.00	7	189	1.00	6	186	1.00	372	263	254
102	188	0.80	10	186	1.00	2	187	0.83	343	243	277
107	180	1.00	1	190	1.00	1	185	1.00	370	261	282
112	175	1.00	1	190	1.00	1	183	1.00	365	258	282
117	180	1.00	1	190	1.00	1	185	1.00	370	261	



Site ID #	1256
Control#	
Check #	63884
Program	Customized Rebates
Measure(s)	Chiller Retrofit, Installation of VSD on Supply Pump
Site Description	County Office Building

Measure Description: Install a variable speed drive on the compressor of an existing 700 ton chiller and add an additional high efficiency, variable speed 400 to chiller.

Summery of Rebate Calculations: Rebate calculations were performed using visual DOE. The simulations documented in the application include a basecase run calibrated to billing data and an enhanced case run incorporating the new chiller characteristics. The variable speed drive savings are undocumented.

Comments on Calculations: There are minor discrepancies between the standard DOE-2 output included with the application and the Visual-DOE output used to document the impact calculations. In terms of energy impacts, both the standard DOE-2 and visual-DOE output show large savings for the condenser as well as the chiller. No rational is given for condenser savings, as the project to not affect either the cooling tower or condenser loop pumps.

Evaluation Process: An on-site survey was conducted to verify equipment and operational characteristics. Both the retrofit chiller and the added chiller were found to be installed and operating in a fashion consistent with what was stated in the application.

The Visual-DOE output was checked against the standard DOE-2 output included with the application. As mentioned previously, there was a savings shown for the condenser operation as well as the chiller. Discussions with the plant manager indicated that no change had taken place to explain this change in energy consumption. For this reason, the impact estimate was adjusted to reflect no change in the amount of energy used for the condenser.

Documentation to support the savings associated with the variable speed drive on the chilled water supply pump were not supplied with the application. In order to verify the savings, the basecase DOE-2 model used for the application estimate was obtained. This model was first simulated to ensure that the output was consistent with the application. Once this was the basecase energy usage was confirmed, the model was modified to reflect the use of a variable speed pump on the chilled water supply. Results from this simulation showed the impacts associated with the variable speed drive to be approximately 80 percent of the value listed on the application. These results were used as the basis for the evaluation impacts.

Demand impacts for the retrofit were computed based on the on-site survey data. During the peak period only the 700 to retrofit chiller is operating, loaded at approximately 91 percent. Peak demand impact associated with the retrofit chiller was computed as the product of the chiller capacity times the loading factor (91 percent) and the difference in full load kW/ton of the Title 24 baseline and retrofit chillers. This assumes a negligible difference in efficiency between full load and 91 percent loaded. The result of this computation is 68.80 kW, as opposed to an application estimate of 197.0 kW. Since the modified case simulation model was not available for review, the source of this discrepancy could not be identified.

Additional Notes:

Impact Results

	kW	kWh	Therm
MDSS	197.00	650,328	0
Adjusted Engineering	68.80	456,224	0
Engineering Realization Rate	0.35	0.70	N/A

Energy Impacts						
	Chiller Retrofit		Chilled Water Pump VSD	Evaluation Estimate		
End-Use	**Base Case**	**Modified Case**	**Modified Case**			
Lighting	1,246,850	1,246,850	-	1,246,850		
Equipment	439,940	439,940	-	439,940		
Heating	58,310	58,310	-	58,310		
Cooling	970,990	676,820	-	676,820		
Cooling Tower	414,060	257,020	-	**414,060**		
Pumps - Cooling	456,400	456,400	-	**186,083**		
Pumps - Heating	N/A	N/A	-	108,263		
Fans	1,383,450	1,383,450	-	1,383,450		
Hot Water	-	-	-			
Total	4,970,000	4,518,790	4,319,887	4,513,776		
Impacts			650,113	456,224		
Red Indicates a calculated Value						
Demand Impacts						
	Existing Efficiency	Baseline Efficiency	Enhanced Efficiency	Capacity	Peak Loading	Impact
	0.78	0.748	0.640	700	0.91	**68.80**
Red Indicates a calculated Value						

Site ID#:	1929
Check #	61202
Measure	Retrofit Existing VAV Boxes with Damper Kits and DDC Controls

Measure Description:

The retrofit site is a large 23 story office building, with 1,500,000 sq ft of conditioned space. The retrofit performed at this site is a VAV box upgrade which includes the replacement of older damper equipment and the installation of DDC terminal unit controls (and velocity sensors) that provide feedback to the central plant. In addition, pneumatic thermostats were replaced with electronic thermostats. MDSS records list this as HVAC Controls, action code 201.

Summary of Calculations in the Original Application:

The calculations estimate savings due to a reduced discharge pressure at each terminal. A reduction in supply air (SA) pressure will save energy due to a reduction in SA motor load (at a particular CFM delivery rate).

In addition, the retrofit has allowed a reduction in the supply air temperature setting. Increased occupant comfort has been achieved with damper systems that will completely close.

Comments on Calculations:

The documentation for this retrofit indicates that savings are achieved due to both the reduced pressure drop at the VAV box (retrofit boxes have a new low pressure damper system), and the ability to completely close off unconditioned zones during unoccupied periods.

The inability to completely close the existing VAV box dampers caused many "cold" complaints, due to supply air that leaks through closed dampers. These cold complaints in turn forced the building engineers to raise the supply air temperature 10 °F above the design setting (to 65 °F), which caused this system to operate in a fashion more closely related to a constant volume than variable air volume system. Upon retrofit of the VAV boxes, the building engineers were able to lower the supply air temperature in accordance with the original building design. Calculations capture this component of retrofit savings with the application of an average CFM factor in the post-retrofit condition.

Evaluation Process:

The application estimates are based upon assumed CFM delivery rates for average operation of the pre- and post-retrofit system. The evaluation process has assessed these assumptions relative to the assumed reduction in supply air temperature.

The evaluation approach re-defines the post-retrofit CFM delivery rate based upon the assumption that the sensible cooling delivery of the system would not change pre- vs post-retrofit. CFM are predicted in the post-retrofit condition using data from the site contact regarding supply air temperatures in both the pre- and post-retrofit system.

Additional Notes:

An on-site inspection of this facility was conducted on November 13, 1996 with Mario Yamas and Tom Hayes.

Impact Results for Site ID# 1929

	kW	kWh	Therm
MDSS	115	2,318,100	0
Evaluation Estimates	115.2	3,491,159	0
Engineering Realization Rate	1.00	1.51	NA

The application estimates of savings are based upon assumed fan loads during both "occupied" hours (schedule A) and unoccupied hours (schedule B).

To verify assumptions regarding the CFM delivery requirements, on-site records were obtained.

First, the building plans were inspected to determine the CFM capacity of each fan.

A summary is provided below in conjunction with supply fan records from the application

Supply Fan	Building Plan Supply Fan Design CFM	Building Plan Number of Supply Fans	Application Supply Fan Design CFM	Application Number of Supply Fans	Building Plan Return Fan Design CFM	Building Plan Number of Return Fans
AC-1	52,000	2	52,000	2	44,000	2
AC-2	115,000	2	115,000	2	95,000	2
AC-3	25,000	2	25,000	2	22,500	2
AC-4	170,000	2	170,000	2	74,000	2
AC-5	170,000	2	170,000	2	74,000	2
AC-6	87,500	2	87,500	2	61,000	2
AC-7	87,500	2	87,500	2	61,000	2
AC-8	*	*	74,000	1	¥	¥
AC-9	†	†	67,000	1	¥	¥
AC-10	†	†	50,000	1	¥	¥
AC-11	†	†	36,000	1	¥	¥
Total	1,414,000	CFM Supply Air Capacity				

This design capacity figure excludes AC-8 through AC-11 which is consistent with monitored records that were obtained (see below).

* This fan was not specified in the building design plans, however records were recorded for this fan in the application. Application calculations excluded this fan.

† On-site records did not indicate the existence of fans 9-11, however records were recorded for these fans in the application.

¥ Return fan records were also recorded during the on-site inspection of this retrofit.

Second, hourly monitored CFM delivery per floor were recorded during the on-site.

Monitored data were available for a four day period in November.

From this data, below are the maximum observed CFM load per floor

Zone	Max Observed CFM	Served by AC
1N	19,151	AC-1,2 & 3
2S	24,577	AC-1,2 & 3
2N	10,207	AC-1,2 & 3
3N	11,384	AC-1,2 & 3
4S	28,112	AC-1,2 & 3
4N	19,552	AC-1,2 & 3
5S	*	AC-1,2 & 3
5N	*	AC-1,2 & 3
9	32,672	AC-6 &7

10	17,416	AC-6 &7										
11	16,148	AC-6 &7										
12	15,998	AC-6 &7										
13	15,293	AC-6 &7										
14	19,062	AC-6 &7										
15	16,301	AC-6 &7										
18	18,943	AC-6 &7										
16	15,485	AC-6 &7										
17	15,053	AC-6 &7										
19	20,110	AC-6 &7										
20	13,316	AC-6 &7										
21	16,049	AC-6 &7										
22	10,853	AC-6 &7										
23	13,528	AC-6 &7										
6N	8,567	AC-4 & 5										
6S	10,145	AC-4 & 5										
7N	11,467	AC-4 & 5										
7S	19,207	AC-4 & 5										
8N	15,588	AC-4 & 5										
8S	14,229	AC-4 & 5										
Total	486,074	Maximum observed CFM distributed during a four day period.										
	% of Design CFM	34.38%										
* The 5th floor is not currently trended due to ongoing remodeling.												
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The application estimates of savings are based upon assumed fan loads during both "occupied" hours (schedule A) and unoccupied hours (schedule B).

Summarized below are the assumed fan loads from the application

Each assumed fan load, as recorded in the application is recorded below.

In addition, analysis is conducted of the assumed fan CFM supplied using these methods

				Existing Operation Before Retrofit					Post-Retrofit Operation	
Supply Fan	Fan system	Supply Fan Design CFM	Schedule of Supply Air Fan Operation	Hours per Year Operating Under a Particular Schedule	Motor Rated HP	Motor Efficiency	Peak Hour BHP	Averge CFM Factor	Peak Hour BHP	Averge CFM Factor
AC-1	S-1A	52,000	A	2600	60	0.86	53.50	0.95	47.50	0.85
AC-1	S-1A	52,000	B	6160	60	0.86	53.50	0.95	47.50	0.80
AC-1	S-1B	52,000	A	2600	60	0.86	53.50	0.95	47.50	0.85
AC-1	S-1B	52,000	B	3458	60	0.86	53.50	0.95	47.50	0.80
AC-2	S-2A	115,000	A	2600	150	0.88	122.00	0.95	106.70	0.85
AC-2	S-2A	115,000	B	6160	150	0.88	122.00	0.95	106.70	0.80
AC-2	S-2B	115,000	A	2600	150	0.88	122.00	0.95	106.70	0.85
AC-2	S-2B	115,000	B	0	150	0.88	122.00	0.95	106.70	-
AC-3	S-3A	25,000	A	2600	40	0.86	28.00	0.95	23.80	0.85
AC-3	S-3A	25,000	B	6160	40	0.86	28.00	0.95	23.80	0.80
AC-3	S-3B	25,000	A	2600	40	0.86	28.00	0.95	23.80	0.85
AC-3	S-3B	25,000	B	3094	40	0.86	28.00	0.95	23.80	0.80
AC-4	S-4	170,000	A	3640	200	0.88	190.00	0.95	172.50	0.90
AC-4	S-4	170,000	B	5120	200	0.88	190.00	0.95	172.50	0.85
AC-5	S-5	170,000	A	3640	200	0.88	190.00	0.95	172.50	0.90
AC-5	S-5	170,000	B	5120	200	0.88	190.00	0.95	172.50	0.85
AC-6	S-6A	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-6	S-6A	87,500	B	6160	125	0.87	92.00	0.95	79.80	0.80
AC-6	S-6B	87,600	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-6	S-6B	87,500	B	1560	125	0.87	92.00	0.95	79.80	0.80
AC-7	S-7A	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-7	S-7A	87,500	B	6160	125	0.87	92.00	0.95	79.80	0.80
AC-7	S-7B	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-7	S-7B	87,500	B	1560	125	0.87	92.00	0.95	79.80	0.80

Supply Fan	Fan system	Calculated Post-Retrofit Average CFM Rate*
AC-1	S-1A	44,200
AC-1	S-1A	41,600
AC-1	S-1B	44,200
AC-1	S-1B	41,600
AC-2	S-2A	97,750
AC-2	S-2A	92,000
AC-2	S-2B	97,750
AC-2	S-2B	0
AC-3	S-3A	21,250
AC-3	S-3A	20,000
AC-3	S-3B	21,250
AC-3	S-3B	20,000
AC-4	S-4	153,000
AC-4	S-4	144,500

AC-5	S-5	153,000											
AC-5	S-5	144,500											
AC-6	S-6A	74,375											
AC-6	S-6A	70,000											
AC-6	S-6B	74,375											
AC-6	S-6B	70,000											
AC-7	S-7A	74,375											
AC-7	S-7A	70,000											
AC-7	S-7B	74,375											
AC-7	S-7B	70,000											
Sum Schedule A CFM		929,900	CFM	52%	Measured maximum CFM (observed in early November) as a percentage of modeled (from the application) schedule A CFM.								
Sum Schedule B CFM		784,200	CFM	62%	Measured CFM (observed in early November) as a percentage of modeled (from the application) schedule B CFM.								
* During the system peak all fans are assumed to operate under design CFM loads.													
	Comparisons between the CFM values derived using average CFM factors (from the application) and those observed in early November, application assumptions appear reasonable.												
	Given that temperatures in November are relatively mild, it is not surprising that delivered CFM measured during that period was lower than the average (which includes periods with warmer temperatures).												
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Green designates a result.													

The application estimates of savings are based upon assumed fan loads during pre- and post-retrofit, which are in turn based upon assumed supply air delivery temperatures.
In general, the application describes this reduction in air delivery as being associated with a pre-retrofit supply air temperature of 65 °F and a post-retrofit value of 55 °F.
The site contact indicated that in general this reduction in supply air temperature was realized following the retrofit.
However, those records indicate that the realized temperature differential varies with fan system, and at times, the reduction in supply air temperature was not as dramatic as indicated by the appplication.
To further assess the reasonableness of application fan load assumptions, analyses are carried out below to measure the Btuh load differences assumed (pre- vs post-retrofit) at the supply air temperatures specified.

				Existing Operation Before Retrofit					Post-Retrofit Operation	
Supply Fan	Fan system	Supply Fan Design CFM	Schedule of Supply Air Fan Operation	Hours per Year Operating Under a Particular Schedule	Motor Rated HP	Motor Efficiency	Peak Hour BHP	Averge CFM Factor	Peak Hour BHP	Averge CFM Factor
AC-1	S-1A	52,000	A	2600	60	0.86	53.50	0.95	47.50	0.85
AC-1	S-1A	52,000	B	6160	60	0.86	53.50	0.95	47.50	0.80
AC-1	S-1B	52,000	A	2600	60	0.86	53.50	0.95	47.50	0.85
AC-1	S-1B	52,000	B	3458	60	0.86	53.50	0.95	47.50	0.80
AC-2	S-2A	115,000	A	2600	150	0.88	122.00	0.95	106.70	0.85
AC-2	S-2A	115,000	B	6160	150	0.88	122.00	0.95	106.70	0.80
AC-2	S-2B	115,000	A	2600	150	0.88	122.00	0.95	106.70	0.85
AC-2	S-2B	115,000	B	0	150	0.88	122.00	0.95	106.70	-
AC-3	S-3A	25,000	A	2600	40	0.86	28.00	0.95	23.80	0.85
AC-3	S-3A	25,000	B	6160	40	0.86	28.00	0.95	23.80	0.80
AC-3	S-3B	25,000	A	2600	40	0.86	28.00	0.95	23.80	0.85
AC-3	S-3B	25,000	B	3094	40	0.86	28.00	0.95	23.80	0.80
AC-4	S-4	170,000	A	3640	200	0.88	190.00	0.95	172.50	0.90
AC-4	S-4	170,000	B	5120	200	0.88	190.00	0.95	172.50	0.85
AC-5	S-5	170,000	A	3640	200	0.88	190.00	0.95	172.50	0.90
AC-5	S-5	170,000	B	5120	200	0.88	190.00	0.95	172.50	0.85
AC-6	S-6A	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-6	S-6A	87,500	B	6160	125	0.87	92.00	0.95	79.80	0.80
AC-6	S-6B	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-6	S-6B	87,500	B	1560	125	0.87	92.00	0.95	79.80	0.80
AC-7	S-7A	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-7	S-7A	87,500	B	6160	125	0.87	92.00	0.95	79.80	0.80
AC-7	S-7B	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-7	S-7B	87,500	B	1560	125	0.87	92.00	0.95	79.80	0.80

		Existing Operation Before Retrofit			Post-Retrofit Operation			Post-Retrofit Operation		
Supply Fan	Fan system	Calculated Pre-Retrofit Average CFM Rate	Assumed Application-Based Supply Air Temperature Differential	Average Btuh Sensible Cooling Delivery of the System*	Calculated Post-Retrofit Average CFM Rate	Assumed Application-Based Supply Air Temperature Differential	Average Btuh Sensible Cooling Delivery of the System*	Calculated Post-Retrofit Average CFM Rate	Required Supply Air Temperature Differential†	Average Btuh Sensible Cooling Delivery of the System*
AC-1	S-1A	49,400	7	375,193	44,200	17	815,269	44,200	8	369,269
AC-1	S-1A	49,400	7	375,193	41,600	17	767,312	41,600	8	347,547
AC-1	S-1B	49,400	7	375,193	44,200	17	815,269	44,200	8	369,269
AC-1	S-1B	49,400	7	375,193	41,600	17	767,312	41,600	8	347,547
AC-2	S-2A	109,250	7	829,754	97,750	17	1,802,999	97,750	8	816,652
AC-2	S-2A	109,250	7	829,754	92,000	17	1,696,940	92,000	8	768,614
AC-2	S-2B	109,250	7	829,754	97,750	17	1,802,999	97,750	8	816,652
AC-2	S-2B	109,250	7	829,754	0	17	0	0	8	0
AC-3	S-3A	23,750	7	180,381	21,250	17	391,956	21,250	8	177,533
AC-3	S-3A	23,750	7	180,381	20,000	17	368,900	20,000	8	167,090

AC-3	S-3B	23,750	7	180,381	21,250	17	391,956	21,250	8	177,533				
AC-3	S-3B	23,750	7	180,381	20,000	17	368,900	20,000	8	167,090				
AC-4	S-4	161,500	7	1,226,593	153,000	17	2,822,085	153,000	8	1,278,239				
AC-4	S-4	161,500	7	1,226,593	144,500	17	2,665,303	144,500	8	1,207,225				
AC-5	S-5	161,500	7	1,226,593	153,000	17	2,822,085	153,000	8	1,278,239				
AC-5	S-5	161,500	7	1,226,593	144,500	17	2,665,303	144,500	8	1,207,225				
AC-6	S-6A	83,125	7	631,334	74,375	17	1,371,847	74,375	8	621,366				
AC-6	S-6A	83,125	7	631,334	70,000	17	1,291,150	70,000	8	584,815				
AC-6	S-6B	83,125	7	631,334	74,375	17	1,371,847	74,375	8	621,366				
AC-6	S-6B	83,125	7	631,334	70,000	17	1,291,150	70,000	8	584,815				
AC-7	S-7A	83,125	7	631,334	74,375	17	1,371,847	74,375	8	621,366				
AC-7	S-7A	83,125	7	631,334	70,000	17	1,291,150	70,000	8	584,815				
AC-7	S-7B	83,125	7	631,334	74,375	17	1,371,847	74,375	8	621,366				
AC-7	S-7B	83,125	7	631,334	70,000	17	1,291,150	70,000	8	584,815				
		Sum Schedule A Btuh		7,749,179	Btuh		17,152,006	Btuh		7,768,850	Btuh			
		Sum Schedule B Btuh		7,749,179	Btuh		14,464,569	Btuh		6,551,599	Btuh			

* The sensible capacity is calculated using 1.08 Btuh/CFM-Δ°F.

† The required supply air temperature differential is the value that will yield a post-retrofit cooling load that is equivalent to the pre-retrofit load.

Based on the schedule A, and the supply air delivery assumptions from this application, an equivalent Btuh load would be delivered in the post-retrofit condition based on a supply air temperature of 64.3 °F.

This shows that the reduction in fan energy used for the application is inconsistent with the additional assumptions regarding reduced supply air temperatures.

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Evaluation estimates are based upon site contact supplied pre- vs. post-retrofit supply air temperatures.

Due to the inconsistent findings already shown (within the application assumptions), this analysis attempts to revise the average CFM factor based upon assumed application existing loads and site contact based supply air

It is assumed that the pre- and post-retrofit sensible cooling loads are equal.

These analyes utilize the supply air temperatures provided and then back into required CFM based on those assumptions.

					Existing Operation Before Retrofit				Post-Retrofit Operation	
Supply Fan	Fan system	Supply Fan Design CFM	Schedule of Supply Air Fan Operation	Hours per Year Operating Under a Particular Schedule	Motor Rated HP	Motor Efficiency	Peak Hour BHP	Averge CFM Factor	Peak Hour BHP	Averge CFM Factor
AC-1	S-1A	52,000	A	2600	60	0.86	53.50	0.35	47.50	0.85
AC-1	S-1A	52,000	B	6160	60	0.86	53.50	0.95	47.50	0.80
AC-1	S-1B	52,000	A	2600	60	0.86	53.50	0.95	47.50	0.85
AC-1	S-1B	52,000	B	3458	60	0.86	53.50	0.95	47.50	0.80
AC-2	S-2A	115,000	A	2600	150	0.88	122.00	0.95	106.70	0.85
AC-2	S-2A	115,000	B	6160	150	0.88	122.00	0.95	106.70	0.80
AC-2	S-2B	115,000	A	2600	150	0.88	122.00	0.95	106.70	0.85
AC-2	S-2B	115,000	B	0	150	0.88	122.00	0.95	106.70	-
AC-3	S-3A	25,000	A	2600	40	0.86	28.00	0.95	23.80	0.85
AC-3	S-3A	25,000	B	6160	40	0.86	28.00	0.95	23.80	0.80
AC-3	S-3B	25,000	A	2600	40	0.86	28.00	0.95	23.80	0.85
AC-3	S-3B	25,000	B	3094	40	0.86	28.00	0.95	23.80	0.80
AC-4	S-4	170,000	A	3640	200	0.88	190.00	0.95	172.50	0.90
AC-4	S-4	170,000	B	5120	200	0.88	190.00	0.95	172.50	0.85
AC-5	S-5	170,000	A	3640	200	0.88	190.00	0.95	172.50	0.90
AC-5	S-5	170,000	B	5120	200	0.88	190.00	0.95	172.50	0.85
AC-6	S-6A	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-6	S-6A	87,500	B	6160	125	0.87	92.00	0.95	79.80	0.80
AC-6	S-6B	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-6	S-6B	87,500	B	1560	125	0.87	92.00	0.95	79.80	0.80
AC-7	S-7A	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-7	S-7A	87,500	B	6160	125	0.87	92.00	0.95	79.80	0.80
AC-7	S-7B	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-7	S-7B	87,500	B	1560	125	0.87	92.00	0.95	79.80	0.80

		Existing Operation Before Retrofit				Post-Retrofit Operation					Post-Retrofit Operation		
Supply Fan	Fan system	Calculated Pre Retrofit Average CFM Rate	Assumed Site Contact-Based Supply Air Temperature	Assumed Site Contact-Based Supply Air Temperature Differential	Average Btuh Sensible Cooling Delivery of the System*	Calculated Post-Retrofit Average CFM Rate	Assumed Site Contact Based Supply Air Temperature	Assumed Site Contact Based Supply Air Temperature Differential	Average Btuh Sensible Cooling Delivery of the System*	Calculated Post-Retrofit Average CFM Rate	Required Supply Air Temperature Differential†	Average Btuh Sensible Cooling Delivery of the System*	Calculated Averge CFM Factor
AC-1	S-1A	49,400	65	7	375,193	44,200	60	12	575,484	29,614	12	385,574	0.57
AC-1	S-1A	49,400	65	7	375,193	41,600	60	12	541,632	27,872	12	362,893	0.54
AC-1	S-1B	49,400	65	7	375,193	44,200	60	12	575,484	29,614	12	385,574	0.57
AC-1	S-1B	49,400	65	7	375,193	41,600	60	12	541,632	27,872	12	362,893	0.54
AC-2	S-2A	109,250	65	7	829,754	97,750	60	12	1,272,705	65,493	12	852,712	0.57
AC-2	S-2A	109,250	65	7	829,754	92,000	60	12	1,197,840	61,640	12	802,553	0.54
AC-2	S-2B	109,250	65	7	829,754	97,750	60	12	1,272,705	65,493	12	852,712	0.57
AC-2	S-2B	109,250	65	7	829,754	0	60	12	0	0	12	0	0.00
AC-3	S-3A	23,750	65	7	180,381	21,250	53	19	438,069	14,238	19	293,506	0.57
AC-3	S-3A	23,750	65	7	180,381	20,000	53	19	412,300	13,400	19	276,241	0.54
AC-3	S-3B	23,750	65	7	180,381	21,250	53	19	438,069	14,238	19	293,506	0.57
AC-3	S-3B	23,750	65	7	180,381	20,000	53	19	412,300	13,400	19	276,241	0.54
AC-4	S-4	161,500	60	12	2,102,730	153,000	55	17	2,822,085	102,510	17	1,890,797	0.60
AC-4	S-4	161,500	60	12	2,102,730	144,500	55	17	2,665,303	96,815	17	1,785,753	0.57
AC-5	S-5	161,500	60	12	2,102,730	153,000	55	17	2,822,085	102,510	17	1,890,797	0.60

AC-5	S-5	161,500	60	12	2,102,730	144,500	55	17	2,665,303	96,815	17	1,785,753	0.57		
AC-6	S-6A	83,125	65	7	631,334	74,375	60	12	968,363	49,831	12	648,803	0.57		
AC-6	S-6A	83,125	65	7	631,334	70,000	60	12	911,400	46,900	12	610,638	0.54		
AC-6	S-6B	83,125	65	7	631,334	74,375	60	12	968,363	49,831	12	648,803	0.57		
AC-6	S-6B	83,125	65	7	631,334	70,000	60	12	911,400	46,900	12	610,638	0.54		
AC-7	S-7A	83,125	65	7	631,334	74,375	60	12	968,363	49,831	12	648,803	0.57		
AC-7	S-7A	83,125	65	7	631,334	70,000	60	12	911,400	46,900	12	610,638	0.54		
AC-7	S-7B	83,125	65	7	631,334	74,375	60	12	968,363	49,831	12	648,803	0.57		
AC-7	S-7B	83,125	65	7	631,334	70,000	60	12	911,400	46,900	12	610,638	0.54		
				Sum Schedule A Btuh	9,501,454	Btuh			14,090,138	Btuh		9,440,391	Btuh		
				Sum Schedule B Btuh	9,501,454	Btuh			12,081,909	Btuh		8,094,879	Btuh		

* The sensible capacity is calculated using 1.08 Btuh/CFM-Δ°F.

† The required supply air temperature differential is the value that will yield a post-retrofit cooling load that is equivalent to the pre-retrofit load.

Based on the schedule A, and the supply air delivery assumptions from this application, an equivalent Btuh load would be delivered in the post-retrofit condition based on a supply air temperature of 64.3 °F.

This shows that the reduction in fan energy used for the application is inconsistent with the additional assumptions regarding reduced supply air temperatures.

Blue font designates an input.

Red font designates a calculation.

Green designates a result.

The average CFM factor has been re-computed based upon the assumptions that the building cooling load is equivalent in the pre- and post-retrofit condition.

The methods applied in the application are assumed, using the evaluation-based average CFM factor.

These analyes utilize the supply air temperatures provided and then back into required CFM based on those assumptions.

				Existing Operation Before Retrofit					Post-Retrofit Operation	
Supply Fan	Fan system	Supply Fan Design CFM	Schedule of Supply Air Fan Operation	Hours per Year Operating Under a Particular Schedule	Motor Rated HP	Motor Efficiency	Peak Hour BHP	Averge CFM Factor	Peak Hour BHP	Averge CFM Factor
AC-1	S-1A	52,000	A	2600	60	0.86	53.50	0.95	47.50	0.85
AC-1	S-1A	52,000	B	6160	60	0.86	53.50	0.95	47.50	0.80
AC-1	S-1B	52,000	A	2600	60	0.86	53.50	0.95	47.50	0.85
AC-1	S-1B	52,000	B	3458	60	0.86	53.50	0.95	47.50	0.80
AC-2	S-2A	115,000	A	2600	150	0.88	122.00	0.95	106.70	0.85
AC-2	S-2A	115,000	B	6160	150	0.88	122.00	0.95	106.70	0.80
AC-2	S-2B	115,000	A	2600	150	0.88	122.00	0.95	106.70	0.85
AC-2	S-2B	115,000	B	0	150	0.88	122.00	0.95	106.70	--
AC-3	S-3A	25,000	A	2600	40	0.86	28.00	0.95	23.80	0.85
AC-3	S-3A	25,000	B	6160	40	0.86	28.00	0.95	23.80	0.80
AC-3	S-3B	25,000	A	2600	40	0.86	28.00	0.95	23.80	0.85
AC-3	S-3B	25,000	B	3094	40	0.86	28.00	0.95	23.80	0.80
AC-4	S-4	170,000	A	3640	200	0.88	190.00	0.95	172.50	0.90
AC-4	S-4	170,000	B	5120	200	0.88	190.00	0.95	172.50	0.85
AC-5	S-5	170,000	A	3640	200	0.88	190.00	0.95	172.50	0.90
AC-5	S-5	170,000	B	5120	200	0.88	190.00	0.95	172.50	0.85
AC-6	S-6A	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-6	S-6A	87,500	B	6160	125	0.87	92.00	0.95	79.80	0.80
AC-6	S-6B	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-6	S-6B	87,500	B	1560	125	0.87	92.00	0.95	79.80	0.80
AC-7	S-7A	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-7	S-7A	87,500	B	6160	125	0.87	92.00	0.95	79.80	0.80
AC-7	S-7B	87,500	A	2600	125	0.87	92.00	0.95	79.80	0.85
AC-7	S-7B	87,500	B	1560	125	0.87	92.00	0.95	79.80	0.80

		Evaluation Estimate of Energy Impact					Alternate Estimate of Energy Impact		
Supply Fan	Fan system	Pre-Retrofit Average BHP	Calculated Averge CFM Factor	Post-Retrofit Average BHP*	Average BHP savings	Annual Energy Savings† (kWh)	Annual Energy Level using Pre-retrofit BHP (kWh)	Back-calcualted AC-2/S-2B Annual Energy Level (kWh)	Annual Energy Savings¥ (kWh)
AC-1	S-1A	45.87	0.57	8.77	37.10	83,664	103,452		58,916
AC-1	S-1A	45.87	0.54	7.31	38.56	206,016	245,101		131,374
AC-1	S-1B	45.87	0.57	8.77	37.10	83,664	103,452		58,916
AC-1	S-1B	45.87	0.54	7.31	38.56	115,650	137,591		73,749
AC-2	S-2A	104.60	0.57	19.71	84.89	187,109	230,547		131,297

AC-2	S-2A	104.60	0.54	16.43	88.17	460,418	546,220		292,774			
AC-2	S-2B	104.60	0.57	19.71	84.89	187,109	230,547		131,297			
AC-2	S-2B	104.60	0.00	0.00	104.60	0	0	75,987	75,987			
AC-3	S-3A	24.01	0.57	4.40	19.61	44,229	54,143		30,834			
AC-3	S-3A	24.01	0.54	3.66	20.34	108,694	128,277		68,757			
AC-3	S-3B	24.01	0.57	4.40	19.61	44,229	54,143		30,834			
AC-3	S-3B	24.01	0.54	3.66	20.34	54,594	64,430		34,535			
AC-4	S-4	162.90	0.60	37.82	125.08	385,961	502,669		303,109			
AC-4	S-4	162.90	0.57	31.86	131.04	568,759	707,051		402,665			
AC-5	S-5	162.90	0.60	37.82	125.08	385,961	502,669		303,109			
AC-5	S-5	162.90	0.57	31.86	131.04	568,759	707,051		402,665			
AC-6	S-6A	78.88	0.57	14.74	64.14	142,993	175,854		100,149			
AC-6	S-6A	78.88	0.54	12.29	66.59	351,730	416,638		223,318			
AC-6	S-6B	78.88	0.57	14.74	64.14	142,993	175,854		100,149			
AC-6	S-6B	78.88	0.54	12.29	66.59	89,075	105,512		56,555			
AC-7	S-7A	78.88	0.57	14.74	64.14	142,993	175,854		100,149			
AC-7	S-7A	78.88	0.54	12.29	66.59	351,730	416,638		223,318			
AC-7	S-7B	78.88	0.57	14.74	64.14	142,993	175,854		100,149			
AC-7	S-7B	78.88	0.54	12.29	66.59	89,075	105,512		56,555			
		Average	0.54		Total	4,938,398	6,065,059	6,141,046	3,491,159	Energy Impact (kWh)		
						Application impact estimate is 2,318,000 kWh.						
						Application pre-retrofit energy level is 6,141,046 kWh.						
						Therefore savings estimated using the calculated CFM and the fan cube law is 80% of the basecase.						
									56.85%	Energy Savings		
* Post-retrofit average BHP estimated using the following fan law:												
	Post retrofit BHP = (post-retrofit average CFM factor)**3 x post-retrofit peak BHP.											
† Annual energy savings are estimated using the following formula:												
	Energy Impact = ((average BHP savings) x 0.746 x hours per year)/motor efficiency											
¥ Due to the extremely high impact figures generated using the fan cube law, an alternate method was applied where energy use is assumed to be directly proportional to CFM delivered.												
	Using this alternate approach, savings were found to be approximately 57% of the basecase.											
The methods used in the application to generate demand impacts were reviewed and found to be acceptable.												
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Site ID #	3083
Control#	
Check #	61488
Program	Customized Rebates
Measure(s)	Chiller Retrofit
Site Description	Highrise Office Building

Measure Description: Retrofit an existing 600 ton centrifugal chiller with an open compressor and a Turbo Modulator (variable speed drive on compressor motor).

Summery of Rebate Calculations: Demand and energy calculations were computed based using a temperature bin method and manufacturers data for the existing and retrofit chillers. The loadline was based on observed loads at the site.

Comments on Calculations: The loadine appears reasonable and accurate. Temperature bin data agree well with both the PG&E approved weather and TMY San Francisco weather. Existing usage is computed as the product of the hourly load for the given temperature bin (expressed in tons) and the current condition efficiency. The current condition efficiency appears to be based on the condenser water temperature and the part load ratio. The condenser water temperature is held constant at 80 degrees for all hours in the existing case, assuming a constant tower setpoint.

Usage associated with the Retrofit chiller is computed in a similar fashion, using an identical loadline, weather and operating hours assumptions. Computations are provided for the retrofit compressor by itself and then in combination with the Turbo Modulator. The two main differences between the existing case and retrofit cases are the equipment efficiencies and the tower setpoint. Equipment efficiencies are consistent with manufacturers ratings. The tower setpoint however is computed as the sum of the mean coincident wet bulb temperature and a tower approach of 7 degrees.

A final observation that the existing case is used as the baseline, not Title 24.

Evaluation Process: The evaluation process consisted of reviewing the application form and supporting documentation, conducting an on-site survey and then recomputing the impacts using the on-site data and a Title 24 baseline.

The on-site survey was conducted on October 15, 1996 with Chief Engineer Jon Burdette. The retrofit equipment and operating conditions were verified via an inspection of the central plant and EMS control system. Data observed on the

EMS system and discussions with Mr. Burdette confirmed the appropriateness of the loadline. Use of an 80 degree tower setpoint for the existing case and a "floating" tower setpoint for the retrofit cases could not be explained, since tower operation had not been altered. In both cases the tower is allowed to float and achieve optimal condenser temperatures.

To recompute the impacts the following assumptions were applied for the existing case:

- Use a Title 24 baseline efficiency of 0.748 kW/ton, based on a centrifugal chiller of greater than 300 tons.
- Apply an adjustment to the efficiency calculation to take into account the actual tower operation. This adjustment was computed using the EIR-FT bi-quadratic equation documented in the DOE-2.1E Supplement.

The above adjustments were incorporated in the calculation methodology and impacts were recalculated. Both demand and energy impacts were substantially reduced. Results form these calculations are summarized below and documented in the attached workbook.

Additional Notes:

Impact Results

	kW	kWh	Therm
MDSS	214	513,204	N/A
Adjusted Engineering	73.6	236,342	N/A
Engineering Realization Rate	0.344	0.461	N/A

Existing Chiller Usage																
Dry Bulb Bin		Coincident Wet Bulb	Tower Approach	Poss ECWT	Tons Load	% Full Load	kW/Ton	Adjusted Basecase kW/Ton	Title 24 Baseline	Application kW Draw	Title 24 Baseline kW Draw	Hours	Application kWh	Title 24 Baseline kWh	Part-Load Adjustment	CWT adjustment
				85	600	100%	0.905	0.905	0.748	543	449	0	0	0	1.000	1.000
95	99	68	7	75	541	90.1%	0.922	0.803	0.664	499	359	1	499	359	1.000	0.888
90	94	66	7	73	510	84.9%	0.913	0.786	0.650	466	331	5	2328	1657	1.000	0.869
85	89	65	7	72	479	79.8%	0.904	0.778	0.643	433	308	19	8227	5853	1.000	0.860
80	84	64	7	71	448	74.6%	0.898	0.770	0.637	402	285	56	22529	15972	1.000	0.851
75	79	62	7	69	417	69.4%	0.894	0.755	0.624	373	260	110	41008	28636	1.000	0.835
70	74	61	7	68	386	64.3%	0.892	0.748	0.618	344	239	346	119132	82599	1.000	0.827
65	69	58	7	65	355	59.1%	0.894	0.729	0.602	317	214	583	185027	124656	1.000	0.805
60	64	56	7	63	324	54.0%	0.9	0.717	0.593	292	192	640	186624	122893	1.000	0.792
55	59	53	7	60	293	48.8%	0.912	0.702	0.580	267	170	591	157925	100411	1.000	0.775
50	54	49	7	56	243	40.5%	0.949	0.685	0.566	231	138	384	88553	52810	1.000	0.757
45	49	44	8	52	174	29.0%	1.07	0.672	0.556	186	97	3	559	290	1.000	0.743
													812,410	536,138		
													>60	382,626		
Retrofit Chiller Usage											kWh					
Dry Bulb Bin		Coincident Wet Bulb	Tower Approach	Poss ECWT	Tons Load	% Full Load	Retrofit kW/Ton	Retrofit kW/Ton w/TM	Retrofit kW Draw	kW Draw w/TM	Hours	Retrofit kWh	Retrofit kWh w/TM			
95	99	68	7	75	541	97.2%	0.571	0.528	308.91	285.65	1	309	286			
90	94	66	7	73	510	91.7%	0.554	0.496	282.54	252.96	5	1,413	1,265			
85	89	65	7	72	479	86.1%	0.544	0.472	260.58	226.09	19	4,951	4,296			
80	84	64	7	71	448	80.5%	0.535	0.448	239.68	200.70	56	13,422	11,239			
75	79	62	7	69	417	74.9%	0.522	0.416	217.67	173.47	110	23,944	19,082			
70	74	61	7	68	386	69.4%	0.515	0.393	198.79	151.70	346	68,781	52,488			
65	69	58	7	65	355	63.8%	0.501	0.351	177.86	124.61	583	103,689	72,645			
60	64	56	7	63	324	58.2%	0.491	0.321	159.08	104.00	640	101,814	66,563			
55	59	53	7	60	293	52.6%	0.478	0.284	140.05	83.21	591	82,772	49,178			
50	54	49	7	56	243	43.7%	0.475	0.239	115.43	58.08	384	44,323	22,302			
45	49	44	8	52	174	31.3%	0.542	0.240	94.31	41.76	3	283	125			
											Total	445,701	299,467			
											>60	401,095	277,041			

	CHWT	CWT	kW	kW/ton						
	44	85	130	0.589						
	44	78.75	142	0.548						
	44	72.5	155	0.567						
		66.25		0.725						
	Coefficiencts									
	a	b	c	d	e	f				
Cap-FT	-1.74204	0.029292	-6.7E-05	0.048054	-0.00029	-0.000106	Bi-Quad	Capacity as a function of Chilled wat		
EIR-FPLR	0.222903	0.313387	0.46371				Quad	Efficency as a function of part load ra		
EIR-FT	3.1175	-0.10924	0.001389	0.00375	0.00015	-0.000375	Bi-Quad	Efficiency as a function of Chilled wa		
	CHWT	CWT	Cap-FT	PLR Frac	EIR-FPLR	EIR-FT	Unadjusted EIR	Adjusted EIR	Unadjusted kW/ton	Unadjusted kW/ton
	44	85	1.003	1.000	1.000	1.00022	1.000		0.750	0.75
	44	80	1.026	0.950	0.939	0.94022	0.883		0.750	0.66
	44	75	1.034	0.900	0.881	0.88772	0.782		0.750	0.59
	44	85	1.003	0.850	0.824	1.00022	0.824		0.750	0.62
	44	85	1.003	0.800	0.770	1.00022	0.771		0.750	0.58
	44	85	1.003	0.750	0.719	1.00022	0.719		0.750	0.54
	44	85	1.003	0.700	0.669	1.00022	0.670		0.750	0.50
	44	85	1.003	0.650	0.623	1.00022	0.623		0.750	0.47
	44	85	1.003	0.600	0.578	1.00022	0.578		0.750	0.43
	44	85	1.003	0.550	0.536	1.00022	0.536		0.750	0.40
	44	85	1.003	0.500	0.496	1.00022	0.496		0.750	0.37
	44	85	1.003	0.450	0.458	1.00022	0.458		0.750	0.34
	44	85	1.003	0.400	0.422	1.00022	0.423		0.750	0.32
	44	85	1.003	0.350	0.389	1.00022	0.389		0.750	0.29

Energy Impacts			
	Existing/Baseline Usage (kWh)	Retrofit Usage (kWh)	Impact (kWh)
Application	813,000	299,796	513,204
Evaluation	536,138	299,796	236,342
Demand Impacts			
	Existing/Baseline Usage (kWh)	Retrofit Usage (kWh)	Impact (kWh)
Application	499	285	214
Evaluation	359	286	74

Site ID #	3179
Control#	0034566
Check #	63400
Program	Customized Rebates
Measure(s)	HVAC System Conversion
Site Description	200,000 Square Foot Office/Warehouse Building

Measure Description:

Replacement of an older water cooled chiller, cooling tower and supply pumps with a new air cooled Chiller and downsized distribution pumps. Installation of economizers on four ceiling mounted air handling units (AHU's) for the warehouse area. Installation of a variable speed drive on the AHU for the office area. Dampers to shut off supply air to the upper floor of the office area. Time clock controls to optimize operation of the heating and cooling systems and pipe insulation for exposed copper heating supply and return water pipes.

Summery of Rebate Calculations:

For the chiller retrofit and associated ancillary equipment, a bin method calculation was carried out. Cooling loads for the pre retrofit case were developed from data collected on site and from analysis of electric bills. Post retrofit cooling loads were developed using the Trace-600 simulation model.

AHU savings for the warehouse were generated by computing the number of hours that the fans operated and multiplying by an estimated fan load.

Comments on Calculations:

The calculations used to compute the change in energy consumption for the site are for the most part accurate and realistic. What needs to be discussed is the implementation of the Title 24 baseline. All impact estimates listed in the application assume that the existing equipment and operation are used as the baseline, not Title 24.

In terms of the insulation on the hot water supply pipes, the temperatures, hours of operation and heat transfer coefficients used were verified during the on-site survey. The heat loss calculations however assumed a constant temperature of 180°F for both supply and return lines.

Evaluation Process:

An on-site survey was conducted at the site to gather equipment and operating characteristics for the measures installed. The on-site survey information was then used to recalculate the impacts using the methods documented in the application. Three sets of calculations were performed: Cooling and Office AHU savings, Warehouse AHU savings and Savings due to pipe insulation.

The chiller retrofit involved replacing a 440 ton water cooled centrifugal chiller with a 100 ton air cooled recipricating chiller. In the process of installing the new chiller, the cooling coils and chilled water distribution for three of the four ceiling mounted air handeling units were removed and economizers were added to each. In addition, the cooling tower and associated condenser pumps were removed and the chilled water supply pumps were replaced with new, smaller pumps. Finally, a variable speed drive was addedd to the supply fan for the office area as well as dampers to control the amount of air flow.

The evaluation focused on recalculating the baseline and retrofit energy consumption using the on-site data as well as Title 24 baseline information. The following assumptions were implemented when computing the impact:

- The post installation load line generated by the TRACE-600 model was used as the basis for computing the cooling load on the chiller. At the time of the retrofit, the facility was converted from a manufacturing to warehouse occupancy. It is assumed that the change in occupancy resulted in the elimination of the cooling coils and chilled water distribution in three of the four warehouse AHU's. Elimimating the space conditioning from a major portion of the space is not considered an act of energy efficiency.

- Using the post installation load line, baseline energy consumption was computed for an air cooled chiller with an ARI rated efficiency of 1.30 kW/ton, the Title 24 minimum efficiency.

- Since the rated kW/ton for air cooled chillers includes energy consumption for the condenser, the cooling tower and condenser pump for the existing water cooled chiller were not included in the calculation of baseline energy consumption.

- Since the chilled water supply pump operates independently of the type of chiller installed, 100 percent of the savings assoiated with downsizing the pump is used.

The savings associated with the warehouse AHU's are are computed based on a reduction of operating hours by installing controls to lockout operation for stated hours. Pre and post hours of operation were verified by the site contact, Mr. Chris Damelos. The following assumptions were applied when recalculating the application impact:

- A spot measurment of an operating fan in the warehouse was included as part of the on-site survey. The measured fan consumption was 10.75 kW, as contrasted with the value of 14.5 kW calculated in the application.

Savings associated with insulating the hot water supply lines was calculated based on the length of pipe insulated, a supply temperature of 180 °F, an average space temperature of 75°F and heat loss coefficients from ASHRAE. The application calculations assumed a constant temperature for both supply and return, an unrealistic assumption if indeed the heating coils are in operation and providing heat to the space. Further, all of the piping is attached to the ceiling joists below the ceiling insulation. Based on the above, it was assumed that there is some savings associated with delivering the heat to the heating coils since the heat would be circulated more efficiently throuout the space. The assumed savings was thus estimated to be 25 percent of the application estimate.

Additional Notes:

Impact Results

	kW	kWh	Therm
MDSS	248.5	249,636	1,419
Adjusted Engineering	83.8	121,544	355
Engineering Realization Rate	0.337	0.487	0.250

Existing System as reported in application.											
Outside Air Temp	Annual Operating Hours	Chiller Load (Tons)	Chiller Load (kW)	CHW Pump (kW)	CW Pump (kW)	Cooling Tower (kW)	Office CFM	Office AHU (kW)	Total Load (kW)	Total Energy (kWh)
25	9	0	0	0	0	0	36,000	17.1	17.1	154
30	36	0	0	0	0	0	36,000	17.1	17.1	616
35	100	0	0	0	0	0	36,000	17.1	17.1	1,710
40	237	0	0	0	0	0	36,000	17.1	17.1	4,053
45	347	0	0	0	0	0	36,000	17.1	17.1	5,934
50	439	0	0	0	0	0	36,000	17.1	17.1	7,507
55	436	0	0	0	0	0	36,000	17.1	17.1	7,456
60	401	0	0	0	0	0	36,000	17.1	17.1	6,857
65	229	0	0	0	0	0	36,000	17.1	17.1	3,916
70	222	110	94	29.8	14.9	35.4	36,000	17.1	190.7	42,335
75	184	130	111	29.8	14.9	35.4	36,000	17.1	207.7	38,217
80	199	160	136	29.8	14.9	35.4	36,000	17.1	233.2	46,407
85	109	190	162	29.8	14.9	35.4	36,000	17.1	258.7	28,198
90	107	220	187	29.8	14.9	35.4	36,000	17.1	284.2	30,409
95+	73	250	213	29.8	14.9	35.4	36,000	17.1	309.7	22,608
	3128									246,376
Retrofit System as reported in application.										
Outside Air Temp	Annual Operating Hours	Chiller Load (Tons)	Chiller Load (kW)	CHW Pump (kW)	CW Pump (kW)	Cooling Tower (kW)	Office CFM	Office AHU (kW)	Total Load (kW)	Total Energy (kWh)
25	9	0	0	0	0	0	10,000	1.8	1.8	16
30	36	0	0	0	0	0	10,000	1.8	1.8	65
35	100	0	0	0	0	0	10,000	1.8	1.8	180
40	237	0	0	0	0	0	10,000	1.8	1.8	427
45	347	0	0	0	0	0	10,000	1.8	1.8	625
50	439	0	0	0	0	0	10,000	1.8	1.8	790
55	436	0	0	0	0	0	10,000	1.8	1.8	785
60	401	0	0	0	0	0	10,000	1.8	1.8	722
65	229	0	0	0	0	0	10,000	1.8	1.8	412
70	222	35	30	3.7	0	0	11,500	1.9	35.8	7,957
75	184	50	44	3.7	0	0	12,700	2.0	50.0	9,192
80	199	64	58	3.7	0	0	14,000	2.2	63.9	12,716
85	109	69	68	3.7	0	0	15,300	2.5	73.8	8,045
90	107	77	81	3.7	0	0	16,700	2.9	87.7	9,385
95+	73	93	103	3.7	0	0	18,000	3.3	110.3	8,052
	3,128									59,368
Evaluation Calculations of Chiller Consumption										

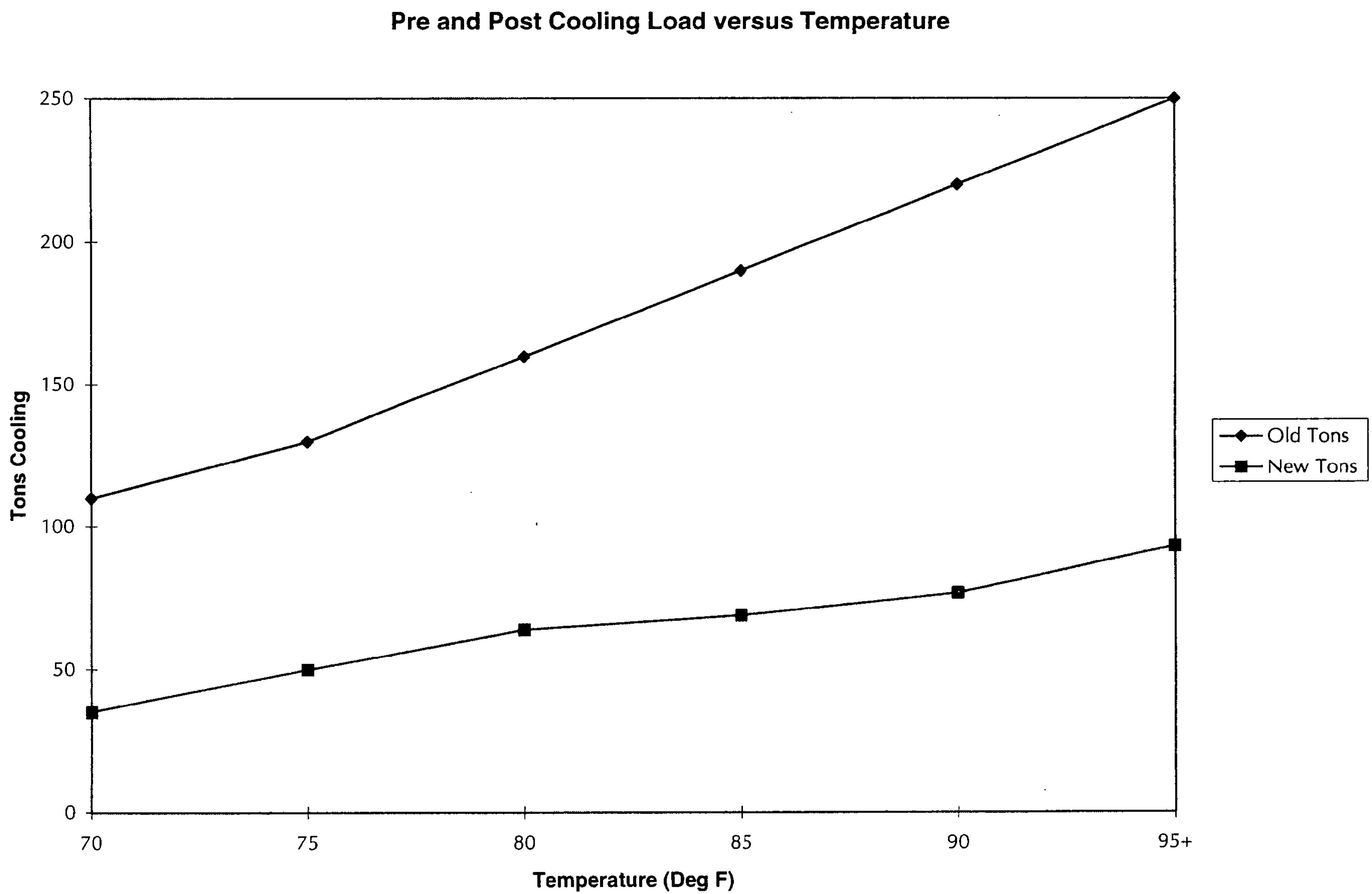
Outside Air Temp	Annual Hours	Chiller Load (Tons)	Installed Chiller Load (kW)	Baseline Chiller Load (kW)	New CHW Pump (kW)	Old CHW Pump (kW)	New Office CFM	Old Office CFM	New Office AHU (kW)	Old Office AHU (kW)	New Total Load (kW)	Old Total Load (kW)	New Total Energy (kWh)	Old Total Energy (kWh)	
25	9	0	0	0	0	0	10,000	36,000	1.8	17.1	1.8	17.1	16	154	
30	36	0	0	0	0	0	10,000	36,000	1.8	17.1	1.8	17.1	65	616	
35	100	0	0	0	0	0	10,000	36,000	1.8	17.1	1.8	17.1	180	1,710	
40	237	0	0	0	0	0	10,000	36,000	1.8	17.1	1.8	17.1	427	4,053	
45	347	0	0	0	0	0	10,000	36,000	1.8	17.1	1.8	17.1	625	5,934	
50	439	0	0	0	0	0	10,000	36,000	1.8	17.1	1.8	17.1	790	7,507	
55	436	0	0	0	0	0	10,000	36,000	1.8	17.1	1.8	17.1	785	7,456	
60	401	0	0	0	0	0	10,000	36,000	1.8	17.1	1.8	17.1	722	6,857	
65	229	0	0	0	0	0	10,000	36,000	1.8	17.1	1.8	17.1	412	3,916	
70	222	35	30	34	3.7	29.8	11,500	36,000	1.9	17.1	35.8	80.6	7,957	17,884	
75	184	50	44	49	3.7	29.8	12,700	36,000	2.0	17.1	50.0	96.2	9,192	17,693	
80	199	64	58	65	3.7	29.8	14,000	36,000	2.2	17.1	63.9	111.4	12,716	22,178	
85	109	69	68	75	3.7	29.8	15,300	36,000	2.5	17.1	73.8	122.1	8,045	13,313	
90	107	77	81	90	3.7	29.8	16,700	36,000	2.9	17.1	87.7	137.2	9,385	14,677	
95+	73	93	103	115	3.7	29.8	18,000	36,000	3.3	17.1	110.3	161.9	8,052	11,816	
	3,128										**110.3**	**161.9**	**59,368**	**135,762**	Total
												51.6		**76,394**	Impact

Cooling Load Information

QADB Temp	Old Tons	New Tons
70	110	35
75	130	50
80	160	64
85	190	69
90	220	77
95+	250	93

Chiller Part Load kW Values

% Disp.	OADB Temp	Tons	Unit kW	Base kW	Unit kW/Ton		Base kW/Ton
25%	65	30.9	26.7	29.7	0.86		0.96
	70	49.1	43.8	48.7	0.89		0.99
50%	75	67.2	60.9	67.8	0.91		1.01
	80	76.7	75.9	84.4	0.98		1.09
75%	85	86.2	90.8	101.1	1.05		1.17
	909	95.2	106.2	118.2	1.11		1.24
100%	95	104.1	121.6	135.3	1.17		1.30


Pre and Post Cooling Load versus Temperature
250
200
150
100
50
0
Tons Cooling
70
75
80
85
90
95+
Temperature (Deg F)
Old Tons
New Tons

Information from the application:										
Existing Operation										
Season	Time Period	Days	HVAC Mode	Occupancy Status	Air Handler (CFM)	Air Handler (kW)	Adjusted Air Handler (kW)	Hours per Year	Warehouse Air Handler Usage (kWh/Year)	Adjusted Warehouse Air Handler Usage (kWh/Year)
Summer	5AM - 5PM	M-F	Cooling	Occupied	128,000	58	43	1,800	104,400	77400
Summer	5PM - 5AM	M-F	Off	Unoccupied	0	0	0	1,800	-	0
Summer	24 hours	S - S	Off	Unoccupied	0	0	0	1,464	-	0
Winter	5AM - 5PM	M-F	Heating	Occupied	128,000	58	43	1,320	76,560	56760
Winter	5PM - 5AM	M-F	Off	Unoccupied	0	0		1,320	-	0
Winter	24 hours	S - S	Off	Unoccupied	0	0		1,056	-	0
								8,760	180,960	134,160
New Operation										
Season	Time Period	Days	HVAC Mode	Occupancy Status	Air Handler (CFM)	Air Handler (kW)	Adjusted Air Handler (kW)	Hours per Year	Warehouse Air Handler Usage (kWh/Year)	Adjusted Warehouse Air Handler Usage (kWh/Year)
Summer	5AM - 5PM	M-F	Cooling	Occupied	32,000	14.5	10.75	1,800	26,100	19350
Summer	3AM - 5AM	M-F	OSA Flush	Unoccupied	128,000	58	43	300	17,400	12900
Summer	5PM - 3AM	M-F	Off	Unoccupied	0	0	0	1,500	-	0
Summer	24 hours	S - S	Off	Unoccupied	0	0	0	1,464	-	0
Winter	5AM - 5PM	M-F	Heating	Occupied	128,000	58	43	1,320	76,560	0
Winter	5PM - 5AM	M-F	Off	Unoccupied	0	0		1,320	-	56760
Winter	24 hours	S - S	Off	Unoccupied	0	0		1,056	-	0
								8,760	120,060	89,010

Energy Summary

	Basecase Cooling and Office AHU Usage (kWh)	New Cooling and Office AHU Usage (kWh)	Impacts for Cooling and Office AHU (kWh)	Existing Warehouse AHU Usage	New Warehouse AHU Usage	Impacts for Warehouse AHU (Annual kWh)	Total Annual Impacts (kWh)
Stated On Application	246,384	57,696	188,688	181,102	120,154	60,948	249,636
Recalculated based on Application	246,376	59,368	187,008	180,960	120,060	60,900	247,908
Evaluation Estimate	135,762	59,368	76,394	134,160	89,010	45,150	121,544

Demand Summary

	Basecase Cooling and Office AHU Demand (kW)	New Cooling and Office AHU Demand (kW)	Impacts for Cooling and Office AHU (kW)	Existing Warehouse AHU Usage	New Warehouse AHU Usage	Impacts for Warehouse AHU (Annual kWh)	Total Annual Impacts (kWh)
Stated On Application	309.7	104.7	205.0	58.0	14.5	43.5	248.5
Recalculated based on Application	309.7	110.3	199.4	58.0	14.5	43.5	242.9
Evaluation Estimate	161.9	110.3	51.6	43.0	10.8	32.3	83.8

Therm Summary

	Existing "Losses" (therm)	New "Losses" (therm)	Impacts for Pipe insulation
Stated On Application	1,625	206	1,419
Recalculated based on Application	1,625	206	1,419
Evaluation Estimate	561	206	355

Site ID #	3181
Check #	62978
Program	Customized Rebates
Measure(s)	Plate & Frame Heat Exchanger Installation
Site Description	1.5 Million Square Foot Office Complex

Measure Description: This measure involved the installation of a Plate and Frame Heat Exchanger (PFE) to take advantage of "Free Cooling". By installing the PFE, the cooling towers and chilled water distribution system could be used to provide cooling to the complex when wet bulb temperatures permit.

Summery of Rebate Calculations: Rebate calculations were performed using a temperature "Bin" method calculation. A bin is defined as a five degree range of outdoor dry bulb. The mean coincident wet bulb temperature associated with each bin was calculated as the average wet bulb temperature coincident with each of the observations of dry bulb. Cooling loads were estimated using tons delivered from the central and plant and outdoor temperature at the site. This data was collected using the Building Management Control System (BMCS) by the contractor that installed the system. Load profiles (in tons) were generated as a function of temperature for both "On" and "Off" hours, where on hours coincide with hours of occupancy.

Comments on Calculations The calculations are based on actual operational data collected from the central plant. Savings estimates for this site are based on chiller savings only. These estimates are stated to be conservative due to additional savings associated with a reduction in usage of the secondary chiller loop pumps.

Evaluation Process The evaluation was carried out by performing an on-site survey and reviewing the calculations. The on-site survey confirmed the presence and operation of the PFE with the following exception. As stated by the Chief Engineer, use of the PFE is limited to when the wet bulb temperature is below 45°. The evaluation estimates reflect this adjustment.

Impact Results for Site ID# 3181

	kW	kWh	Therm
MDSS	0	2,235,848	0
Adjusted Engineering	0	908,302	0
Engineering Realization Rate	N/A	0.41	NA

Coincident Wet Bulb	Off-Hrs/Year	Off-Hr Load (Tons)	Off-Hr Chiller Load (kW)	Off-Hr Chiller Usage (kWh)	On-Hrs/Year		On-Hr Load (Tons)	On-Hr Chiller Load (kW)	On-Hr Chiller Usage (kWh)	
23	5	460	391	1,955	-		-	-	-	
27	25	475	404	10,094	-		-	-	-	
31	76	490	417	31,654	4		490	417	1,666	
36	147	510	434	63,725	68		510	434	29,478	
40	586	530	451	263,993	89		530	451	40,095	
44	814	568	483	392,999	186		618	525	**97,706**	
48	1,062	597	507	**538,912**	358		668	568	**203,272**	
52	1,163	645	548	**637,615**	482		715	608	**292,936**	
54	658	677	575	**378,646**	517		820	697	**360,349**	
57	502	706	600	**301,250**	323		1,020	867	**280,041**	
59	322	740	629	**202,538**	218		1,454	1,236	**269,426**	
61	287	836	711	203,942	133		1,965	1,670	**222,143**	
63	206	940	799	164,594	94		1,872	1,591	**149,573**	
65	159	1020	867	137,853	61		1,872	1,591	97,063	
66	87	1120	952	82,824	43		1,872	1,591	68,422	
67	40	1190	1,012	40,460	25		1,872	1,591	39,780	
69	13	1260	1,071	13,923	7		1,872	1,591	11,138	
	6,139			**3,453,054**	2,601				**2,151,949**	

a number that does not match the application

Heat exchanger

Coincident Wet Bulb	Off-Hrs/Year	Off-Hr Load (Tons)	Total Site CHWS flow	CHWS flow thru PFE	PFE Supply (tons)	PFE Supply (tons-hrs)	Off-Hr Load (Tons)	Off-Hr Chiller Load (kW)	Off-Hr Chiller Usage (kWh)	Evaluation Off Hr Chiller Usage
23	5	460	1,380	1,380	460	2,300	-	-	-	
27	25	475	1,425	1,425	475	11,875	-	-	-	
31	76	490	1,470	1,470	490	37,240	-	-	-	
36	147	510	1,530	1,530	510	74,970	-	-	-	
40	586	530	1,590	1,590	530	310,580	-	-	-	
44	814	568	1,704	1,704	568	462,352	-	-	-	
48	1,062	597	1,791	1,791	597	**634,014**	-	-	-	538,912
52	1,163	645	1,935	1,935	323	**375,068**	323	274	**318,807**	637,615
54	658	677	2,031	2,031	169	**111,367**	508	432	**283,985**	378,646
57	502	706	2,118	-	-		706	600	**301,250**	301,250
59	322	740	2,220	-	-		740	629	**202,538**	202,538
61	287	836	2,508	-	-		836	711	**203,942**	203,942
63	206	940	2,820	-	-		940	799	**164,594**	164,594
65	159	1020	3,060	-	-		1,020	867	**137,853**	137,853
66	87	1120	3,360	-	-		1,120	952	**82,824**	82,824
67	40	1190	3,570	-	-		1,190	1,012	**40,460**	40,460
69	13	1260	3,780	-	-		1,260	1,071	**13,923**	13,923
	6,139			14,856	4,122	**2,019,765**			**1,736,253**	2,702,557

Heat exchanger

Coincident Wet Bulb	On-Hrs/Year	On-Hr Load (Tons)	Total Site CHWS flow	CHWS flow thru PFE	PFE Supply (tons)	PFE Supply (tons-hrs)	On-Hr Load (Tons)	On-Hr Chiller Load (kW)	On-Hr Chiller Usage (kWh)	Evaluation On Hr Chiller Usage
23	-	-	-	-	-	-	-	-	-	
27	-	-	-	-	-	-	-	-	-	
31	4	490	1,470	1,470	490	1,960	-	-	-	
36	68	510	1,530	1,530	510	34,680	-	-	-	
40	89	530	1,590	1,590	530	47,170	-	-	-	
44	186	618	1,854	1,854	618	**114,948**	-	-	-	
48	358	668	2,004	2,004	668	**239,144**	-	-	-	203,272
52	482	715	2,145	2,145	358	**172,315**	358	304	**146,468**	292,936
54	517	820	2,460	-	-	-	820	697	**360,349**	360,349
57	323	1,020	3,060	-	-		1,020	867	**280,041**	280,041
59	218	1,454	4,362	-	-		1,454	1,236	**269,426**	269,426
61	133	1,965	5,895	-	-		1,965	1,670	**222,143**	222,143
63	94	1,872	5,616	-	-		1,872	1,591	**149,573**	149,573
65	61	1,872	5,616	-	-		1,872	1,591	97,063	97,063
66	43	1,872	5,616	-	-		1,872	1,591	68,422	68,422
67	25	1,872	5,616	-	-		1,872	1,591	39,780	39,780
69	7	1,872	5,616	-	-		1,872	1,591	11,138	11,138
	2,601			10,593	3,174	**610,217**			**1,633,265**	1,994,143

Site ID #	3186
Control#	
Check #	60416
Program	Customized Rebates
Measure(s)	Retrofit Humidification System
Site Description	Cotton Warehouses

Measure Description:

Replace 14 existing 20 horsepower compressors with 8 high efficiency 2 horsepower pumps. These systems provide humidification for 14 cotton warehouses near Fresno. The exisiting systems used separate water and air lines, with a dedicated air compressor for each warehouse. For the new system, 2 horsepower high efficiency pumps are used to force pressurized water through a series of nozzles to provide humidification. Six of the 2 horsepower pumps serve two warehouses each and the remaining 2 pumps serve one warehouse. The existing system was operated using time clocks and the new system is operated using humidity sensors mounted inside each warehouse.

Summery of Rebate Calculations:

Existing usage was computed based on the hours of operation set for the existing time clocks in conjunction with calculated motor demand. Loading on the motors was computed based on field measurments of operating RPM as compared to the manufacturers rated RPM. Post installation usage was computed in a simillar fashion, but used operating hours logged from identical pumps installed previousely. Pump demand was computed based on nameplate data combined with efficiency and loading from the PG&E Resource Binder. Loading based on field measured RPM was also presented but was not used.

Comments on Calculations:

The calculations of savings are clean, straight forward and accurate. Assumptions used for efficiencies and loading all tended to be conservative.

Evaluation Process:

The evaluation was carried out by reviewing the application form, conducting an on-site survey and then recalculating the impacts based the data collected on-site.

The site survey verified the presence and operation of the new humidification system. An analysis of billing data verified the energy savings as documented. Demand estimates were recomputed due to the fact that the existing compressors did not operate continusouly during the peak period. Base on the reported hours of operation, the existing compressors were operating only 2/3 of the period between 12 and 6 PM. For this reason, the existing demand estimate was reduced to 2/3 of the application value and the demand impactcs were recalculated.

Additional Notes:

Impact Results

	kW	kWh	Therm
MDSS	109.63	340,350	0
Adjusted Engineering	73.37	341,437	0
Engineering Realization Rate	0.67	1.00	1.00

Month	Hours	Motor HP	Efficiency	Loading	kW/Unit	kWh/Unit	Total kW	Total kWh		Assumed Total Facility Usage			
Jan	124	20	0.876	0.4969	8.46	1,049	118.48	14,692		50,373			
Feb	112	20	0.876	0.4969	8.46	948	118.48	13,270		45,498			
Mar	124	20	0.876	0.4969	8.46	1,049	118.48	14,692		50,373			
Apr	180	20	0.876	0.4969	8.46	1,523	118.48	21,327		73,122			
May	248	20	0.876	0.4969	8.46	2,099	118.48	29,384		100,746			
Jun	360	20	0.876	0.4969	8.46	3,047	118.48	42,654		146,244			
Jul	496	20	0.876	0.4969	8.46	4,198	118.48	58,768		201,491			
Aug	496	20	0.876	0.4969	8.46	4,198	118.48	58,768		201,491			
Sep	360	20	0.876	0.4969	8.46	3,047	118.48	42,654		146,244			
Oct	248	20	0.876	0.4969	8.46	2,099	118.48	29,384		100,746			
Nov	180	20	0.876	0.4969	8.46	1,523	118.48	21,327		73,122			
Dec	124	20	0.876	0.4969	8.46	1,049	118.48	14,692		50,373			
	3,052							**361,615**		**1,239,822**			

Month	Hours	Motor HP	Efficiency	Field Verified Efficiency	Loading	Application kW/Unit	Application kWh/Unit	Application Total kW	Application Total kWh	Evaluation kW/Unit	Evaluation kWh/Unit	Evaluation Total kW	Evaluation Total kWh
	2402	2	0.782	0.825	0.58	1.11	2658	8.85	21,264	1.05	2522	8.40	20178
Jan	98	2	0.782	0.825	0.58	1.11	108	8.85	864	1.05	102	8.40	820
Feb	88	2	0.782	0.825	0.58	1.11	98	8.85	780	1.05	93	8.40	740
Mar	98	2	0.782	0.825	0.58	1.11	108	8.85	864	1.05	102	8.40	820
Apr	142	2	0.782	0.825	0.58	1.11	157	8.85	1,254	1.05	149	8.40	1190
May	195	2	0.782	0.825	0.58	1.11	216	8.85	1,728	1.05	205	8.40	1640
Jun	283	2	0.782	0.825	0.58	1.11	314	8.85	2,508	1.05	298	8.40	2380
Jul	390	2	0.782	0.825	0.58	1.11	432	8.85	3,456	1.05	410	8.40	3279
Aug	390	2	0.782	0.825	0.58	1.11	432	8.85	3,456	1.05	410	8.40	3279
Sep	283	2	0.782	0.825	0.58	1.11	314	8.85	2,508	1.05	298	8.40	2380
Oct	195	2	0.782	0.825	0.58	1.11	216	8.85	1,728	1.05	205	8.40	1640
Nov	142	2	0.782	0.825	0.58	1.11	157	8.85	1,254	1.05	149	8.40	1190
Dec	98	2	0.782	0.825	0.58	1.11	108	8.85	864	1.05	102	8.40	820
									21,264				**20,178**

Demand Analysis

	HP	Loading	Efficiency	Field Verified Efficiency	Application kW/Unit	Application Total kW	Diversity Factor	Evaluation kW/Unit	Evaluation Total kW
Existing	20	0.497	0.876	0.876	8.46	118.48	0.67	5.64	**78.99**
Retrofit	2	0.580	0.782	0.825	1.11	8.85	0.67	0.70	**5.62**

Energy Impacts			
	Existing Usage (kWh)	Retrofit Usage (kWh)	Impact (kWh)
Application	361,615	21,264	340,350
Evaluation	361,615	20,178	341,437
Demand Impacts			
	Existing Demand (kW)	Retrofit Demand (kW)	Impact (kW)
Application	118.48	8.85	109.63
Evaluation	78.99	5.62	73.37

Site ID#:	**3191**
Check #	63754
Measure	Replace Central Plant Equipment and Install EMS

Measure Description:	The retrofit site is a multi-building laboratory and office complex, with 232,000 sqft of conditioned space. This building is cooled by a chilled water system that includes an existing ice-water storage system, and evaporative cooling towers for heat rejection. The equipment replacement includes a chiller changeout, and tower replacement. MDSS records list this as Change/Add Other Equipment; action code 239.
Summary of Calculations in the Original Application:	The impacts are estimated using a bin models to simulate both the pre-retrofit system and the post-retrofit system. The measure level impacts recorded in this application are measure #1 -- central plant replacement, and measure #2 -- EMS expansion.
Comments on Calculations:	The calculation are well documented in this application. The chiller calculations are based upon the pre-retrofit chiller equipment rather than a baseline chiller system. Estimates for tower water loop pumps in the post-retrofit condition assume a 15 hp pump. On-site records show, however, that the new pumps installed are 10 hp.
Evaluation Process:	Calculations were prepared in order to investigate the significance of the minor calculation errors that were discovered.
Additional Notes:	An on-site inspection of this facility was conducted on November 14, 1996 with Daniel Faubion and Fernando Pineda. During this on-site a new equipment inventory was recorded and the new EMS control system was explored (and described in detail by the company mechanical superintendent). Analyses have shown that the application estimates of savings are reasonable, and were adopted as the evaluation estimate of savings.

Impact Results for Site_ID# 3191

	kW	kWh	Therm
Application	68.1	611,673	0
MDSS	68.1	611,673	0
Evaluation Estimates	68.1	611,673	0
Engineering Realization Rate	1.0	1.0	NA
Customer Billing Summary			

Based on the on-site audit (conducted at this facility) the HVAC equipment were inventoried										
Equipment	Existing or New Equipment?	Manufacturer	Model Number	Number of Units	Refrigerant	Rated HP	Voltage	Notes		
Chiller	New	York	YTC3C3B2-CGG, YDTJ-76	1	R123	180	460	CH-1		
Chiller	New	York	YTC3C3B2-CGG, YDTJ-76	1	R123	180	460	CH-2		
Condenser Water Pump	New	Baldor Super E (Motor)	37G6768X36G1	4†		10	460	12.7 Amps. 1 pump per tower*.		
Tower Fan	New		G47044	4†		10	460	1 fan per tower.		
Evaporative Cooling Tower	New	Baltimore Air Coil	15200CR	4†						
* Application incorrectly claims 15 hp/condensing water pump.										
† Only 2 of the towers are associated with this chiller and EMS application.										
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Red font designates a calculation.										
Green designates a result.										

Two minor errors were found in the application estimates. The effects of those errors on model accuracy is explored here.

The new condensing water pumps were mis-specified as 15 hp in the application. On-site records show that these are actually 10 hp pumps.

This affects the measure #1 "pump savings calculations" -- see page 8.6 on the application

Proposed Case kW = ((2 x 10 x .8/.898) + (2 x 8.762/.906)) x .746
= 27.72 kW
Application estimate is for 34.94 kW

Proposed Case kWh = (27.72 kW) x (1992 + 945 + 768)
= 102,706 kWh
Application estimate is for 129,454 kWh

This also affects the measure #2 "EMS pump savings" -- see page 8.28 on the application

Proposed Case kWh Savings = (27.72 kW / 34.94 kW) x (44,478 kWh EMS Pump Savings)
= 35,287 kWh
Application estimate is for 44,478 kWh saved

Total Demand Savings = 7.22 kW increase in savings

Total Energy Savings = 17,557 kWh increase in savings

Also, chiller savings were modeled with the existing system representing baseline. The baseline was adjusted in accordance with Title 20 standards.

This affects the measure #1 "base chiller usage" estimates -- see page 8.5 on the application

Base Case kW = (282 kW * 0.837 kW/ton) / 0.86 kW/ton
= 274.46 kW
Application estimate is for 282 base kW, using 0.86 kW/ton compressor efficiency

Base Case kWh = (835,812 kWh * 0.837 kW/ton) / 0.86 kW/ton
= 813,459 kWh
Application estimate is for 835,812 base kWh, using 0.86 kW/ton compressor efficiency

Demand Savings = 7.54 kW decrease in savings

Energy Savings = 22,000 kWh decrease in savings

Estimated Impacts:

Estimate of energy impacts

Annual Energy Impacts = (611,673 kWh/year + 17,557 kWh/year - 22,000 kWh/year)
= 607,230 kWh/year
The application estimate is 611,673 kWh/year.

Estimate of peak hour demand impacts

Peak Demand Impacts = (68.1 kW + 7.22 kW - 7.54 kW)
= 67.78 kW
The application estimate is 68.1 kW.

Based on the very small adjustment detected, application estimates were adopted as the evaluation impacts.

Site ID#:	3560
Check #	62983
Measure	Insulation Retrofit to Steam and Condensate Return Piping

Measure Description:

Pipe insulation was added to 12" diameter 400 °F steam lines and 2" diameter 250 °F condensate return lines. Measure recorded in the MDSS as action code 270, Pipe/Duct Insulation.

These steam lines run from a central plant building through underground tunnels, providing heat for several government buildings.

Summary of Calculations in the Original Application:

Savings are estimated in this application for reduced pipe losses following the installation of additional pipe insulation. The calculation used are based upon ASHRAE heat loss methods, as specified in the 1989 Fundamentals.

Savings cited in the application suggest that approximately 3% of the total gas use is saved as a result of this retrofit.

Comments on Calculations:

The application savings are thoroughly documented.

No errors were detected in the methods applied.

Evaluation Process:

Application calculations were thoroughly reviewed, and the central plant billing history was examined.

An on-site inspection found the pipe insulation in relatively good condition. In some instances, however, the jackets surrounding the steam pipe expansion fittings had been removed.

Underground tunnel temperatures were measured during the on-site, and found to be 81 °F. Application records and the site contact indicated that these temperatures were often as high as 110 °F prior to the retrofit.

Steam temperatures were also measured, high pressure condensate return pipes were found to be 243 °F and low temperature condensate return pipes (5" diameter) were 140 °F. These figures are also consistent with application records.

Additional Notes:

An on-site inspection of this facility was conducted with Frank Yates on November 12, 1996.

Impact Results for Site ID# 3560

	kW	kWh	Therm
MDSS	0	0	80,730
Evaluation Estimates	0	0	80,730
Engineering Realization Rate	NA	NA	1.0

Account	Year	January	February	March	April	May	June	July	August	September	October	November	December	Oct-Sept Annual Therms	Therm Savings
FPSAE00311	1992	302460	243316	206608	181903	201664	222332	281084	283773	198383	152465	159700	265216	2,585,379	143,584
	1993	258063	197206	167799	257502	180878	226550	247544	248647	223809	139558	208590	312660	2,936,549	494,754
	1994	268391	216184	241408	220560	217185	264692	281464	312610	253247	155845	249686	339835	2,464,456	
	1995	285505	265998	296947	205101	185037	132787	114803	124073	108839	127046	207428	313375	2,441,795	
	1996	343209	260986	226637	197976	181533	144817	151876	145685	141227	0	0	0		

Average	319,169	Therm savings measured
Claimed	80,730	
Percent of Bill	3%	

Site ID #	**3584**
Check #	63214
Program	Customized Rebates
Measure	High Efficiency Chillers
Site Description	High-Rise Office Building

Measure Description: Replace two existing steam fired absorption chillers with three identical, high efficiency electric chillers. The chillers installed are 500 ton centrifugal units manufactured by the Carrier Corporation.

Summery of Rebate Calculations: Temperature bin model of basecase and high-efficiency chillers was used. A linear "load line" beginning with a peak cooling load estimated to be 1,390 tons was used to estimate hourly building cooling requirements. The load-line begins at 89 degrees and decreases 15% for each 5 degree reduction in outdoor temperature. The weather data used was from Nimitz Field, Alameda. Part-load performance was stated to be based on manufacturers specifications. Loading of the three chillers was done manually. Baseline chiller energy consumption was calculated in a similar to fashion, using performance data from two 750 ton chillers with baseline efficiency.

Comments on Calculations Impacts are summarized in the "Project Summary" attached to the application. Several spreadsheets are used to document the impact calculations reported in the project summary. Energy impacts from these spreadsheets agree with the project summary and the MDSS records. Demand impacts from these spreadsheets are slightly different than those found in the project summary and the MDSS. A secondary demand impact calculation is documented in the project summary itself. The efficiency values used for the spreadsheet calculations are slightly higher (better) than those found in the chiller specification sheets included with the application. It appears that the energy impacts were not recalculated to reflect the actual efficiencies of the units. As mentioned above, the demand impacts however were recalculated. Finally, the impacts were calculated using a baseline chiller with an efficiency of 0.70 kW/Ton. According to the *Energy Efficiency Standards for Residential and Nonresidential Buildings*, effective July 1992 (Page 34), the baseline efficiency used should be 0.74 kW/Ton. This based on a statement from the chief engineer that regardless of participating in the program, the chillers installed would have used R-134, an ozone friendly refrigerant, which impacts the baseline chiller efficiency.

Evaluation Process The evaluation process was carried out in three parts: reviewing the application, conducting a site survey and using the site information to adjust the estimates of impacts.

After reviewing the application, several pieces of information were identified that could be verified with the site survey. Primarily, the loading on the chiller plant, especially at times of peak, needed to be verified to validate the load line. Second, the facility hours of operation and loading on the chiller plant for the "off" hours.

Finally, the make model and efficiency of the chillers could be verified.

The primary objective of the site visit was to obtain data to validate the load line used in the impact calculations. Discussions with the chief engineer and a tour of the central plant reveled that the chiller kW could be tracked with the EMS system controlling all chillers. Several observations of load were recorded by the chief engineer during the second week of October, a period with record high temperatures.

The resulting data were used to develop a load line. These data and the resulting load line are displayed in Exhibits 1 & 2 attached. Both the observed data and the load line used in the application agree that the chiller plant will be fully loaded at peak temperatures. At below peak temperatures however, the observed and application load lines differ. Both load lines follow a linear profile, ending at an outdoor air temperature of 55 degrees, when the chillers are locked out. According to the chief engineer, below 55 degrees outside air dampers are opened to completely cool the building. The application load line assumes that the thermal load on the building at 55 degrees is nearly zero. Observed data indicate that there is still a load of approximately 240 tons when the outdoor air temperature reaches 55 degrees. For this reason, the load line used in the evaluation is higher than that of the application load line.

Operating hours collected from the plant engineer were substantially different than those reported in the application. According to the chief, the chillers are available for space conditioning from 5:30 AM to 7:00 PM Monday through Saturday, 6:00 AM to 5:00 PM Sunday and locked out on Holidays. The application states 24 hour operation, 365 days a year.

Evaluation impacts were computed by using the load line developed from EMS data, long term (TMY) San Francisco weather data, operating hours collected from the chief engineer and the correct baseline of 0.74 kW per ton. Results are summarized below and detailed in Exhibit-3. A last point that should be made is that impacts were generated for the constant load of 175 tons (reported as 150-200 by the chief engineer) needed to cool the computer areas. This load was reportedly ignored in the application, and accounts for approximately 25% of the annual energy impact.

Impact Results for Site ID# 3584

	kW	kWh	Therm
MDSS	270.6	534,818	0
Adjusted Engineering	332.0	1,068,678	0
Engineering Realization Rate	1.23	2.00	-

EMS Data											
Date	Time	Temp.	Ch_1	Ch_2	Ch_3	Sum kW(1)	Load Line(2)	Linear(3)			
8-Oct	15:00	97	268.79	272.17	271.02	812	884	812	Slope	8.686025	
8-Oct	16:00	96	265.41	267.01	266.03	798	864	803			
8-Oct	14:00	94	260.69	278.68	262.73	802	824	786	Intercept	-30.554	
8-Oct	9:30	79	194	240	266	700	524	656			
9-Oct	14:00	71	214.37	239.31	0	454	364	586			
9-Oct	8:00	69	184.18	197.45	188.72	570	324	569			
14-Oct	11:00	63	187.65	210.01	194.25	592	204	517			
		55						447			
Assumed Load Line from application						1) Load by temperature from EMS data at the site					
		Temp	Total kW	Load Line		2) Load by temperature as stated in the application					
		97		884		3) Load by temperature using a linear regression with the EMS data					
		96		864							
		94		824							
		87	684	684							
		82	571	584							
		79		524							
		77	427	484							
		72	372	384							
		71		364							
		69		324							
		67	285	284							
		63		204							
		62	173	184							
		57	97	84							
	Delta	30	587								
			20								

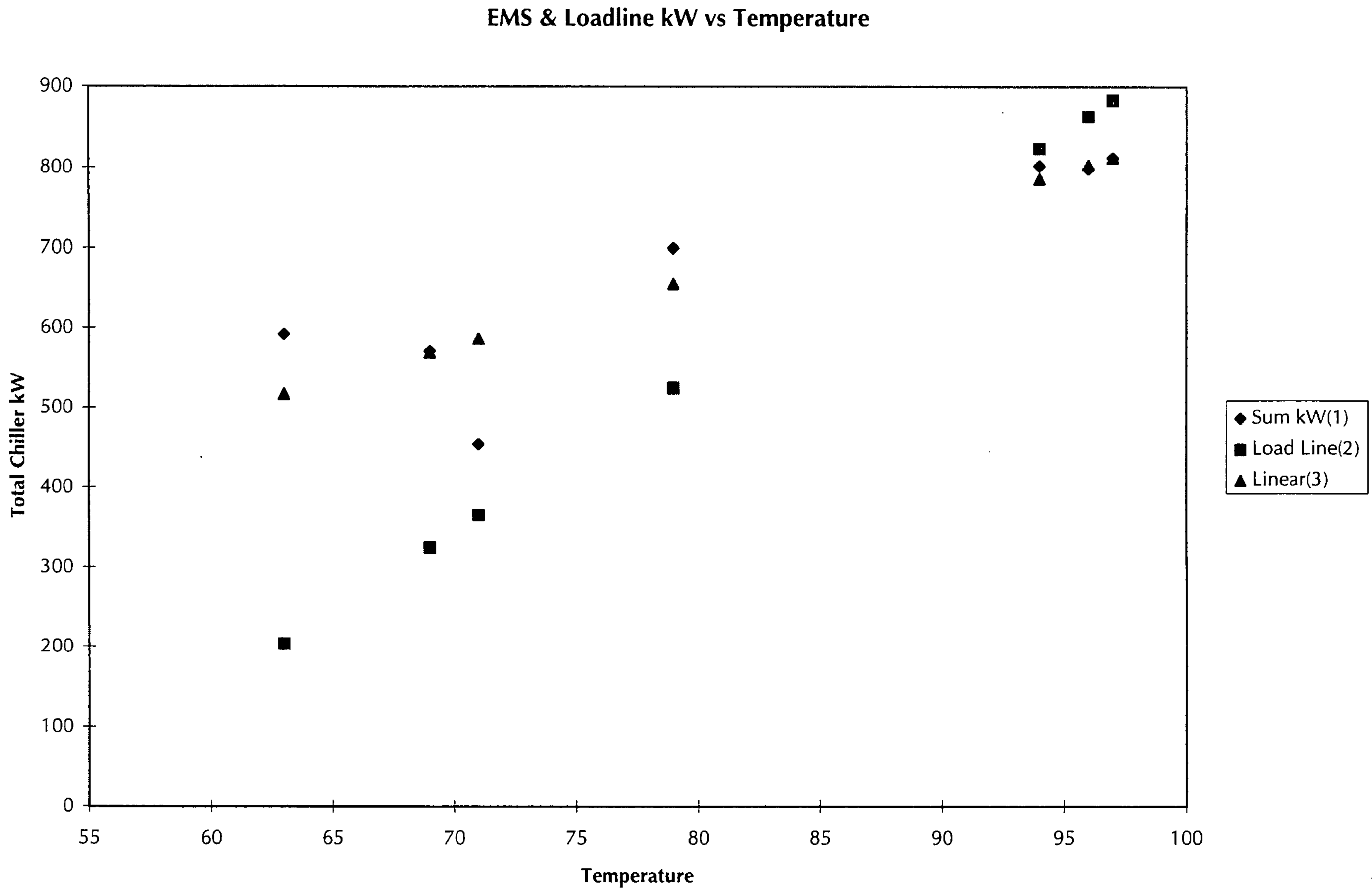
EMS & Loadline kW vs Temperature
Total Chiller kW
900
800
700
600
500
400
300
200
100
0
55
60
65
70
75
80
85
90
95
100
Temperature
Sum kW(1)
Load Line(2)
Linear(3)

Exhibit 3: Impact Calculations 3584

Annual Hours	TMY Temp Bin	Approx Tons	Actual - 0.50 kW/Ton Ch kW	Actual - 0.50 kW/Ton Ch kWh	Baseline - 0.748 kW/Ton Ch kW	Baseline - 0.748 kW/Ton Ch kWh
0	95-99	1624	-	-	-	-
7	90-94	1537	818	5,380	1,150	8,048
21	85-89	1450	725	15,228	1,085	22,781
65	80-84	1363	682	44,311	1,020	66,289
136	75-79	1277	638	86,805	955	129,860
396	70-74	1190	595	235,557	890	352,393
766	65-69	1103	551	422,380	825	631,880
1132	60-64	1016	508	575,033	760	860,249
785	55-59	929	465	364,671	695	545,548
5452	All Other	175	88	477,050	131	713,667
Total Usage				2,226,413		3,330,714

Energy Impact (kWh)	1,104,301
Demand Impact (kW)	332.0

Site ID#:	4047
Check #	60816
Measure	Economizer Retrofit

Measure Description:

The retrofit site is a hospital, with 159,000 sq ft of conditioned space. Cooling for this hospital is provided by unitary single-packaged air conditioners. Forty three of these packaged air conditioners were retrofit with economizers.

MDSS records list this as Add Economizer; action code 228.

Summary of Calculations in the Original Application:

The economizer impacts are estimated using an outside air temperature bin model. DX loads are calculated using an assumed (constant) supply air volume in conjunction with mixed air temperature and supply air temperature conditions for each bin. One bin calculation was run for each unit.

Comments on Calculations:

The assumed building loads used in these models appear to be incorrect. First, the load delivered by each packaged unit during the highest outdoor temperature bins exceeds the capacity of each system. Secondly, the bin model balance point at 50 °F outdoor temperature has a building load that is 50-80% of the capacity of each system. The building load should be dropping near zero at the balance point.

DX units are assumed to run 24 hours and 7 days per week.

Evaluation Process:

A bin model was rerun using updated assumptions surrounding DX loading. Instead of running each unit independently, the bin model was run using the combined capacity and supply delivery of all 43 retrofit units.

Additionally, DX schedules have been implemented in conjunction with the economizer retrofit. A Johnson Controls MetaSys energy management system (EMS) was installed at about the same time as the economizers. This unitary controller now sets the schedule for all DX units in the hospital. To capture true first year savings, this information surrounding the first year impacts, was incorporated within the modified bin model.

Additional Notes:

An on-site inspection of this facility was conducted on November 13, 1996 with Ron Bass, the chief engineer.

During this inspection it was determined that the economizer lockout had been mistakenly set to 65 °F. This setting was promptly changed to 70 °F. The bin models in this analysis are run with the 65 °F lockout to capture the appropriate first year savings using the 65 °F setting.

Interestingly, the economizer damper actuators in 33/43 units failed within the first year of installation. Eventually, all 43 actuators were replaced, and now the economizers function according to design.

In addition, the economizer relief dampers were all screwed shut, and a new relief damper was installed upstream of the economizer. This was done in an effort to prevent exhausted air (at the economizer) from re-entering the mixed air stream through the outside air vent (since the outside air damper was located right next to the relief damper). This retrofit to the economizers should improve performance by ensuring that outside air is drawn into the system rather than a mixture of exhaust air and outside air.

Impact Results for Site ID# 4047

	kW	kWh	Therm
MDSS	0	567,618	0
Evaluation Estimates	0	55,628	0
Engineering Realization Rate	NA	0.10	NA

Input - Facility Operation

The site contact furnished information surrounding the operation of direct expansion (DX) air conditioners:						
	The DX schedules are a function of occupancy for all daytypes:					
DX Use Begins	DX Use Ends	Percentage of units on schedule	Annual Hours per Year Chiller Operation			
8:00 AM	5:00 PM	82%	3,285			
12:00 AM Midnight	12:00 AM Midnight	12%	8,760			
7:00 AM	6:00 PM	6%	4,015			
Weighted Averge			3,966			
	All supply air fans run continuously during the scheduled hours of DX operation.					
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Red font designates a calculation.						
Green designates a result.						

Data used in these calcualtions are provided below based largely upon information supplied by the site contact, or alternatively from the application.

The application provides make and model for each of the DX units retrofit. Assumptions in the application are noted and verified below:

The units installed were identified in product literature and recorded

Manufacturer	Model	Number of Units Installed	Application CFM	Application Efficiency (kW/ton)	Evaluation CFM	Evaluation Capacity (tons)	Evaluation Efficiency (EER)	Notes
Carrier	48HNT030	1	1,100	1.26	1,100	2.5		Specifications could not be located for this unit
Carrier	48DJE006	6	2,000	1.21	1,750	5.0	11.00	Specifications based on the 48HJE series
Carrier	48DJE004	14	1,200	1.20	1,200	3.0	11.20	Specifications based on the 48HJE series
Day and Night	580AN024	1	800	1.33	800	2.0		
Carrier	48HJD006	2	2,000	1.00	1,750	5.0	11.00	Specifications based on the 48HJE series
Carrier	50QQ024	1	800	1.26	800	2.0		Specifications could not be located for this unit
Carrier	48DJE005	16	1,600	1.22	1,450	4.0	11.05	Specifications based on the 48HJE series
Carrier	48DJE008	1	3,000	1.32	3,000	7.5	11.00	Specifications based on the 48HJE series
Carrier	48NLT024	1	800	1.26	800	2.0	8.50	Specifications based on the 48NLX series (9.5 SEER recorded as 8.5 EER)
Total		43		1.23				

Various parameters are specified below

Parameter	Value Reported	Units of Parameter	Notes
DX lockout	55	°F	With economizer. Pre-retrofit, however, there was no DX lockout.
Economizer Lockout	65	°F	Upper temperature threshold. This value was updated during the site visit to 70 °F.
Minimum Outside Air	20%	% of max supply air	Supplied by site contact, and based upon a 5% damper position.
Peak Diversity Factor	0.89	dimensionless	This peak hour coincident diversity factor is an evaluation result for the hospital business type.
Peak DX Load	144	tons	Based on site contact estimate of part load at peak and the total DX capacity retrofit
Return Air Temp.	75	°F	
Supply Air Temp.	50	°F	
DX Capacity	162.0	tons	Total for all DX systems retrofit
DX Efficiency	1.2	kW/ton	Average based on application records
DX Supply Air	60,500	CFM	Total for all DX systems retrofit

Blue font designates an input.
Red font designates a calculation.
Green designates a result.

Estimated energy required to meet the building load using the 43 retrofit units, without the economizer											
It was necessary to update certain parameters (provided in the application and from the site contact) to achieve the appropriate building load using the bin model specified in the application.											
The following parameters were updated:											
Supply Air Temperature		55	Variable with outdoor temperature to achieve desired load at balance point								
Weather data from the application for Travis AFB/Fairfield were used.											
Outdoor Temperature Bin (°F)	Median Outdoor Temperature (°F)	Annual Observations per Bin (hours)	Scheduled DX Operating Hours per Bin (hours)	DX Load (tons)	Target DX Energy Use (kWh)	CFM Delivered	Mixed Air Temperature (°F)	Supply Air Temperature (°F)	Calculated DX Sensible Load (Tons)	Revised Chiller Energy Use (kWh)	
105-109	107	5	2	144	394	60,500	81	55	144	394	
100-104	102	16	7	132	1155	60,500	80	56	132	1157	
95-99	97	60	27	120	3939	60,500	79	57	120	3947	
90-94	92	126	57	108	7444	60,500	78	59	108	7467	
85-89	87	197	89	96	10345	60,500	77	60	96	10392	
80-84	82	295	134	84	13555	60,500	76	61	84	13640	
75-79	77	430	195	72	16936	60,500	75	62	72	17082	
70-74	72	563	255	60	18478	60,500	74	63	61	18699	
65-69	67	773	350	48	20297	60,500	73	64	49	20640	
60-64	62	1,177	533	36	23178	60,500	72	66	37	23762	
55-59	57	1,593	722	24	20914	60,500	71	67	25	21786	
50-54	52	1,407	638	12	9236	60,500	70	68	13	10079	
45-49	47	987	447	0	0	60,500	69				
40-44	42	676	306	0	0	60,500	68				
35-39	37	313	142	0	0	60,500	67				
30-34	32	108	49	0	0	60,500	66				
25-29	27	23	10	0	0	60,500	65				
20-24	22	2	1	0	0	60,500	64				
		8,751	3,966	934	145,870					149,045	kWh
										Application estimate is 1,171,231 kWh.	
Blue font designates an input.											
Red font designates a calculation.											
Green font designates a result.											

Estimated energy required to meet the building load using the 43 retrofit units, with the economizer

It was necessary to update certain parameters (provided in the application and from the site contact) to achieve the appropriate building load using the bin model specified in the application.

The following parameters were updated:

Supply Air Temperature	55	Variable with outdoor temperature to achieve desired load at balance point

Weather data from the application for Travis AFB/Fairfield were used.

Outdoor Temperature Bin (°F)	Median Outdoor Temperature (°F)	Annual Observations per Bin (hours)	Scheduled DX Operating Hours per Bin (hours)	DX Load (tons)	Target DX Energy Use (kWh)	CFM Delivered	Mixed Air Temperature (°F)	Supply Air Temperature (°F)	Calculated DX Sensible Load (Tons)	Revised Chiller Energy Use (kWh)	
105-109	107	5	2	144	394	60,500	81	55	144	394	
100-104	102	16	7	132	1155	60,500	80	56	132	1157	
95-99	97	60	27	120	3939	60,500	79	57	120	3947	
90-94	92	126	57	108	7444	60,500	78	59	108	7467	
85-89	87	197	89	96	10345	60,500	77	60	96	10392	
80-84	82	295	134	84	13555	60,500	76	61	84	13640	
75-79	77	430	195	72	16936	60,500	75	62	72	17082	
70-74	72	563	255	60	18478	60,500	74	63	61	18699	
65-69	67	773	350	48	20297	60,500	73	64	49	20640	
60-64	62	1,177	533	36	23178	60,500	62	62	0	0	
55-59	57	1,593	722	24	20914	60,500	57	57	0	0	
50-54	52	1,407	638	12	9236	60,500	52	52	0	0	
45-49	47	987	447	0	0	60,500	69				
40-44	42	676	306	0	0	60,500	68				
35-39	37	313	142	0	0	60,500	67				
30-34	32	108	49	0	0	60,500	66				
25-29	27	23	10	0	0	60,500	65				
20-24	22	2	1	0	0	60,500	64				
		8,751	3,966	934	145,870					93,417	kWh

Application estimate is 603,613 kWh.

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Site ID#:	4293
Check #	60499
Measure	Replace Hydronic Circulation Pumps

Measure Description:

The retrofit site is a 28 story office building, with 1,000,000 sq ft of conditioned space. This building is heated and cooled by a hydronic system, where cold and hot water is circulated in pipes above the suspended ceiling. Small pumps that were used to circulate the water on each floor, ranging in size from 1/8 hp to 1/3 hp, were replaced with new energy efficient models.

The new pumps not only require less energy to pump water, but also require less maintenance than the older pumps. Leaks were common, and pump repair and lubrication required a significant amount of maintenance staff attention. The new pumps are both self-lubricating and very reliable.

MDSS records list this as HVAC Energy Efficiency Motor - Pump; action code 242.

Summary of Calculations in the Original Application:

The impacts are estimated using a pump schedule (5 days/week, 11 hours per day, and 52 weeks per year -- less 7 holidays per year), and measured pump amperage reading for both the replaced pumps and the new energy efficient models.

Comments on Calculations:

The measured amperage loads for the retrofit pumps appear to be incorrect. The pump sizes are clearly documented in the application (including references to original design specification), but the amperage measurements are too large, given the size of each pump (hp).

The demand impact recorded is the undiversified connected load of the pre-retrofit pumps. This should be the difference in load for the existing pumps minus the new energy efficient pumps.

Other estimates, surrounding the pump operating schedule, appear reasonable.

Evaluation Process:

New pump specifications were gathered on-site, and pump operating schedules were verified.

Energy and demand impact calculations were revised based upon these updated references.

Additional Notes:

An on-site inspection of this facility was conducted on November 11, 1996 with Dick Esposito, Jim Kelsey and Lloyd.

During this on-site additional information were recorded surrounding the pre-retrofit motor loading during the operating schedule. Valves in the plumbing at the point of use are used to adjust the quantity of hot or cold water supplied, based on thermostat demand. Even when there was zero demand, the pumps would operate continuously, though a bypass loop is created using these demand valves. It was suggested that the pump loads in bypass would be similar to the loads with demand.

In conjunction with pump replacement, a Novar EMS system was installed, though not as part of this application. This EMS system now controls pump operating based on demand. A pneumatic switch will shut off pumps automatically when zones are satisfied. This benefit, however, is due to the EMS installation, not the pump replacement. Because of this, and because no estimate was available surrounding the percentage of time that pumps now experience zero demand, all evaluation estimates are based upon the pre-retrofit operating strategy used for these pumps.

Impact Results for Site ID# 4293

	kW	kWh	Therm
MDSS	101.6	263,707	0
Evaluation Estimates	28.15	78,560	0
Engineering Realization Rate	0.28	0.30	NA

Input - Facility Operation

The contact provided the schedule for pump operation							
	The assumptions from the application regarding holiday operation were adopted						
Daytype	Pump Use Begins	Pump Use Ends	Hours/Day Pump Operation	Average Days per Year per Daytype	Hours/Year Pump Operation	Holidays per Year per Daytype*	Holiday Adjusted Hours/Year Pump Operation
Weekday	7:00 AM	6:00 PM	11	260.7	2867.9	7	2790.9
Saturday	Pumps off	Pumps off	0	52.1	0.0	0	0.0
Sunday	Pumps off	Pumps off	0	52.1	0.0	0	0.0
Total			11	365	2868	7	2791
* Seven holidays per year (from the application form).							
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Both the on-site audit (conducted at this facility) and the application form, provides the equipment and assumptions used to model pump energy use at this facility

First, information are provided on these equipment, according to the application

Equipment	Existing or New Equipment?	Manufacturer	Model Number	Number of Pumps	Application Pump Size (hp)	Application Measured Operating Amps	Application Voltage	Application Watts per Pump
Pump	Existing			50	0.333	5.4	117.0	630.7
Pump	Existing			74	0.250	3.9	117.0	453.6
Pump	Existing			124	0.125	2.5	117.0	294.3
Pump	New	Bell and Gosset	Circulator SLC-30	248		0.5	117.0	59.4

Then, based on pump size alone, pump connected load is estimated (to verify the accuracy of measured figures)

Equipment	Existing or New Equipment?	Manufacturer	Model Number	Number of Pumps	Application Pump Size (hp)	Calculated Watts per Pump*
Pump	Existing			50	0.333	248.6
Pump	Existing			74	0.250	186.5
Pump	Existing			124	0.125	93.3

* Watts were calculated using an assumed motor loading of 75% and a motor efficiency of 75%, using the following equation:

Watts = (1,000 watts/kW) x {[(motor hp) x (0.746 kW/hp) x (0.75 motor load)] / (0.75 motor efficiency)}

The calculated motor loads are significantly smaller than the measured values recorded in the application.

All evaluation estimates use the calculated motor loads.

To ensure that new motor loads are equivalent, estimates were also prepared for each new motor

Equipment	Existing or New Equipment?	Manufacturer	Model Number	Number of Pumps	Nameplate Motor Amperage (amps)	Nameplate Motor Load (watts)	Calculated Watts per Pump†
Pump	New	Bell and Gosset	Circulator SLC-30	248	0.740	85	76.5

† It is assumed that the new (smaller) motors will typically operate under a 90% motor loading.

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Estimated energy required to operate the pre-retrofit hydronic pumps:

In the pre-retrofit condition all pumps run continuously during the scheduled hours of operation

Hours per year 2,791 This is generally consistent with the application estimate.

Pump noncoincident kW

NC Demand = {[(248.6 Watts) x (50 1/3 hp pumps)] + [(186.5 Watts) x (74 1/4 hp pumps)] + [(93.3 Watts) x (124 1/8 hp pumps)]} / 1000

= 47.12 kW

The application baseline noncoincident demand is 101.6 kW.

Estimate of energy use per year for the pre-retrofit pumps

47.12 x 2791 = 131,508 kWh/year

Estimate of demand at the time of system peak for the pre-retrofit pumps

Demand = 47.12 kW

This term is undiversified since all the pumps operate continuously during the system peak hour

Estimated energy required to operate the post-retrofit hydronic pumps:

In the post-retrofit condition all pumps run continuously during the scheduled hours of operation

Hours per year 2,791 This is generally consistent with the application estimate.

Pump noncoincident kW

NC Demand = [(76.5 Watts) x (248 pumps)] / 1000

= 18.97 kW

The application post-retrofit noncoincident demand is 14.73 kW.

Estimate of energy use per year for the post-retrofit pumps

18.97 x 2791 = 52,948 kWh/year

Estimate of demand at the time of system peak for the post-retrofit pumps

Demand = 18.97 kW

This term is undiversified since all the pumps operate continuously during the system peak hour

Estimated impacts:

Estimate of energy impacts

Annual Energy Impacts = 78,560 kWh/year

The application estimate is significantly larger -- 263,707 kWh/year.

Estimate of peak hour demand impacts

Demand = 28.15 kW

The application estimate is significantly larger -- 101.6 kW.

This application estimate, however, is the undiversified base system peak hour use, not the impact.

Site ID#:	4538
Check #	57721
Measure	Install Economizers. Timeclock to Control Garage Exhaust Fans.

Measure Description:

The retrofit site is a 3 story office building, with 122,000 sq ft of conditioned space. The retrofit includes the installation of outside air economizer fans and dampers (using the existing gravity vents). The six retrofit economizer vents serve 6 air handlers located on the first and second floor (3 AHU on each floor). The third floor already operated with 100% outside air and therefore that cooling system was not retrofit.

In addition, timeclocks were installed to control the operation of 3 garage exhaust fans. Under pre-retrofit operation, these fans ran 24 hours per day and 365 days per year.

MDSS records list this as Add Economizer, and HVAC - Other; action codes 228, and 299, respectively.

Summary of Calculations in the Original Application:

The economizer impacts are estimated using an outside air temperature bin model. Chiller loads are calculated using an assumed (constant) supply air volume of 72,000 CFM in conjunction with the mixed air temperature and supply air temperature conditions for each bin.

The garage exhaust fan calculations are based upon reduced hours of operation for those (due to control by timeclocks).

Comments on Calculations:

The assumed building loads for this site are in error. First, the site contact indicated that the chiller serving this building never runs at its full capacity. The Carrier GT225 chiller is served by 8 small reciprocating compressors, and even on the hottest days, only 5 of these compressors will normally run. In addition, the bin model balance point at 50 °F outdoor temperature should have a building load that is approaching zero; this model, however, indicates that the building still experiences a load of 156 tons in the 52 °F bin (even though the maximum reported load for the hottest bin is 214 tons).

Secondly, the loads reported in the application bin model (for the first and second floor of this building) mistakenly include the third floor chiller loads. The third floor was not retrofit and so those loads should not be included in the savings calculations.

Lastly, the supply air fans in this building are VAV with a reported minimum setting that is 60% of the design supply air delivery. However, the bin models assume a constant volume delivery of 72,000 CFM for the retrofit mixed air boxes.

Additionally, the economizer retrofit included the installation of six new 5 hp fans serving the economizer vents. The application estimates do not account for the added loads associated with these fans.

The calculations used to estimate the reduction in fan use for the garage fans fails to incorporate an adjustment for the typical fan motor operating load.

Evaluation Process: Bin models were rerun using updated assumptions surrounding chiller loading. All mixed air temperature assumptions and supply air delivery assumptions were updated to be consistent with a VAV system.

Weather data were examined, including a determination of the distribution of temperatures as a function of time of day. Saturday savings (although estimated in the application) were removed because the chillers do not run on Saturdays, just the air handlers run (including new economizer fans).

Garage exhaust fan calculations were updated to include both on-site records for fan operation and updated assumptions regarding BHP motor loads.

Additional Notes: An on-site inspection of this facility was conducted on November 21, 1996 with David Starky.

Impact Results for Site ID# 4538

	kW	kWh	Therm
MDSS	0	449,007	0
Evaluation Estimates	0	49,256	0
Engineering Realization Rate	NA	0.11	NA

Exhibit 4538-1 Evaluation Energy Impact Summary			
	Annual Energy Use (kWh)		
Impact Component	Pre-Retrofit	Post-Retrofit	Impact
Chiller	189,668	99,278	90,390
Economizer Fan	-	92,826	-92,826
Garage Exhaust Fans	76,851	25,160	51,692
Total	266,519	217,263	49,256

Input - Facility Operation

The contact provided the schedule used to start-up this facility each day, including the start-up of chiller operation.

First, the general schedule of daily operation:

Weekday Schedule	Explanation of Procedure Implemented
5:30 AM	Building engineer arrives
6:00 AM - 7:00 AM	Starts boiler system, shuts outside air and heats up building
7:00 AM	Begin introduction of fresh air (run supply air fans)
8:00 AM	Start chillers
10:00 AM	In the winter, chillers are often shut down
5:30 PM	Hot water pumps are shut off
6:00 PM	Everything is shut off

Saturday Schedule	Explanation of Procedure Implemented
8:00 AM	Begin introduction of fresh air (run supply air fans)
1:00 PM	Shut off fresh air and supply air fans

Next, the chiller schedules by daytype are recorded

Daytype	Chiller Use Begins	Chiller Use Ends	12 Midnight - 8:00 AM Hours/Day Chiller Operation	8:00 AM - 4:00 PM Hours/Day Chiller Operation	4:00 PM - 12 Midnight Hours/Day Chiller Operation	Average Days per Year per Daytype	12 Midnight - 8:00 AM Hours/Year Chiller Operation	8:00 AM - 4:00 PM Hours per Year Chiller Operation	4:00 PM - 12 Midnight Hours per Year Chiller Operation	Annual Hours per Year Chiller Operation
Weekday	8:00 AM	6:00 PM	0	8	2	260.7	0.0	2085.7	521.4	2607.1
Saturday	Chillers off	Chillers off	0	0	0	52.1	0.0	0.0	0.0	0.0
Sunday	Chillers off	Chillers off	0	0	0	52.1	0.0	0.0	0.0	0.0
Total			0	8	2	365	0	2086	521	2607.1

Daytype	Chiller Use Begins	Chiller Use Ends	Holidays per Year per Daytype*	12 Midnight - 8:00 AM Holiday Adjusted Hours/Year Chiller Operation	8:00 AM - 4:00 PM Holiday Adjusted Hours per Year Chiller Operation	4:00 PM - 12 Midnight Holiday Adjusted Hours per Year Chiller Operation	Annual Holiday Adjusted Hours per Year Chiller Operation
Weekday	8:00 AM	6:00 PM	9	0.0	2013.7	503.4	2517.1
Saturday	Chillers off	Chillers off	0	0.0	0.0	0.0	0.0
Sunday	Chillers off	Chillers off	0	0.0	0.0	0.0	0.0
Total			9	0	2014	503	2517.1

Input - Facility Operation

Lastly, supply air fan and economizer fan operating schedules were recorded

Daytype	Fan Use Begins	Fan Use Ends	12 Midnight - 8:00 AM Hours/Day Fan Operation	8:00 AM - 4:00 PM Hours/Day Fan Operation	4:00 PM - 12 Midnight Hours/Day Fan Operation	Average Days per Year per Daytype	12 Midnight - 8:00 AM Hours/Year Fan Operation	8:00 AM - 4:00 PM Hours per Year Fan Operation	4:00 PM - 12 Midnight Hours per Year Fan Operation	Annual Hours per Year Fan Operation
Weekday	7:00 AM	6:00 PM	1	8	2	260.7	260.7	2085.7	521.4	2867.9
Saturday	8:00 AM	1:00 PM	0	5	0	52.1	0.0	260.7	0.0	260.7
Sunday	Fans off	Fans off	0	0	0	52.1	0.0	0.0	0.0	0.0
Total			1	13	2	365	261	2346	521	3128.6

Daytype	Fan Use Begins	Fan Use Ends	Holidays per Year per Daytype*	12 Midnight - 8:00 AM Holiday Adjusted Hours/Year Fan Operation	8:00 AM - 4:00 PM Holiday Adjusted Hours per Year Fan Operation	4:00 PM - 12 Midnight Holiday Adjusted Hours per Year Fan Operation	Annual Holiday Adjusted Hours per Year Fan Operation
Weekday	7:00 AM	6:00 PM	9	251.7	2013.7	503.4	2768.9
Saturday	8:00 AM	1:00 PM	0	0.0	260.7	0.0	260.7
Sunday	Fans off	Fans off	0	0.0	0.0	0.0	0.0
Total			9	252	2274	503	3029.6

* Eight holidays per year (from the application form) in addition to one day for planned shutdowns.

The contact also provided the schedule for post-retrofit garage exhaust fan operation.

Daytype	Fan Use Begins	Fan Use Ends	Hours/Day Fan Operation	Average Days per Year per Daytype	Hours/Year Fan Operation§
Weekday	7:00 AM	6:00 PM	11	260.7	2867.9
Saturday	Fans off	Fans off	0	52.1	0.0
Sunday	Fans off	Fans off	0	52.1	0.0
Total			11	365	2868

§ The application estimates for the post-retrofit condition are for fan operation 12 hrs/day, for all daytypes, or 4,380 hrs/year.

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During the on-site audit conducted at this facility, the contact provided a many of the assumptions used to model this facility

First, various equipment were recorded

Equipment	Measure Affected	Manufacturer	Model Number	Capacity	Units for Capacity	Maximum Observed Load	Units for Maximum Load	Voltage	Efficiency
Chiller¥	Economizer	Carrier	30GT225	226.5	tons	150	tons		
Economizer Fan	Economizer			5.0	hp	3.75	hp	208	0.875
Economizer Fan	Economizer			5.0	hp	3.75	hp	208	0.875
Economizer Fan	Economizer			5.0	hp	3.75	hp	208	0.875
Economizer Fan	Economizer			5.0	hp	3.75	hp	208	0.875
Economizer Fan	Economizer			5.0	hp	3.75	hp	208	0.875
Economizer Fan	Economizer			5.0	hp	3.75	hp	208	0.875
Boiler	NA	Bryan	L-80-G	4,320	kBtuh				
Garage Exhaust Fan	Garage Exhst	General Electric	5K184AD205	5	hp	3.5	hp	208	0.84
Garage Exhaust Fan	Garage Exhst			7.5	hp	5.3	hp	208	
Garage Exhaust Fan	Garage Exhst			7.5	hp	5.3	hp	208	

¥ This chiller was installed approximately 2 months after the economizer retrofit was completed.
The existing chiller, a 360 ton unit was taken off-line, but remains in the mechanical room on the roof.

Secondly, various parameters were specified

Parameter	Value Reported	Units of Parameter	Notes
Chiller Lockout	50	°F	
Economizer Lockout	75	°F	Upper temperature threshold
Minimum Outside Air	15%	% of max supply air	
Economizer CFM	60,000	CFM	Six economizer fans @ 10,000 CFM each
Peak Chiller Load	150	tons	Based on site contact estimate†
Economizer Lockout	45		Lower temperature threshold (not even minimum air is brought in)
VAV Supply Fans	72,000	CFM	This is for all six fans serving floors 1 and 2 (@ 11,000-15,000 CFM each)
VAV Supply Fans	60%	min % of capacity	The VAV supply fan is configured for a maximum reduction of 40%.
Return Air Temp.	75	°F	
Supply Air Temp.	50	°F	
Garage Exhaust Fan	8,760	hours/year	Pre-retrofit exhaust fan hours of operation
Economizer Fan	100%	percent of capacity	The economizer fan normally provides 100% of its capacity and is 100% loaded
Economizer Fan	0%	minimum OA	When minimum OA is required, economizer fans are off.
Chiller Capacity	226.5	tons	Rated capacity per ARI 590-92
Chiller Power	291.2	kW	Rated capacity per ARI 590-92

† The 226.5 ton chiller only operates at roughly 5/8 of its total capacity on-peak.
The area served by this chiller also includes the third floor of this building.
Therefore, assume that two-thirds of the chiller load is required by the 1st and 2nd floors.
Site contact indicated that 90% of the time the building loads are met by just 100 tons of chiller capacity.

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Estimated energy required to meet the building load on the 1st and 2nd floors, without the economizer

It was necessary to update certain parameters (provided in the application and from the site contact) to achieve the appropriate building load using the bin model specified in the application.

The following parameters were updated:

Supply air Fan Capacity	60,000
Supply Air Temperature	55
Return Air Temperature	*72*

Outdoor Air Temperature	Mean Outdoor Air Temperature (°F)	Midnight - 8AM Total Bin Hours	Midnight - 8AM Total Bin Hours	4PM - 12 Midnight Total Bin Hours	Midnight - 8AM Chiller Hours	Midnight - 8AM Chiller Hours	4PM - 12 Midnight Chiller Hours	Floor 1 and 2 Chiller Load (tons)	Preliminary Chiller Energy Use (kWh)	CFM Delivered	Mixed Air Temperature (°F)	Supply Air Temperature (°F)	Calculated Chiller Sensible Load (Tons)	Revised Chiller Energy Use (kWh)	
95-99	97	0	1	0	0	1	0	100	92	60,000	76	55	112	103	
90-94	92	0	5	0	0	4	0	90	414	60,000	75	55	108	497	
85-89	87	0	19	2	0	14	0	80	1436	60,000	74	55	104	1866	
80-84	82	0	56	7	0	40	1	70	3722	57,000	74	55	95	5068	
75-79	77	1	110	24	0	79	4	60	6408	54,000	73	55	87	9257	
70-74	72	6	346	69	0	248	12	50	16723	51,000	72	55	78	26098	
65-69	67	45	583	215	0	418	38	40	23450	48,000	71	55	69	40680	
60-64	62	291	640	535	0	458	98	30	21368	45,000	70	56	61	43269	
55-59	57	966	591	973	0	423	174	20	15355	42,000	69	55	52	40008	
50-54	52	916	384	746	0	275	133	10	5250	39,000	67	55	43	22821	
45-49	47	475	145	273	0	104	49	0	0	36,000	66	55		0	
40-44	42	175	30	68	0	21	12	0	0	36,000	65	55		0	
35-39	37	40	2	6	0	1	1	0	0	36,000	63	55		0	
30-34	32	1	0	0	0	0	0	0	0	36,000	62	55		0	
Total		2916	2912	2918	0	2086	521		94,219					189,868	kWh

Application estimate is 738,344 kWh.

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Estimated energy required to meet the building load on the 1st and 2nd floors, with the economizer

It was necessary to update certain parameters (provided in the application and from the site contact) to achieve the appropriate building load using the bin model specified in the application.

The following parameters were updated:

Supply air Fan Capacity	60,000
Supply Air Temperature	55
Return Air Temperature	72

Outdoor Air Temperature	Mean Outdoor Air Temperature (°F)	Midnight - 8AM Total Bin Hours	Midnight - 8AM Total Bin Hours	4PM - 12 Midnight Total Bin Hours	Midnight - 8AM Chiller Hours	Midnight - 8AM Chiller Hours	4PM - 12 Midnight Chiller Hours	CFM Delivered	Mixed Air Temperature (°F)	Supply Air Temperature (°F)	Calculated Chiller Sensible Load (Tons)	Chiller Energy Use (kWh)	Hours of Economizer Fan Operation (hours)	Energy Use of New Economizer Fans (kWh)
95-99	97	0	1	0	0	1	0	60,000	76	55	112	103		
90-94	92	0	5	0	0	4	0	60,000	75	55	108	497		
85-89	87	0	19	2	0	14	0	60,000	74	55	104	1866		
80-84	82	0	56	7	0	40	1	57,000	74	55	95	5068		
75-79	77	1	110	24	0	79	4	54,000	73	55	87	9257		
70-74	72	6	346	69	0	248	12	51,000	72	55	78	26098		
65-69	67	45	583	215	0	418	38	48,000	67	55	52	30391	843	16171
60-64	62	291	640	535	0	458	96	45,000	62	55	28	20192	1466	28122
55-59	57	966	591	973	0	423	174	42,000	57	55	8	5804	2530	48533
50-54	52	916	384	746	0	275	133	39,000	55	55	0	0		
45-49	47	475	145	273	0	104	49	36,000	55					
40-44	42	175	30	68	0	21	12	36,000	72					
35-39	37	40	2	6	0	1	1	36,000	72					
30-34	32	1	0	0	0	0	0	36,000	72					
Total		2916	2912	2918	0	2086	521					99,278	kWh	92,826

Application estimate is 365,578 kWh.

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Garage Exhause Fans

Estimated energy required to operate the pre-retrofit garage fans:								
	In the pre-retrofit condition all three fans always run							
		Hours per year	8,760	This is consistent with the application estimate.				
	Fan noncoincident kW							
		NC Demand =	(3.5+5.3+5.3 BHP) x (0.746 kW/hp) / (0.84 motor efficiency)					
		=	8.77	kW	Application does not adjust for motor loading (BHP).			
	Estimate of energy use per year for garage exhaust fans							
		8.77 x 8760 =	76,851	kWh/year				
Estimated energy required to operate the post-retrofit garage fans:								
	In the post-retrofit condition the three fans operate on a shedule (refer to facility operation inputs)							
		Hours per year	2,868	Application varies considerably -- 4,380 hours/year				
	Estimate of energy use per year for garage exhaust fans							
		8.77 x 2868 =	25,160	kWh/year				

Appendix C
Billing Regression Analysis

C. BILLING REGRESSION ANALYSIS

This appendix documents the detailed analytical steps undertaken in the billing regression analysis of Pacific Gas and Electric Company's (PG&E's) 1995 Nonresidential Retrofit Program for the Commercial Sector (the Commercial Program). Both net and gross billing analysis models were implemented, however, the net model was unable to provide statistically valid results due to problems of multi-colinearity. This appendix begins with a discussion of the analysis periods and data sources used in the billing regression analysis. Then, the results of the data censoring that was applied to the billing 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.

C.1 OVERVIEW

The key objective of the billing analysis is to determine the first-year program energy impacts. A statistical analysis is employed to model the differences of customers' energy usage between pre- and post-installation periods. The model is specified using actual customer billing data and independent variables that explain changes in customers' energy usage, including engineering estimates of 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 engineering impact estimates. Realized impacts represent the fractions of the engineering estimates actually "observed" or "detected" in the statistical analysis of actual billing data. The SAE coefficients estimated in the billing analysis regression models are relative to the results of the evaluation-based engineering estimates, not the PG&E Program ex ante estimates. The SAE coefficients, the estimation of which is the topic of this appendix, are then used to estimate program impacts and realization rates relative to the ex ante estimates.

As discussed below, the billing regression analysis was conducted on a sample of telephone surveyed participants and nonparticipants. Because many Commercial Program participants installed measures under multiple end uses, one integrated billing analysis approach was used to model the Lighting, HVAC and Refrigeration end uses.

C.2 DATA SOURCES FOR BILLING REGRESSION ANALYSIS

The billing regression analysis for the 1995 Commercial Program Evaluation uses data from five primary data sources: the PG&E Management Decision Support System (MDSS) tracking database, the billing database, the telephone survey data, the engineering estimates of changes of usage between the pre- and post-installation periods, and the weather data tapes from PG&E's load research weather sites. A summary of the data elements used in the regression analysis are presented below.

C.2.1 Program Participant Tracking System

The participant tracking system for the Retrofit Express (RE), Retrofit Efficiency Options (REO) and Customized Incentives Programs was maintained as part of the MDSS. It contains program applications, rebate and technical information about installed measures, including measure description, quantity, rebate amount, and ex ante demand, ad energy and therm savings estimates. The MDSS database is linked to the billing database and other program databases through PG&E's customers control numbers.

C.2.2 PG&E Billing Data

For this evaluation, the PG&E billing data were obtained from two different data sources within PG&E. 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 *Appendix A: Sample Design*. The billing histories contained in this data base only run through September 1995.

The second billing dataset, which consists only of customer accounts in the surveyed dataset, was later obtained from PG&E Load Data Services. This billing dataset contains bill readings that run through September 1996, 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, from January 1992 to September 1996.

C.2.3 Weather Data

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

C.2.4 Telephone Survey Data

All available telephone surveys (except for the Canvass surveys, which do not collect detailed information regarding changes that have occurred at the premise) collected as part of the evaluation for the Commercial Sector Program were used in the billing regression analysis. Four telephone survey samples totaling 1,217 participants and 652 nonparticipants were collected for the Commercial Sector Evaluation. The 1,217 participant surveys included 614 Lighting participants, 487 HVAC participants, and 241 Refrigeration participants. Because of the significant levels of cross-over among participants across the Commercial Program end uses, one integrated billing regression model was developed to evaluate all three Commercial Program end uses.

The data collected in the telephone survey supplies information on energy-related changes at each site for the billing period covered by the billing regression analysis. For a detailed discussion of the telephone survey sample design and the final sample distribution, see *Appendix A: Sample Design*.

C.2.5 Engineering Estimates

Engineering estimates of savings were estimated for each of the 1,217 participants. Separate estimates were calculated for every measure installed under the Commercial Sector Program. The engineering estimates were calculated based on expected savings from the pre-installation technology to the post-installation technology. For some technologies, such as Central A/Cs installed in the HVAC program, the savings estimates will differ from the impact estimates. This is due to the impacts being calculated relative to a baseline efficiency, compared to the savings estimates which are based on a pre-existing unit's efficiency. *Appendix B: Engineering Detailed Computational Methods* discusses the calculation of the savings estimates used in the billing analysis in greater detail.

For all measures, customer-specific engineering estimates were used in the SAE billing regression model, except for some Customized Incentive measures. For customers with EMS and "Other HVAC" Customized Incentive measures who were not on-site audited, the impact estimates supporting the application were used as the engineering estimates for the SAE analysis. From the engineering analysis based on the on-site audited measures, it was determined that the application's energy estimate was reasonable and accurate for all but one EMS application (which was not part of the SAE analysis).

For the "Other HVAC" Customized Incentive measures, the measures can be so unique and the impact estimates so dependent on building characteristics and other equipment installed at the facility, that it is very difficult to estimate an impact without performing an on-site audit. However, the level of documentation provided along with the applications was sufficient to allow for an assessment of the quality of the impact calculations made. A review of the applications associated with the "Other HVAC" Customized Incentive measures indicated that the applications provided the best data for use in the SAE analysis. In other words, performing an engineering analysis based solely on the application, without an on-site audit, would result in reverting to the application's estimate.

C.3 DATA AGGREGATION AND ANALYSIS DATASET DEVELOPMENT

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

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

Of the three, the premise number serves as the best indicator of a unique site. However, there are some premise numbers that contain multiple sites. To address this issue, service address was also used to help identify a unique site. If there was more than one service address for a premise number, it was broken out into multiple sites. Therefore, a unique site was defined as all of the control numbers within a unique combination of service address,[1] premise number, and corporation number. A unique Site ID was created based on this combination of address, premise, and corporation to serve as the key variable for linking data.

The billing data was provided at the control number level. Therefore, the monthly billing data was aggregated to the Site ID level. A concern with aggregating to the Site ID level is that there may be control numbers associated with a different premise number, service address, or corporation number that are in the same physical site and are being affected by the installed measures. If this is

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

the case, the billing analysis will have the effect of underestimating the impacts. This a topic that will be discussed further in the *Data Censoring* section below.

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

The engineering estimates of change were also aggregated to the Site ID level. However, prior to aggregating to the Site ID level, the installation dates for each individual measure were analyzed to ensure that only the impacts occurring within the billing analysis periods were being aggregated. The selection of analysis periods is discussed in the next section.

All data elements mentioned above were linked to the final analysis database by Site ID. Exhibits C-1 through C-4 below provide the sample frame that was available for the billing analysis for each end use (Lighting, HVAC, and Refrigeration) and also for nonparticipants. The sample sizes are provided by business type and technology (for participants). The values presented are the unique number of the Site IDs within a given segment.

Exhibit C-1
Billing Analysis Sample Frame
Pre-Censoring
Indoor Lighting End-Use Technologies

	Business Type												
Program and Technology Group	**Office**	**Retail**	**College/ University**	**School**	**Grocery**	**Restaurant**	**Health Care**	**Hotel/Motel**	**Warehouse**	**Personal Service**	**Community Service**	**Misc.**	**Total**
Retrofit Express Program													
Compact Fluorescent	61	29	4	57	9	11	19	17	6	3	17	3	236
Incandescent to Fluorescent	5	-	-	4	-	1	-	2	2	-	2	-	16
Efficient Ballast	8	7	2	7	4	-	2	-	2	-	1	1	34
T8 Lamps and Electronic Ballasts	154	68	8	115	30	17	29	8	25	8	33	9	504
Optical Reflectors w/ Fluor. Delamp	75	32	5	34	13	11	10	1	10	5	7	4	207
High Intensity Discharge	8	7	2	13	1	1	-	1	15	5	5	7	65
Halogen	13	4	2	8	-	2	1	1	1	-	6	1	39
Exit Signs	38	12	3	29	2	5	5	1	2	1	7	1	106
Controls	28	2	3	34	1	1	5	2	4	1	6	5	92
Retrofit Express Total	177	80	9	120	42	27	33	21	34	14	42	15	614
Customized Incentives Program													
Compact Fluorescent													
Standard Fluorescent													
High Intensity Discharge													
Halogen													
Exit Signs													
Controls													
Other													
Customized Incentives Total	5	1	0	0	10	0	0	0	1	0	1	0	18
Total	177	80	9	120	42	27	33	21	34	14	42	15	614

Exhibit C-2
Billing Analysis Sample Frame
Pre-Censoring
HVAC End-Use Technologies

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	93	32	1	30	4	12	24	3	8	5	27	5	244
Variable Speed Drive HVAC Fan	16	11	1	2	-	-	-	1	-	-	-	1	32
Package Terminal A/C	2	-	-	7	-	2	-	15	-	-	-	-	26
Programmable Thermostat	53	12	-	14	-	7	7	2	3	3	15	1	117
Reflective Window Film	44	9	1	3	3	2	12	4	5	2	10	2	97
Water Chiller	1	1	-	1	-	-	1	-	-	-	2	-	6
Other RE Measures	1	1	-	1	1	1	1	-	-	-	1	-	7
Retrofit Express Total	170	52	3	49	8	19	37	23	13	8	40	7	429
Retrofit Efficiency Options Program													
Variable Frequency Drive	1	-	1	-	-	-	-	-	-	-	-	-	2
Water Chiller	-	-	-	1	-	-	2	-	-	-	1	-	4
CAV to VAV	1	-	-	-	-	-	-	-	-	-	-	-	1
Cooling Tower	-	-	-	1	-	-	-	-	-	-	-	-	1
Retrofit Efficiency Options Total	2	-	1	1	-	-	2	-	-	-	1	-	7
Customized Incentives Program													
HVAC Variable Speed Drive	2	1	-	-	1	-	-	-	-	-	1	-	5
High Efficiency Chiller	1	-	-	-	-	-	-	-	-	-	-	-	1
Energy Management System	8	-	2	17	1	-	2	1	1	-	-	-	32
Other CI Measures	9	-	1	4	-	-	5	-	2	-	1	1	23
Customized Incentives Total	20	1	3	20	2	-	6	1	2	-	2	1	58
Total	190	53	6	68	10	19	43	24	15	8	43	8	487

Exhibit C-3
Billing Analysis Sample Frame
Pre-Censoring
Refrigeration End-Use Technologies

Program and Technology	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Refrigeration Load Reduction													
Low Temperature Glass/Acrylic Door	-	-	-	-	-	-	-	-	-	-	-	-	-
Heatless Door	-	-	-	-	2	-	-	-	-	-	-	-	2
Cooler/Freezer Door Gaskets	-	1	-	-	11	3	-	-	-	1	-	-	16
Auto Closer for Cooler/Freezer	-	1	-	-	2	1	-	1	-	1	-	-	6
Medium Temperature Case w/ Door	1	-	-	-	6	2	-	-	-	-	-	-	9
Strip Curtains for Walk-in	1	1	-	-	8	5	-	-	6	-	1	-	22
Low Temperature Case w/ Door	-	-	-	-	3	1	-	-	-	-	-	-	4
Night Covers for Display Cases	-	1	-	-	21	1	-	-	-	-	-	-	23
Compressor Upgrades													
Mechanical Subcooler	-	-	-	-	1	-	-	-	-	-	-	-	1
Multiplex Comprssor System	-	-	-	-	1	-	-	-	-	-	-	-	1
Adjustable Speed Drive	-	-	-	-	-	-	-	-	1	-	-	-	1
Floating Head Pressure Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Condenser Upgrades													
Oversized Air-Cooled Condenser	-	-	-	-	1	-	-	-	-	-	-	-	1
Oversized Evaporative Condenser	-	-	-	-	-	-	-	-	1	-	-	1	2
Evaporator Upgrades													
Walk-in Cooler PSC Evaporator Motor	-	-	-	-	1	-	-	-	-	-	-	-	1
Display PSC Evaporator Motor	-	-	-	-	2	-	-	-	-	-	-	-	2
Other													
Anti-Sweat Heater Control	-	-	-	-	1	-	-	-	-	-	-	-	1
Suction Line Insulation	1	-	-	-	1	-	-	-	1	-	-	-	3
Display Case Electronic Ballast	-	1	-	-	4	-	-	-	1	-	-	-	6
Non-Electric Condensate Evaporator	3	4	1	2	17	120	-	1	1	3	12	1	165
Retrofit Express Total	5	8	1	2	63	128	-	1	8	4	13	2	235
Customized Incentives Program													
Compressor Upgrades													
Floating Head Pressure Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Booster Desuperheaters	-	-	-	-	-	-	-	-	-	-	-	-	-
Condenser Upgrades													
Oversized Condensers	-	-	-	-	-	-	-	-	-	-	-	-	-
Other													
Refrigeration EMS	-	1	-	-	2	-	-	-		-	-	1	4
Refrigeration Add/Change	1	-	-	-	-	-	-	-	-	-	-	1	2
Refrigeration Other	-	1	-	-		-	-	-	1	-	-	-	2
Customized Incentives Total	1	1	-	-	2	-	-	-	1	-	-	2	7
Total	6	8	1	2	64	128	-	1	10	4	13	3	241

Exhibit C-4
Billing Analysis Sample Frame
Pre-Censoring
Nonparticipants

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Total	75	130	2	28	190	35	28	16	58	6	34	50	652

C.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 actually installed measures in 1992, 1993, 1994 or 1995, with 1995 installations accounting for approximately two-thirds of total installations.

C.4.1 Selection of Installation Date

Although installation date is a field in the MDSS it is rarely collected (only 2 percent of the time). Because the "paid date" can be off by as much as 3 years from the installation date, another approach was developed to estimate installation date. For 68 percent of the MDSS records, a pre- and post-installation inspection date was collected. From these two variables, an interval containing the installation date could be determined. Another date field in the MDSS that is populated 100 percent of the time is the date the application was received by PG&E. This date always occurs after the pre-installation inspection date (when populated) and rarely exceeds the post-installation inspection date (when populated) by more than a month (6 percent). In fact, the application received date and post-installation inspection date are within a month of each other 78 percent of the time. Therefore, the application received date was used as a proxy for the installation date.

In addition, the telephone survey asked every participant to estimate the installation date. If the installation date provided through the self reported survey fell between the pre- and post-installation inspection dates, the customer reported date was used over the application received date.

C.4.2 Selection of Analysis Periods

Billing data were available from January 1992 through September 1996. To maximize the number of post installation months, a post period of October 1995 through September 1996 was used. Because the majority of installations occurred during 1995, the only feasible pre-periods were October 1992 through September 1993 and October 1993 through September 1994. Survey data gathered change information dating back from the beginning of 1993. Therefore,. both pre-installation periods could be used. However, the further back the pre-installation period is chosen, the more likely there are to be changes that have occurred at the site. To minimize the number of changes that have occurred outside the program between the pre- and post-installation periods (and to minimize the errors associated with self-reported changes and dates the changes occurred), the October 1993 through September 1994 pre-installation period was selected.

The only disadvantage to selecting the more recent pre-installation period is that some participants may have actually installed the participating measure during or before the pre-installation period. There were no rebated Lighting or Refrigeration installations, and only 18 rebated HVAC installations (2 percent of HVAC) in the analysis sample that occurred prior to the pre-installation period. In addition, only 2 percent of the rebated Lighting and Refrigeration installations, and 8 percent of the rebated HVAC installations occurred during the pre-installation period.

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

Exhibits C-5 through C-7 provide the cumulative participation by month for the participants that are part of the billing analysis sample frame.

Exhibit C-5
Commercial Lighting Rebated Technologies
By Estimated Installation Date

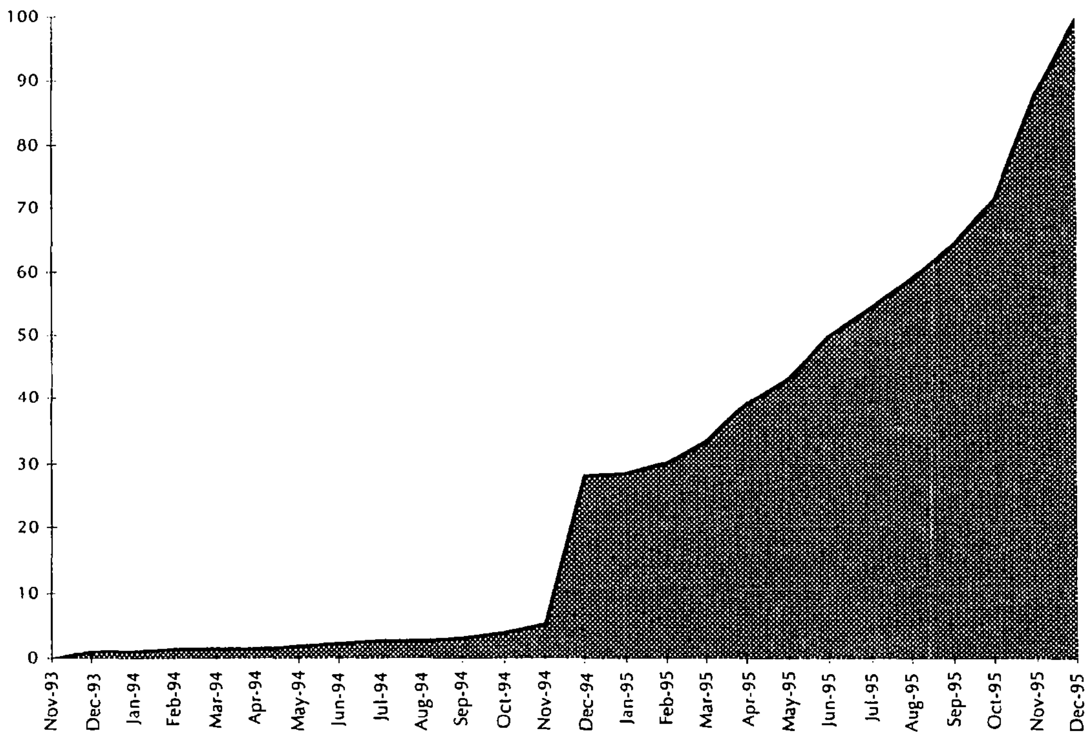


Exhibit C-6
Commercial HVAC Rebated Technologies
By Estimated Installation Date

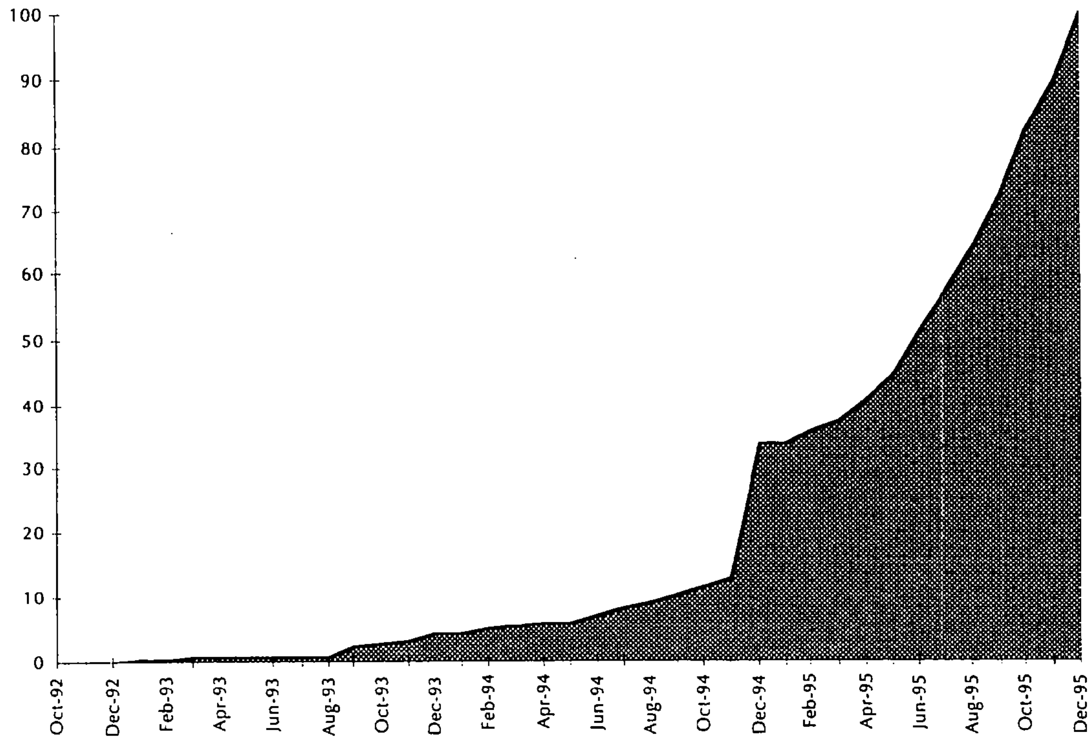
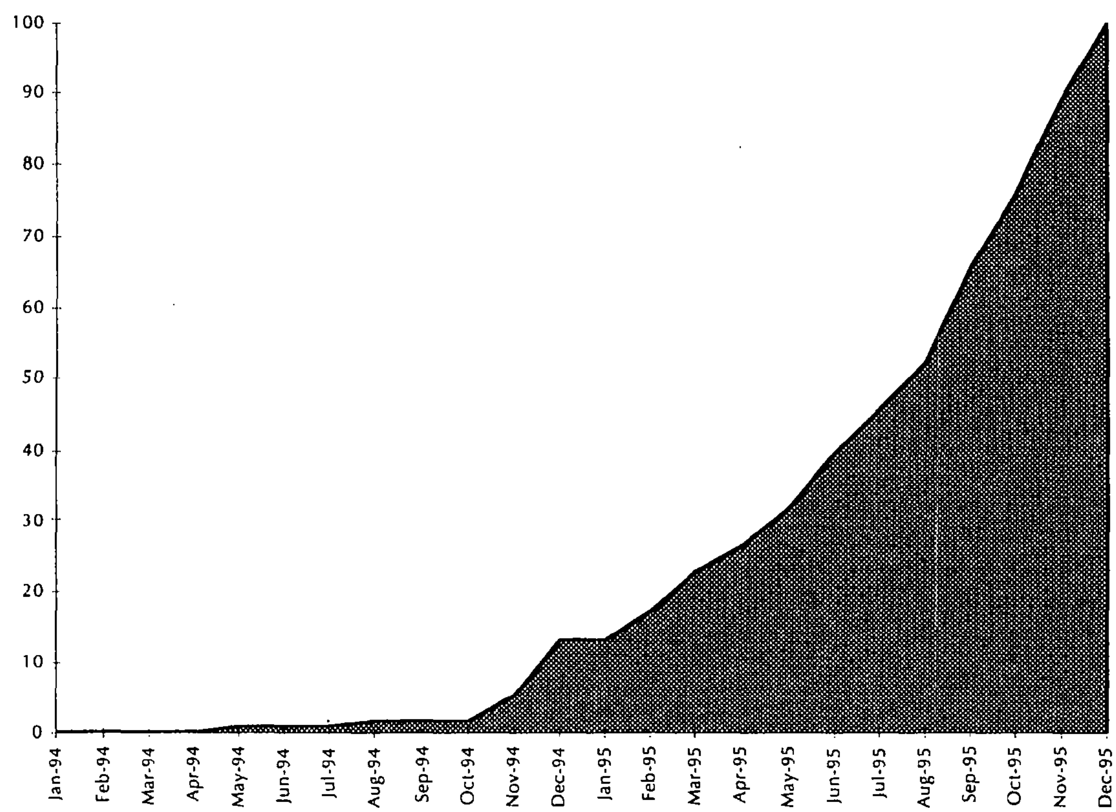


Exhibit C-7
Commercial Refrigeration Rebated Technologies
By Estimated Installation Date



C.5 DATA CENSORING

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

C.5.1 Invalid Usage

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

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

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

The pre-installation annual bill could not be more than twice or less than one half the post-installation bill, unless the telephone survey responses indicated that the customer had a change at the site that may have caused an increase or decrease in usage, respectively. For example, if a customer doubled their usage and reported an increase in square footage, or an increase in employees, or an additional measure installed, the customer remained in the sample. However, if the customer reported no changes, or only changes that would indicate a decrease in usage, such as a removal of a measure, then the customer was removed from the analysis.

Exhibit C-8 presents the number of participants and nonparticipants that were deleted for each of the above criteria. Note that only 22 nonparticipants were deleted, whereas 123 participants were deleted. This is due to the fact that the nonparticipants were pre-screened to have relatively valid billing data prior to being selected into the nonparticipant survey sample frame. The participants, however, were often a census and no pre-screening was done on their billing data prior to being selected into the participant survey sample frame. Of the 123 participants, 87 were deleted due to the zero bill criteria.

Exhibit C-8
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria
Customers with Invalid Billing Data

Participant or Nonparticipant	Zero Monthly Bills >6?	Usage Doubled or Cut in Half, No Corresponding Change at Site?	Usage Tripled or Cut to a Third?	Number Removed From Analysis
NP	NO	NO	YES	4
NP	NO	YES	YES	3
NP	YES	NO	NO	3
NP	YES	NO	YES	3
NP	YES	YES	NO	1
NP	YES	YES	YES	8
TOTAL				22
P	NO	NO	YES	17
P	NO	NO	YES	3
P	NO	YES	NO	2
P	NO	YES	YES	7
P	NO	YES	YES	6
P	NO	YES	YES	1
P	YES	NO	NO	2
P	YES	NO	NO	8
P	YES	NO	YES	5
P	YES	NO	YES	2
P	YES	YES	NO	5
P	YES	YES	NO	5
P	YES	YES	NO	1
P	YES	YES	YES	38
P	YES	YES	YES	21
TOTAL				123

C.5.2 Large Customers

Customers whose annual post-installation energy consumption exceeded three million kWh were excluded from the billing analysis. Customers of this size were deleted for a number of reasons.

First, there were 98 participants dropped for this reason, compared to only 10 nonparticipants. This indicated that the nonparticipants would not provide a good control for this group of participants. Very large customers are more likely to participate because they are more aware of the program, since they have more contact with PG&E representatives. Therefore, it is difficult to find a sample of nonparticipants that adequately represents these customers.

Large customers installing measures that provide relatively low levels of savings are particularly problematic in billing analyses of this type. It is very difficult to detect an annual impact even as large as 10,000 kWh in a customer's bill which exceeds 10 million kWh, for example. In addition, large customers are more likely to have made changes at the site, which could significantly affect their energy usage. If the model does not adequately capture all of these changes (possibly due to the unique nature of the change, or an error in the self-reported survey responses) it is likely that the coefficient on the program *energy* impact may reflect the change. While this is true of all customers, regardless of size, it is more of a concern for larger customers because the magnitude of their changes can have significant influence over the results of the model.

C.5.3 Aggregation to Site ID Level

As mentioned above, one concern with aggregating to the Site ID level is that there may be control numbers associated with a different premise number, service address, or corporation number that are in the same physical site and are being affected by the installed measures. If this is the case, the billing analysis will have the effect of underestimating the impacts. Therefore, a comparison was made between the engineering energy impact and the pre- and post-installation bills to identify any customers where this problem of bill aggregation may exist.

There were 148 participants that were identified as having total Commercial Sector Program energy impacts that were either more than 50 percent of their pre-installation usage or more than 100 percent of their post-installation usage. These 148 participants were further analyzed to determine whether the impact was large relative to usage because of a problem in aggregating the bill, or if the engineering estimates were just over-estimated, in which case the customer would not be removed from the billing analysis.

Three criteria were used to determine if there was a problem with aggregating the bill for these 148 participants. If a participant failed any of these criteria, the customer was removed from the analysis on the basis that the bills were not properly aggregated and the entire impact will not be detected in an analysis of the customer's billing data.

If the customer's annual kWh per square foot was in the bottom tenth percentile of all participants, the customer was removed.

If the customer's annual kWh per employee was in the bottom tenth percentile of all participants, the customer was removed.

The first billing data pull, which consisted of every nonresidential customer in PG&E's service territory over the period of January 1992 to September 1995, was compared to the second data pull, which is being used for the billing analysis. Customer bills from the first billing data pull were aggregated to the Site ID level in the same way described above. These annual aggregated bills were compared to the aggregated bills used in the analysis. If the aggregated bills from the first data pull were more than 50 percent larger than the bills being used in the billing analysis, the customer was removed. This would indicate that either not all of the control numbers that link to a site were provided in the second data pull or, more likely, since 1995 (when the first billing data was pulled and when the customer participated) there has been customer turnover at the site, and there are now additional premise numbers that no longer link to one unique site.

As a results of these three criteria, 102 of the 148 premises were removed. Of the 102 removed customers, 45 failed the invalid usage data screening checks as well. Therefore, only 57 premises were removed solely on these data screening criteria alone.

Exhibit C-9 presents the number of participants that were removed from the analysis for each of the above criteria.

Exhibit C-9
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria
Customers with Billing Aggregation Problems

Low Usage per Sqft?	Low Usage Per Employee?	Low Usage Relative to 1995 Billing Data Pull?	Number of Participants Removed
YES	NO	NO	3
YES	YES	NO	1
YES	YES	YES	1
NO	NO	YES	5
NO	YES	NO	1
NO	YES	YES	2
YES	NO	NO	27
YES	NO	YES	11
YES	YES	NO	9
YES	YES	YES	7
NO	NO	YES	1
NO	YES	NO	2
NO	YES	YES	1
YES	NO	NO	12
YES	NO	YES	2
YES	YES	NO	11
YES	YES	YES	6
TOTAL			102

C.5.4 Other Censoring

In addition to all of the above censoring, three other participants were removed from the analysis for the following reasons. One customer was removed from the analysis because the customer was noted as a "Z-Customer" in the MDSS. PG&E does not claim impacts on "Z-Coded" customers.

Another site had a retrofit performed that will affect a neighboring customer's utility bill. The refrigeration equipment (compressors and condensers) serving the participant are maintained and operated by a nonparticipant. The participant buys liquid ammonia from the nonparticipant via lines running under an adjacent road (driveway) and suction gas is returned to the nonparticipant following use. The impacts of this retrofit (which affect ice production) will be realized by the manufacturer of the liquid ammonia product, a nonparticipant. Therefore, the participating customer was removed from the analysis.

Finally, two other customers were identified as having added the rebated measure installed under the Commercial Program, causing a net increase in energy from the pre- to post-installation period. One of these customers was previously identified as being a large customer and deleted. Therefore, only one extra customer was removed.

Exhibit C-10 summarizes the total number of participants and nonparticipants that were removed from the billing analysis. Exhibits C-11 to C-14 present the final sample sizes used in the billing analysis by business type and technology for participants and by business type for nonparticipants.

Exhibit C-10
Distribution of Customers Removed from Billing Analysis
By Data Censoring Criteria

Participant or Nonparticipant	Zero Monthly Bills >6?	Usage Doubled or Cut in Half, No Corresponding Change at Site?	Usage Tripled or Cut to a Third?	PG&E's Z-Coded Customer?	Impact Affects NP Site?	Rebated Measure Increases Usage?	Large Customer?	Bill Not Aggregated Properly?	Number Removed From Analysis
NP	NO	NO	NO	NO	NO	NO	YES	NO	10
NP	NO	NO	YES	NO	NO	NO	NO	NO	4
NP	NO	YES	YES	NO	NO	NO	NO	NO	3
NP	YES	NO	NO	NO	NO	NO	NO	NO	3
NP	YES	NO	YES	NO	NO	NO	NO	NO	3
NP	YES	YES	NO	NO	NO	NO	NO	NO	1
NP	YES	YES	YES	NO	NO	NO	NO	NO	8
TOTAL									32
P	NO	NO	NO	NO	NO	NO	NO	YES	57
P	NO	NO	NO	NO	NO	NO	YES	NO	98
P	NO	NO	NO	NO	NO	YES	YES	NO	1
P	NO	NO	NO	NO	NO	YES	NO	NO	1
P	NO	NO	NO	NO	YES	NO	NO	NO	1
P	NO	NO	NO	YES	NO	NO	NO	NO	1
P	NO	NO	YES	NO	NO	NO	NO	NO	17
P	NO	NO	YES	NO	NO	NO	NO	YES	3
P	NO	YES	NO	NO	NO	NO	NO	NO	2
P	NO	YES	YES	NO	NO	NO	NO	NO	7
P	NO	YES	YES	NO	NO	NO	NO	YES	6
P	NO	YES	YES	NO	NO	NO	YES	NO	1
P	YES	NO	NO	NO	NO	NO	NO	NO	2
P	YES	NO	NO	NO	NO	NO	NO	YES	8
P	YES	NO	YES	NO	NO	NO	NO	NO	5
P	YES	NO	YES	NO	NO	NO	NO	YES	2
P	YES	YES	NO	NO	NO	NO	NO	NO	5
P	YES	YES	NO	NO	NO	NO	NO	YES	5
P	YES	YES	NO	NO	NO	NO	YES	NO	1
P	YES	YES	YES	NO	NO	NO	NO	NO	38
P	YES	YES	YES	NO	NO	NO	NO	YES	21
TOTAL									282

Exhibit C-11
Billing Analysis Sample Used
Post-Censoring
Indoor Lighting End-Use Technologies

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	46	20	2	47	8	10	15	13	5	3	12	2	183
Incandescent to Fluorescent	5	0	0	3	0	1	0	1	0	0	1	0	11
Efficient Ballast	5	7	1	4	4	0	1	0	1	0	1	0	24
T8 Lamps and Electronic Ballasts	109	53	2	95	29	13	25	6	16	8	22	6	384
Optical Reflectors w/ Fluor. Delamp	60	24	2	26	12	10	8	1	5	5	4	2	159
High Intensity Discharge	3	5	1	10	0	0	0	1	10	4	2	5	41
Halogen	8	3	1	7	1	2	1	1	1	0	5	1	31
Exit Signs	29	10	1	22	2	5	4	0	2	1	5	1	82
Controls	14	1	0	25	0	1	3	2	2	1	4	4	57
Retrofit Express Total	123	61	3	99	40	22	27	16	20	13	30	10	464
Customized Incentives Program													
Compact Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Standard Fluorescent	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High Intensity Discharge	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Halogen	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Exit Signs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Controls	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Other	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Total	5	0	0	0	9	0	0	0	1	0	0	0	15
Total	123	61	3	99	40	22	27	16	20	13	30	10	464

Exhibit C-12
Billing Analysis Sample Used
Post-Censoring
HVAC End-Use Technologies

Program and Technology Group	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	75	26	-	24	4	10	20	3	8	4	19	5	198
Variable Speed Drive HVAC Fan	12	10	-	2	-	-	-	-	-	-	-	1	25
Package Terminal A/C	2	-	-	7	-	2	-	13	-	-	-	-	24
Programmable Thermostat	36	10	-	13	-	6	7	2	2	2	10	1	89
Reflective Window Film	34	9	-	3	3	2	7	3	3	2	8	2	76
Water Chiller	-	1	-	1	-	-	-	-	-	-	2	-	4
Other RE Measures	-	1	-	-	1	1	-	-	-	-	-	-	3
Retrofit Express Total	131	45	-	41	8	17	27	19	11	7	30	7	343
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	1	-	-	-	-	-	-	-	-	1
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	1	-	-	-	-	-	-	-	-	1
Retrofit Efficiency Options Total	-	-	-	1	-	-	-	-	-	-	-	-	1
Customized Incentives Program													
HVAC Variable Speed Drive	1	-	-	-	1	-	-	-	-	-	-	-	2
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	4	-	-	14	1	-	-	-	1	-	-	-	20
Other CI Measures	2	-	1	1	-	-	-	-	1	-	-	-	5
Customized Incentives Total	7	-	1	15	2	-	-	-	1	-	-	-	26
Total	138	45	1	55	10	17	27	19	12	7	30	7	368

Exhibit C-13
Billing Analysis Sample Used
Post-Censoring
Refrigeration End-Use Technologies

Program and Technology	Business Type												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Refrigeration Load Reduction													
Low Temperature Glass/Acrylic Door	-	-	-	-	-	-	-	-	-	-	-	-	-
Heatless Door	-	-	-	-	2	-	-	-	-	-	-	-	2
Cooler/Freezer Door Gaskets	-	1	-	-	11	3	-	-	-	1	-	-	16
Auto Closer for Cooler/Freezer	-	1	-	-	2	1	-	1	-	1	-	-	6
Medium Temperature Case w/ Door	-	-	-	-	6	1	-	-	-	-	-	-	7
Strip Curtains for Walk-in	1	1	-	-	7	5	-	-	1	-	1	-	16
Low Temperature Case w/ Door	-	-	-	-	3	1	-	-	-	-	-	-	4
Night Covers for Display Cases	-	1	-	-	21	1	-	-	-	-	-	-	23
Compressor Upgrades													
Mechanical Subcooler	-	-	-	-	1	-	-	-	-	-	-	-	1
Multiplex Comprssor System	-	-	-	-	1	-	-	-	-	-	-	-	1
Adjustable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Floating Head Pressure Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Condenser Upgrades													
Oversized Air-Cooled Condenser	-	-	-	-	1	-	-	-	-	-	-	-	1
Oversized Evaporative Condenser	-	-	-	-	-	-	-	-	-	-	-	-	-
Evaporator Upgrades													
Walk-in Cooler PSC Evaporator Motor	-	-	-	-	1	-	-	-	-	-	-	-	1
Display PSC Evaporator Motor	-	-	-	-	2	-	-	-	-	-	-	-	2
Other													
Anti-Sweat Heater Control	-	-	-	-	1	-	-	-	-	-	-	-	1
Suction Line Insulation	1	-	-	-	1	-	-	-	-	-	-	-	2
Display Case Electronic Ballast	-	1	-	-	4	-	-	-	-	-	-	-	5
Non-Electric Condensate Evaporator	3	3	1	2	11	87	-	1	1	3	9	-	121
Retrofit Express Total	4	7	1	2	56	94	-	1	2	4	10	-	181
Customized Incentives Program													
Compressor Upgrades													
Floating Head Pressure Controls	-	-	-	-	-	-	-	-	-	-	-	-	-
Booster Desuperheaters	-	-	-	-	-	-	-	-	-	-	-	-	-
Condenser Upgrades													
Oversized Condensers	-	-	-	-	-	-	-	-	-	-	-	-	-
Other													
Refrigeration EMS	-	-	-	-	2	-	-	-	-	-	-	-	2
Refrigeration Add/Change	1	-	-	-	-	-	-	-	-	-	-	-	1
Refrigeration Other	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Total	1	-	-	-	2	-	-	-	-	-	-	-	3
Total	5	7	1	2	57	94	-	1	2	4	10	-	183

Exhibit C-14
Billing Analysis Sample Used
Post-Censoring
Nonparticipants

	Business Type												
Program and Technology Group	**Office**	**Retail**	**College/ University**	**School**	**Grocery**	**Restaurant**	**Health Care**	**Hotel/Motel**	**Warehouse**	**Personal Service**	**Community Service**	**Misc.**	**Total**
Total	74	124	1	26	185	34	27	15	53	6	31	44	620

C.6 MODEL SPECIFICATION

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

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

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

C.6.1 Baseline Model

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

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

Where

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

ΔCDD_i and ΔHDD_i are the annual change of cooling and heating degree days (base 65°F) between the post-installation year and pre-installation year;

$Elec_i$ is an indicator variable (0/1) for the ith customer, which equals 1 if the customer has electric heating;

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

α_j is the indicator variable (0/1) for the jth business type, which equals 1 if the customer is in that business type and 0 otherwise;

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

ε is the random error term of the model.

For each customer in the analysis dataset, a post-installation predicted usage value is calculated using the parameters of the baseline models estimated for the 1994 to 1996 analysis period. They both take the same functional form with different segment-level intercept series (α_j) and slopes (β, γ and ϕ):

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

Exhibit C-15 summarizes the final baseline model results that were estimated using 620 customers, as discussed in the *Data Censoring* section. Exhibit C-15 summaries the independent variables used in the baseline model, together with the t-statistics and the sample sizes available for each parameter estimate used to predict the post-period usage. The final functional relation is estimated as follows:

Baseline Model (1994 to 1996):

$$\begin{aligned} k\hat{W}h_{96,i} = & -40834 * OFF\_LG + 1349 * OFF\_SM - 19849 * RET\_LG - 120 * RET\_SM \\ & +942 * SCHOOLS + 5378 * GROCERY + 8461 * SUPERMKT + 4756 * REST \\ & +10964 * HEALTH + 2403 * HOTEL + 4167 * WAREHOUS + 675 * PERSONAL \\ & +4795 * COMMUN + 37895 * MISCBT \\ & +1.13 * OFF\_LG4 + 0.91 * OFF\_SM4 + 0.99 * RET\_LG4 + 1.00 * RET\_SM4 \\ & +1.00 * SCHOOLS4 + 0.98 * GROCERY4 + 0.98 * SUPERMKT4 + 0.99 * REST4 \\ & +0.99 * COLLEGE4 + 0.94 * HEALTH4 + 1.02 * HOTEL4 + 1.04 * WAREHOUS4 \\ & +0.94 * PERSONAL4 + 0.95 * COMMUN4 + 0.95 * MISCBT4 \\ & +0.0000456 * CDD_{96-94,i} * kWh_{94,i} + 0.0000324 * HDD_{96-94,i} * kWh_{94,i} \end{aligned}$$

Exhibit C-15
Billing Regression Analysis Final Baseline Model Outputs

Parameter Descriptions	Analysis Variable Name	Units	Parameter Estimate	t-Statistic	Sample Size
Intercepts					
Large Office	OFF_LG	(0,1)	-40834	0.99	19
Small Office	OFF_SM	(0,1)	1349	0.07	55
Large Retail	RET_LG	(0,1)	19849	0.44	22
Small Retail	RET_SM	(0,1)	-121	0.01	102
Schools	SCHOOLS	(0,1)	942	0.04	26
Grocery	GROCERY	(0,1)	5378	0.33	127
Supermarket	SUPERMKT	(0,1)	8461	0.30	58
Restaruant	REST	(0,1)	4756	0.19	34
College/University	COLLEGE	(0,1)	0	-	1
Health Care	HEALTH	(0,1)	10964	0.50	27
Hotel/Motel	HOTEL	(0,1)	2403	0.07	15
Warehouse	WAREHOUS	(0,1)	4167	0.19	53
Personal Service	PERSONAL	(0,1)	675	0.01	6
Community Service	COMMUN	(0,1)	4795	0.25	31
Miscellaneous	MISCBT	(0,1)	37895	1.95	44
Pre Usage					
Large Office	OFF_LG4	kWh	1.13	27.16	19
Small Office	OFF_SM4	kWh	0.91	7.39	55
Large Retail	RET_LG4	kWh	0.99	26.44	22
Small Retail	RET_SM4	kWh	1.00	9.48	102
Schools	SCHOOLS4	kWh	1.00	33.42	26
Grocery	GROCERY4	kWh	0.98	8.90	127
Supermarket	SUPERMKT4	kWh	0.98	38.46	58
Restaruant	REST4	kWh	0.99	10.94	34
College/University	COLLEGE4	kWh	0.99	3.36	1
Health Care	HEALTH4	kWh	0.94	28.61	27
Hotel/Motel	HOTEL4	kWh	1.02	9.50	15
Warehouse	WAREHOUS4	kWh	1.04	53.01	53
Personal Service	PERSONAL4	kWh	0.94	4.37	6
Community Service	COMMUN4	kWh	0.95	25.30	31
Miscellaneous	MISCBT4	kWh	0.95	35.82	44
Weather Variables					
Change in HDD	HDD9694	HDD*kWh	0.0000324	1.06	620
Change in CDD	CDD9694	CDD*kWh	0.0000456	0.78	620

C.6.2 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:

$$kWh_{96,i} - F_{94}(kWh_{94}, \Delta CDD \ \Delta HDD) = \sum_m \beta'_m Eng_m + \sum_k \eta'_k Chg_{i,k} + \mu_i$$

The difference between predicted and actual usage in 1996 was used as the dependent variable in a SAE model. Based upon the estimated participation month, the pro-rated engineering estimates and change variables were used to explain the deviation of the actual usage from the predicted usage. As discussed above, the predicted usage is estimated using only the comparison group to forecast the 1996 usage as a function of 1994 usage and change of cooling and heating degree days from 1994 to 1996. This usage prediction presents what would have happened in the absence of the program.

C.7 BILLING REGRESSION ANALYSIS RESULTS

The coefficients of the engineering impact, termed the SAE coefficients, are used to calculate the ex post gross energy impacts. Independent realization rates are estimated to provide PG&E with business type- and technology group-level results. Exhibit C-16 summarizes the final SAE model results that were estimated using 935 participants, as discussed in the *Data Censoring* section. Exhibit C-16 summaries the independent variables used in the SAE model, together with the t-statistics and the sample sizes available for each parameter estimate.

Exhibit C-16
Billing Regression Analysis Final Model Outputs

Parameter Descriptions	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients				
Lighting End Use				
Office Flourescents	kWh	-1.00	14.67	116
Other Flourescents	kWh	-0.68	7.41	261
Controls	kWh	-1.38	2.09	57
Warehouse HIDs	kWh	0.02	0.07	10
School HIDS	kWh	0.11	0.30	10
Other RE Lighting	kWh	-1.26	2.15	119
Custom Lighting	kWh	-0.51	3.07	15
HVAC End Use				
Central A/Cs	kWh	-2.07	3.67	184
ASDs	kWh	-1.90	6.75	27
Chillers	kWh	-1.58	2.39	5
EMS	kWh	-1.03	8.38	20
Other Custom HVAC	kWh	-0.65	4.76	5
Office Thermostats	kWh	0.05	1.06	36
Other RE/REO HVAC	kWh	-0.90	2.89	153
Refrigeration				
Custom Refrigeration	kWh	-0.75	2.00	3
RE/REO Refrigeration	kWh	-0.53	1.98	181
Other End Uses	kWh			
Other	kWh	-1.71	2.90	62
Change Variables	kWh			
Cooling System Replacement	(0,1)*kWh	-0.03	0.70	10
Lighting System Replacement	(0,1)*kWh	-0.08	4.17	48
Change in Employees	(±1,0)*kWh	0.01	0.64	57
Square Foot Change	± sqft	4.42	2.37	27
Heating System Replacement	(0,1)*kWh	-0.07	0.04	4
Other Equipment Change	(0,1)*kWh	0.03	1.17	42
Remove Equipment	(0,1)*kWh	0.08	0.64	2
Refrigeration Replacement	(0,1)*kWh	0.00	0.01	3
Add Equipement	(0,1)*kWh	0.11	0.49	11
Other Additions	(0,1)*kWh	0.14	12.41	375

The dependent variable is the difference between the actual and predicted 1996 usage using the 1994 baseline model.

SAE coefficients are calculated for 16 different combinations of business type and measure. Primarily those measures that have broad participation and relatively high expected impacts were supported by separate SAE coefficients. In addition, a separate SAE coefficient was calculated for other Commercial Program measures outside Lighting, HVAC, and Refrigeration.

Attempts were made to estimate the SAE coefficients at a finer level of segmentation, but generally either one of two problems were encountered. First, available sample sizes were too small to support a finer level of segmentation. Second, certain parameters were correlated with each other and needed to be combined into a single parameter (a standard econometric solution to solving the problem of colinearity). For example, it was determined that there was a high incidence of compact and standard fluorescent installations at the same site in office buildings. Therefore, there was enough correlation between the compact and fluorescent engineering estimates to warrant combining the two estimates into a single fluorescent estimate in the model.

All but three of the SAE coefficients are significant at the 95 percent confidence level (t-statistics greater than 1.96). In addition, all of the statistically significant SAE coefficients were the correct sign, and therefore were used in the calculation of the final ex post energy calculations. The three SAE coefficients that were not significant at the 95 percent confidence interval (HIDs in warehouses and schools, and thermostats in offices) were not used in the final ex post energy calculations. Because each of the insignificant SAE coefficients were also the wrong sign, they were set to zero. Therefore, no energy impacts are being claimed for these three segments.

All the of the HVAC technologies are represented in the SAE billing analysis, except for REO Variable Frequency Drives (VFD), REO CAV to VAV, and Customized Incentive Chillers, as shown in Exhibit C-12. Although these measures represent only ten percent of the energy impact, an approach needed to be developed for adjusting the engineering energy impact estimate for these measures.

The REO VFD measure is very similar to those installed under the RE and Customized Incentive programs, and the engineering estimate is calculated using the same approach. Therefore, engineering energy impact estimate for the REO VFD measure was adjusted by the SAE coefficient estimated for the RE and Customized Incentive measures.

Three approaches were considered for adjusting the engineering energy impact estimate for the REO CAV to VAV measure: (1) applying the Other RE HVAC SAE coefficient, (2) applying the Other Custom HVAC SAE coefficient, or (3) leaving the engineering estimate unadjusted. Because the REO CAV to VAV measure is usually installed in large businesses, typical of those installing Customized Incentive measures, the Other Custom HVAC SAE coefficient was used to adjust the engineering energy impact estimate for the REO CAV to VAV measure. This is also the most conservative approach since the SAE coefficient is only 0.65.

The engineering energy impact for Chillers was estimated differently for Customized Incentive applications than for RE and REO applications, due to the different types of businesses that install these measures. Therefore, the engineering energy impact estimate for Customized Incentive Chillers was left unadjusted, which is conservative compared to the alternative approach of applying the 1.58 SAE coefficient estimated for the RE and REO applications.

The SAE coefficient of 0.65 for Other Custom HVAC measures is based on a sample size of only five sites, compared to the 43 unique sites that installed "Other" Customized Incentive HVAC measures in 1995. In addition, these five sites represent only seven percent of the total ex ante energy impact contributed by these 43 sites. Also, one third of the customers installing "Other" Customized Incentive HVAC measures have usage over 3 million kWh per year, which are not represented in the SAE analysis.

The larger customers (usage over 3 million kWh per year), however, are very well represented in the on-site audit sample, for which calibrated engineering energy impacts were estimated. Sixteen sites, which represent 53 percent of the total ex ante energy impact, were on-site audited, one of which was included in the SAE billing analysis. The ratio of the engineering energy impact estimate to the ex ante estimate is 0.79 for the on-site audit sample. This can be directly compared to the SAE coefficient, because ex ante estimates were used as the engineering energy impact estimates for the billing analysis, as mentioned above.

Three approaches were considered for estimating the ex post gross energy impact for the "Other" Customized Incentive HVAC measures:

- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population.

- The 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate from the on-site audit sample could be applied to the ex ante estimate of gross energy impact for the population.

- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population that is most similar to the SAE sample, and the 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate could be applied to the population most similar to the on-site audit sample.

The approach of applying the SAE coefficient to the ex ante estimate of gross energy impact for the population, which is the most conservative method, was chosen for two reasons. First, the SAE coefficient provides a statistically adjusted result that is significant at the 95 percent confidence level. Second, the 0.79 ratio based on the on-site audit is very sensitive to a few individual on-site results. For example, the ratio of the engineering to ex ante estimate is 1.51 for the site with the largest energy impact. If the engineering estimate was set equal to the ex ante estimate for this customer, the overall ratio for all on-sites would be 0.64. Conversely, if the site with the second largest energy impact, which has a ratio of 0.41, had an engineering estimate set equal to the ex ant estimate, the overall ratio would be 0.95.

The SAE coefficient of 0.75 for Customized Incentive Refrigeration measures is based on a sample size of only three sites, compared to the 53 unique sites that installed Customized Incentive Refrigeration measures in 1995. Adjusting the engineering estimates of energy impact by 0.75 for all Customized Incentive measures should be considered conservative because it is likely that a sample size of three may not be representative of the population. An alternative approach would be to adjust only those measures that are similar to the three represented in the billing analysis, and leave the remaining measures unadjusted. It was found that the ratio of the engineering energy to the ex ante gross energy estimate was 98 percent over all 53 unique sites, and 94 percent for the three sites used in the SAE analysis. Because the ratio for the SAE sample is similar to the population's ratio and because the SAE coefficient was statistically significant at the 95 percent confidence level, the conservative approach of adjusting all Customized Incentive Refrigeration measures by 0.75 was chosen.

Impact estimates from the MDSS for other end uses were included in the model for customers that installed measures outside the Lighting, HVAC, and Refrigeration end uses. Although this result is statistically significant and the correct sign, it is not recommended that this value be used because the sample may not be representative of the population of participants installing these measures.

The majority of the change variables that were included in the model were not statistically significant at the 95 percent confidence level. Most of the parameter estimates are the correct sign, and those that are not have very low t-statistics. All but one variable, was determined solely on telephone survey responses. The change variable termed "other additions" was determined by comparing the predicted estimate of post-installation usage, based on the baseline model, to the actual post-installation usage. If the predicted usage is less than the actual post-installation usage, it is likely that some change occurred at the premise that would cause the usage to increase. An analysis of these customers revealed that two thirds of them indicated through the telephone survey that some change did occur at the premise. However, almost half of these customers did not provide a date for when the change occurred. Therefore, the "other additions" variable was created in an attempt to capture other changes that would cause usage to increase, which were not explained by the other independent variables in the model.

The final SAE coefficients for the Lighting, HVAC, and Refrigeration end uses are provided in Exhibits C-17 through C-19, respectively. The SAE coefficients are multiplied by the evaluation estimates of gross energy impact to calculate the gross ex post energy impacts.

Exhibit C-17
Commercial Indoor Lighting Gross Energy Impact SAE Coefficients By Business Type and Technology Group

Business Type / Program and Technology Group	SAE Coefficients												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Compact Fluorescent	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
Incandescent to Fluorescent	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
Efficient Ballast	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
T8 Lamps and Electronic Ballasts	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
Optical Reflectors w/ Fluor. Delamp	1.00	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	
High Intensity Discharge	1.26	1.26	1.26	0.00	1.26	1.26	1.26	1.26	0.00	1.26	1.26	1.26	
Halogen	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	
Exit Signs	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	
Controls	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	1.38	
Retrofit Express Total													
Customized Incentives Program													
Compact Fluorescent	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Standard Fluorescent	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
High Intensity Discharge	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Halogen	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Exit Signs	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Controls	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Other	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	
Customized Incentives Total													
Total													

Exhibit C-18
Commercial HVAC Gross Energy Impact SAE Coefficients
By Business Type and Technology Group

Business Type / Program and Technology Group	SAE Coefficients												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	2.069	
Variable Speed Drive HVAC Fan	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	
Package Terminal A/C	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Programmable Thermostat	0.000	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Reflective Window Film	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Water Chiller	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	
Other Measures	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Retrofit Express Total													
Retrofit Efficiency Options Program													
Variable Frequency Drive	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	
Water Chiller	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	1.582	
CAV to VAV	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	
Cooling Tower	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	0.898	
Retrofit Efficiency Options Total													
Customized Incentives Program													
HVAC Variable Speed Drive	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	1.901	
High Efficiency Chiller	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	
Energy Management System	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	1.026	
Other Measures	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	0.653	
Customized Incentives Total													
Total													

Exhibit C-19
Commercial Refrigeration Gross Energy Impact SAE Coefficients By Business Type and Technology Group

Business Type / Program and Technology	SAE Coefficients												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Refrigeration Load Reduction													
Low Temperature Glass/Acrylic Door	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Heatless Door	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Cooler/Freezer Door Gaskets	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Auto Closer for Cooler/Freezer	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Medium Temperature Case w/ Door	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Strip Curtains for Walk-in	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Low Temperature Case w/ Door	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Night Covers for Display Cases	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Compressor Upgrades													
Mechanical Subcooler	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Multiplex Comprssor System	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Adjustable Speed Drive	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Floating Head Pressure Controls	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Condenser Upgrades													
Oversized Air-Cooled Condenser	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Oversized Evaporative Condenser	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Evaporator Upgrades													
Walk-in Cooler PSC Evaporator Motor	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Display PSC Evaporator Motor	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Other													
Anti-Sweat Heater Control	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Suction Line Insulation	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Display Case Electronic Ballast	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Non-Electric Condensate Evaporator	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	0.526	
Retrofit Express Total													
Customized Incentives Program													
Compressor Upgrades													
Floating Head Pressure Controls	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Booster Desuperheaters	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Condenser Upgrades													
Oversized Condensers	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Other													
Refrigeration EMS	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Refrigeration Add/Change	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Refrigeration Other	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	0.753	
Customized Incentives Total													
Total													

C.7.1 Relative Precision Calculation

Relative precision at 90 percent and 80 percent confidence levels for the adjusted gross energy impact estimates are calculated for each of the SAE analysis segments. As mentioned above, there are a total of sixteen analysis segments that were explicitly modeled, and the relative precision estimates based upon the model output are presented in Exhibit C-20 below. In order to calculate the total program level adjusted gross impact and relative precision, the segment-level results were weighted by their unadjusted engineering energy impact estimates in the following equations.

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

Where β_i and Eng_i are the SAE coefficients and unadjusted engineering impact estimates for segment i, respectively. The program level standard error can be estimated as:[2]

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

Where CVi = (std(βi)/βi) is the coefficient of variation in segment i, estimated in the billing regression model. Finally, the relative precision at 90 percent and 80 percent confidence levels were calculated as

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

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

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

Exhibit C-20
Relative Precision Calculation

SAE Analysis Level	Engineering Gross Energy Impact Estimate (MWh)	SAE Coefficient	t-Statistic	Relative Precision at 80%	Relative Precision at 90%
Lighting End Use					
Office Flourescents	51,455	1.00	14.67	9%	11%
Other Flourescents	76,591	0.68	7.41	17%	22%
Controls	5,318	1.38	2.09	61%	79%
Warehouse HIDs	4,306	0.00	-	-	-
School HIDS	815	0.00	-	-	-
Other RE Lighting	17,534	1.26	2.15	60%	77%
Customized Incentives Lighting	10,242	0.51	3.07	42%	54%
Total	166,261	0.83		13%	16%
HVAC End Use					
Central A/Cs	878	2.07	3.67	35%	45%
ASDs	8,971	1.90	6.75	19%	24%
Chillers	2,966	1.58	2.39	54%	69%
EMS	10,290	1.03	8.38	15%	20%
Other Customized Incentives HVAC	18,668	0.65	4.76	27%	35%
Office Thermostats	1,332	0.00	-	-	-
Other RE/REO HVAC	6,087	0.90	2.89	44%	57%
Total	49,192	1.03		12%	15%
Refrigeration					
Customized Incentives Refrigeration	18,206	0.75	2.00	64%	82%
RE/REO Refrigeration	8,566	0.53	1.98	65%	83%
Total	26,772	0.68		51%	65%

C.8 NET BILLING ANALYSIS

In addition to conducting a billing analysis to estimate gross energy impacts, a net billing analysis was performed, with the objective of estimating SAE coefficients that could be applied to gross engineering estimates to calculate net energy impact. The net billing analysis model specification differs from the gross billing analysis model, which used two different multivariate regression models (a baseline model using a control group and an SAE model using participants). Instead, the net billing analysis model runs one integrated model combining both the participants and nonparticipants.

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

One solution to this problem is to include an Inverse Mills Ratio in the model to correct for self-selection. This method was developed by Heckman (1976, 1979[3]) and is used by others (Goldberg and Train, 1996[4]) to address the problem of self-selection into energy retrofit programs. The Mills Ratio technique assumes that the unobserved factors that are influencing participation are distributed normally. The influence of these unobserved factors on participation can be approximated by a Mills Ratio which itself is distributed normally. Using the Mills Ratio corrects for the self-selection bias in the net savings regression as the unobserved factors affecting participation are now controlled for in the model. As a result, standard regression techniques should produce unbiased coefficient estimates.

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

To correct for self-selection, a probit model of program participation is estimated separately for each of the Lighting, HVAC, and Refrigeration retrofit programs. Upon estimation, the parameters of the participation model are then used to calculate an Inverse Mills Ratio for both participants and nonparticipants. This Mills Ratio is then included in the net savings regression that combines both participants and nonparticipants. If the Mills Ratio controls for those unobserved factors that determine participation, and the other model assumptions are met,. then the net savings model can then be estimated as if participation in the program is randomly determined.

Using the Inverse Mills Ratio to correct for selection relies on several assumptions. First, the net savings due to the program, whether expressed as naturally occurring savings or a net-to-gross ratio, must be normally distributed. In addition, the Mills Ratio must not be highly correlated with the other independent variables used in the net billing regression. In this application, both of these assumptions are found to be violated. Net savings due to the program is biased upward toward large customers and is not distributed normally. The Mills Ratio term used in the net savings regression is also found to be highly correlated with other independent variables, which introduces multi-collinearity into the model. As a result of these violations, the regression analysis using the Mills Ratio technique does not yield reliable estimates in this application. A description of the methods used for this application are given in the following sections. *Section C.8.1* describes the data and variables used for the probit participation model and *Section C.8.2* gives the estimation results. *Section C.8.3* describes how the Inverse Mills Ratio is used in the Net Billing Model and *Section C.8.4* gives the estimation results from the Net Billing Model.

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

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

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

C.8.1 Probit Model of Participation

The first stage of calculating the Mills Ratio is to develop a probit model of program participation. The probit model is a discrete choice model with a dependent variable of either zero or one reflecting whether or not an event occurred. In this case, individuals received a value of one if they participated in the retrofit program and a zero otherwise. The sample includes all 1,217 participants and 652 nonparticipants, and includes information obtained from the telephone surveys as well as billing data. All of these 1,869 survey respondents were used to estimate the participation probit for each program. Of the 1,869, 614 are participants in the Lighting program, 487 are participants in the HVAC program, and 241 are participants in the Refrigeration program. For those customers with missing information, an average value is assigned based on both building type and program participation.

For each of the three retrofit programs, the participation model specification is the same:

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

A description of the explanatory variables is given in Exhibit C-21. The dependent variable PARTICIPATION has a value of one if the customer participated in the 1995 Retrofit program and a zero if they did not participate. The independent variables used are those characteristics that are likely to influence program participation. The first set of variables (X) used in the participation probit describe the customer's business activity. These consist of indicator variables for various building types. The second group of variables (Y) reflect the building characteristics. These include customer size and energy use as well as recent changes in high energy equipment. The third group of variables (Z) contain information on participation in other PG&E programs. Finally, the error term (ε) is assumed to be normally distributed for the probit specification.

Exhibit C-21
Explanatory Variables Description

Variable Name	Units	Variable Type	Description
ADDLIGHT	0,1	Y	Customer added light equipment since 1/93
AVGUSE	Kwh	Y	Average monthly electricity use over 1992-1994
ADDCOOL	0,1	Y	Customer added cooling equipment since 1/93
ADDREF	0,1	Y	Customer added refrigeration equipment since 1/93
ARCOOL	0,1	Y	Cooling equipment was added and removed since 1/93
ARLIGHT	0,1	Y	Lighting equipment was added and removed since 1/93
ARREF	0,1	Y	Refrigeration equipment was added and removed since 1/93
CCHGPGE	0,1	Y	Cooling change was part of a PG&E program
LCHGPGE	0,1	Y	Lighting change was part of a PG&E program
COLLEGE	0,1	X	College
COMMSERV	0,1	X	Community service building
GROCERY	0,1	X	Grocery
HEALTH	0,1	X	Health Care Building
HOTEL	0,1	X	Hotel
MISCCOM	0,1	X	Miscellanious commercial building
OFFICE	0,1	X	Office building
PERSONAL	0,1	X	Personal service building
RESTRNT	0,1	X	Restaurant
SCHOOL	0,1	X	School
RETAIL	0,1	X	Retail Building
WAREHSE	0,1	X	Warehouse
MEDCUST	0,1	Y	Medium sized customer, based on electricty use
LARGCUST	0,1	Y	Large sized customer, based on electricity use
LIGHT95	0,1	Y	Lighting change done in 1995 or later
COOL95	0,1	Y	Cooling change done in 1995 or later
HEAT95	0,1	Y	Heating change done in 1995 or later
OTHER95	0,1	Y	Other equipment change done in 1995 or later
GASHEAT	0,1	Y	Customer has gas heating
ELECHEAT	0,1	Y	Customer has electric heating
DUALHEAT	0,1	Y	Customer has dual heating
HAWARE	0,1	Z	Customer is an HVAC part and became aware of the PG&E program either before or at the same time the new equipment was selected
LAWARE	0,1	Z	Customer is an lighting part and became aware of the PG&E program either before or at the same time the new equipment was selected

C.8.2 Probit Estimation Results

The results of the probit estimation for each program are given in Exhibits C-22, C-23, and C-24.

Exhibit C-22
Lighting Program Probit Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
ADDLIGHT	-0.21	0.17	22%
AVGUSE	0.00	0.00	1%
ADDCOOL	0.02	0.17	91%
ADDREF	-0.25	0.26	34%
ARCOOL	0.08	0.15	58%
ARLIGHT	-1.02	0.17	1%
ARREF	-0.34	0.27	22%
CCHGPGE	0.47	0.28	10%
LCHGPGE	-0.13	0.20	51%
COLLEGE	-0.36	0.31	24%
COMMSERV	-0.10	0.14	50%
GROCERY	-1.51	0.13	10%
HEALTH	-0.65	0.17	16%
HOTEL	-0.29	0.21	1%
MISCCOM	-1.17	0.15	8%
OFFICE	-0.22	0.12	2%
PERSONAL	-0.45	0.20	1%
RESTRNT	-1.17	0.14	1%
SCHOOL	-0.52	0.13	1%
RETAIL	-0.66	0.13	2%
WAREHSE	-0.39	0.17	2%
MEDCUST	0.41	0.08	1%
LARGCUST	0.58	0.10	1%
LIGHT95	-0.11	0.24	66%
COOL95	0.10	0.27	70%
HEAT95	0.34	0.27	21%
OTHER95	-0.36	0.25	14%
GASHEAT	0.18	0.10	6%
ELECHEAT	-0.06	0.11	60%
DUALHEAT	0.14	0.29	63%
HAWARE	-0.65	0.09	1%

Exhibit C-23
HVAC Program Probit Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
ADDLIGHT	0.13	0.24	59%
AVGUSE	0.00	0.00	3%
ADDCOOL	-0.33	0.26	20%
ADDREF	-0.09	0.46	84%
ARCOOL	-0.71	0.26	1%
ARLIGHT	0.07	0.20	73%
ARREF	-0.30	0.53	58%
CCHGPGE	1.33	0.44	1%
LCHGPGE	0.56	0.24	2%
COLLEGE	-1.12	0.48	2%
COMMSERV	-0.50	0.23	3%
GROCERY	-2.16	0.24	1%
HEALTH	-0.37	0.24	11%
HOTEL	-0.39	0.3	19%
MISCCOM	-1.74	0.26	1%
OFFICE	-0.24	0.19	20%
PERSONAL	-0.70	0.29	2%
RESTRNT	-1.43	0.22	1%
SCHOOL	-0.70	0.20	1%
RETAIL	-1.07	0.21	1%
WAREHSE	-0.81	0.26	1%
MEDCUST	-0.13	0.12	25%
LARGCUST	-0.11	0.15	46%
LIGHT95	0.31	0.28	26%
COOL95	-0.63	0.55	25%
HEAT95	-0.26	0.44	56%
OTHER95	-0.11	0.36	75%
GASHEAT	0.62	0.16	1%
ELECHEAT	0.40	0.18	3%
DUALHEAT	0.33	0.43	45%
LAWARE	-0.79	0.12	1%

Exhibit C-24
Refrigeration Program Probit Estimation Results

Variable Name	Coefficient Estimate	Standard Error	Significance Level
ADDLIGHT	-0.08	0.32	80%
AVGUSE	0.00	0.00	62%
ADDCOOL	-0.06	0.33	86%
ADDREF	-0.16	0.27	56%
ARCOOL	-0.51	0.34	13%
ARLIGHT	-0.29	0.26	27%
ARREF	0.44	0.24	7%
CCHGPGE	0.66	0.62	29%
LCHGPGE	0.39	0.30	20%
COLLEGE	-0.66	0.60	23%
COMMSERV	-1.52	0.42	1%
GROCERY	-0.38	0.14	1%
HEALTH	-6.56	0.83	99%
HOTEL	-1.00	0.44	2%
MISCCOM	-1.00	0.23	1%
OFFICE	-1.09	0.24	1%
PERSONAL	-1.81	0.67	1%
RESTRNT	0.80	0.16	1%
SCHOOL	-0.85	0.23	1%
RETAIL	-0.90	0.21	1%
WAREHSE	-0.50	0.27	7%
MEDCUST	-0.33	0.14	2%
LARGCUST	-0.35	0.15	2%
LIGHT95	0.77	0.30	1%
COOL95	0.81	0.40	4%
HEAT95	0.21	0.41	60%
OTHER95	-0.32	0.52	54%
GASHEAT	-0.28	0.13	4%
ELECHEAT	-0.33	0.16	4%
DUALHEAT	0.16	0.46	73%
LAWARE	-0.86	0.21	1%
HAWARE	-1.48	0.36	1%

In general, the estimation results conform to expectations. For the Lighting probit, customer size as reflected by energy use has a positive impact on program participation. In addition, those customers with gas heating and with a recent cooling equipment change are also more likely to participate. All of the building type variables have negative coefficient estimates, which reflects the fact that each building type has more nonparticipants than participants included in the sample. Finally, recent additions and removals in lighting equipment as well as changes in HVAC equipment have a negative effect on program participation.

For the HVAC probit, large customers based on average monthly electricity use tend to participate in the program. Recent changes in lighting and cooling due to PG&E programs also have a positive impact on program participation. As with the lighting model, all of the building types have negative coefficient estimates.

For the Refrigeration model, smaller customers tend to participate more relative to the medium- and large-sized customers. In addition, restaurants are more likely to participate in the program while other business types are less likely to participate. Recent changes in cooling and lighting equipment also tend to increase participation.

Upon estimation, the coefficient estimates are used to calculate the Inverse Mills Ratio for use in the net savings regression. The product of all of the independent variables and respective coefficient estimates are used in the following calculation

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

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

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

where ϕ is the standard normal probability density function and Φ is the standard normal cumulative density function. Again, this Mills Ratio is used as a measure of the influence that unobserved factors have on program participation. In the following sections, the Mills Ratio is included in the net billing regression as an additional explanatory variable to correct for the problem of self-selection into the Lighting program.

C.8.3 Net Billing Model

The net billing regression analysis for the Commercial Program Evaluation uses a model specification similar to the baseline model used in the gross billing analysis, with three significant differences.

- Both participants and nonparticipants are used in the model.
- The engineering impact estimates are included as independent variables in the model. For nonparticipants, these values are all zero.
- The Mills Ratio is entered into the model in two ways. First, the three Mills Ratios, corresponding to each end use, are included as independent variables. Second, the three Mills Ratios are interacted with the total engineering impact estimate for each corresponding end use.

The resulting SAE coefficients on the energy impacts are then used to adjust the engineering estimates of expected annual energy impacts for the entire participant population to estimate the net ex post energy impacts. The net billing analysis model has the following functional form:

$$kWh_{post,i} = \sum_j(\alpha_j + \beta_j kWh_{pre,i}) + \gamma(\Delta CDD_i) * kWh_{pre,i} + \phi(\Delta HDD_i) * Elec_i * kWh_{pre,i} + \sum_k \eta_k Chg_{i,k}$$
$$+\sum_m(\rho_m Eng_{m,i}) + \delta_1 Mills_{light,i} + \delta_2 Mills_{HVAC,i} + \delta_3 Mills_{refrig,i} + \delta_4 Mills_{light,i} * Eng_{light,i} + \delta_5 Mills_{HVAC,i} Eng_{HVAC,i}$$
$$+\delta_6 Mills_{refrig,i} Eng_{refrig,i} + \varepsilon$$

Where

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

ΔCDD_i and ΔHDD_i are the annual change of cooling and heating degree days (base 65°F) between the post-installation year and pre-installation year;

$Elec_i$ is an indicator variable (0/1) for the ith customer, which equals 1 if the customer has electric heating;

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

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

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

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

$Mills_{refrig,i}$ is the Mills Ratio for the Refrigeration end use for customer I;

$Eng_{light,i}$ is the engineering estimate for all Lighting technologies for customer i;

$Eng_{HVAC,i}$ is the engineering estimate for all HVAC technologies for customer i;

$Eng_{refrig,i}$ is the engineering estimate for all Refrigeration technologies for customer i;

α_j is the indicator variable (0/1) for the jth business type, which equals 1 if the customer is in that business type and 0 otherwise;

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

ρ_m are the SAE coefficients for the engineering impact estimates for technology m;

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

ε is the random error term of the model.

This model was run with the same set of 620 nonparticipants and 935 participants that were used in the gross billing analysis model. The results of the model are presented below. The parameter estimates, t-statistics and sample sizes are presented for all of the SAE coefficients and Mills ratios.

Exhibit C-25
Net Billing Regression Analysis Final Model Outputs

Parameter Descriptions	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients				
Lighting End Use				
Office Flourescents	kWh	-0.35	0.75	116
Other Flourescents	kWh	-0.70	1.40	261
Controls	kWh	-0.60	0.83	57
Warehouse HIDs	kWh	0.08	0.14	10
School HIDS	kWh	0.13	0.23	10
Other RE Lighting	kWh	-0.05	0.07	119
Customized Incentives Lighting	kWh	-0.47	0.92	15
HVAC End Use				
Central A/Cs	kWh	-3.64	3.41	184
ASDs	kWh	-2.53	2.40	27
Chillers	kWh	-1.85	1.76	5
EMS	kWh	-2.20	3.17	20
Other Customized Incentives HVAC	kWh	-1.31	1.60	5
Office Thermostats	kWh	-0.83	0.85	36
Other RE/REO HVAC	kWh	-1.70	1.75	153
Refrigeration				
Customized Incentives Refrigeration	kWh	5.78	2.08	3
RE/REO Refrigeration	kWh	4.72	2.02	181
Other End Uses	kWh			
Other	kWh	-2.18	3.94	62
Mills Ratios				
Single Mills				
Lighting	unitless	-3083	1.18	1555
HVAC	unitless	2980	1.08	1555
Refrigeration	unitless	4051	1.00	1555
Double Mills, Interacted with Impact				
Lighting	kWh	0.07	0.33	464
HVAC	kWh	0.54	1.56	368
Refrigeration	kWh	-1.92	2.21	183

It was found that there was a significant problem of multi-collinearity with the net billing model. The double Mills ratios (the Mills ratio interacted with the engineering energy impacts) were found to be extremely highly correlated with the corresponding engineering energy impacts. Exhibit C-26 below presents the correlation of estimates between the double Mills and the engineering energy impacts.

Exhibit C-26
Correlation Between Double Mills Ratios and Energy Impact Estimates

Parameter Descriptions	Double Mills Ratios		
	Lighting	HVAC	Refrigeration
Engineering Energy Impact Estimates			
Lighting End Use			
Office Flourescents	-0.99	-0.06	-0.014
Other Flourescents	-0.98	-0.11	-0.0132
Controls	-0.50	-0.04	-0.0121
Warehouse HIDs	-0.91	-0.07	-0.0137
School HIDS	-0.78	-0.06	-0.0109
Other RE Lighting	-0.65	-0.09	-0.01
Customized Incentives Lighting	-0.95	-0.06	-0.0061
HVAC End Use			
Central A/Cs	-0.06	-0.85	-0.0035
ASDs	-0.12	-0.96	-0.008
Chillers	-0.05	-0.81	-0.004
EMS	-0.08	-0.98	-0.008
Other Customized Incentives HVAC	-0.10	-0.99	-0.0075
Office Thermostats	-0.05	-0.87	-0.0054
Other RE/REO HVAC	-0.09	-0.95	-0.0066
Refrigeration			
Customized Incentives Refrigeration	-0.01	0.00	-0.9916
RE/REO Refrigeration	-0.01	-0.01	-0.9936
Other End Uses			
Other	0.07	-0.02	-0.003

As a result of the multi-collinearity problem, the majority of the SAE coefficients in the net billing model are insignificant at the 95 percent confidence level. In addition, the high correlation between the double Mills Ratios and the engineering impact estimates results in relatively meaningless parameter estimates. For example, because the HVAC double Mills Ratio is 99 percent negatively correlated with the "other Custom HVAC" energy impact estimate, the SAE coefficient on the energy impact will tend to become more negative as the parameter estimate on the Mills Ratio becomes more positive. Therefore, because of the positive parameter estimate of 0.54 on the HVAC double Mills Ratio, we see the SAE coefficient on the "other Custom HVAC" energy impact being driven down to a value of -1.31 (from -.65 in the gross billing analysis). This would indicate a net ex post impact estimate that is twice as large as the gross ex post impact estimate. Conversely, the negative parameter on the Refrigeration double Mills Ratio is causing the SAE coefficient on the refrigeration energy impacts to become positive.

A number of alternative model specifications were implemented, however all suffered from the problem of multi-collinearity. Therefore, the results of the net billing analysis were not incorporated into the final net ex post energy impact estimates. *Appendix D* discusses the results of the net to gross analysis that was conducted to estimate the final net ex post energy impact estimates.

Appendix D
Net-to-Gross Analysis

D. NET-TO-GROSS METHOD

In this appendix, the methods used to derive net-to-gross (NTG) results for the evaluation of PG&E's 1995 Nonresidential Energy Efficiency Incentives (EEI) Programs, Commercial Sector Technologies is presented. After a brief review of data sources in *Section D.1*, the approaches to estimating free-ridership and spillover from participant self-reports are described in *Sections D.2 and D.3*, respectively. Finally, investigation into the use of more sophisticated discrete choice modeling techniques to estimate HVAC program net effects is discussed in *Section D.4*.

D.1 DATA SOURCES

Data used in the NTG analysis include 487 telephone surveys from HVAC end use participants surveyed from April through August 1996, and 451 HVAC end use nonparticipants surveyed from June through August 1996. Other data used in the analysis include 156 telephone surveys from canvass nonparticipants and 634 canvass nonparticipants who were "thanked and terminated" because they had not made an equipment retrofit or installation. The canvass nonparticipants were surveyed from June through July 1996.

D.2 SELF-REPORT-BASED ESTIMATES OF FREE-RIDERSHIP

The RE/REO/Customized Incentives participants surveyed installed or adopted the following technology groups. (Participants who installed multiple technologies may be included in more than one technology group.)

Technology Group	N
Central Air Conditioner	244
Adjustable Speed Drive	32
HVAC Controls	119
Package Terminal	26
Reflective Window Film	97
Water Chillers	10
Other	11
Custom	58

Because free-ridership often varies by technology, results were calculated for each technology group. However, caution should be employed in interpreting the analysis results, given the small group sizes for some technology groups.

D.2.1 Methods for Scoring Free-Ridership

Multiple methods were used in scoring free-ridership. The methods used vary slightly from each other and elaborate on the technique described in the work plan. All of them use participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. The complete text of the participant surveys may be found in *Appendix S-1*.

Six methods were used in this analysis. Each is described below.

Method 1 is the method described in the work plan. If the customer indicated that he had not been shopping for new HVAC equipment before becoming aware of the program, he was scored initially as a net participant. A customers was then classified as a free-rider if he met the following two conditions: (1) stated that he would have installed high-efficiency equipment within the year and had already selected the equipment; and (2) stated that he would have purchased high-efficiency equipment if the program had not existed.

To be classified as a free-rider under *Method 2*; a customer must have: (1) stated that he became aware of the program *after* making an equipment selection; (2) stated that he had already decided to purchase high-efficiency equipment before becoming aware of the program; and (3) stated that he would have purchased high-efficiency equipment if the program had not existed. As a consistency check, if a customer indicated that he would not have replaced the equipment (an unprompted response), free-ridership was scored as "0" for the site. This method generates high NTG ratios because of the final condition that must be met in order to be scored as a free-rider. Most customers reported that they would not have replaced equipment and hence were scored as net participants.

With *Method 3*, if the customer stated that he would have purchased high-efficiency equipment if the program had not existed, he was scored as a free-rider. Additional questions were used to "override" this preliminary assignment. If he answered that he hadn't considered purchasing new equipment before becoming aware of the program or hadn't yet decided on equipment, then the site was rescored as a net participant. If the customer indicated that he had not been shopping but had been approached by a vendor/contractor, then free-ridership was set at "0." As a last check, information volunteered by customers was used to revert the customer back to free-ridership status, if appropriate.

Method 4 is identical to Method 3 except deferred free-riders[1] are assigned a NTG ratio value of "0.5."

Method 5 is similar to the method described in the work plan except additional questions are used to validate results. If the customer indicated that he had not been shopping for new HVAC equipment before becoming aware of the program, then he is scored initially as a net participant. A customer was then classified as a free-rider if he met the two conditions stated in Method 1. If the customer stated that the most important factor in his decision to install the equipment was the rebate, free-ridership was set to "0." However, if, when asked why he hadn't installed the equipment prior to participating, the customer stated that he was planning to, the site was scored as a free-rider.

Method 6 is similar to Methods 1 and 5, except that customers citing information and referral services associated with the program as the most important factor in deciding to install the equipment were scored as net participants. An opportunity to revert to free-ridership status was also allowed with this method.

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[1] Deferred free-riders are those who were planning on installing energy-efficient equipment prior to becoming aware of the program but whose purchase was accelerated by the program.

D.2.2 Free-Ridership Results

NTG results weighted by avoided cost (AC) and calculated by subtracting the free-ridership rates obtained through each of the methods described above are presented in Exhibit D-1. Results are presented overall and by segment. Technologies classified as "other" include air handlers (2), cooling towers (3), evaporative condensers (5), and constant-to-variable air volume (1).

Exhibit D-1
NTG Weighted by Avoided Cost

	RE/REO Technology groups								
	Adjustable Speed Drive	HVAC Controls	Water Chiller	Central AC	Reflective Window Film	Package Terminal	Other	Custom	Overall
N	32	119	10	244	97	26	11	58	597
% Avoided Cost	12.37%	11.82%	9.37%	4.13%	3.07%	0.86%	15.02%	31.63%	88.27%
Method 1	0.897	0.807	0.700	0.835	0.699	0.943	0.876	0.854	0.843
Method 2	0.868	0.893	0.875	0.933	0.970	0.966	0.970	0.849	0.871
Method 3	0.793	0.872	0.855	0.758	0.968	0.623	0.769	0.899	0.876
Method 4	0.713	0.806	0.785	0.730	0.828	0.647	0.750	0.833	0.811
Method 5	0.823	0.794	0.700	0.769	0.694	0.943	0.876	0.840	0.825
Method 6	0.731	0.787	0.700	0.758	0.697	0.943	0.876	0.840	0.819

Overall, weighted NTG results range from a low of 0.811 for Method 4 to a high of 0.876 for Method 4. Results obtained using Method 1 (initially proposed in the workplan) were consistent with those from the other methods, and the Method 1 result of 0.843 overall NTG was used as the basis for subsequent adjustment for spillover.

D.3 SELF-REPORT-BASED ESTIMATES OF SPILLOVER

HVAC spillover can be defined as HVAC efficiency improvements implemented outside the program but influenced by the program. Preliminary estimates of HVAC spillover rates were generated by analyzing responses to a combination of questions asked of 487 participants and 1,241 nonparticipants.

D.3.1 Methods for Scoring Spillover

The integrated approach to estimating HVAC spillover is summarized below.

All surveyed respondents were asked if they had installed HVAC equipment outside the program since January 1993. Participants who answered "yes" to the first question were asked if these changes were made after participating in the program. Nonparticipants, and participants who said the changes were made after participation, were asked if they made the equipment changes through a PG&E program.

Participants who passed the first two screening questions and had not changed out HVAC equipment through a PG&E program, and nonparticipants who passed the first two screening questions and were aware of the program at the time of equipment purchase, were asked how influential the program was in their decision. Those who said that the program had influenced their decision2 were included in the preliminary estimate of program spillover.

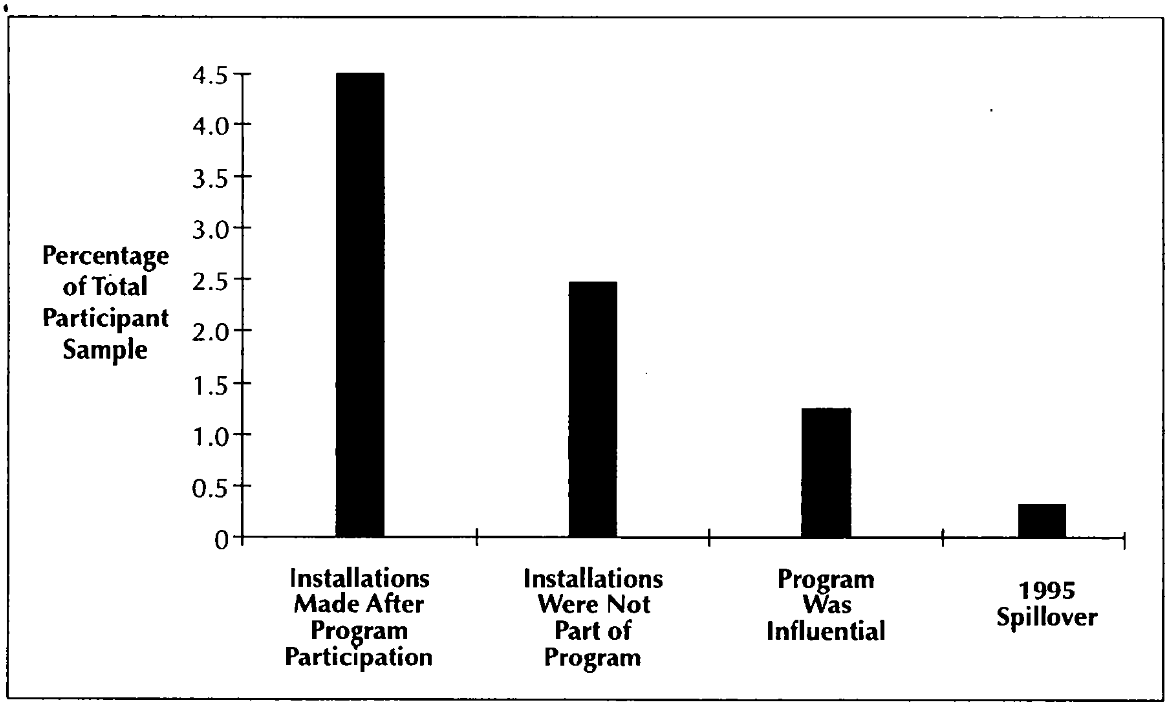
Survey-based estimates were be applied to the HVAC participant population and the HVAC nonparticipant population along with estimates of impact per site, resulting in a final spillover impact.

It should be noted that this analysis provides a preliminary indication of spillover rates and more in-depth analysis is required to quantify spillover impacts.

D.3.2 Spillover Result— Participants

Results of the sequential analysis of survey responses to estimate a participant spillover rate of 0.41 percent are illustrated in Exhibit D-2.

Exhibit D-2
HVAC Spillover Indicators
Program Participants



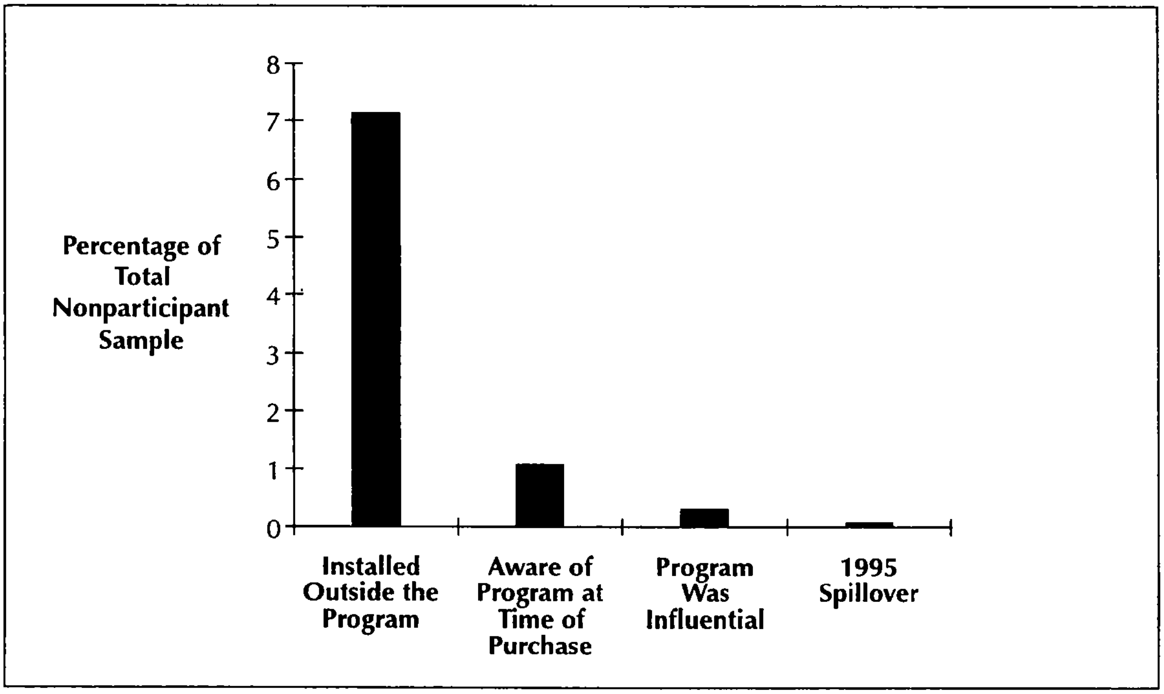
[2] "To what extent did participating in the program influence your additional equipment selection?" Values of 2, 3, 4, and 5 (slightly influential to very influential) were considered to demonstrate program influence on the purchase.

Forty-five surveyed participants (9 percent of the total participant sample) reported that since January 1993 they had added HVAC equipment. Forty-nine percent of those participants who added equipment (4.5 percent of the total participant sample) added the equipment after participating in the program. Twenty-seven percent (2 percent of the total participant sample) did not install the equipment through the program. Six of these respondents (1 percent of the total participant sample) reported the program influenced their additional HVAC equipment installations. Of these 6, 2 installed additional HVAC equipment in 1995. Two of 489 participants yields an initial unweighted spillover rate of 0.41 percent for 1995.

D.3.3 Spillover Results—Nonparticipants

Results of the sequential analysis of survey responses to estimate a nonparticipant spillover rate of 0.08 percent are illustrated in Exhibit D-3.

Exhibit D-3
HVAC Spillover Indicators
Program Nonparticipants



One hundred twenty-six of 1,241 program nonparticipants reported making HVAC changes outside the program, of which 88 respondents confirmed their installations were not done through the program. Thirteen respondents (1 percent of the total nonparticipant sample) reported they were aware of the program before they purchased the equipment. Of these 13, 3 respondents reported their knowledge of the program was influential on their equipment selection. One of these 3 respondents installed HVAC equipment in 1995. One of 1,241 nonparticipants yields an unweighted spillover estimate of 0.08 percent for 1995.

Because the levels of self-reported spillover are so low and based on such a small number of responses, it was decided not to apply a correction for either participant or nonparticipant spillover. One minus the self-reported rate of free-ridership (0.843) was therefore used as the self-reported NTG ratio for the HVAC program overall, with the corresponding measure-specific NTG ratios used for individual technologies.

In the following section, efforts to refine the self-reported NTG results through the use of discrete choice modeling are discussed.

D.4 OVERVIEW OF DISCRETE CHOICE METHOD

In this section, discrete choice modeling techniques are assessed for their practicality in estimating net-to-gross (NTG) ratios and free-ridership rates. This approach is similar to that used to evaluate high-efficiency equipment purchases in PG&E's 1995 Commercial Lighting Energy Efficiency Incentives (EEI) Program. In that analysis, the technology examined is high-efficiency fluorescent lighting, which comprises over 70 percent of the total energy impact of the Lighting program. Because fluorescent lighting is such a large portion of the Lighting program, detailed information was collected on lighting measures adopted both in and outside of the Lighting program. For the 1995 PG&E HVAC Commercial EEI Program (the HVAC program), the technologies that are best suited for discrete choice analysis are split and package units.[3] However, these measures account for less than 3 percent of the total energy impact due to the HVAC program. Information is available on the type of measures adopted outside the program, but not on whether these measures are standard or high-efficiency. This requires that assumptions be made regarding the efficiency of these measures in order to specify a model.

The approach adopted in this section is to explore different logit model specifications using a variety of assumptions regarding the technology adopted outside the program. These different models provide a range of possible NTG ratios based on whether customers outside the program purchase standard or high-efficiency HVAC equipment. The wide range of estimates across model specifications illustrates the sensitivity of these models to the accurate information regarding the efficiency characteristics of equipment purchased outside the program.

A discrete choice logit model is used to estimate both a NTG ratio and the free-ridership rate associated with the HVAC program. The decision to purchase high-efficiency equipment is explained in the logit model by the cost and savings of the equipment, any rebate offered by the HVAC program, awareness of the HVAC program, and other customer characteristics. In this application, the specific technologies examined are split and package HVAC units. Once estimated, the model can be used to determine the probability of purchasing high-efficiency equipment in the absence of the HVAC program. This is simulated by setting program awareness and the rebate amount equal to zero in the logit purchase model.

The data used to estimate the logit models of high-efficiency purchases is described in *Section D.4.1* and *Section D.4.2*. The logit model specification and variable definitions are given in *Section D.4.3*. The estimation results are discussed in *Section D.4.4* and the net-to-gross ratios are calculated in *Section D.4.5*.

D.4.1 Data Sources for the Net-to-Gross Analysis

The data used for the NTG analysis are a combination of telephone survey information and the program information contained in the MDSS dataset. The sample is divided into both a high-efficiency equipment purchase group and a group of customers that purchase HVAC equipment outside the HVAC program. The sample used to estimate the logit model contains information on

[3] There was not enough data available for purchases made outside of the HVAC program to estimate additional logit models for other HVAC technologies.

332 customers adopting 424 separate HVAC measures both in and outside the HVAC program. Of these, 255 customers did 338 separate measures within the HVAC program. The remaining 77 customers did 86 measures outside the program.

D.4.2 Estimating HVAC Equipment Economic Variables

For those customers that installed high-efficiency equipment within the HVAC program, the incremental cost, savings, and rebate data from the MDSS dataset is used in the model. For those customers who installed equipment outside of the HVAC program, the costs are determined by technology type to reflect the comparable technology inside the program. The costs and savings information for high-efficiency equipment is used as it most likely reflects what the customer evaluates when making the purchase decision. If a split system is installed outside the program, the incremental costs, savings, and rebate for the high-efficiency split system are assigned. Similarly, if a package unit is purchased outside the program, the cost, savings, and rebate are assigned for a high-efficiency HVAC unit under the program.[4]

D.4.3 Logit Purchase Model Specification

The logit model is a discrete choice model with a dependent variable of either zero or one. In this application, customers are given a value of one if they purchased high-efficiency HVAC equipment and a zero if they purchased standard efficiency HVAC equipment. The logit model specification is defined as:

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

The variable group X contains variables that capture the influence of the HVAC program such as awareness of the program and rebate amount. Building characteristics variables such as intercepts specific to energy use, and changes to high energy equipment are contained in Y. Variable group Z contains variables indicating building type. The error term ε is assumed to be distributed logistic consistent with the logit model specification.

Variable definitions are given in Exhibit D-4. The effect of the HVAC program on equipment purchases is reflected through PERREBATE and AWARE. PERREBATE is defined as the incremental cost of the measure minus the rebate divided by the incremental cost of the measure. This value reflects the fraction of incremental cost that is not covered by the rebate and has to be paid by the customer. AWARE is awareness of the HVAC program as reported in the telephone survey. If a customer indicates that they are unaware of the HVAC program, they are assigned a rebate amount of zero in the model.

[4] For HVAC measures done outside the HVAC program, capacity is assumed to be less than 65,000 Btuh. The smaller sizes are assumed since they comprise over 70 percent of the measures done in the program. In addition, measures adopted outside the program are likely to involve smaller rather than larger measures.

Exhibit D-4
Description of Variables Used in High-Efficiency Purchase Logit Model

Variable Name	Units	Variable Type	Description
USELEVEL1	constant	Y	Monthly electricity usage in the lowest 20 % range
USELEVEL2	constant	Y	Monthly electricity usage in the 20-40 percentile
USELEVEL3	constant	Y	Monthly electricity usage in the 40-60 percentile
USELEVEL4	constant	Y	Monthly electricity usage in the 60-80 percentile
USELEVEL5	constant	Y	Monthly electricity usage in the 80-100 percentile
PERREBATE	ratio	X	(cost -rebate)/ cost = % of costs not covered by rebate
AWARE	0,1	X	Aware of the HVAC program
ELECHEAT	0,1	Y	Customer has electric heat
ADDLIGHT	0,1	Y	Added lighting since 1/93
ARLIGHT	0,1	Y	Added and removed lighting since 1/93
ADDHEAT	0,1	Y	Added heating equipment since 1/93
ARHEAT	0,1	Y	Added and removed heating equipment since 1/93
OFFICE	0,1	Z	Office building
COMMSERV	0,1	Z	Community service building
GROCERY	0,1	Z	Grocery
HEALTH	0,1	Z	Health building
WAREHSE	0,1	Z	Warehouse
RESTRNT	0,1	Z	Restaurant
RETAIL	0,1	Z	Retail
MISSCOM	0,1	Z	Miscellaneous commercial

D.4.4 Logit Model Estimation Results

The models explored in this section are developed based on different assumptions regarding the efficiency of the equipment purchased outside the program. The first model assumes that all purchases made outside the program were for standard efficiency HVAC equipment. The second model assumes that for half those customers outside the HVAC program and that were aware of the program, high-efficiency equipment was purchased. Similarly, a third model assumes that half of those in the sample that were unaware of the HVAC program and purchased equipment outside of the program purchased high-efficiency equipment. The final model assumes that half of those outside the program, both unaware and aware, purchase high-efficiency equipment.

Likelihood ratio tests done for each of the four models show significant explanatory power for each model. As shown in Exhibit D-9, estimated probabilities of purchasing high-efficiency HVAC equipment are relatively high for program participants, which conforms to expectations. In addition, other measures of predictive power such as Somers' D and the Goodman-Kruskal Gamma test have values above 0.7, which also indicates good predictive power. The estimation results for each model are discussed below.

Model 1: Purchases outside the program are standard efficiency

The first model specification assumes that all purchases made outside the program are for standard efficiency HVAC equipment. Those that participated in the HVAC program are given a one for the dependent variable while those purchasing outside the program have a zero value.

The coefficient estimates are given in Exhibit D-5. The effect of the HVAC program is captured in PERREBATE, the net incremental cost paid by the customer for high-efficiency equipment.[5] As expected, the net cost ratio as expressed by PERREBATE has a strong negative effect on purchasing high-efficiency equipment. As the net cost increases, the likelihood of purchasing high-efficiency over standard equipment decreases. The effect of this variable is misleading, however, due to the assumption of standard efficiency purchases outside the HVAC program. If there are customers adopting high-efficiency measures outside the HVAC program, the Model 1 specification assigns too much importance to the rebate and the estimated effects of the program are inflated using this specification.

Exhibit D-5
Model 1: Standard Efficiency for Measures Outside HVAC Program
Logit Estimation Results

Variable	Coefficient Estimate	Standard Error	Significance Level
USELEVEL1	4.6	0.67	1%
USELEVEL2	4.6	0.66	1%
USELEVEL3	5.06	0.69	1%
USELEVEL4	4.49	0.66	1%
USELEVEL5	4.47	0.64	1%
PERREBATE	-5.73	0.62	1%
ELECHEAT	-0.05	0.47	92%
ADDLIGHT	0.01	0.62	99%
ARLIGHT	-0.27	0.49	58%
ADDHEAT	0.33	1.12	77%
ARHEAT	-0.17	0.57	77%
OFFICE	0.17	0.51	74%
COMMSERV	0.2	0.74	78%
GROCERY	-2.66	0.91	1%
HEALTH	-0.84	0.59	16%
WAREHSE	0.15	0.83	86%
RESTRNT	0.03	0.91	97%
RETAIL	-1.32	0.57	2%
MISSCOM	-0.53	0.88	55%

Model 2: Half of those outside the HVAC program and are aware of the program purchase high-efficiency equipment

Model 2 assumes that of those aware of the HVAC program and making purchases outside the program, half of the customers are purchasing high-efficiency equipment. This is simulated by randomly assigning those customers outside of the program and aware of the program a value of one for the dependent variable.

[5] For Model 1 and Model 2, an awareness variable is not included. This is due from these specifications having most of those aware customers purchasing high-efficiency equipment. As a result, awareness becomes an almost perfect predictor of high-efficiency purchases, which makes the model unestimatable.

The estimation results for Model 2 are given in Exhibit D-6. As with Model 1, the coefficient estimate on PERREBATE is negative and statistically significant. The larger magnitude of the estimate is due to the greater portion of the sample that is assumed to purchase high-efficiency equipment and are aware of the program relative to Model 1.

Exhibit D-6
Model 2: 50% of Those Outside and Aware of the Program Purchase High-Efficiency Equipment
Logit Estimation Results

Variable	Coefficient Estimate	Standard Error	Significance Level
USELEVEL1	6.1	0.93	1%
USELEVEL2	6.27	0.91	1%
USELEVEL3	6.66	0.9	1%
USELEVEL4	6.07	0.87	1%
USELEVEL5	6.08	0.87	1%
PERREBATE	-7.47	0.77	1%
ELECHEAT	0.35	0.64	59%
ADDLIGHT	0.43	0.85	61%
ARLIGHT	0.29	0.67	67%
ARHEAT	-0.17	0.77	83%
OFFICE	-0.51	0.65	44%
COMMSERV	-0.07	0.96	94%
GROCERY	-3.12	1.06	1%
HEALTH	-0.68	0.83	42%
WAREHSE	0.34	0.98	73%
RESTRNT	-0.47	1.15	68%
RETAIL	-1.23	0.78	12%
MISSCOM	-1.19	1.13	29%

Model 3: Half of those outside the HVAC program and are unaware of the program purchase high-efficiency equipment

In this specification, half of those customers that are unaware of the program are randomly assigned as purchasing high-efficiency equipment. These estimation results are given in exhibit D-7.

Model 3 has both AWARE and PERREBATE to reflect the influence of the HVAC program on high-efficiency equipment purchases. However, those that are unaware of the program are assumed to be purchasing high-efficiency equipment. As a result, the effect of both program awareness and rebate amount is diminished, since high-efficiency equipment is being purchased by those unaware of the program and are receiving no rebate. This is clearly evident in the coefficient estimate for PERREBATE, which is positive and statistically insignificant for this specification.

Exhibit D-7
Model 3: 50% of Those Outside and Unaware of the Program Purchase High-Efficiency Equipment Logit Estimation Results

Variable	Coefficient Estimate	Standard Error	Significance Level
USELEVEL1	-0.62	1.24	61%
USELEVEL2	-0.64	1.26	61%
USELEVEL3	-0.55	1.25	66%
USELEVEL4	-0.81	1.25	52%
USELEVEL5	-1.02	1.26	41%
PERREBATE	0.62	1.12	58%
AWARE	3.2	0.85	1%
ELECHEAT	-0.66	0.44	13%
ADDLIGHT	0.07	0.61	91%
ARLIGHT	-0.31	0.46	49%
ARHEAT	-0.34	0.52	52%
OFFICE	0.77	0.46	13%
COMMSERV	-0.02	0.66	97%
GROCERY	-2.18	0.84	1%
HEALTH	0.15	0.61	81%
WAREHSE	0.33	0.82	69%
RESTRNT	0.85	0.92	35%
RETAIL	-1.01	0.53	6%
MISSCOM	-0.62	0.74	41%

Model 4: Half of those outside the HVAC program, both aware and unaware, purchase high-efficiency equipment.

In this model, customers are randomly assigned as purchasing high-efficiency HVAC equipment, with no distinction made based on awareness of the HVAC program. The estimation results are similar to those from Model 3. AWARE is positive and significant and greater in magnitude than the estimate in Model 3, which reflects the greater number of those customers aware of the HVAC program assumed to be purchasing high-efficiency equipment. However, the estimate for PERREBATE is again positive and insignificant, giving the counterintuitive result that higher net incremental costs have a positive effect on high-efficiency equipment purchases.

Exhibit D-8
Model 4: 50% of Those Outside the Program
Both Aware and Unaware
Purchase High-Efficiency Equipment
Logit Estimation Results

Variable	Coefficient Estimate	Standard Error	Significance Level
USELEVEL1	2.77	2.39	25%
USELEVEL2	0.09	1.98	96%
USELEVEL3	-1.06	1.94	59%
USELEVEL4	0.11	1.93	95%
USELEVEL5	-1.49	1.96	45%
PERREBATE	0.82	1.8	65%
AWARE	4.59	1.32	1%
ELECHEAT	-0.36	0.7	61%
ADDLIGHT	0.35	0.92	70%
ARLIGHT	-0.67	0.6	27%
ARHEAT	-0.26	0.74	73%
OFFICE	-0.1	0.73	89%
COMMSERV	-0.21	1.07	85%
GROCERY	-3.14	1.02	1%
HEALTH	-1.24	0.81	13%
WAREHSE	-1.43	1	15%
RESTRNT	-0.53	1.06	62%
RETAIL	-1.22	0.78	12%
MISSCOM	-1.44	1.08	18%

The wide variety of parameter estimates across the four models illustrates how sensitive these models are to underlying assumptions. The consequences of the wide range of estimates is demonstrated through the estimated NTG ratios discussed in *Section D.4.6*.

Estimated Probabilities

The estimated model parameter can be used to calculate the probability of purchasing high-efficiency for each the four models. Probabilities are calculated with and in absence of the HVAC program. With the logit model, the probability of purchasing is given by:

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

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

The estimated probabilities for each model are given in Exhibit D-9.

Exhibit D-9
Estimated Probabilities of Purchasing High-Efficiency HVAC Equipment

		With Program	In Absence Of Program
Model 1	Program Participants	0.89	0.23
	Nonparticipants	0.43	0.19
Model 2	Program Participants	0.94	0.18
	Nonparticipants	0.33	0.16
Model 3	Program Participants	0.89	0.48
	Nonparticipants	0.62	0.37
Model 4	Program Participants	0.94	0.52
	Nonparticipants	0.5	0.31

As expected, HVAC program participants have a high probability of purchasing high-efficiency equipment. For program participants, estimated probabilities for purchasing high-efficiency range from 0.89 to 0.94. Similarly, those purchasing outside the program have a lower estimated probability of purchasing high-efficiency equipment, with estimates ranging from 0.33 to 0.62.

The probability of a high-efficiency equipment purchase in absence of the HVAC program is estimated by removing the effect of the HVAC program from the model. This is done by setting both the awareness variable and the rebate amount equal to zero. When the rebate is set to zero in PERREBATE, the customer is faced with paying the entire incremental cost of the high-efficiency measure. Using the new PERREBATE and AWARE values, the purchases probability is recalculated using the logistic density function given above. All other variable values remain the same as they are not expected to change in absence of the HVAC program.

The new probabilities of a high-efficiency purchase in absence of the HVAC program are also given in Exhibit D-9. In the absence of the HVAC program, the probability of purchasing high-efficiency equipment drops substantially. The new estimated probability of purchasing high-efficiency equipment in absence of the program ranges from 0.18 to 0.52 for those purchasing within HVAC program. For outside the HVAC program, the estimated probability of a high-efficiency purchase ranges from 0.16 to 0.37.

D.4.5 Net-To-Gross Ratio Calculations

The NTG ratio is calculated using the probability of purchasing high-efficiency equipment both with and without the existence of the HVAC program. The expected impact with the program is the probability of choosing high-efficiency equipment multiplied by the energy impact of the equipment. Similarly, the expected energy impact in absence of the HVAC program is the probability of purchasing high-efficiency equipment without the program multiplied by the energy impact of the equipment. The NTG ratio is the net savings due to the program divided by the expected energy that results from having the program. This method is also used to estimate free-ridership rates and nonparticipant spillover. As a comparison across models indicates, the estimated impact of the program is sensitive to the assumptions made regarding the efficiency of the equipment purchased outside the program.

For those that participated in the HVAC program, the expected energy savings is:

$$\text{EXPECTED IMPACT}_W^{HEIN} = P_W^{HEIN} * \text{IMPACT}$$

where P_W^{HEIN} = Probability of a high-efficiency purchase made by a program participant with the existence of the HVAC program

IMPACT = Energy impact of the high-efficiency equipment adopted

For those who purchase high-efficiency equipment outside the HVAC program, the expected savings is calculated in the same manner:

$$\text{EXPECTED IMPACT}_W^{HEOUT} = P_W^{HEOUT} * \text{IMPACT}$$

where P_W^{HEOUT} = Probability of a high-efficiency purchase for a customer outside of the program with the existence of the HVAC program

The calculations for expected energy impacts in the absence of the program follow the same format. For program participants and those purchasing HVAC equipment outside the program, the expected energy savings in absence of the program is given by:

$$\text{EXPECTED IMPACT}_{WO}^{HEIN} = P_{WO}^{HEIN} * \text{IMPACT}$$

$$\text{EXPECTED IMPACT}_{WO}^{HEOUT} = P_{WO}^{HEOUT} * \text{IMPACT}$$

where P_{WO}^{HEIN} = Probability of a high-efficiency purchase made by a program participant without the HVAC program

P_{WO}^{HEOUT} = Probability of a high-efficiency purchase for a customer outside of the program without the HVAC program

These calculations are made for each of the four models for both program participants and nonparticipants and the results are given in Exhibit D-10.

The expected impact for both groups of HVAC purchasers with and without the HVAC program is used to calculate the net energy savings due to the HVAC program as well as a NTG ratio. To calculate the NTG ratio, the net energy savings for each group is weighted up to the population. For program participants, the weight reflects the total energy impact by building type represented in the sample. For those that did high-efficiency outside the HVAC program but also participated in the HVAC program in some other fashion, the weight assigned is the same assigned to the program participants. If the customer purchased HVAC equipment outside the program and did not participate in the HVAC program in any way, the weight assigned reflects the number of similar customers in the nonparticipant population.

Exhibit D-10
Estimated Energy Impacts and Net-to-Gross Ratios

	Estimated Energy Impact			
	With Program (GWh)	In Absence Of Program (GWh)	Net Impact (GWh)	Net-to-Gross Ratio
Model 1				
HE Equipment Purchased Inside Program	1.30	0.32	0.98	0.76
HE Equipment Purchased Outside Program	0.00	0.00	NA	
Model 2				
HE Equipment Purchased Inside Program	1.37	0.25	1.12	2.88
HE Equipment Purchased Outside Program	3.64	0.81	2.83	
Model 3				
HE Equipment Purchased Inside Program	1.33	0.68	0.65	0.49
HE Equipment Purchased Outside Program	0.00	0.00	NA	
Model 4				
HE Equipment Purchased Inside Program	1.39	0.69	0.71	1.31
HE Equipment Purchased Outside Program	7.11	5.99	1.11	

To calculate the NTG ratio, the net savings is divided by the expected energy savings with the program. For Model 1 and Model 3, there is no estimated spillover from the HVAC program.[6] As a result, the NTG ratio is determined from the estimated impact of the program on program participants. For program participants the NTG ratio (NTG) is

$$NTG^{HEIN} = (EXPECTED\ IMPACT_{W}^{HEIN} - EXPECTED\ IMPACT_{WO}^{HEIN}) / EXPECTED\ IMPACT_{W}^{HEIN}$$

The NTG ratio is estimated for each model and the results are summarized in Exhibit D-7. For Model 1 where all purchases outside the program are assumed to be for standard efficiency equipment, the estimated NTG ratio for program participants is

$$(130.00 - 31.63) / 130.00$$

$$= 0.76$$

The level of free-ridership among program participants is one minus the NTG ratio, or 0.24. This means that 24 percent of the estimated program impact among participants would have been achieved without the HVAC program.

The NTG ratio is calculated in the same manner for Model 3 where half of those unaware of the program are assumed to purchase high efficiency equipment. For program participants in Model 3, the estimated NTG ratio is 0.49. This lower ratio results from the positive coefficient estimate on PERREBATE, which tends to diminish the effect of the HVAC program.

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[6] For Model 1, all measures done outside of the HVAC program are assumed to be standard efficiency. For Model 3, high efficiency measures done outside the program are assumed to be done by those unaware of the program. In either case, removing the HVAC program has no effect on those outside the program and results in zero spillover.

Model 2 and Model 4 include nonparticipant spillover that should be incorporated into the NTG ratio estimate. In these models, spillover occurs for that portion of the sample that is assumed to make high efficiency purchases outside of the HVAC program. These customers are assigned a weight reflecting the number of similar customers in the nonparticipant population and as a consequence, estimated spillover is high relative to the impact to program participants.

The NTG ratio calculation for Model 2 and Model 4 is given by

$$NTG = (NET\ IMPACT^{HEIN} + NET\ IMPACT^{HEOUT}) \ /\ EXPECTED\ IMPACT_{W}^{HEIN}$$

where
$$NET\ IMPACT^{HEIN} = EXPECTED\ IMPACT_{W}^{HEIN} - EXPECTED\ IMPACT_{WO}^{HEIN}$$
$$NET\ IMPACT^{HEOUT} = EXPECTED\ IMPACT_{W}^{HEOUT} - EXPECTED\ IMPACT_{WO}^{HEOUT}$$

The estimated NTG ratios incorporating nonparticipant spillover in Model 2 and Model 4 are also given in Exhibit D-7. Using the estimated impacts from Model 2, the NTG ratio including nonparticipant spillover is

$$NTG = (1.12 + 2.83) / 1.37 = 2.88$$

Similarly, the estimated nonparticipant spillover for Model 4 is also relatively high at 1.31.

These spillover estimates are unreliable due to the data limitations already discussed. Nevertheless, the high magnitude is indicative of the potential for a large nonparticipant spillover effect due to the HVAC program. This suggests that further study with more specific data is warranted.

Given the range of NTG estimates, it is possible to solve for the assumptions consistent with the self reported NTG ratio. Since the self reported NTG ratio is 0.84, Model 1 provides the closest estimate of with a NTG ratio of 0.76. This suggests that of the four model specifications, assuming purchases outside the HVAC program are for standard efficiency equipment is most consistent with the self reported information.

D.4.6 Summary

As an alternative to self-reported NTG results, several different logit models specifications for high-efficiency HVAC equipment purchases were explored. Different models were developed based on assumptions concerning HVAC equipment purchased outside the HVAC program. The estimation results illustrate the sensitivity of these models to assumptions made regarding the energy efficiency of HVAC equipment purchased outside the program. NTG ratio estimates range from 0.49 to 2.88 across the four models presented in this section. Accurate information regarding the energy efficiency of a large sample of equipment purchased outside the HVAC program, similar to the data collected for the Lighting program, is essential for developing a model that more accurately estimates the NTG ratio for the HVAC program.

Because the results of the discrete choice analysis did not provide a basis for modifying the NTG ratios calculated from survey data, the results of the self-reported NTG analysis were used in the evaluation to adjust gross impact results.

Appendix E
Results Tables

Commercial HVAC Ex Ante Gross Energy Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Energy Impacts (kWh)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	492,811	121,008	30,832	177,227	15,702	89,913	188,710	9,118	10,906	56,177	239,896	30,432	1,462,731
Variable Speed Drive HVAC Fan	1,165,644	1,982,649	324,599	22,590	26,355	-	33,885	22,590	37,650	737,940	-	30,120	4,384,022
Package Terminal A/C	8,478	1,462	4,474	50,099	-	16,810	37,077	140,648	451	-	4,572	-	264,071
Programmable Thermostat	1,817,833	330,586	4,093	888,845	24,558	126,883	143,255	16,372	209,846	114,916	425,135	148,440	4,250,762
Reflective Window Film	1,621,117	71,295	101,442	40,106	49,564	28,256	193,332	92,862	84,291	75,991	209,556	37,002	2,604,815
Water Chiller	10,212	16,800	-	20,750	-	-	52,402	-	-	-	7,292	-	107,456
Other RE Measures	103,228	-	-	354,235	55,811	30,231	131,625	147,000	-	21,000	116,292	-	959,422
Retrofit Express Total	5,219,323	2,523,799	465,441	1,553,852	171,990	292,093	780,286	428,589	343,144	1,006,024	1,002,745	245,994	14,033,280
Retrofit Efficiency Options Program													
Variable Frequency Drive	762,580	185,380	625,423	-	-	-	-	-	-	-	-	-	1,573,383
Water Chiller	903,243	517,676	-	-	-	-	550,464	-	-	-	232,560	-	2,203,943
CAV to VAV	2,654,240	-	-	-	-	-	-	-	-	-	-	-	2,654,240
Cooling Tower	26,455	44,520	-	-	-	-	185,846	-	-	-	-	-	256,821
Retrofit Efficiency Options Total	4,346,518	747,576	625,423	0	0	0	736,310	0	0	0	232,560	0	6,688,386
Customized Incentives Program													
HVAC Variable Speed Drive	1,012,569	-	-	-	1,237,948	-	359,734	187,963	-	-	536,740	-	3,334,954
High Efficiency Chiller	1,185,146	-	-	-	-	-	-	-	-	-	-	-	1,185,146
Energy Management System	2,440,817	-	1,195,981	3,677,546	727,266	-	1,910,025	587,031	11,382	83,936	-	-	10,633,984
Other Customized Incentives Measures	9,393,471	-	803,606	400,888	-	-	2,493,372	-	352,106	2,318,100	252,588	-	16,014,131
Customized Incentives Total	14,032,003	0	1,999,587	4,078,434	1,965,214	0	4,763,131	774,994	363,488	2,402,036	789,328	0	31,168,215
Total	23,597,844	3,271,375	3,090,451	5,632,286	2,137,204	292,093	6,279,727	1,203,583	706,632	3,408,060	2,024,633	245,994	51,889,884

Commercial HVAC Ex Ante Net Energy Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Energy Impacts (kWh)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	330,183	81,075	20,658	118,742	10,520	60,242	126,436	6,109	7,307	37,639	160,730	20,389	980,030
Variable Speed Drive HVAC Fan	780,981	1,328,374	217,482	15,135	17,658	-	22,703	15,135	25,225	494,420	-	20,180	2,937,294
Package Terminal A/C	5,680	979	2,998	33,567	-	11,262	24,842	94,234	302	-	3,063	-	176,928
Programmable Thermostat	1,217,948	221,493	2,742	595,526	16,454	85,012	95,981	10,969	140,597	76,994	284,840	99,455	2,848,009
Reflective Window Film	1,086,148	47,768	67,966	26,871	33,208	18,932	129,532	62,218	56,475	50,914	140,403	24,791	1,745,225
Water Chiller	6,842	11,256	-	13,902	-	-	35,109	-	-	-	4,886	-	71,995
Other RE Measures	69,224	-	-	237,337	37,393	20,255	88,189	98,490	-	14,070	77,916	-	642,874
Retrofit Express Total	3,497,006	1,690,945	311,846	1,041,080	115,233	195,702	522,791	287,155	229,907	674,036	671,839	164,816	9,402,355
Retrofit Efficiency Options Program													
Variable Frequency Drive	510,928	124,205	419,033	-	-	-	-	-	-	-	-	-	1,054,166
Water Chiller	605,173	346,843	-	-	-	-	368,810	-	-	-	155,815	-	1,476,641
CAV to VAV	1,778,340	-	-	-	-	-	-	-	-	-	-	-	1,778,340
Cooling Tower	17,725	29,828	-	-	-	-	124,517	-	-	-	-	-	172,070
Retrofit Efficiency Options Total	2,912,166	500,876	419,033	0	0	0	493,327	0	0	0	155,815	0	4,481,217
Customized Incentives Program													
HVAC Variable Speed Drive	759,427	-	-	-	928,461	-	269,801	140,972	-	-	402,555	-	2,501,216
High Efficiency Chiller	888,860	-	-	-	-	-	-	-	-	-	-	-	888,860
Energy Management System	1,830,613	-	896,986	2,758,160	545,450	-	1,432,519	440,273	8,537	62,952	-	-	7,975,490
Other Customized Incentives Measures	7,045,105	-	602,705	300,666	-	-	1,870,029	-	264,080	1,738,575	189,441	-	12,010,601
Customized Incentives Total	10,524,005	0	1,499,691	3,058,826	1,473,911	0	3,572,349	581,246	272,616	1,801,527	591,996	0	23,376,167
Total	16,933,177	2,191,821	2,230,569	4,099,906	1,589,144	195,702	4,588,468	868,400	502,523	2,475,564	1,419,650	164,816	37,259,739

Commercial HVAC Unadjusted Engineering Gross Energy Impacts By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Energy Impacts (kWh)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	254,050	136,003	19,785	90,645	26,794	78,603	61,902	7,769	24,139	43,173	116,657	18,432	877,953
Variable Speed Drive HVAC Fan	1,479,717	2,721,680	507,527	18,746	68,866	-	64,206	73,709	53,118	984,390	-	44,681	6,016,641
Package Terminal A/C	8,526	1,744	4,100	46,812	-	15,571	35,488	133,992	455	-	5,225	-	251,913
Programmable Thermostat	1,332,230	308,045	10,437	663,682	39,192	143,991	138,112	21,854	242,702	149,303	499,702	62,911	3,612,161
Reflective Window Film	1,706,804	75,063	112,236	42,226	52,184	29,750	203,551	97,770	88,747	80,007	210,713	38,958	2,738,008
Water Chiller	39,017	42,285	-	43,263	-	-	-	-	-	-	16,223	-	140,788
Other RE Measures	141,670	-	-	208,197	26,376	13,581	74,184	68,208	-	9,744	54,141	-	596,101
Retrofit Express Total	4,962,015	3,284,820	654,085	1,113,570	213,413	281,496	577,443	403,302	409,160	1,266,617	902,661	164,982	14,233,565
Retrofit Efficiency Options Program													
Variable Frequency Drive	214,730	52,110	260,026	-	-	-	-	-	-	-	-	-	526,865
Water Chiller	68,677	373,053	-	-	-	-	586,872	-	-	-	235,846	-	1,264,448
CAV to VAV	2,654,240	-	-	-	-	-	-	-	-	-	-	-	2,654,240
Cooling Tower	30,878	39,340	-	-	-	-	150,446	-	-	-	-	-	220,664
Retrofit Efficiency Options Total	2,968,524	464,503	260,026	0	0	0	737,318	0	0	0	235,846	0	4,666,217
Customized Incentives Program													
HVAC Variable Speed Drive	849,781	-	-	-	754,971	-	359,734	187,963	-	-	275,431	-	2,427,880
High Efficiency Chiller	1,560,525	-	-	-	-	-	-	-	-	-	-	-	1,560,525
Energy Management System	2,440,817	-	1,195,981	3,333,251	727,266	-	1,910,025	587,031	11,382	83,936	-	-	10,289,689
Other Customized Incentives Measures	9,393,471	-	803,606	400,888	-	-	2,493,372	-	352,106	2,318,100	252,588	-	16,014,131
Customized Incentives Total	14,244,594	0	1,999,587	3,734,139	1,482,238	0	4,763,131	774,994	363,488	2,402,036	528,019	0	30,292,226
Total	22,175,134	3,749,323	2,913,698	4,847,709	1,695,651	281,496	6,077,892	1,178,296	772,648	3,668,653	1,666,526	164,982	49,192,007

Commercial HVAC Gross Energy Impact SAE Energy Coefficients
By Business Type and Technology Group

Business Type / Program and Technology Group	SAE Coefficients												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	
Variable Speed Drive HVAC Fan	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
Package Terminal A/C	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Programmable Thermostat	0.00	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Reflective Window Film	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Water Chiller	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	
Other RE Measures	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Retrofit Express Total													
Retrofit Efficiency Options Program													
Variable Frequency Drive	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
Water Chiller	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	1.58	
CAV to VAV	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	
Cooling Tower	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	
Retrofit Efficiency Options Total													
Customized Incentives Program													
HVAC Variable Speed Drive	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	
High Efficiency Chiller	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Energy Management System	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	
Other Customized Incentives Measures	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	
Customized Incentives Total													
Total													

Commercial HVAC Ex Post Gross Energy Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Energy Impacts (kWh)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	525,642	281,396	40,936	187,548	55,439	162,633	128,079	16,074	49,946	89,327	241,370	38,137	1,816,527
Variable Speed Drive HVAC Fan	2,813,602	5,175,127	965,036	35,644	130,946	-	122,085	140,154	101,000	1,871,764	-	84,959	11,440,318
Package Terminal A/C	7,654	1,566	3,680	42,023	-	13,979	31,857	120,285	408	-	4,690	-	226,144
Programmable Thermostat	0	276,534	9,369	595,792	35,183	129,262	123,984	19,618	217,875	134,030	448,586	56,476	2,046,708
Reflective Window Film	1,532,208	67,385	100,755	37,906	46,846	26,707	182,729	87,769	79,668	71,823	189,158	34,973	2,457,926
Water Chiller	61,742	66,913	-	68,460	-	-	-	-	-	-	25,672	-	222,787
Other RE Measures	127,178	-	-	186,899	23,678	12,192	66,595	61,231	-	8,747	48,603	-	535,124
Retrofit Express Total	5,068,027	5,868,921	1,119,777	1,154,273	292,092	344,772	655,330	445,131	448,897	2,175,692	958,078	214,545	18,745,534
Retrofit Efficiency Options Program													
Variable Frequency Drive	408,297	99,084	494,425	-	-	-	-	-	-	-	-	-	1,001,806
Water Chiller	108,676	590,332	-	-	-	-	928,687	-	-	-	373,211	-	2,000,905
CAV to VAV	1,733,726	-	-	-	-	-	-	-	-	-	-	-	1,733,726
Cooling Tower	27,719	35,316	-	-	-	-	135,056	-	-	-	-	-	198,091
Retrofit Efficiency Options Total	2,278,418	724,732	494,425	0	0	0	1,063,743	0	0	0	373,211	0	4,934,528
Customized Incentives Program													
HVAC Variable Speed Drive	1,615,813	-	-	-	1,435,537	-	684,015	357,401	-	-	523,716	-	4,616,483
High Efficiency Chiller	1,560,525	-	-	-	-	-	-	-	-	-	-	-	1,560,525
Energy Management System	2,504,659	-	1,227,263	3,420,436	746,289	-	1,959,984	602,385	11,680	86,131	-	-	10,558,827
Other Customized Incentives Measures	6,135,731	-	524,908	261,856	-	-	1,628,648	-	229,992	1,514,162	164,988	-	10,460,286
Customized Incentives Total	11,816,728	0	1,752,171	3,682,292	2,181,826	0	4,272,647	959,787	241,672	1,600,293	688,704	0	27,196,121
Total	19,163,174	6,593,652	3,366,373	4,836,565	2,473,918	344,772	5,991,719	1,404,918	690,569	3,775,985	2,019,993	214,545	50,876,182

Commercial HVAC Net-to-Gross Adjustments
By Business Type and Technology Group

Business Type / Program and Technology Group	Net-to-Gross Adjustments												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	[redacted]
Variable Speed Drive HVAC Fan	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	[redacted]
Package Terminal A/C	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	[redacted]
Programmable Thermostat	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	[redacted]
Reflective Window Film	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	[redacted]
Water Chiller	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	[redacted]
Other RE Measures	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	[redacted]
Retrofit Express Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Retrofit Efficiency Options Program													[redacted]
Variable Frequency Drive	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	[redacted]
Water Chiller	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	[redacted]
CAV to VAV	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	[redacted]
Cooling Tower	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	[redacted]
Retrofit Efficiency Options Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Customized Incentives Program													[redacted]
HVAC Variable Speed Drive	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	[redacted]
High Efficiency Chiller	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	[redacted]
Energy Management System	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	[redacted]
Other Customized Incentives Measures	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	[redacted]
Customized Incentives Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Commercial HVAC Ex Post Net Energy Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Energy Impacts (kWh)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	438,911	234,966	34,182	156,603	46,292	135,798	106,946	13,422	41,705	74,588	201,544	31,844	1,516,800
Variable Speed Drive HVAC Fan	2,523,801	4,642,089	865,637	31,973	117,458	-	109,510	125,718	90,597	1,678,972	-	76,209	10,261,966
Package Terminal A/C	7,218	1,477	3,470	39,628	-	13,182	30,042	113,429	385	-	4,423	-	213,253
Programmable Thermostat	0	223,163	7,561	480,804	28,393	104,314	100,055	15,832	175,825	108,162	362,009	45,576	1,651,693
Reflective Window Film	1,071,013	47,102	70,428	26,496	32,745	18,668	127,727	61,351	55,688	50,204	132,221	24,446	1,718,090
Water Chiller	43,220	46,839	-	47,922	-	-	-	-	-	-	17,970	-	155,951
Other RE Measures	111,408	-	-	163,724	20,742	10,680	58,338	53,638	-	7,663	42,576	-	468,768
Retrofit Express Total	4,195,571	5,195,635	981,279	947,150	245,630	282,642	532,618	383,389	364,200	1,919,590	760,743	178,075	15,986,522
Retrofit Efficiency Options Program													
Variable Frequency Drive	357,668	86,798	433,116	-	-	-	-	-	-	-	-	-	877,582
Water Chiller	76,073	413,232	-	-	-	-	650,081	-	-	-	261,247	-	1,400,633
CAV to VAV	1,518,744	-	-	-	-	-	-	-	-	-	-	-	1,518,744
Cooling Tower	24,282	30,937	-	-	-	-	118,309	-	-	-	-	-	173,528
Retrofit Efficiency Options Total	1,976,768	530,966	433,116	0	0	0	768,390	0	0	0	261,247	0	3,970,487
Customized Incentives Program													
HVAC Variable Speed Drive	1,379,905	-	-	-	1,225,949	-	584,149	305,221	-	-	447,254	-	3,942,476
High Efficiency Chiller	1,332,688	-	-	-	-	-	-	-	-	-	-	-	1,332,688
Energy Management System	2,138,979	-	1,048,083	2,921,052	637,331	-	1,673,826	514,437	9,974	73,556	-	-	9,017,238
Other Customized Incentives Measures	5,239,914	-	448,272	223,625	-	-	1,390,866	-	196,414	1,293,094	140,900	-	8,933,084
Customized Incentives Total	10,091,486	0	1,496,354	3,144,677	1,863,279	0	3,648,840	819,658	206,388	1,366,651	588,154	0	23,225,487
Total	16,263,825	5,726,602	2,910,749	4,091,827	2,108,909	282,642	4,949,848	1,203,047	570,588	3,286,240	1,610,144	178,075	43,182,496

Commercial HVAC Gross Energy Realization Rates By Business Type and Technology Group

Business Type / Program and Technology Group	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
	Gross Energy Realization Rates												
Retrofit Express Program													
Central A/C	1.07	2.33	1.33	1.06	3.53	1.81	0.68	1.76	4.58	1.59	1.01	1.25	1.24
Variable Speed Drive HVAC Fan	2.41	2.61	2.97	1.58	4.97	-	3.60	6.20	2.68	2.54	-	2.82	2.61
Package Terminal A/C	0.90	1.07	0.82	0.84	-	0.83	0.86	0.86	0.90	-	1.03	-	0.86
Programmable Thermostat	0.00	0.84	2.29	0.67	1.43	1.02	0.87	1.20	1.04	1.17	1.06	0.38	0.48
Reflective Window Film	0.95	0.95	0.99	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.90	0.95	0.94
Water Chiller	6.05	3.98	-	3.30	-	-	-	-	-	-	3.52	-	2.07
Other RE Measures	1.23	-	-	0.53	0.42	0.40	0.51	0.42	-	0.42	0.42	-	0.56
Retrofit Express Total	0.97	2.33	2.41	0.74	1.70	1.18	0.84	1.04	1.31	2.16	0.96	0.87	1.34
Retrofit Efficiency Options Program													
Variable Frequency Drive	0.54	0.53	0.79	-	-	-	-	-	-	-	-	-	0.64
Water Chiller	0.12	1.14	-	-	-	-	1.69	-	-	-	1.60	-	0.91
CAV to VAV	0.65	-	-	-	-	-	-	-	-	-	-	-	0.65
Cooling Tower	1.05	0.79	-	-	-	-	0.73	-	-	-	-	-	0.77
Retrofit Efficiency Options Total	0.52	0.97	0.79	-	-	-	1.44	-	-	-	1.60	-	0.74
Customized Incentives Program													
HVAC Variable Speed Drive	1.60	-	-	-	1.16	-	1.90	1.90	-	-	0.98	-	1.38
High Efficiency Chiller	1.32	-	-	-	-	-	-	-	-	-	-	-	1.32
Energy Management System	1.03	-	1.03	0.93	1.03	-	1.03	1.03	1.03	1.03	-	-	0.99
Other Customized Incentives Measures	0.65	-	0.65	0.65	-	-	0.65	-	0.65	0.65	0.65	-	0.65
Customized Incentives Total	0.84	-	0.88	0.90	1.11	-	0.90	1.24	0.66	0.67	0.87	-	0.87
Total	0.81	2.02	1.09	0.86	1.16	1.18	0.95	1.17	0.98	1.11	1.00	0.87	0.98

Commercial HVAC Net Energy Realization Rates By Business Type and Technology Group

Business Type / Program and Technology Group	Net Energy Realization Rates												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	1.33	2.90	1.65	1.32	4.40	2.25	0.85	2.20	5.71	1.98	1.25	1.56	1.55
Variable Speed Drive HVAC Fan	3.23	3.49	3.98	2.11	6.65	-	4.82	8.31	3.59	3.40	-	3.78	3.49
Package Terminal A/C	1.27	1.51	1.16	1.18	-	1.17	1.21	1.20	1.27	-	1.44	-	1.21
Programmable Thermostat	0.00	1.01	2.76	0.81	1.73	1.23	1.04	1.44	1.25	1.40	1.27	0.46	0.58
Reflective Window Film	0.99	0.99	1.04	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.94	0.99	0.98
Water Chiller	6.32	4.16	-	3.45	-	-	-	-	-	-	3.68	-	2.17
Other RE Measures	1.61	-	-	0.69	0.55	0.53	0.66	0.54	-	0.54	0.55	-	0.73
Retrofit Express Total	1.20	3.07	3.15	0.91	2.13	1.44	1.02	1.34	1.58	2.85	1.13	1.08	1.70
Retrofit Efficiency Options Program													
Variable Frequency Drive	0.70	0.70	1.03	-	-	-	-	-	-	-	-	-	0.83
Water Chiller	0.13	1.19	-	-	-	-	1.76	-	-	-	1.68	-	0.95
CAV to VAV	0.85	-	-	-	-	-	-	-	-	-	-	-	0.85
Cooling Tower	1.37	1.04	-	-	-	-	0.95	-	-	-	-	-	1.01
Retrofit Efficiency Options Total	0.68	1.06	1.03	-	-	-	1.56	-	-	-	1.68	-	0.89
Customized Incentives Program													
HVAC Variable Speed Drive	1.82	-	-	-	1.32	-	2.17	2.17	-	-	1.11	-	1.58
High Efficiency Chiller	1.50	-	-	-	-	-	-	-	-	-	-	-	1.50
Energy Management System	1.17	-	1.17	1.06	1.17	-	1.17	1.17	1.17	1.17	-	-	1.13
Other Customized Incentives Measures	0.74	-	0.74	0.74	-	-	0.74	-	0.74	0.74	0.74	-	0.74
Customized Incentives Total	0.96	-	1.00	1.03	1.26	-	1.02	1.41	0.76	0.76	0.99	-	0.99
Total	0.96	2.61	1.30	1.00	1.33	1.44	1.08	1.39	1.14	1.33	1.13	1.08	1.16

Commercial HVAC Ex Ante Gross Demand Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Demand Impacts (kW)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	369	114	19	264	20	52	75	10	27	35	150	19	1,153
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	0
Package Terminal A/C	6	1	3	73	-	10	15	151	1	-	3	-	263
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	0
Reflective Window Film	695	31	43	17	21	12	83	40	36	33	90	16	1,116
Water Chiller	8	16	-	31	-	-	29	-	-	-	5	-	88
Other RE Measures	78	-	-	183	21	12	156	54	-	8	46	-	557
Retrofit Express Total	1,156	161	66	569	62	86	357	254	64	75	293	35	3,178
Retrofit Efficiency Options Program													
Variable Frequency Drive	15	4	4	-	-	-	-	-	-	-	-	-	23
Water Chiller	679	337	-	-	-	-	201	-	-	-	168	-	1,385
CAV to VAV	83	-	-	-	-	-	-	-	-	-	-	-	83
Cooling Tower	18	42	-	-	-	-	30	-	-	-	-	-	90
Retrofit Efficiency Options Total	796	382	4	0	0	0	231	0	0	0	168	0	1,581
Customized Incentives Program													
HVAC Variable Speed Drive	26	-	-	-	22	-	-	-	-	-	28	-	76
High Efficiency Chiller	468	-	-	-	-	-	-	-	-	-	-	-	468
Energy Management System	-	-	-	47	-	-	22	78	-	-	-	-	147
Other Customized Incentives Measures	1,397	-	-	79	-	-	26	-	110	115	-	-	1,727
Customized Incentives Total	1,891	0	0	126	22	0	48	78	110	115	28	0	2,417
Total	3,843	544	69	694	83	86	636	332	174	191	489	35	7,176

Commercial HVAC Ex Ante Net Demand Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Demand Impacts (kW)												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	247	76	13	177	13	35	50	7	18	24	100	13	773
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	4	1	2	49	-	7	10	101	1	-	2	-	176
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	465	20	29	12	14	8	56	27	24	22	60	11	748
Water Chiller	5	11	-	21	-	-	19	-	-	-	3	-	59
Other RE Measures	52	-	-	123	14	8	104	36	-	5	31	-	373
Retrofit Express Total	774	108	44	381	41	58	239	170	43	50	196	23	2,129
Retrofit Efficiency Options Program													
Variable Frequency Drive	10	2	3	-	-	-	-	-	-	-	-	-	15
Water Chiller	455	225	-	-	-	-	135	-	-	-	113	-	928
CAV to VAV	56	-	-	-	-	-	-	-	-	-	-	-	56
Cooling Tower	12	28	-	-	-	-	20	-	-	-	-	-	60
Retrofit Efficiency Options Total	533	256	3	0	0	0	155	0	0	0	113	0	1,059
Customized Incentives Program													
HVAC Variable Speed Drive	20	-	-	-	16	-	-	-	-	-	21	-	57
High Efficiency Chiller	351	-	-	-	-	-	-	-	-	-	-	-	351
Energy Management System	-	-	-	35	-	-	17	59	-	-	-	-	110
Other Customized Incentives Measures	1,048	-	-	59	-	-	20	-	82	86	-	-	1,295
Customized Incentives Total	1,418	0	0	94	16	0	36	59	82	86	21	0	1,813
Total	2,726	364	47	475	57	58	430	229	125	137	330	23	5,001

Commercial HVAC Ex Post Gross Demand Impacts
By Business Type and Technology Group

Business Type / **Program and Technology Group**	**Commercial HVAC First-Year Demand Impacts (kW)**												
	Office	**Retail**	**College/ University**	**School**	**Grocery**	**Restaurant**	**Health Care**	**Hotel/Motel**	**Warehouse**	**Personal Service**	**Community Service**	**Misc.**	**Total**
Retrofit Express Program													
Central A/C	398	121	19	79	21	55	83	9	28	38	146	19	1,016
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	0
Package Terminal A/C	7	2	2	22	-	10	17	147	1	-	3	-	212
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	0
Reflective Window Film	322	14	19	2	9	6	39	16	15	15	35	7	499
Water Chiller	34	27	-	4	-	-	-	-	-	-	8	-	73
Other RE Measures	131	-	-	27	9	7	76	18	-	3	17	-	288
Retrofit Express Total	893	163	40	134	39	78	214	190	44	56	210	25	2,088
Retrofit Efficiency Options Program	-	-	-	-	-	-	-	-	-	-	-	-	
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	0
Water Chiller	10	149	-	-	-	-	235	-	-	-	127	-	522
CAV to VAV	83	-	-	-	-	-	-	-	-	-	-	-	83
Cooling Tower	23	40	-	-	-	-	90	-	-	-	-	-	153
Retrofit Efficiency Options Total	116	189	0	0	0	0	325	0	0	0	127	0	758
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	0
High Efficiency Chiller	401	-	-	-	-	-	-	-	-	-	-	-	401
Energy Management System	-	-	-	-	-	-	-	-	-	-	-	-	0
Other Customized Incentives Measures	648	-	-	41	-	-	13	-	73	115	-	-	891
Customized Incentives Total	1,049	0	0	41	0	0	13	0	73	115	0	0	1,292
Total	2,059	353	40	175	39	78	553	190	118	171	337	25	4,138

Commercial HVAC Ex Post Net Demand Impacts
By Business Type and Technology Group

Business Type / **Program and Technology Group**	**Commercial HVAC First-Year Demand Impacts (kW)**												
	Office	**Retail**	**College/ University**	**School**	**Grocery**	**Restaurant**	**Health Care**	**Hotel/Motel**	**Warehouse**	**Personal Service**	**Community Service**	**Misc.**	**Total**
Retrofit Express Program													
Central A/C	332	101	16	66	17	46	69	8	23	32	122	15	848
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	0
Package Terminal A/C	7	1	2	21	-	10	16	138	1	-	3	-	200
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	0
Reflective Window Film	225	10	13	2	7	4	27	11	11	10	25	5	349
Water Chiller	24	19	-	3	-	-	-	-	-	-	6	-	51
Other RE Measures	115	-	-	23	8	7	66	15	-	3	15	-	252
Retrofit Express Total	704	131	31	115	32	66	178	173	35	45	170	20	1,700
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	0
Water Chiller	7	104	-	-	-	-	165	-	-	-	89	-	365
CAV to VAV	73	-	-	-	-	-	-	-	-	-	-	-	73
Cooling Tower	20	35	-	-	-	-	79	-	-	-	-	-	134
Retrofit Efficiency Options Total	100	140	0	0	0	0	243	0	0	0	89	0	572
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	0
High Efficiency Chiller	342	-	-	-	-	-	-	-	-	-	-	-	342
Energy Management System	-	-	-	-	-	-	-	-	-	-	-	-	0
Other Customized Incentives Measures	554	-	-	35	-	-	11	-	63	98	-	-	761
Customized Incentives Total	896	0	0	35	0	0	11	0	63	98	0	0	1,103
Total	1,700	271	31	150	32	66	433	173	98	143	259	20	3,376

Commercial HVAC Gross Demand Impact Realization Rates By Business Type and Technology Group

Business Type / Program and Technology Group	Gross Demand Realization Rates												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	1.08	1.06	1.00	0.30	1.06	1.06	1.11	0.97	1.02	1.08	0.97	0.97	0.88
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	1.16	1.11	0.89	0.31	-	1.06	1.13	0.97	1.07	-	1.10	-	0.81
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	0.46	0.45	0.43	0.13	0.45	0.46	0.47	0.41	0.43	0.46	0.39	0.42	0.45
Water Chiller	4.49	1.70	-	0.12	-	-	-	-	-	-	1.84	-	0.83
Other RE Measures	1.68	-	-	0.14	0.44	0.61	0.49	0.33	-	0.41	0.37	-	0.52
Retrofit Express Total	0.77	1.01	0.61	0.24	0.64	0.91	0.60	0.75	0.69	0.74	0.72	0.72	0.66
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	0.01	0.44	-	-	-	-	1.17	-	-	-	0.76	-	0.38
CAV to VAV	1.00	-	-	-	-	-	-	-	-	-	-	-	1.00
Cooling Tower	1.27	0.96	-	-	-	-	3.02	-	-	-	-	-	1.70
Retrofit Efficiency Options Total	0.15	0.50	-	-	-	-	1.41	-	-	-	0.76	-	0.48
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	0.86	-	-	-	-	-	-	-	-	-	-	-	0.86
Energy Management System	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Customized Incentives Measures	0.46	-	-	0.52	-	-	0.52	-	0.67	1.00	-	-	0.52
Customized Incentives Total	0.55	-	-	0.32	-	-	0.28	-	0.67	1.00	-	-	0.53
Total	0.54	0.65	0.58	0.25	0.47	0.91	0.87	0.57	0.68	0.90	0.69	0.72	0.58

Commercial HVAC Net Demand Impact Realization Rates By Business Type and Technology Group

Business Type / Program and Technology Group	Net Demand Realization Rates												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	1.34	1.33	1.24	0.37	1.32	1.32	1.38	1.20	1.27	1.35	1.21	1.21	1.10
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	1.64	1.56	1.25	0.43	-	1.50	1.59	1.37	1.50	-	1.54	-	1.13
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	0.48	0.47	0.45	0.13	0.46	0.48	0.49	0.43	0.45	0.48	0.41	0.44	0.47
Water Chiller	4.69	1.77	-	0.12	-	-	-	-	-	-	1.93	-	0.87
Other RE Measures	2.19	-	-	0.19	0.58	0.79	0.64	0.43	-	0.54	0.49	-	0.68
Retrofit Express Total	0.91	1.21	0.71	0.30	0.77	1.14	0.75	1.01	0.81	0.89	0.87	0.86	0.80
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	0.02	0.46	-	-	-	-	1.22	-	-	-	0.79	-	0.39
CAV to VAV	1.31	-	-	-	-	-	-	-	-	-	-	-	1.31
Cooling Tower	1.66	1.25	-	-	-	-	3.95	-	-	-	-	-	2.23
Retrofit Efficiency Options Total	0.19	0.55	-	-	-	-	1.57	-	-	-	0.79	-	0.54
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	0.98	-	-	-	-	-	-	-	-	-	-	-	0.98
Energy Management System	-	-	-	-	-	-	-	-	-	-	-	-	-
Other Customized Incentives Measures	0.53	-	-	0.59	-	-	0.59	-	0.76	1.14	-	-	0.59
Customized Incentives Total	0.63	-	-	0.37	-	-	0.32	-	0.76	1.14	-	-	0.61
Total	0.62	0.74	0.67	0.31	0.56	1.14	1.01	0.76	0.78	1.05	0.79	0.86	0.68

Commercial HVAC Ex Ante Gross Therm Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Therm Impacts												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	71,670	-	-	379,573	-	-	597,692	9,327	615	-	-	-	1,058,877
Other Customized Incentives Measures	660,671	-	23,700	28,726	-	-	263,911	-	192	-	13,403	8,243	998,846
Customized Incentives Total	732,341	0	23,700	408,299	0	0	861,603	9,327	807	0	13,403	8,243	2,057,723
Total	732,341	0	23,700	408,299	0	0	861,603	9,327	807	0	13,403	8,243	2,057,723

Commercial HVAC Ex Ante Net Therm Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Therm Impacts												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	53,753	-	-	284,680	-	-	448,269	6,995	461	-	-	-	794,158
Other Customized Incentives Measures	495,503	-	17,775	21,545	-	-	197,933	-	144	-	10,052	6,182	749,135
Customized Incentives Total	549,256	0	17,775	306,224	0	0	646,202	6,995	605	0	10,052	6,182	1,543,292
Total	549,256	0	17,775	306,224	0	0	646,202	6,995	605	0	10,052	6,182	1,543,292

Commercial HVAC Ex Post Gross Therm Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Therm Impacts												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	71,670	-	-	379,573	-	-	597,692	9,327	615	-	-	-	1,058,877
Other Customized Incentives Measures	659,610	-	23,700	28,726	-	-	263,911	-	192	-	13,403	8,243	997,785
Customized Incentives Total	731,280	0	23,700	408,299	0	0	861,603	9,327	807	0	13,403	8,243	2,056,662
Total	731,280	0	23,700	408,299	0	0	861,603	9,327	807	0	13,403	8,243	2,056,662

Commercial HVAC Ex Post Net Therm Impacts
By Business Type and Technology Group

Business Type / Program and Technology Group	Commercial HVAC First-Year Therm Impacts												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	61,206	-	-	324,155	-	-	510,429	7,965	525	-	-	-	904,281
Other Customized Incentives Measures	563,307	-	20,240	24,532	-	-	225,380	-	164	-	11,446	7,040	852,108
Customized Incentives Total	624,513	0	20,240	348,687	0	0	735,809	7,965	689	0	11,446	7,040	1,756,389
Total	624,513	0	20,240	348,687	0	0	735,809	7,965	689	0	11,446	7,040	1,756,389

Commercial HVAC Gross Therm Realization Rates
By Business Type and Technology Group

Business Type / Program and Technology Group	Gross Therm Realization Rates												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	1.00	-	-	1.00	-	-	1.00	1.00	1.00	-	-	-	1.00
Other Customized Incentives Measures	1.00	-	1.00	1.00	-	-	1.00	-	1.00	-	1.00	1.00	1.00
Customized Incentives Total	1.00	-	1.00	1.00	-	-	1.00	1.00	1.00	-	1.00	1.00	1.00
Total	1.00	-	1.00	1.00	-	-	1.00	1.00	1.00	-	1.00	1.00	1.00

Commercial HVAC Net Therm Realization Rates
By Business Type and Technology Group

Business Type / Program and Technology Group	Net Therm Realization Rates												
	Office	Retail	College/ University	School	Grocery	Restaurant	Health Care	Hotel/Motel	Warehouse	Personal Service	Community Service	Misc.	Total
Retrofit Express Program													
Central A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Variable Speed Drive HVAC Fan	-	-	-	-	-	-	-	-	-	-	-	-	-
Package Terminal A/C	-	-	-	-	-	-	-	-	-	-	-	-	-
Programmable Thermostat	-	-	-	-	-	-	-	-	-	-	-	-	-
Reflective Window Film	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Other RE Measures	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Express Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Program													
Variable Frequency Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
Water Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
CAV to VAV	-	-	-	-	-	-	-	-	-	-	-	-	-
Cooling Tower	-	-	-	-	-	-	-	-	-	-	-	-	-
Retrofit Efficiency Options Total	-	-	-	-	-	-	-	-	-	-	-	-	-
Customized Incentives Program													
HVAC Variable Speed Drive	-	-	-	-	-	-	-	-	-	-	-	-	-
High Efficiency Chiller	-	-	-	-	-	-	-	-	-	-	-	-	-
Energy Management System	1.14	-	-	1.14	-	-	1.14	1.14	1.14	-	-	-	1.14
Other Customized Incentives Measures	1.14	-	1.14	1.14	-	-	1.14	-	1.14	-	1.14	1.14	1.14
Customized Incentives Total	1.14	-	1.14	1.14	-	-	1.14	1.14	1.14	-	1.14	1.14	1.14
Total	1.14	-	1.14	1.14	-	-	1.14	1.14	1.14	-	1.14	1.14	1.14

Commercial HVAC Measures
Measure Code Key

Business Type / Program and Technology Group	PG&E Measure Classification	
	Measure Code	**Action Code**
Retrofit Express Program		
Central A/C	S1-S4	
Variable Speed Drive HVAC Fan	S22	
Package Terminal A/C	S6	
Programmable Thermostat	S17, S18, S19	
Reflective Window Film	S20	
Water Chiller	S9, S10, S11, S16	
Other RE Measures	S5, S7, S14, S15, S12, S21	
Retrofit Efficiency Options Program		
Variable Frequency Drive	S91, S93	
Water Chiller	S97, S98, S99	
CAV to VAV	S86	
Cooling Tower	S94, S95, S96	
Customized Incentives Program		
HVAC Variable Speed Drive	S0	248
High Efficiency Chiller	S0	232
Energy Management System	S0	204
Other CI Measures	S0	All Others

Appendix F
Summary of Gross Program Impacts by Costing Period

F. SUMMARY OF GROSS PROGRAM IMPACTS BY COSTING PERIOD

Ex post program gross demand and energy impacts are summarized by time-of-use (TOU) costing periods in Exhibit F-1, in order to support Pacific Gas and Electric Company's (PG&E's) cost-effectiveness calculations. The adjustment factors presented in Exhibit F-1 were obtained from Tables 3-7 and 3-8 of PG&E's Advice Filing 1978-G/1608-D, dated October 1, 1996. The gross demand and energy impacts by costing period reported in Exhibit F-1 are calculated by multiplying the program's ex post gross demand and energy impact by the corresponding adjustment factor.

Exhibit F-1
Ex Post Gross Demand and Energy Savings by Costing Period
For Commercial HVAC Technologies

PG&E Cost Period	Time-of-Use Impact Distribution			
	Program kW Savings Coincident with System Max in Period	kW Adjustment Factor	kWh Savings	kWh Adjustment Factor
Summer On-Peak: May 1 to Oct. 31 12:00 PM - 6:00 PM Weekdays	4,138	1.00	6,715,656	0.13
Summer Partial Peak: May 1 to Oct. 31 8:30 AM - 12:00 PM & 6:00 PM - 9:30 PM Weekdays	3,732	0.90	6,715,656	0.13
Summer Off-Peak: May to Oct. 31 9:30 PM - 8:30 AM	2,201	0.53	15,211,979	0.30
Winter Partial Peak: Nov. 1 to April 31 8:30 AM - 9:30 PM Weekdays	2,131	0.52	13,329,560	0.26
Winter Off-Peak: Nov. 1 to April 31 9:30 PM - 8:30 AM Other	1,779	0.43	8,903,332	0.18

Appendix G
Protocol Tables 6 & 7

G. PROTOCOL TABLES 6 AND 7

1995 COMMERCIAL ENERGY EFFICIENCY INCENTIVES PROGRAM EVALUATION OF HVAC TECHNOLOGIES

PG&E STUDY ID #326

This Appendix 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 January 1996 Pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, and 95-12-054.

Table 6 Assumptions

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

- Items 1.A, 1.B, 2.C, 3.C: The change model of estimates did not require an evaluation of base usage for these technologies.
- Item 2.B: The per-unit gross and net impacts required by the Protocols specify one term in the denominator, square footage. The interpretation of this term is:
  - Square footage estimates of the conditioned area were derived using the square foot variables in the MDSS (for the participant group only). This is the total area of the facility, not just the retrofit area.
- Item 2.B: The per-unit constant of 104,133,197 (Sq. Ft.., used in the denominator) was taken directly from Table E-3 of the Technical Appendix of the Annual Summary Report on Demand Side Management Programs in 1995 and 1996, revised in December 1996.
- Items 6 and 7: The number of measures reported are the purchased number in the MDSS. As such, they reflect a variety of units of measure, including square feet, number of units, feet of window film, number of thermostats, etc.

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

Protocol Table 6
Items 1-5
PG&E HVAC Study ID #326

Table Item			Relative Precision	
Item Number	Description	Estimate	90% Confidence	80% Confidence
1.A†	Pre-installation usage, Base usage, and Base usage per designated unit* of measurement.	N/A	N/A	N/A
1.B†	Impact Year usage, Impact year usage per designated unit* of measurement.	N/A	N/A	N/A
2.A	Gross Peak kW (Demand) Impacts	4,138	29%	22%
	Gross kWh (Energy) Impacts	50,876,182	15%	12%
	Gross thm (Therm) Impacts	2,056,662	29%	22%
	Net Peak kw (Demand) Impacts	3,376	29%	23%
	Net kWh (Energy) Impacts	43,182,496	16%	12%
	Net thm (Therm) Impacts	1,756,389	29%	23%
2.B	Per designated unit* Gross Demand Impacts	0.00004	29%	22%
	Per designated unit* Gross Energy Impacts	0.49	15%	12%
	Per designated unit Gross Therm Impacts	0.01975	29%	22%
	Per designated unit* Net Demand Impacts	0.00003	29%	23%
	Per designated unit* Net Energy Impacts	0.41	16%	12%
	Per designated unit Net Therm Impacts	0.01687	29%	23%
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	0.58	29%	22%
	Gross Energy Realization Rate	0.98	15%	12%
	Gross Therm Realization Rate	1.00	29%	22%
	Net Demand Realization Rate	0.68	29%	23%
	Net Energy Realization Rate	1.16	16%	12%
	Net Therm Realization Rate	1.14	29%	23%
3.A	Net-to-Gross ratio based on Avg. Load Impacts	0.85	3%	2%
3.B	Net-to-Gross ratio based on Avg. Load Impacts per designated unit* of measurement.	0.85	3%	2%
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)	35,414	15.1%	11.8%
	Pre-installation Avg. (mean) Sq. Foot (comparison group)	25,230	25.5%	19.9%
	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)	35,919	15.2%	11.9%
	Post-installation Avg. (mean) Sq. Foot (comparison group)	25,934	26.6%	20.7%
	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 was Sq. Ft.

Shaded cells were not evaluated because per designated unit calculations did not use these estimates.

Protocol Table 6
Item 6: HVAC Measure Count Data
PG&E Study ID #326

	Number of Measures Paid in 1995		
Program and Technology Group Description	**All Participants (Item 6.B)**	**Participant Sample (Item 6.A)**	**Comparison Group (Item 6.C)**
Retrofit Express Program			
Central A/C	1,229	569	323
Variable Speed Drive HVAC Fan	6,227	3,033	0
Package Terminal A/C	973	543	16
Programmable Thermostat	1,138	531	1
Reflective Window Film	186,427	119,798	0
Water Chiller	9	7	18
Other RE Measures	200	121	33
Total for Retrofit Express:	**196,202**	**124,602**	**391**
Retrofit Efficiency Options Program			
Variable Frequency Driver	12	6	[redacted]
Water Chiller	8	4	
CAV to VAV	2	1	
Cooling Tower	4	1	
Total for Retrofit Efficiency Options:	**26**	**12**	**0**
Customized Incentives Program			
HVAC Variable Speed Drive	23	4	[redacted]
High Efficiency Chiller	2	1	
Energy Management System	62	33	
Other Customized Incentives Measures	55	28	
Total for Customized Incentives:	**142**	**66**	**0**
TOTAL:	**196,370**	**124,680**	**391**

Protocol Table 6
Item 7.A: HVAC Market Segment Data by Business Type
PG&E Study ID # 326

	HVAC	
Business Type	**# of Part.**	**% of Part.**
Office	353	31%
Retail	122	11%
Col/Univ	17	1%
School	114	10%
Grocery	42	4%
Restaurant	53	5%
Health Care/Hospital	123	11%
Hotel/Motel	59	5%
Warehouse	58	5%
Personal Service	57	5%
Community Service	116	10%
Misc. Commercial	34	3%
TOTAL:	**1148**	**100%**

Protocol Table 6
Item 7.B: HVAC Market Segment Data
by 3-Digit SIC Code
PG&E Study ID # 326

Industry (3-Digit SIC Code)	HVAC	
	# of Part.	% of Part.
652	151	13%
821	114	10%
701	58	5%
581	53	5%
866	44	4%
801	33	3%
541	32	3%
799	23	2%
806	22	2%
802	21	2%
422	19	2%
594	18	2%
653	18	2%
531	17	1%
533	17	1%
650	17	1%
809	16	1%
737	15	1%
602	14	1%
832	14	1%
919	14	1%
805	13	1%
873	13	1%
822	12	1%
804	11	1%
573	10	1%
753	10	1%
811	10	1%
922	10	1%
633	9	1%
864	9	1%
504	8	1%
591	8	1%
603	8	1%
431	7	1%
508	7	1%
599	7	1%
913	7	1%
506	6	1%
514	6	1%
571	6	1%
606	6	1%
641	6	1%
723	6	1%
074	5	0%
458	5	0%

Protocol Table 6
Item 7.B: HVAC Market Segment Data
by 3-Digit SIC Code
PG&E Study ID # 326

Industry (3-Digit SIC Code)	HVAC # of Part.	HVAC % of Part.
481	5	0%
551	5	0%
553	5	0%
651	5	0%
721	5	0%
738	5	0%
769	5	0%
835	5	0%
836	5	0%
871	5	0%
495	4	0%
525	4	0%
614	4	0%
824	4	0%
484	3	0%
501	3	0%
507	3	0%
546	3	0%
554	3	0%
593	3	0%
655	3	0%
672	3	0%
735	3	0%
861	3	0%
863	3	0%
872	3	0%
943	3	0%
413	2	0%
472	2	0%
483	2	0%
509	2	0%
512	2	0%
517	2	0%
519	2	0%
523	2	0%
539	2	0%
544	2	0%
566	2	0%
592	2	0%
596	2	0%
609	2	0%
615	2	0%
636	2	0%
662	2	0%
722	2	0%
729	2	0%

Protocol Table 6
Item 7.B: HVAC Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 326

	HVAC	
Industry (3-Digit SIC Code)	# of Part.	% of Part.
733	2	0%
734	2	0%
736	2	0%
754	2	0%
762	2	0%
783	2	0%
784	2	0%
791	2	0%
793	2	0%
807	2	0%
823	2	0%
839	2	0%
841	2	0%
862	2	0%
869	2	0%
874	2	0%
962	2	0%
075	1	0%
421	1	0%
423	1	0%
449	1	0%
473	1	0%
478	1	0%
492	1	0%
493	1	0%
502	1	0%
542	1	0%
543	1	0%
549	1	0%
556	1	0%
562	1	0%
564	1	0%
569	1	0%
572	1	0%
598	1	0%
616	1	0%
631	1	0%
702	1	0%
725	1	0%
726	1	0%
731	1	0%
732	1	0%
781	1	0%
794	1	0%
829	1	0%
833	1	0%

Protocol Table 6
Item 7.B: HVAC Market Segment Data by 3-Digit SIC Code
PG&E Study ID # 326

	HVAC	
Industry (3-Digit SIC Code)	# of Part.	% of Part.
842	1	0%
931	1	0%
941	1	0%
944	1	0%
951	1	0%
964	1	0%
971	1	0%
002	0	0%
072	0	0%
076	0	0%
078	0	0%
411	0	0%
415	0	0%
417	0	0%
451	0	0%
498	0	0%
503	0	0%
505	0	0%
511	0	0%
516	0	0%
518	0	0%
521	0	0%
526	0	0%
540	0	0%
552	0	0%
555	0	0%
557	0	0%
559	0	0%
560	0	0%
561	0	0%
563	0	0%
565	0	0%
621	0	0%
632	0	0%
703	0	0%
704	0	0%
724	0	0%
751	0	0%
752	0	0%
782	0	0%
792	0	0%
808	0	0%
830	0	0%
921	0	0%
953	0	0%
TOTAL:	**1148**	**100%**

PROTOCOL TABLE 7

1995 COMMERCIAL ENERGY EFFICIENCY INCENTIVES PROGRAM EVALUATION OF HVAC TECHNOLOGIES PG&E STUDY ID #326

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 1995 Nonresidential Energy Efficiency Incentives Program for Commercial Sector HVAC Technologies.

Study ID Number: 326

2. Program, Program Year and Program Description

Program: PG&E Nonresidential Energy Efficiency Incentives Program, Commercial Sector.

Program Year: Rebates Received in the 1995 Calendar Year.

Program Description:

The Nonresidential Energy Efficiency Incentives Program offered by PG&E has three components: the Retrofit Express (RE) Program, the Retrofit Efficiency Options (REO) and the Customized Incentive Program.

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

The Customized Incentives Program offers financial incentives to customers who undertake large or complex projects that save gas or electricity. These customers must submit calculations for the projected first year energy savings, along with an application, prior to the start of the customers' installation of high-efficiency equipment. The maximum total incentive amount for the Customized Program is $500,000 per account. The minimum qualifying incentive amount is $2,500 per project.

3. End Uses and/or Measures Covered

End Use Covered: HVAC Technologies.

Measures Covered: For the list of RE and REO Program measures covered in this evaluation, see Exhibit B-3 in the main report. Customized Incentives Program measures generally map into related technology categories.

4. Methods and Models Used

The PG&E Commercial HVAC 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 HVAC technology relative to a baseline, typically defined by Title 24, and computed using CEC long term weather data. A detailed discussion of the HVAC 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 typical weather. A detailed discussion of the final SAE model specification can be found in *Section 3.3.*

Net-to-Gross – The net-to-gross (NTG) ratio adjusts the program baseline, derived using estimates of free-ridership and spillover (associated with the program). The HVAC end-use NTG ratio's were calculated based on survey self-report using a representative nonparticipant sample to account for naturally occurring conservation. The NTG analysis approach is presented in detail in *Section-3.4,* and a thorough discussion surrounding the methods used to score those results is provided in *Appendix D.*

5. Participant and Comparison Group Definition

Participant

Participants are defined as those PG&E commercial customers who received PG&E rebates in the 1995 calendar year for installing at least one lighting measure under the Nonresidential EEI Program.

Comparison Group

The comparison group for this study is defined as a group of PG&E commercial customers who did not receive any HVAC end-use rebates in the 1995 calendar year under the Nonresidential EEI Program, and who share as many characteristics as possible with the commercial sector participant group in terms of annual usage and business type distribution. Customers who participated in the previous years or those who simply participated by installing a non-HVAC end-use measure, are eligible for the comparison group.

6. *Analysis Sample Size*

The final analysis dataset has 2,025 observations based upon 2,025 telephone survey completes (of which 487 were HVAC end-use participants, and the remaining 1,538 served as a comparison group for that sample). In addition, 107 on-site audits were conducted at HVAC end-use participant sites, which included the installation of end-use meters at 20 of these sites. The distribution of the sample by business type and technology is presented in *Appendix A, Section A-3.*

B. DATABASE MANAGEMENT

1. Data Description and Flow Chart

The Evaluation of PG&E Commercial HVAC Technologies was based on a nested sample design approach (see *Section 3.1.1).* The main feature of this approach is that it consists of four groups of customers subsetted according to the availability of detailed evaluation data (within each group). The largest customer group included all of the commercial customers who received rebates for eligible HVAC technologies in 1995 (the "participant population") with monthly PG&E billing data and participant tracking data. The smallest group included the participants with the most comprehensive information available -- EUM data, on-site audit data, telephone survey, participant tracking data, and billing data. A similar nested sample design was also implemented for the comparison group, the exception being that EUM data were not collected for the comparison group. The advantage of the nested sample design was that it yielded overlapping samples which were used to compute bias in many of the intermediate engineering parameters derived.

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

2. Key Data Elements and Sources

A complete list of data elements and their sources can be found in *Section 3.1.1* and *Appendix C, Section 2* of the report. The key analysis data elements and their sources are listed below:

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

PG&E Billing Data. Initially, the PG&E billing data were obtained from two PG&E data sources. 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 *Appendix A.* The billing histories contained in this database only run through September 1995.

The second billing dataset, which consists only of customer accounts in the surveyed dataset, was later obtained from PG&E's Load Data Services.[1] This billing dataset contains bill readings that run through September 1996, 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, from January 1992 to September 1996.

Telephone Survey Data. Two telephone survey samples (487 participants and 1,538 comparison group customers) were collected as part of this evaluation. They were designed to be representative of the population of each business type. The telephone survey supplies information on customer decision-making, equipment operating characteristics, equipment stocks, and energy-related changes at each site for the billing period covered by the statistical billing analysis.

On-Site Audit Data. On-site audit data were collected as part of this evaluation for both the participant and comparison group. The on-site audit is designed to support the telephone sample for the largest participation segments. This sample contributes site-specific equipment details, and better estimates of operating hours and operating factors. There were a total of 107 participant on-site audits conducted for this HVAC end-use evaluation.

End Use Metered Data. The EUM logger data collected for the Evaluation provides operating information for both Central Air Conditioner (CAC) and Variable Speed Drive (VSD) measures. For the CAC measures, the EUM data are used to better estimate the peak duty cycles of CAC's in actual operation. For VSD's, EUM data provided a basis for determining the level at which a given fan is operating.

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

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

3. Data Attrition Process

All data elements mentioned above were first validated and then merged together to form the final analysis dataset. Records with out-of-range or questionable data were either deleted or flagged to ensure that only those records with sufficient data, both in terms of data quality and representativeness, were used in the analysis. The key data attrition decisions are summarized in *Appendix C, Section 5.*

4. Internal Data Quality Procedures

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

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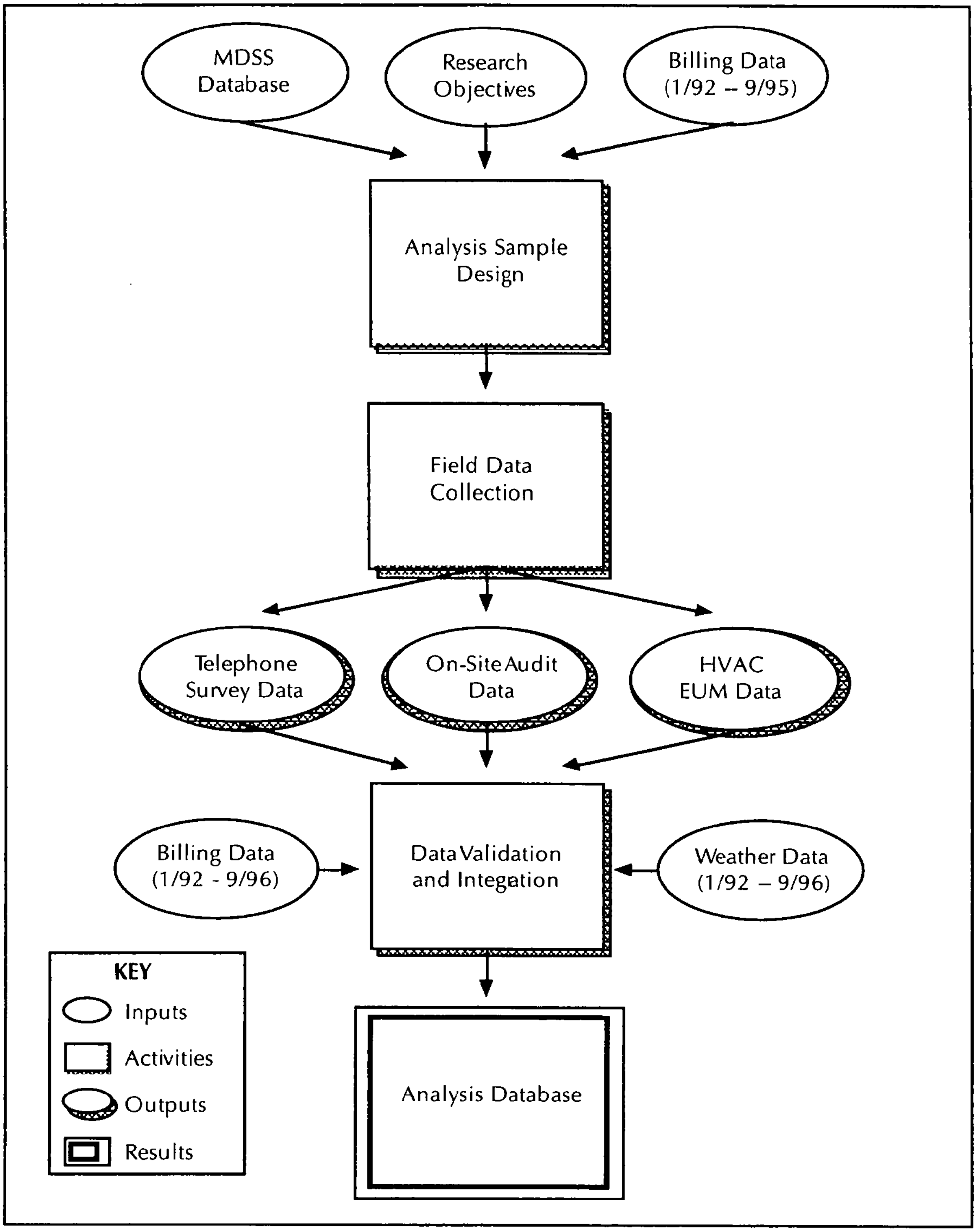
[1] A preliminary analysis has concluded that the monthly usage and bill read date information in these two datasets is consistent.

Exhibit A
Analysis Database Development



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

Pre-Survey Usage and Account Characteristic Data Validation. The goal of this stage of data validation was to screen out customers who had unreasonable or unreliable usage data, or who had changes in key elements of their billing data over the 1992 to 1995 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 sample 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 *Appendix A*.

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

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

5. Unused Data Elements

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

C. SAMPLING

1. Sampling Procedures and Protocols

The sample design for the Commercial HVAC Evaluation was based upon analysis of 1995 program participation data and PG&E billing data. The goal of the sample design was to achieve the most efficient utilization of project resources in order to estimate the first-year gross and net impacts in a manner that met the sample size and evaluation accuracy requirements defined by the Protocols.

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

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

Technology segmentation is important because the use of electricity, and therefore the program impacts, varies by program measure. Therefore, by grouping together common technologies, the variation in impacts is reduced, which, in turn, results in more accurate estimates of the SAE realization rates. For example, all CAC (S1-S5) retrofit measures are grouped together, despite the fact that variation in capacity and efficiency will yield different levels of projected energy impacts. These factors are directly accounted for in the engineering estimates. That is, the engineering estimates account for interparticipant variation so that what is assumed is that the fraction of the expected impact is stable within a segment, rather than the level of the impact. This assumption is the basis for SAE models.

Twelve business types and nine technology groups were defined and used in the sample design and sample allocation for the RE/REO programs. For each business type and technology combination, the sample was allocated in proportion to avoided costs. The purpose of this weighting scheme is to identify which technologies and/or business types account for the greatest impact on the program's resource and shareholder values.

Given the low participation in the Customized Incentives program, all hard copy application forms were reviewed and a census was attempted for all eligible participants.

The sampling unit for both participant and comparison groups was defined as customer premise. A premise is defined as all billing accounts that correspond to the same location and customer. The final participant sample frame consists of 2,560 premises drawn from the eligible population of 5,694 program participants who were paid in 1995 from both the RE, REO and Customized Incentives programs.

The comparison group sample frame consists of 4,153 customers drawn from the eligible population of 172,354 commercial customers that satisfied all of the screening criteria used in construction of the sample frame._ In drawing the sample frame, targets are established for each business type and usage segment, so that the sample frame distribution, by business type and usage segment, is the same as that of the participant population.

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

Finally, the achieved samples and their distributions can be found in *Appendix A*. Based on the total energy usage, the samples relative precision was estimated to be 4.6 percent at the 90 percent level. The procedures used in the relative precision calculation and a summary of how the Evaluation sample design meets the Protocols' requirement in terms of sample size and relative precision are presented in *Appendix A*.

2. Survey Information

Telephone survey instruments are presented in the *Survey Appendix , Section S-1* (for participants) and *Section S-2* (for comparison group customers). Participant and comparison group customer's survey response frequencies are presented in *Section S-9*. Finally, reasons for refusals are presented in *Section S-10*.

On-site audit instruments are presented in the *Survey Appendix , Section S4*.

3. Statistical Descriptions

As mentioned above, a complete set of participant and comparison group customer's responses frequencies are presented in *Survey Appendix S-9*. In addition, statistics on usage and engineering impact variables that were used in the billing data regression models are also presented in *Appendix C*.

D. DATA SCREENING AND ANALYSIS

A detailed discussion of the billing data regression data analysis is presented in *Appendix C*. The statistical billing model described in this section incorporates analysis for three distinct end uses, lighting, HVAC and refrigeration (for Study ID's 324, 326 and 330, respectively). Specific procedures and modeling issues are discussed below.

1. Outliers, Missing Data and Weather Adjustment

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

Invalid Usage

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

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

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

The pre-installation annual bill could not be more than twice or less than one half the post-installation bill, unless the telephone survey responses indicated that the customer had a change at the site that may have caused an increase or decrease in usage, respectively. For example, if a customer doubled their usage and reported an increase in square footage, or an increase in employees, or an additional measure installed, the customer remained in the sample. However, if the customer reported no changes, or only changes that would indicate a decrease in usage, such as a removal of a measure, then the customer was removed from the analysis.

Appendix C presents the number of participants and nonparticipants that were deleted for each of the above criteria. Note that only 22 nonparticipants were deleted, whereas 123 participants were deleted. This is due to the fact that the nonparticipants were pre-screened to have relatively valid billing data prior to being selected into the nonparticipant survey sample frame. The participants, however, were often a census and no pre-screening was done on their billing data prior to being selected into the participant survey sample frame. Of the 123 participants, 87 were deleted due to the zero bill criteria.

Large Customers

Customers whose annual post-installation energy consumption exceeded three million kWh were excluded from the billing analysis. Customers of this size were deleted for a number of reasons. First, there were 98 participants dropped for this reason, compared to only 10 nonparticipants. This indicated that the nonparticipants would not provide a good control for this group of participants. Very large customers are more likely to participate because they are more aware of the program, since they have more contact with PG&E representatives. Therefore, it is difficult to find a sample of nonparticipants that adequately represents these customers.

Large customers installing measures that provide relatively low levels of savings are particularly problematic in billing analyses of this type. It is very difficult to detect an annual impact even as large as 10,000 kWh in a customer's bill which exceeds 10 million kWh, for example. In addition, large customers are more likely to have made changes at the site, which could significantly affect their energy usage. If the model does not adequately capture all of these changes (possibly due to the unique nature of the change, or an error in the self-reported survey responses) it is likely that the coefficient on the program *energy* impact may reflect the change. While this is true of all customers, regardless of size, it is more of a concern for larger customers because the magnitude of their changes can have significant influence over the results of the model.

Aggregation to Site ID Level

As mentioned above, one concern with aggregating to the Site ID level is that there may be control numbers associated with a different premise number, service address, or corporation number that are in the same physical site and are being affected by the installed measures. If this is the case, the billing analysis will have the effect of underestimating the impacts. Therefore, a comparison was made between the engineering energy impact and the pre- and post-installation bills to identify any customers where this problem of bill aggregation may exist.

There were 148 participants that were identified as having total Commercial Sector Program energy impacts that were either more than 50 percent of their pre-installation usage or more than 100 percent of their post-installation usage. These 148 participants were further analyzed to determine whether the impact was large relative to usage because of a problem in aggregating the bill, or if the engineering estimates were just over-estimated, in which case the customer would not be removed from the billing analysis.

Three criteria were used to determine if there was a problem with aggregating the bill for these 148 participants. If a participant failed any of these criteria, the customer was removed from the analysis on the basis that the bills were not properly aggregated and the entire impact would not be detected in an analysis of the customer's billing data.

If the customer's annual kWh per square foot was in the bottom tenth percentile of all participants, the customer was removed.

If the customer's annual kWh per employee was in the bottom tenth percentile of all participants, the customer was removed.

The first billing data pull, which consisted of every nonresidential customer in PG&E's service territory over the period of January 1992 to September 1995, was compared to the second data pull, which is being used for the billing analysis. Customer bills from the first billing data pull were aggregated to the Site ID level in the same way described above. These annual aggregated bills were compared to the aggregated bills used in the analysis. If the aggregated bills from the first data pull were more than 50 percent larger than the bills being used in the billing analysis, the customer was removed. This would indicate that either not all of the control numbers that link to a site were provided in the second data pull or, more likely, since 1995 (when the first billing data was pulled and when the customer participated) there has been customer turnover at the site, and there are now additional premise numbers that no longer link to one unique site.

As a results of these three criteria, 102 of the 148 premises were removed. Of the 102 removed customers, 45 failed the invalid usage data screening checks as well. Therefore, only 57 premises were removed solely on these data screening criteria alone.

Appendix C presents the number of participants that were removed from the analysis for each of the above criteria.

Other Censoring

In addition to all of the above censoring, three other participants were removed from the analysis for the following reasons:

One customer was removed from the analysis because the customer was noted as a "Z-Customer" in the MDSS. PG&E does not claim impacts on "Z-Coded" customers.

Another site had a retrofit performed that will affect a neighboring customer's utility bill. The refrigeration equipment (compressors and condensers) serving the participant are maintained and operated by a nonparticipant. The participant buys liquid ammonia from the nonparticipant via lines running under an adjacent road (driveway) and suction gas is returned to the nonparticipant following use. The impacts of this retrofit (which affect ice production) will be realized by the manufacturer of the liquid ammonia product, a nonparticipant. Therefore, the participating customer was removed from the analysis.

Finally, two other customers were identified as having added the rebated measure installed under the Commercial Program, causing a net increase in energy from the pre- to post-installation period. One of these customers was previously identified as being a large customer and deleted. Therefore, only one extra customer was removed.

Appendix C summarizes all of these data screening criteria and provides the pre- and post-censoring sample sizes by technology and business type.

2. Background Variables

Background variables, such as interest rates, unemployment rates and other economic factors, were not explicitly modeled 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 *Appendix C*, the final model was fitted in two steps. The first step is to estimate a baseline model to develop the relationship between the pre-installation year usage and the post-installation year usage, followed by an SAE model to estimate the SAE realization rates based on the engineering estimates of program impacts. Section 1 above describes in detail all of the data screening criteria. *Appendix C* also details the number of customers that were screened for each criteria.

4. Regression Statistics

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

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

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

The dependent variable is the difference between the actual and predicted 1996 usage using the 1994 baseline model.

SAE coefficients were calculated for 16 different combinations of business type and measure. Primarily those measures that have broad participation and relatively high expected impacts were supported by separate SAE coefficients. In addition, a separate SAE coefficient was calculated for other Commercial Program measures outside Lighting, HVAC, and Refrigeration.

Attempts were made to estimate the SAE coefficients at a finer level of segmentation, but generally either one of two problems were encountered. First, available sample sizes were too small to support a finer level of segmentation. Second, certain parameters were correlated with each other and needed to be combined into a single parameter (a standard econometric solution to solving the problem of colinearity). For example, it was determined that there was a high incidence of compact and standard fluorescent installations at the same site in office buildings. Therefore, there was enough correlation between the compact and fluorescent engineering estimates to warrant combining the two estimates into a single fluorescent estimate in the model.

All but three of the SAE coefficients are significant at the 95 percent confidence level (t-statistics greater than 1.96). In addition, all of the statistically significant SAE coefficients were the correct sign, and therefore were used in the calculation of the final ex post energy calculations. The three SAE coefficients that were not significant at the 95 percent confidence interval (HIDs in warehouses and schools, and thermostats in offices) were not used in the final ex post energy calculations. Because each of the insignificant SAE coefficients were also the wrong sign, they were set to zero. Therefore, no energy impacts are being claimed for these three segments.

Exhibit B
Final SAE Model Output

Parameter Descriptions	Units	Parameter Estimate	t-Statistic	Sample Size
SAE Coefficients				
Lighting End Use				
Office Flourescents	kWh	-1.00	14.67	116
Other Flourescents	kWh	-0.68	7.41	261
Controls	kWh	-1.38	2.09	57
Warehouse HIDs	kWh	0.02	0.07	10
School HIDS	kWh	0.11	0.30	10
Other RE Lighting	kWh	-1.26	2.15	119
Custom Lighting	kWh	-0.51	3.07	15
HVAC End Use				
Central A/Cs	kWh	-2.07	3.67	184
ASDs	kWh	-1.90	6.75	27
Chillers	kWh	-1.58	2.39	5
EMS	kWh	-1.03	8.38	20
Other Custom HVAC	kWh	-0.65	4.76	5
Office Thermostats	kWh	0.05	1.06	36
Other RE/REO HVAC	kWh	-0.90	2.89	153
Refrigeration				
Custom Refrigeration	kWh	-0.75	2.00	3
RE/REO Refrigeration	kWh	-0.53	1.98	181
Other End Uses	kWh			
Other	kWh	-1.71	2.90	62
Change Variables	kWh			
Cooling System Replacement	(0,1)*kWh	-0.03	0.70	10
Lighting System Replacement	(0,1)*kWh	-0.08	4.17	48
Change in Employees	(±1,0)*kWh	0.01	0.64	57
Square Foot Change	± sqft	4.42	2.37	27
Heating System Replacement	(0,1)*kWh	-0.07	0.04	4
Other Equipment Change	(0,1)*kWh	0.03	1.17	42
Remove Equipment	(0,1)*kWh	0.08	0.64	2
Refrigeration Replacement	(0,1)*kWh	0.00	0.01	3
Add Equipement	(0,1)*kWh	0.11	0.49	11
Other Additions	(0,1)*kWh	0.14	12.41	375

All of the HVAC technologies are represented in the SAE billing analysis, except for REO Variable Frequency Drives (VFD), REO CAV to VAV, and Customized Incentive Chillers. Although these measures represent only ten percent of the energy impact, an approach needed to be developed for adjusting the engineering energy impact estimate for these measures.

- The REO VFD measure is very similar to those installed under the RE and Customized Incentive programs, and the engineering estimate is calculated using the same approach. Therefore, engineering energy impact estimate for the REO VFD measure was adjusted by the SAE coefficient estimated for the RE and Customized Incentive measures.

- Three approaches were considered for adjusting the engineering energy impact estimate for the REO CAV to VAV measure: (1) applying the Other RE HVAC SAE coefficient, (2) applying the Other Custom HVAC SAE coefficient, or (3) leaving the engineering estimate unadjusted. Because the REO CAV to VAV measure is usually installed in large businesses, typical of those installing Customized Incentive measures, the Other Custom HVAC SAE coefficient was used to adjust the engineering energy impact estimate for the REO CAV to VAV measure. This is also the most conservative approach since the SAE coefficient is only 0.65.

- The engineering energy impact for Chillers was estimated differently for Customized Incentive applications than for RE and REO applications, due to the different types of businesses that install these measures. Therefore, the engineering energy impact estimate for Customized Incentive Chillers was left unadjusted, which is conservative compared to the alternative approach of applying the 1.58 SAE coefficient estimated for the RE and REO applications.

The SAE coefficient of 0.65 for Other Custom HVAC measures is based on a sample size of only five sites, compared to the 43 unique sites that installed "Other" Customized Incentive HVAC measures in 1995. In addition, these five sites represent only seven percent of the total ex ante energy impact contributed by these 43 sites. Also, one third of the customers installing "Other" Customized Incentive HVAC measures have usage over 3 million kWh per year, which are not represented in the SAE analysis.

The larger customers (usage over 3 million kWh per year), however, are very well represented in the on-site audit sample, for which calibrated engineering energy impacts were estimated. Sixteen sites, which represent 53 percent of the total ex ante energy impact, were on-site audited, one of which was included in the SAE billing analysis. The ratio of the engineering energy impact estimate to the ex ante estimate is 0.79 for the on-site audit sample. This can be directly compared to the SAE coefficient, because ex ante estimates were used as the engineering energy impact estimates for the billing analysis, as mentioned above.

Three approaches were considered for estimating the ex post gross energy impact for the "Other" Customized Incentive HVAC measures:

- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population.

- The 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate from the on-site audit sample could be applied to the ex ante estimate of gross energy impact for the population.

- The SAE coefficient of 0.65 could be applied to the ex ante estimate of gross energy impact for the population that is most similar to the SAE sample, and the 0.79 ratio of engineering energy engineering energy impact estimate to the ex ante estimate could be applied to the population most similar to the on-site audit sample.

The approach of applying the SAE coefficient to the ex ante estimate of gross energy impact for the population, which is the most conservative method, was chosen for two reasons. First, the SAE coefficient provides a statistically adjusted result that is significant at the 95 percent confidence level. Second, the 0.79 ratio based on the on-site audit is very sensitive to a few individual on-site results. For example, the ratio of the engineering to ex ante estimate is 1.51 for the site with the largest energy impact. If the engineering estimate was set equal to the ex ante estimate for this customer, the overall ratio for all on-sites would be 0.64. Conversely, if the site with the second largest energy impact, which has a ratio of 0.41, had an engineering estimate set equal to the ex ant estimate, the overall ratio would be 0.95.

The SAE coefficient of 0.75 for Customized Incentive Refrigeration measures is based on a sample size of only three sites, compared to the 53 unique sites that installed Customized Incentive Refrigeration measures in 1995. Adjusting the engineering estimates of energy impact by 0.75 for all Customized Incentive measures should be considered conservative because it is likely that a sample size of three may not be representative of the population. An alternative approach would be to adjust only those measures that are similar to the three represented in the billing analysis, and leave the remaining measures unadjusted. It was found that the ratio of the engineering energy to the ex ante gross energy estimate was 98 percent over all 53 unique sites, and 94 percent for the three sites used in the SAE analysis. Because the ratio for the SAE sample is similar to the population's ratio and because the SAE coefficient was statistically significant at the 95 percent confidence level, the conservative approach of adjusting all Customized Incentive Refrigeration measures by 0.75 was chosen.

Impact estimates from the MDSS for other end uses were included in the model for customers that installed measures outside the Lighting, HVAC, and Refrigeration end uses. Although this result is statistically significant and the correct sign, it is not recommended that this value be used because the sample may not be representative of the population of participants installing these measures.

The majority of the change variables that were included in the model were not statistically significant at the 95 percent confidence level. Most of the parameter estimates are the correct sign, and those that are not have very low t-statistics. All but one variable, was determined solely on telephone survey responses. The change variable termed "other additions" was determined by comparing the predicted estimate of post-installation usage, based on the baseline model, to the actual post-installation usage. If the predicted usage is less than the actual post-installation usage, it is likely that some change occurred at the premise that would cause the usage to increase. An analysis of these customers revealed that two thirds of them indicated through the telephone survey that some change did occur at the premise. However, almost half of these customers did not provide a date for when the change occurred. Therefore, the "other additions" variable was created in an attempt to capture other changes that would cause usage to increase, which were not explained by the other independent variables in the model.

5. Model Specification

The model specifications are presented in *Appendix C*. 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 intercepted 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) eliminate the multiple time period interactions by only one yearly pre-installation period and one yearly post-installation period for each stage.

Self-selection. Self-selection is not treated explicitly in the billing regression analysis. The reasons for excluding such a correction is based on the following considerations: (1) the objective of the billing regression analysis is to estimate the program gross energy impacts, where self-selection bias is believed to have a limited effect on the regression result (when both cross-sectional and time series data are used), and (2) the existing self-selection correction procedures all have serious flaws in their underlying assumptions. For example, the Mills ratio approach was attempted, but resulted in serious multi-collinearity problems between the double inverse Mills ratio variable and the engineering estimates of impact.

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

Net Impact. As mentioned in the Self-selection section, a net billing model was implemented using the double inverse Mills ratio approach, but resulted in problems with multi-colinearity that were uncorrectable. Therefore, a gross billing analysis model was used and adjusted by a net-to-gross ratio using discrete choice and self report methods.

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 the systematic bias in the data. These steps included (1) thorough auditor/coder training; (2) instrument pretest; and (3) cross-validation between on-site audit data and telephone survey responses.

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

7. Autocorrelation

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

8. Heteroskdasticity

See discussion above.

9. Collinearity

See discussion above.

10. Influential Data Points

See discussion above.

11. Missing Data

See discussion above.

12. Precision

The precision calculation for the gross SAE realization rates are presented in *Section 3*. 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.[2] The functional relation can be best described in the following equations:

  $$\overline{N} = \Sigma_i w_i * \overline{N}_i \text{ with } w_i = MWh_i$$

  $$StdErr_{NTG} = \sqrt{\Sigma_1\left((w_i)^2 * StdErr_i^2\right)}$$

  where

  N = Net-to-Gross Value

  i = Technology Group

  w = Weight

- Then, the relative precision[3] for the program NTG value for energy was calculated and combined with the relative precision of the gross energy impact to yield an overall relative precision for the net energy impacts:

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

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

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

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

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

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

- Per-unit NTG relative precision's 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 a survey self-report analysis. For a detailed NTG analysis discussion, see *Appendix D.*

The self-report method used to score free-ridership uses participant responses to survey questions regarding the timing of and reasons for equipment replacement actions. The complete text of the participant surveys may be found in *Survey Appendix S-1.* Questions used for the self-report analysis are summarized in *Appendix D.*

As described in *Appendix D,* a series of questions was posed to program participants. If the customer indicated that he had not been shopping for new equipment before becoming aware of the program, he was scored initially as a net participant. A customer was then classified as a free-rider if he (1) stated that he would have installed high-efficiency equipment within the year and had already selected the equipment; and (2) stated that he would have purchased high-efficiency equipment if the program had not existed.

The net-to-gross ratio using the self-report method relied only on free ridership and did not include any estimate of spillover. This conservative approach was used for all HVAC technologies.