IMPACT EVALUATION OF THE INDUSTRIAL HVAC END USE IN PG&E'S 1994 RETROFIT ENERGY-EFFICIENCY PROGRAMS

Final Report

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E EXECUTIVE SUMMARY

This report presents the 1994 impact evaluation results for the industrial HVAC end use in Pacific Gas and Electric Company's (PG&E's) retrofit energy efficiency programs. This is one of four separate reports documenting the methodology, results, and recommendations of an evaluation of selected projects that received incentives in 1994 through PG&E's Commercial, Industrial, and Agricultural Programs (the CIA Programs). Other reports address the following end uses: Industrial Process, Industrial Miscellaneous, and Commercial Miscellaneous.

E.1 BACKGROUND

The industrial HVAC measures addressed in this evaluation were covered by separate PG&E incentive programs:

- The CIA Retrofit Customized Program (the Customized Program); and
- The CIA Retrofit Express Program (the Express Program).

In 1994, a total of 170 sites participated in the Industrial HVAC portion of these programs. PG&E estimated total ex ante impacts at these sites to be 3,889 kW, 12,751,077 kWh, and 118,026 Therms.

Each of the programs is described briefly below.

E.1.1 The Customized Program

The Customized Program provides incentives to commercial, industrial, and agricultural customers to install custom-designed energy-efficiency measures. The program covers both new construction and retrofit projects. Both electric and gas projects are covered by the Customized Program, although the majority of projects are electric. Any measures covered under the Express Program cannot be included in the Customized Program.

E.1.2 The Express Program

The Express Program provides incentives for commercial, industrial, and agricultural customers to retrofit their facilities with energy-efficient equipment from a pre-specified list of measures. Incentives are provided for equipment in the areas of air conditioning, agricultural, food service, refrigeration, lighting, and motors.

E.2 PROJECT OVERVIEW

E.2.1 Evaluation Objectives

The primary objectives of the evaluation were to:

- Determine defensible estimates of the gross and net impacts (kW, kWh, and Therm) resulting from industrial HVAC measures installed through PG&E's incentive programs;
- Identify any discrepancies between estimated and measured impacts; and
- Suggest reasons for such discrepancies, such as differences between planning assumptions and what is found on-site for factors such as number of measures installed, connected load, and hours of operation.

E.2.2 Gross Savings Analysis

The evaluation employed an enhanced engineering approach to quantify gross measure impacts for each study site. The principal source of data for the study came from on-site surveys. This data was supplemented with strategic monitoring data as well as data from existing data sources, including PG&E project files, customer's facility management systems, manufacturer's equipment performance data, and billing data.

A site-specific engineering analysis was conducted to determine savings for each site. Two primary analytical techniques were used to evaluate savings: 1) an hourly building model (DOE-2), and 2) simpler, site-specific engineering "bin analysis" models. The DOE-2 analyses were used on all but two of the studied sites. The two engineering bin analyses, supported with metering/monitoring data, were conducted for sites that installed adjustable speed drives on nonweather-sensitive ventilation fans.

E.2.3 Net-to-Gross Analysis

To determine net program savings for the industrial HVAC measures, a site-specific net-to-gross analysis was conducted. This analysis primarily focused on free-ridership and was based on on-site findings and structured follow-up telephone surveys of key participant decision makers.

Each site studied received its own net-to-gross ratio, based on a structured analysis of the key factors influencing the customers decision to participate in the program. Site-specific results were aggregated to program totals, weighted by each sites relative contribution to overall program impacts.

E.3 KEY FINDINGS

Based on the results of the impact evaluation, the 1994 industrial HVAC projects are achieving net electric energy savings of 5.6 GWh per year, net summer peak demand savings of 0.78 MW, and net natural gas savings of 34,570 Therms per year. Table E-1 presents key gross and net evaluation impacts.

Table E-1
1994 Industrial HVAC Measures
Gross and Net Savings Estimates

	Annual kWh	Summer Peak kW	Annual Therms
1. PG&E Gross Savings	12,751,077	3,889	118,026
2. PG&E Net-to-Gross Ratio	0.67	0.67	0.67
3. PG&E Net Savings (1×2)	8,543,222	2,606	79,077
4. Evaluation Gross Realization Rate	0.87	0.39	0.57
5. Evaluation Gross Savings (1×4)	11,031,594	1,522	67,784
6. Evaluation Net-to-Gross Ratio	0.51	0.51	0.51
7. Evaluation Net Savings (5×6)	5,626,113	776	34,570
8. Net Savings Realization Rate (7÷3)	0.66	0.30	0.44

The table reveals the following key findings:

- Eighty seven percent of gross kWh savings, 39 percent of gross summer peak kW savings, and 57 percent of gross natural gas savings are being realized;
- The program net-to-gross ratio is estimated to be 0.51, indicating that 51 percent of the realized gross savings can be attributed to the programs; and
- Overall, 66 percent of PG&E's net kWh savings estimates, 30 percent of the net kW savings estimates, and 44 percent of the net therm savings estimates are being realized.

Evaluation results are displayed graphically in Figures E-1 through E-3.

Figure E-1
PG&E 1994 Industrial HVAC Measures
Comparison of Annual Energy Impacts

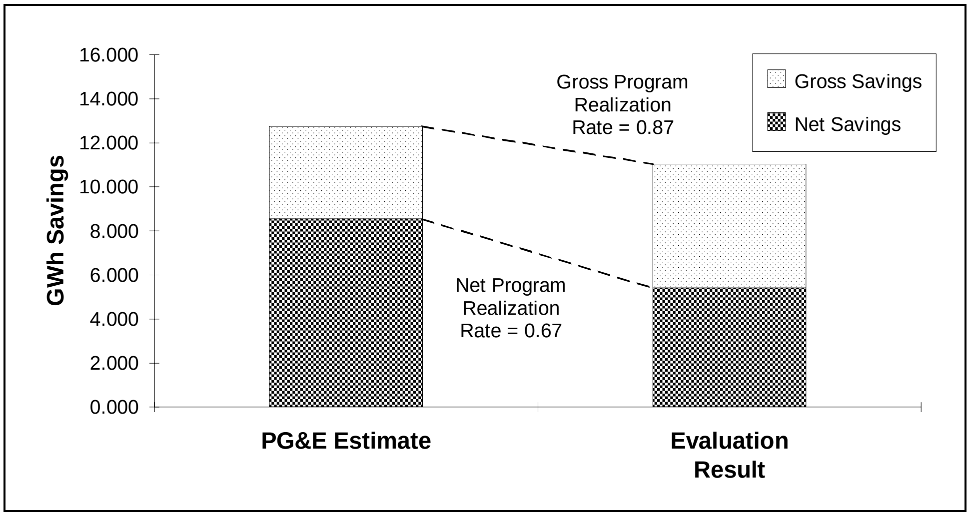


Figure E-2
PG&E 1994 Industrial HVAC Measures
Comparison of Summer Peak Demand Impacts

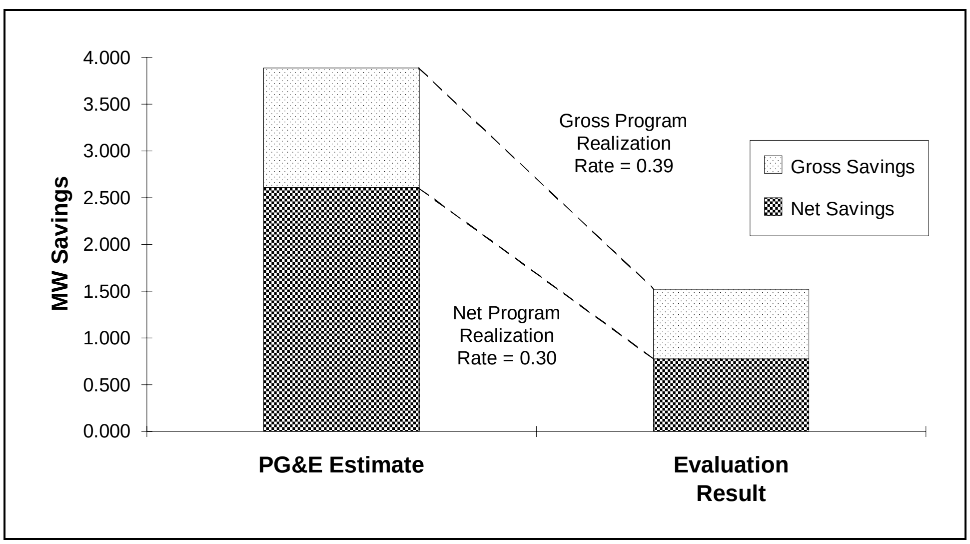
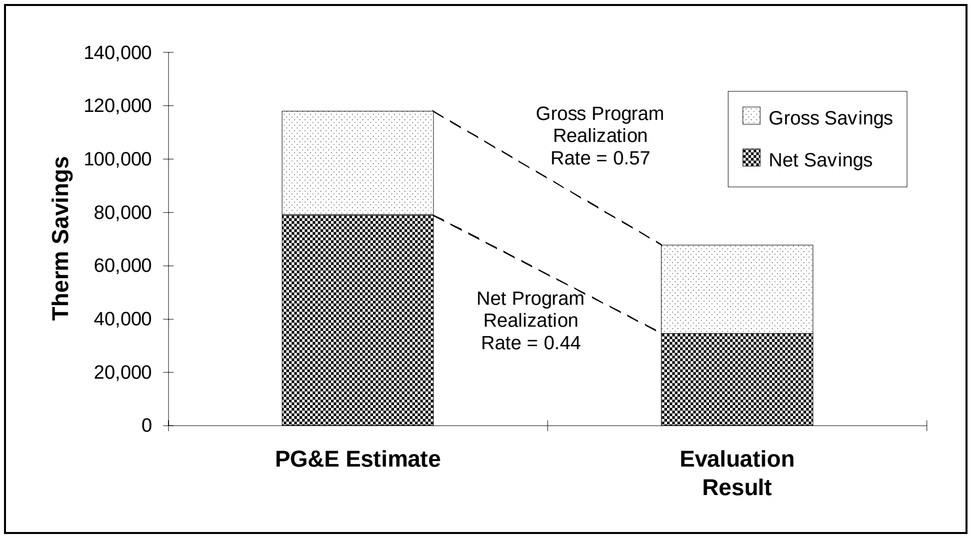


Figure E-3
PG&E 1994 Industrial HVAC Measures
Comparison of Annual Therm Impacts



Key factors causing realization rates to fall below one include:

- Savings reporting discrepancies for Express cooling tower measures in the MDSS tracking system; savings calculations made by the evaluation team using PG&E's documented Express methodology were much lower than the savings reported in MDSS, especially for kW savings;
- Post-retrofit system performance characteristics that were different than expected for a very large site EMS (energy management system) site; and
- Operating conditions that were different than expected for a number of medium sized sites, including differences in operating hours and lower-than-expected HVAC load requirements.

Overall chiller measures and ASD measures provided the best savings results, with gross realization rates near 1.0. Cooling towers, EMSs, and other miscellaneous measures showed gross kWh and kW realization rate of 0.5 or less.

Table E-2 presents the distribution of realization rates for sites analyzed in the evaluation. As the table indicates, a fairly large number of sites were outside the 0.76-1.25 realization rate range, indicating inaccuracies in PG&E's ex ante estimated savings. The table also indicates a number of sites where the evaluation found impacts that PG&E did not estimate. A majority of these sites showed additional savings impacts.

Table E-2
Distribution of Realization Rates

	Number of Sites					
Realization Rate	**kW**	**% Sites**	**kWh**	**% Sites**	**Therms**	**% Sites**
> 1.75	1	3%	4	12%	1	11%
1.26 - 1.75	2	6%	7	21%	2	22%
0.76 - 1.25	2	6%	7	21%		
0.25 - 0.75	6	19%	12	35%	1	11%
< 0.25	7	23%	6	12%	2	22%
PG&E Impact=0 / Eval Impact>0	9	29%			1	11%
PG&E Impact=0 / Eval Impact<0	4	13%			2	22%
Totals	31	100%	36	100%	9	100%

A number of factors caused discrepancies between PG&E's savings estimates and evaluation results, including:

- Equipment/system performance that was different from initial projections; the evaluation, equipment performance was based on measured data whenever possible;
- Different operating conditions in the post-retrofit period than those anticipated in the initial PG&E savings estimates;
- Methodologies used in the initial PG&E savings estimates that oversimplified analyses of complex processes and/or failed to consider all equipment affected by the rebate; and
- Express cooling tower discrepancies as discussed above.

E.4 RECOMMENDATIONS

During the course of the evaluation, the project team was able to identify several factors that could lead to improvements in the PG&E programs and aid in future evaluations of this type. Key evaluation results indicate that program savings were overestimated, especially for kW impacts. In addition, about half of the program participants appear to be free riders. Recommendations for improving the program follow.

Applicability of Express Measures to Large Sites

For large savings sites, use of the Express Program with its standardized savings estimates and standardized operating estimates can lead to large errors in initial impact estimates. For several large sites, the Express Program estimates were very low, due to higher load factor and increased operating hours at these sites.

Recommendation: Set a savings size limit for the Express Program to ensure that large sites receive Custom applications that are site specific.

Use of Equipment Performance Data

Collection of equipment performance data for some types of equipment, such as chillers, is very difficult during the evaluation, although this information can greatly improve impact estimates. Manufacturers are not inclined to release this information unless one is in the process of purchasing equipment. For larger savings sites, acquisition and use of equipment-specific performance data during the program application process could greatly improve the savings estimates associated with the customized rebate applications.

Recommendation: Require that equipment performance data be obtained and used in rebate application savings calculations for large impact sites.

Monitoring Activities

For sites where pre- and post-retrofit monitoring/metering data exist, evaluation analysis activities often can be greatly simplified. In some cases, the evaluation becomes a verification that the monitoring/metering results are still valid after the equipment has been in the field for some time. Use of monitoring/metering data in the rebate application also can greatly improve the accuracy of the impact estimates.

Recommendation: For larger sites, PG&E should consider guidelines for when monitoring/metering activities for both pre- and post-retrofit periods might be considered or required as part of the application.

Review Express Measure Algorithms

For several measures, particularly cooling towers, the evaluation team could not replicate PG&E savings calculations. There appears to be an error in the Express calculations imbedded in the MDSS database leading to an overestimate of savings in the cases encountered.

Recommendation: Review Express measure calculations and MDSS algorithms to ensure that savings are being estimated correctly.

Free Ridership

The significant number of apparent free riders adversely impact net savings estimates. PG&E customer representatives should work more closely with larger impact customers to determine if they would install the equipment anyway. PG&E should investigate ways to limit the ability of free riders to participate in the programs. In lieu of attempts to limit free ridership, PG&E should incorporate lower net-to-gross ratios into its industrial program design.

Recommendation: Take steps to lower free ridership or incorporate lower net-to-gross ratios in program planning.

1 INTRODUCTION

1.1 INTRODUCTION

This report presents the 1994 impact evaluation results for the industrial HVAC end use in PG&E's retrofit energy-efficiency programs. This is one of four separate reports documenting the methodology, results, and recommendations of an evaluation of selected projects that received incentives in 1994 through PG&E's Commercial, Industrial, and Agricultural Programs (the CIA Programs). The evaluation reports are segmented into the following four categories:

- Industrial Process measures;
- Industrial HVAC measures;
- Industrial miscellaneous measures; and
- Commercial miscellaneous measures.

1.2 PROJECT OVERVIEW

1.2.1 Evaluation Objectives

The primary objectives of the overall evaluation were to:

- Determine the gross and net impacts (kW, kWh, and therms) resulting from industrial process, HVAC, and commercial/industrial miscellaneous measures installed through PG&E's incentive programs;
- Identify any discrepancies between the evaluation results and PG&E's ex ante impact estimates; and
- Determine reasons for such discrepancies, such as differences between planning assumptions and what is found on-site for factors such as number of measures installed, connected load, and hours of operation.

1.2.2 Description

The evaluation employed an enhanced engineering approach to quantify gross measure impacts for each study site. The principal source of data for the study came from on-site surveys. This data was supplemented with strategic monitoring data as well as data from existing data sources, including PG&E project files, customer's facility management systems, manufacturer's equipment performance data, and billing data.

For process measure sites and other "customized" applications, a site-specific engineering approach was used in the analysis. For HVAC sites, an hourly building model (DOE-2) or simpler "bin analysis" models were used, depending on the complexity of the site. For other measures such as efficient motors and refrigerator door closers/gaskets, spreadsheet-based engineering models were developed to calculate savings based on equipment performance and customer-supplied operating schedules.

To determine net program savings for the industrial process and industrial HVAC measures, a site-specific net-to-gross analysis was conducted. This analysis primarily focused on free ridership and was based on on-site findings and structured follow-up telephone surveys of key participant decision makers.

1.3 PROGRAM DESCRIPTION

The industrial and commercial measures addressed in this overall evaluation were covered by separate PG&E incentive programs:

- The CIA Retrofit Customized Program (the Customized Program); and
- The CIA Retrofit Express Program (the Express Program).

Each of the programs is described briefly below.

1.3.1 The Customized Program

The Customized Program provides incentives to commercial, industrial, and agricultural customers to install custom-designed energy-efficiency measures. The program covers both new construction and retrofit projects. Both electric and gas projects are covered by the Customized Program, although the majority of projects are electric. Any measures covered under the Express Program cannot be included in the Customized Program.

1.3.2 The Express Program

The Express Program provides incentives for commercial, industrial, and agricultural customers to retrofit their facilities with energy-efficient equipment from a pre-specified list of measures. Incentives are provided for equipment in the areas of air conditioning, agricultural, food service, refrigeration, lighting, and motors.

1.3.3 PG&E Savings Estimates

The number of sites and the initial PG&E savings estimates for the measure segments analyzed in this evaluation are presented in Table 1-1.

Table 1-1
Sites and Savings Estimates by Category
1994 CIA Programs

Category	# Sites	kWh	kW	Therms
Industrial Process	85	42,664,463	6,286	8,565,548
Industrial HVAC	170	12,751,077	3,889	118,026
Industrial Misc.	183	11,987,050	1,740	0
Commercial Misc.	1288	35,065,085	5,772	431,615
Total	1726	102,467,675	17,687	9,115,189

The methodology and results for the industrial HVAC end use are discussed in this report.

1.4 REPORT ORGANIZATION

The remainder of the report focuses on the evaluation of industrial HVAC measures and is organized as follows:

- Section 2 discussed the evaluation methodology;
- Section 3 presents the evaluation results;
- Appendix A includes detailed site data;
- Appendix B presents savings by PG&E costing period;
- Appendix C presents results consistent with Tables 6 and 7 of the Protocols; and
- Appendix D provides the net-to-gross survey guidelines used for interviewing customers.

2 EVALUATION METHODOLOGY

2.1 OVERVIEW

This section presents the evaluation approach used for this study. Key topics covered are:

- Research design
- Estimating gross savings
- Net-to-gross analysis

2.2 RESEARCH DESIGN

The research design is based on the principle that evaluation, field, and analytical resources would be allocated to measure type segments and sites with those segments based on their expected resource value. The design reflects the fact that most of the expected savings come from a minority of the sites. As required by the Protocols, the sites included in the study were responsible for more than 70 percent of the expected kW, kWh, and Therm savings[1].

In the evaluation, "sites" refer to one or more HVAC measures assigned to a PG&E control number. The control number is a unique identifier in the PG&E billing system that represents an account. It is possible to have multiple control number for a given physical site and to have multiple rebate applications per control number. For industrial sites, it often difficult to link multiple control numbers at a given physical site (because the site often can cover multiple streets); therefore to simplify the research design, each control number was designated as a "site."

As table 2-1 indicates, four sites provide 42 percent of the expected HVAC avoided cost savings. The next 62 sites provide an additional 54 percent of the expected savings. The remaining 104 sites contribute only four percent to savings. Site-specific evaluations were conducted for the four largest sites and 32 of the 62 medium sites; the remaining

[1] Although HVAC is considered a miscellaneous end use in the Protocols, the analysis sample was chosen to meet the protocol for industrial energy efficiency incentive programs (Table C-5 of the Protocols).

sites were subject verification activities (and 91 sites were ultimately visited).

Table 2-1
Size Distribution of HVAC Savings

Size	# Sites	Avoided Cost	Percent of Total
Large	4	$4,007,041	42 %
Medium	62	$5,162,177	54%
Small	104	$369,025	4%
Total	170	$9,538,243	100%

2.2.1 Program Statistics

This section summarizes 1994 PG&E Industrial HVAC project tracking data as extracted from the PG&E MDSS system. The program savings totaled 12,751 annual MWh, 3,889 peak kW, and 118,026 annual Therms. Overall, 264 program measure line items were installed at 170 sites. Forty-two Customized measures were installed. The remainder of the measures were installed under the Express Program. The most important measures installed under both programs included chillers, cooling towers, and ASDs (adjustable speed drives). In addition, a number of energy management systems (EMSs) were installed under the Customized Program.

Table 2-2 presents expected energy and demand savings total for both the Customized and Express Programs. At the table indicates, the Customized Program accounted for 55 percent of the kWh savings, all of the Therm savings, but only 18 percent of the kW savings.

Table 2-2
Industrial HVAC Energy Savings by Program

Program	# of Measures	Annual kWh		Summer Peak kW		Annual Therms	
		Amount	% of Total	Amount	% of Total	Amount	% of Total
Customized	42	7,003,519	55	686.4	18	118,026	100
Express	222	5,747,558	45	3,202.6	82	-	-
TOTAL	264	12,751,077	100	3,889.1	100	118,026	100

Table 2-3 presents expected energy savings for key program measure categories: chillers, cooling towers, EMSs, and ASDs. These measure groups account for only six of the 264 implemented measures, but they represent the majority of program savings.

Table 2-3
Industrial HVAC Energy Savings by Measure Category

Measure Category	# of Measures	Annual kWh		Summer Peak kW		Annual Therms	
		Amount	% of Total	Amount	% of Total	Amount	% of Total
Chillers	15	3,202,923	25%	1,122	29%	0	0%
Cooling Towers	20	1,953,569	15%	2,029	52%	0	0%
EMS	11	2,390,101	19%	3	0%	92,540	78%
ASD	22	1,758,431	14%	0	0%	0	0%
All Others	196	3,446,053	27%	735	19%	25,486	22%
Total	264	12,751,077	100%	3,889	100%	118,026	100%

2.2.2 Sample Design

The sample design used information on the distribution of savings across sites and across measures. Sites were categorized by size of savings and then by technology, based on the rebate measure installed. Avoided costs[2] were used to determine the level of detail planned for the data collection and the depth of analysis required to define energy and demand savings to a reasonable degree of precision, hence the amount of project budget allocated to each site. The technology (measure) guides the technical approach to the site review and the method of analysis.

For all but three sites, DOE-2 analyses were conducted. For the larger and more complex sites a rigorous, customized DOE-2 analysis was conducted. Less rigorous DOE-2 modeling with data entry via the “Visual DOE” windows data entry interface was performed on lower impact sites. All “Visual DOE” analyses included a customized modification to the building input files after initial data entry to better match the analysis with the facility.

The four sites with savings amounts significantly higher than the rest were assigned to “Group A.” These sites have total avoided costs greater than $700,000 with savings so large that confirmation of the savings amounts with a high degree of confidence is critical to the

[2] Avoided cost savings were used because they are based on overall energy savings (kWh, kW, and therms).

overall program performance evaluation. These sites were analyzed in detail using detailed hourly load (DOE-2) modeling to document savings.
Other sites were assigned to groups based on the dominant measure. Several homogeneous, measure-specific categories were identified to allow for a sampling strategy and similar technical approach within each group. These measure-specific groups include:

- Group CH: Chiller Replacement (only)
- Group CHT: Chiller and Cooling Tower replacement
- Group CT: Cooling Tower (only)
- Group V: Adjustable Speed Motor Drives

The remaining medium and smaller measures consist primarily of sites in which the dominant measure is a customized measure that does not fit into a specific technology category. These are generally categorized in action codes such as “controls,” “building shell,” or general HVAC system modification (i.e., economizer, conversion to VAV, chiller optimizer, etc.).

These remaining sites, nearly all of which are Customized Program participants, were classified into two strata depending on the avoided cost amounts. Group B sites have avoided cost savings between $100,000 and $400,000, and Group C consists of sites with avoided cost amounts of less than $100,000. Six of the 10 Group B sites were included in the sample, and five of the 14 Group C sites were selected.

The savings for the groups as a whole will be extracted by extending the savings realization rate for the sample group to the group as a whole. Table 2-4 summarizes the research design and sample plan for the HVAC evaluation project. A discussion of each measure group follows.

Table 2-4
HVAC Research Design Summary

	Population			Sample		
Measure Group	# Sites	Avoided Cost	%	# Sites	Avoided Cost	%
Group A: Largest Sites	4	$4,007,041	42.0%	4	$4,007,041	42.0%
Group B: Medium - Various	10	$1,908,734	20.0%	6	$1,096,060	11.5%
Group C: Smaller sites	14	$804,049	8.4%	5	$321,198	3.4%
Group CH: Chiller Replacement	8	$637,537	6.7%	4	$399,176	4.2%
Group CHT: Chiller and Tower	2	$428,377	4.5%	2	$428,377	4.5%
Group CT: Cooling Tower	11	$784,547	8.2%	4	$548,847	5.8%
Group V: VSDs	17	$598,933	6.3%	11	$541,884	5.7%
Group 2: Pkg unit w Therm/timeswitch	52	$217,333	2.9%	0	$0	0.0%
Group 3: Thermostat & timeclock only	8	$61,710	0.6%	0	$0	0.0%
Group 4: Window film	44	$89,983	0.9%	0	$0	0.0%
Total	*170*	*$9,538,244*	*100.0%*	*36*	*$7,447,485*	*77.0%*

Group A

Group A is comprised of four very large sites. These four sites provide 37 percent of program kWh savings. All four sites exceed 800,000 kilowatt-hours in savings annually. These sites provide 49 percent of the total industrial HVAC kilowatt savings and 42 percent of avoided costs. The measures at these four sites also represent the three largest measure-groups: energy management systems, chiller replacement, and cooling towers.

The detailed evaluation for each site consisted of detailed site surveys by senior engineers, interviews with key staff, collection of key performance data from the EMS and/or metering and monitoring activities, and a rigorous engineering modeling approach using DOE-2.

Group B

Group B sites also are marked by large savings. The 10 Group B sites collectively provide 17 percent of the program peak kW savings (together with the Group A sites they total about 66 percent of the kW savings). They also provide an additional 23 percent of the program kilowatt hours savings (with Group A, they total 60 percent), and 20 percent of the shareholder value (with Group A, a total of 66 percent).

Most of the Group B sites are Customized measures not easily categorized or single-measure items. Six of the 10 Group B sites are included in the sample. Three of these sites installed EMSs, and four of these sites installed miscellaneous HVAC measures. These sites also received a detailed site visit and customized DOE-2 analysis.

Group C

Group C consists of 14 sites that make up only 0.7 percent of the kW savings but 14 percent of the energy savings and 8.4 percent of avoided cost. A sample of five Group C sites was included in the study, three EMS-measure sites and two miscellaneous-measure sites. Each site received a DOE-2 analysis.

Groups CH, CHT, and CT

Three groups are comprised of large to medium sized chillers, cooling towers, or a combination of the two. These groups are designated as CH, CT, and CHT, respectively. For each of these three groups, a savings-weighted sample was drawn. The sample sites will received a model-based analysis (either DOE-2 or an engineering “bin analysis.” The sites for these three groups together account for 28 percent of the kW savings, 14 percent of the kilowatt-hour savings, and more than 20 percent of the shareholder value. The sample consisted of 10 of the 21 sites in these groups. All received DOE-2 analyses.

Group V

Group V denotes the 17 VSD sites. These sites account for approximately 6.3 percent of the total program avoided cost. A sample of 11 Group V sites were visited. Two nonweather-sensitive sites received a engineering bin analysis, eight sites received DOE-2 analysis, and the rebated measure could not be located at the final site.

Groups 2, 3, 4

The remaining groups 2, 3, and 4 consist of large populations of small-savings items. Each group is defined by measures. Because of the small savings in these groups, these measures were not included in the analysis sample design. Instead, measure verification audits were performed for theses sites.

Group 2 is made up of the package unit and timeswitch/thermostat group (PG&E measure codes S1-S4 and S17-18). These 52 sites account for 2.9 percent of peak kW savings and 3.4 percent of annual kWh savings. Nearly half of the sites include package units combined with a new timeswitch or thermostat.

Group 3 is comprised of the thermostats and timeclock (only) group. There are eight sites in this group, accounting for less than one percent of the total program avoided cost.

Group 4 is the window film (only) sites. There is a total of 44 sites in this group, accounting for less than 1 percent of the total program avoided cost.

Verification activities involved confirming that the measures were installed and operating.

Sample Plan

For all groups other than Group A, sampling techniques were applied. Size of avoided costs is the most significant criteria considered in selecting sites within each of the measure groups. In most cases, we divided the segment in half by their avoided cost and selected approximately two-thirds of the sample from the sites that are responsible for the larger avoided costs and one-third of the sample from the smaller sites. The final sample was adjusted slightly, based on the ability to recruit several sites.

Overall, the final sites included in the analysis account for 70 percent of total kWh savings, 80 percent of total kW savings, and 97 percent of total Therm savings; see Table 2-5.

Table 2-5
Expected Savings: Analysis Sites vs. Program Population

	# Sites	kWh	kW	Therms	Avoided Cost
Program Total	170	12,751,077	3,889	118,026	$9,538,244
Analysis Sites	36	8,972,175	3,095	114,397	$7,447,485
% of Total	21.2%	70.4%	79.6%	96.9%	77.0%

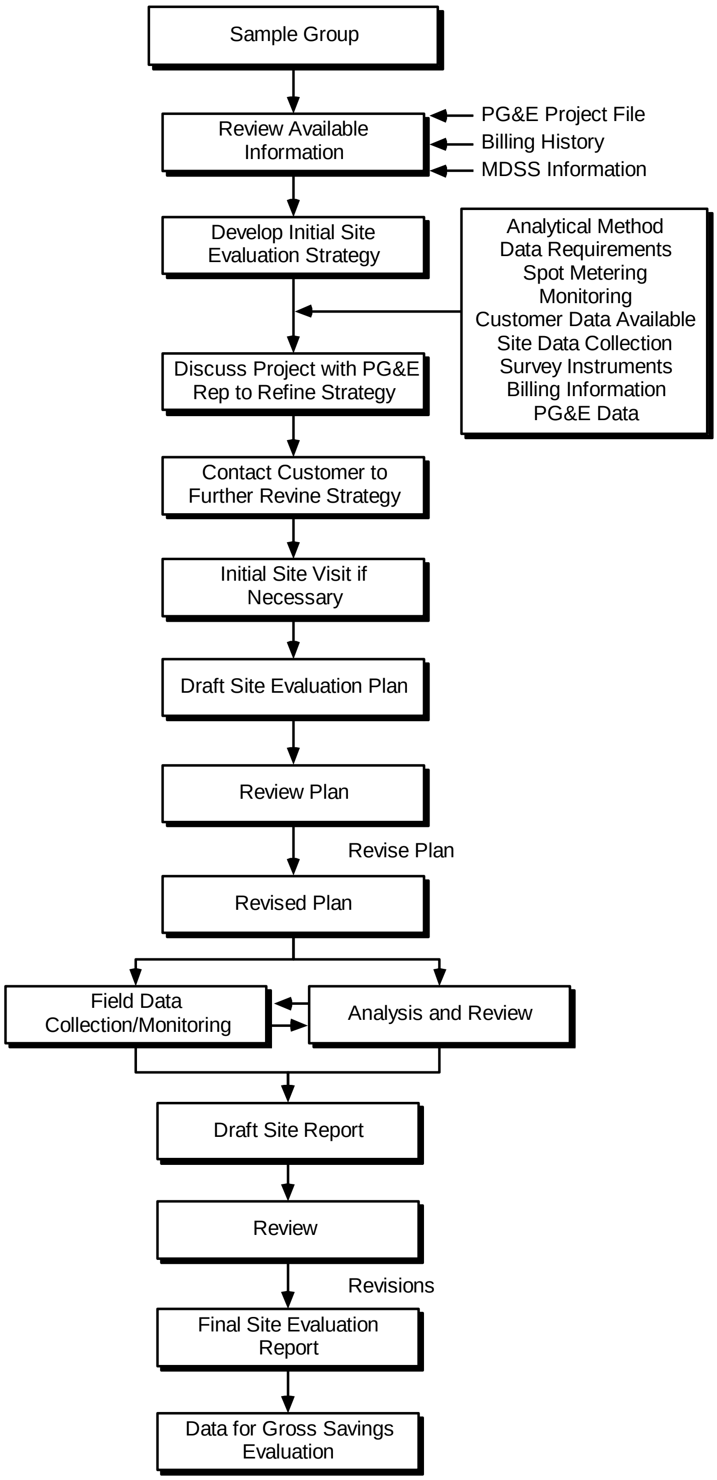
2.3 ESTIMATING GROSS SAVINGS

2.3.1 Site Analysis Procedures

As noted above, the evaluation followed a site-specific approach. Each site in the analysis sample received a customized site-specific evaluation based on the information available, the measures installed, the size of the savings, and other pertinent factors.

All sites followed two primary stages, however: a planning stage and an implementation stage. Figure 2-1 summarizes the site procedures. A discussion of the site analysis procedures follows.

Figure 2-1
Site Procedures



Review of Available Site Information

The first step in the site evaluation process was to review all existing data. Existing data sources include information from MDSS, hard copy of applications, and billing histories. XENERGY then assessed the type of site evaluation required for each site. The primary focus of the initial review was to obtain an understanding of the measures installed and the key assumptions made in the initial impact estimates.

Draft and Review of Site Evaluation Plan

For analysis sites included in the evaluation, XENERGY developed a preliminary evaluation plan specific to the site. The strategy took into consideration any previous analyses and engineering performed, possible metering and/or monitoring strategies, data requirements, data collection approaches, billing history, amount of rebate, total energy savings, and the cost of the proposed evaluation. It then was determined if it was appropriate to perform a computer simulation analysis using DOE-2.1E for the site, or if an enhanced engineering estimate was appropriate. The extent of the required DOE-2 analysis also was determined at this point.

The strategy was refined after discussions with the appropriate PG&E representative. The customer then was contacted to further refine the evaluation strategy. Site logistics and customer convenience issues were factored into the evaluation plans. An initial site visit was performed at this time if it was required to develop the plans.

After contact with the customer, XENERGY submitted a draft evaluation plan that was reviewed and finalized.

Implementation Stage

All data collection and monitoring activities were scheduled and performed in coordination with the customer. The data were analyzed and evaluated and a draft report was produced. The draft site report then was review for completeness, correctness, and clarity by the lead engineer and project managers. Revisions, if needed, were made, and a final site report then was developed. The results from the individual site evaluations were used in the Gross Savings Evaluation.

2.3.2 Analysis Approach

In general, the analytical methods used for the evaluation focused on verifying the pre- and post-retrofit demand and energy use, normalizing the pre-retrofit consumption for operational changes, and observing the difference for each time of use period. Nearly all HVAC measure savings involve reductions in power and energy resulting from reduced motor power which, in turn, is due to efficiency improvements to the fan, pump, or compressor driven by the motor; a reduction in the operating time of the motor-driven equipment; or modifications to the systems or control of systems that the motor-driven equipment serves.

Identifying savings for power consuming equipment or systems required measurement or estimation of baseline and post-retrofit power (kW determined from amperage measurements) and time of use (via monitoring or determined from observations, EMS logs, and interviews). The difference in calculated power and energy for the two cases represents the gross savings. Additional analysis of equipment operation schedules identified the concurrent peak adjustment factors.

Two types of analysis were used for the analysis:

- An hourly load model, DOE 2.1 E, was used to determine savings at the larger savings sites, sites where load profiles were best modeled via building simulations, and other sites where whole-building data collection activities were not too burdensome; and
- An engineering “bin analysis” in a spreadsheet format was used for smaller sites where project resources precluded an hourly model, where load profiles could be determined with reasonable confidence from exogenous sources, and where the technologies being analyzed are amenable to the bin approach.

The choice of modeling approach was based on a review of the PG&E project file and on information gained during the on-site survey. Overall, 33 of the 36 sites in the analysis sample were analyzed using the DOE 2 model. At two of the remaining three sites, an engineering bin analysis was conducted, supported by metering/monitoring of equipment loads. The final site was targeted for an engineering analysis, but the rebated equipment could not be located.

For the DOE 2 hourly load model, a detailed inventory of building shell components and internal loads was completed by trained engineers, working closely with the modeler to assure that the data was collected in the format required for entry into the DOE 2 input file. The data collection process included a review of available plans to catalog building shell components, major HVAC equipment, distribution system configuration, zoning, and lighting equipment. Other internal load equipment was determined by a walk-through of the facility and observation of occupancy density, process equipment, general equipment loads, and special environmental loads. Occupancy and equipment operating schedules were determined by interviews of operating personnel, review of operating logs (from automatic control systems), and direct observation. An attempt was made to confirm all schedules and other learned information through interviews from at least two sources.

For the simpler models, short-term metering and monitoring was related to operating and/or ambient temperature conditions and was annualized using a bin engineering approach. Key data elements included site-specific dry bulb and/or wet bulb temperature profiles, production records, or actual operating parameters such as chiller and condenser supply and return water temperatures.

Study Emphasis

The primary emphasis on the analysis was to improve on PG&E's initial impact estimates by focusing project resources on four key areas:

1. Verification of measure installations;
2. Determination of actual post-installation operating conditions versus predicted operation conditions;
3. Measurement of important operation parameters versus use of assumed values; and
4. Improvement in the analysis methodology.

Verification

As part of the on-site process, measures were confirmed to be installed in a manner consistent with the Program application. In four of the 91 verification visits, some measures could not be confirmed or had been removed. Savings at these sites represented a very small fraction of program totals (about 0.1 percent of avoided costs).

Post-installation Operations

Because the evaluation was conducted during the post-retrofit period, actual operating conditions and equipment usage patterns could be ascertained via monitoring, observation of equipment logs, and interviews with customers. PG&E's estimated impacts were based on forecast or assumed operations that could differ significantly from actual conditions due to changes at the site involving factors such as occupancy patterns and internal loads. Additionally, Express Program savings calculations used standardized operating assumptions while the evaluation used site-specific data.

Measurement of Key Parameters

In many cases, PG&E savings estimates were based on assumptions about key operating parameters. During the evaluation, measurements of these parameters were made on a site-specific basis using equipment logs, metering, and monitoring. Key measurements included motor loadings, chiller and condenser supply and return water temperatures, and building control temperature set points. In some cases, manufacturer's performance specifications particular to the given equipment application were collected and used to support calculations for the post-retrofit and base case technologies.

Methodology

For the evaluation, PG&E's impact methodologies were reviewed for adequacy on a site-by-site basis. Where possible, the evaluation improved on this methodology. Often the evaluation methodology was adjusted to make the best use of available data. For example, if both pre- and post-retrofit submetered data was available, the analysis methodology could be simplified into a comparison of the metered data (with adjustments for any changes in operations).

In many cases, and especially for Express Program measures, PG&E savings were based on simplified calculations that used standardized efficiency changes per equipment unit (such as motor horsepower or chiller tons) times the number of units times full load hours. In these cases, evaluation methods were better able to address actual efficiency gains over a range of part load conditions and for the particular size of equipment being analyzed.

For some of the Customized Program projects, a very thorough, detailed methodology was employed to develop initial savings estimates for the Program application. In these cases, this same methodology was used for the evaluation but was updated to reflect actual post-retrofit conditions.

Key Analysis Issues

A number of important evaluation issues had to be addressed in this study, including: 1) defining baseline energy use; 2) normalizing results to the post-retrofit level of service; 3) annualization of results;

4) model calibration; and 5) locating and verifying equipment. These issues are discussed in this subsection.

Defining the Baseline Technology

Because energy savings are defined as the difference between post-retrofit energy use and baseline energy use, identifying the appropriate baseline technology/process is an important component of the analysis. For the most part, the baseline equipment used to calculate gross savings was set to be consistent with the assumptions used in the original rebate calculation. This approach was chosen by PG&E to provide important feedback to their engineers and program staff about the accuracy of their gross savings calculations for the given baseline equipment.

In cases where an inappropriate baseline was used for the initial savings calculations, the net-to-gross analysis was adjusted to account for the difference between the baseline and what would have occurred without the program. For example, at some sites the initial baseline was fixed at pre-retrofit efficiency levels, whereas “industry standards” or government standards would have dictated a higher nonprogram efficiency level. In these cases, the net-to-gross ratio was adjusted downward to reflect the fact that a standard (and higher) efficiency level would have been chosen anyway, even without the program.

For some Express Program measures, where little to no site-specific information was available from the project files, the baseline determination involved setting the baseline technology *and* the baseline operating characteristics of the affected equipment. In these cases, the site evaluator used information from customer and/or installation contractor interviews to gain an understanding of how the pre-retrofit equipment or standard equipment was or would be operated. This data then was used to characterize the baseline technology and its application. For example with cooling towers, PG&E Express calculations assume standard approach temperature set points that may not be applicable to a given site. For the evaluation, site-specific baseline set points were determined and used in energy impact calculations.

Normalizing Results to Post-retrofit Service Levels

Consistent with the Protocols, energy impacts for this study were normalized to reflect post-retrofit levels of service. For the normalization process, energy usage was related to some measure of site activity (such as production levels, operating hours, or air/fluid flow rates). Then, using this relationship, baseline energy consumption was adjusted to the post-retrofit activity level.

In some cases, this approach was relatively straight forward, especially when the project was a straight retrofit with relatively similar equipment capacities and site activity levels. (The availability of pre-retrofit and/or on-site personnel knowledgeable about pre-retrofit conditions greatly facilitated this effort.)

Many of the rebate projects were associated with significant production/operating changes at the site however. In some of these cases, baseline operating levels were extrapolated past the physical limits of the pre-retrofit equipment by associating the pre-retrofit energy intensity with the new production/operating level. The guideline followed during this normalization process was to establish an adjusted baseline that maintained the efficiency of PG&E's initial baseline technology (which was usually developed based on pre-retrofit operating levels) but scaled energy usage to post-retrofit service levels.

Annualization of Results

In many cases, equipment performance and operating conditions were observed/monitored over a relatively short time frame, whereas the savings must be extrapolated to provide annual results. Similar to the normalization process, energy usage (or savings) per unit of output during the observation period is multiplied by annual output to determine annual energy usage (or savings).

At times, operating records were available to assist in the annualization process. In other cases, hourly load models (such as DOE 2) were used in the analysis and relate building energy usage to typical meteorological year conditions. For some sites, however, annualization of savings was based on interviews with the customers and judgmental adjustments. Annualization with limited data increased the uncertainty of the evaluation results.

Model Calibration

To ensure that the simulation models were tracking site energy usage with reasonable precision, results were calibrated to billing or metering data whenever possible. In limited cases, calibration was not possible because: 1) the affected area was a small part of the total plant being served by one meter, or 2) the billing data was dominated by external loads or other process loads that far exceeded HVAC usage. Overall, six of the 33 DOE 2 analysis sites could not be calibrated to metered or billed data, three sites were calibrated to submetered data, and 24 sites were calibrated to billing data.

Whenever possible, models were calibrated to post-retrofit consumption. For seven sites, pre-retrofit calibration was used. For two of these sites, major site changes occurring during the post-retrofit period negated post-retrofit calibration. For the other five sites, insufficient post-retrofit billing data during the summer month negated post-retrofit calibration.

Locating and Verifying Equipment

To analyze or verify measure savings, the retrofitted equipment had to be located by the on-site surveyor. In very limited instances, it was not possible to locate the equipment. When equipment could not be located, the site surveyor made a determination about the likelihood that the measure was installed, based on discussions with site personnel, the thoroughness of the search given the customer’s time constraints, and his assessment of the size of the measure relative to the size of the site. If it was determined that the measure was probably in place, the site was not included in the analysis, and the program realization rate was applied to the PG&E savings estimates. It was determined that the measure was not in place, site savings were set to zero. An example of a nonverifiable measure installation is a packaged air conditioning unit located in an inaccessible section of the facility’s roof.

2.3.3 Aggregation of Site Findings to Program Findings

This section presents the approach to developing gross savings estimates for the overall project. The primary objective was to combine site and sample information and extrapolate to the population. The gross savings analysis was conducted for the total end use and for each measure group. Savings are reported for kWh, kW, and Therms for each group.

Ratio estimation and stratification were used to extrapolate the results from the detailed site analysis and verifications to the overall program. Because analysis was conducted for 100 percent of Group A sites, estimation is not required for this group. Extrapolation is required for the other groups in which only a sample of sites were evaluated.

The process involves assigning all participants to an analysis strata. The analysis strata could be the same strata used for sampling or could be based on other characteristics that are known for all members of the population. In this case, the sampling strata were used.

Once the stratification is done, a ratio estimator is developed by comparing the initial estimates of savings to the enhanced estimate obtained from site analysis. The total gross impact is derived from the following equation.

$$TOTSAV = \sum_i TOTSAV_i$$

$$TOTSAV_i = \sum_{j \in i} T_j * \frac{\sum_{k \in samp(i)} E_k}{\sum_{k \in samp(i)} T_k}$$

where:

$TOTSAV$	= the total gross energy or demand impact;
$TOTSAV_i$	= the total gross impact for strata i;
T_k	= the tracking system impact estimate for site k; and
E_k	= the evaluation result for site k.

The sampling precision level is calculated using the standard formula for a ratio estimator. The standard error of sampling is primarily a function of the correlation between T and E, the sample size, and the portion of expected savings in the sample. This standard error will under-estimate the overall uncertainty of the total gross impact, however. This under-estimation occurs because the standard error only considers the error from sampling and does not consider any inaccuracy in the enhanced engineering estimate.

2.4 NET-TO-GROSS ANALYSIS

2.4.1 Introduction

This section presents the methodology used in the net-to-gross ratio analysis that was conducted for this project. The net-to-gross ratios developed during the analysis were applied to gross program savings to provide estimates of net or “real” program savings.

The “gross savings” in energy consumption that program participants realize was measured by comparing before and after levels of energy consumption. Gross savings estimates can overstate the real impacts of the program because some program participants might have made some or all of the energy-efficiency equipment changes even without the program in place. These participants are often referred to as "free riders."

The "net savings" are those that can actually be attributed to the program. Without the program, these savings would not have occurred. Net savings are usually found to be lower than gross savings due to the effects of free ridership. In addition, spillover effects, *additional* energy savings induced by the program in nonparticipants and participants, can increase net savings relative to gross savings. For the PG&E Industrial programs, spillover effects were not examined, and the net-to-gross analysis focused on measuring the impacts of free ridership.

A free rider is a program participant who would have, *in the absence of the program*, implemented some or all of the measures for which he/she received program support during the period under analysis. The evaluation employed four net-to-gross classifications:

- *Pure free rider*: a participant who would have installed all program-related measures at the same time even without the program;
- *Partial or incremental free rider*: a participant for whom PG&E did not use the appropriate base case equipment in the estimate of gross impacts. That is, the customer would have installed something anyway, but not of the same efficiency or type as the rebated equipment.
- *Deferred free rider*: a participant who still would have installed program-related measures, but at a later date, if not for the program. If the time of deferral was less than one year, deferred free riders were Customers who indicated that they would have installed the energy-efficiency measures at a time greater than one year from the actual installation date were considered pure free riders.
- *Program-induced Participant*: a participant who would not have installed the energy-efficiency measure in the absence of the program.

2.4.2 Analysis Approach

A separate net-to-gross ratio was estimated for each project in the analysis sample using a self reporting methodology. The net-to-gross sample did not include verification sites that made up less than five percent of program avoided cost savings. The program net-to-gross ratio was calculated by averaging the separate net-to-gross ratios, weighted by the energy savings for each project.

Net-to-Gross Information Sources

Net-to gross information was collected from three sources. The initial data source was from a review of the documentation in the PG&E hard copy file of the retrofits. Many of the files contain memos and other information that provide insight into the reasoning behind the retrofit and the decision process. The second source of data was collected by the evaluating engineer during the on-site survey. The third source of information was developed through follow-up telephone interviews with project decision makers.

On-site Data Collection

Project specific data used to estimate the net-to-gross ratio for each project was collected by the evaluating engineer during the on-site surveys. The purpose of the on-site data collection, from a net-to-gross perspective, was to collect the following types of information:

- background information about the installation;
- potentially significant factors that may have influenced the project purchase decision; and
- the name and contact information of the decision maker for the follow-up telephone interview.

While on-site, the surveying engineer typically asked the following questions:

- What were the primary reasons to install the equipment?
- What factors influenced the decision to install more efficient than standard equipment?

A summary report was prepared for each site. These reports were designed to facilitate the follow-up telephone interview with decision makers and contained the following descriptions:

- the pre-project condition that the project addressed;
- a description of the project; and
- a summery of the net-to-gross issues identified by on-site surveying engineer.

Follow-up Telephone Survey

The follow-up telephone survey instrument (Appendix D) employed open-ended questions that encouraged the decision maker to discuss the relevant factors in the decision making process. Interviewers probed for information about how the rebate effected the efficiency of the equipment installed and whether the rebates influenced project timing. Making use of the project descriptions and preliminary net-to-gross data collected during the on-site surveys, interviewers were able focus the discussion on the key issues concerning how and to what degree the PG&E rebate program influenced each project.

For each project, interviewers tried to contact the primary decision maker. This was not always possible. Many decisions were made by people who were no longer at the company that installed the project. When the primary decision maker was not available, the interviewer would next try to contact someone on the decision making team or someone who was familiar with the decision making process. The contact person was often a facilities engineer who performed the initial analysis and made the initial recommendation. If no person familiar with the project purchase decision could be reached, the project was dropped from the net-to-gross analysis. A total of seven sites were dropped for this reason (six sites involved to one customer).

Additional survey questions were used as consistency checks on the customers' stated intentions. These questions were used to ensure, to the extent possible, that the customer decision maker reported results in a logical, consistent manner and to set limits on the customer-specific net-to-gross ratios when inconsistencies were encountered. These questions examined:

- How important PG&E was in providing information on energy efficiency technologies;
- At what stage in the decision-making process the customer was when he/she first heard about the program; and
- Whether or not the additional cost of the project would have been justified without the rebate.

Site Level Net-to-Gross Analysis Methodology

By nature, a net-to-gross analysis based on self reported data is prone to subjectivity and ambiguity. In practice, the distinction between a free rider and a program-induced participant can frequently be obscure. In many cases, there are elements of both program induced participation and free ridership in a customer's decision to implement a single energy-efficiency project. There are often numerous factors contributing to the decision to implement and energy-efficiency project rather than a single deciding factor. The evaluation attempted to limit this ambiguity in two primary ways:

Develop a Story: Instead of relying simply on the answers to a limited number of generic questions, project-specific net-to-gross evaluations focused on developing the story behind the retrofit. This story was customized to each project and was based on the totality of information collected during the evaluation, not simply the telephone interview. Other key parameters might include the life of the pre-retrofit equipment, the role of PG&E in identifying the retrofit equipment, the magnitude of the rebate amount compared to the rebate cost, and any facility-wide efficiency or related programs undertaken by the customer independent of the rebate program.

Resolve Uncertainty: For each project that had conflicting net-to-gross information from the various data sources, the follow-up telephone survey attempted to focus the participant decision-maker on the conflicting issues to determine the overriding factors affecting net-to-gross calculations. For example, on-site maintenance personnel might have initially indicated that the project would have been done without the rebate, but during the telephone interview, the decision-maker clearly indicated that the rebate was an important factor. The interviewer then would ask the decision maker if there was any support for the maintenance persons beliefs or should they be discarded in the net-to-gross analysis because the maintenance person had no involvement in the decision.

Site-specific "Scoring"

If the first year's energy savings were completely program induced, either because the project would not have been done without the program or because the project was moved forward one year because of the program, then the net-to-gross ratio equaled "1.0."

If the project would have been done the same without the program, saving the same amount of energy and completed in the same time frame, then the project was a pure free rider and the net-to-gross ratio equaled "0.0."

If the project would have been done without the program but was completed sooner because of the program, then the project was a deferred free rider. For these projects, the net-to-gross ratio was estimated by dividing the number of months the project was moved forward by 12 months in a year (e.g., if the project was completed three months sooner due to the program then the net-to-gross ratio was 3 months/12 months = 0.25). If the number of months that the project was moved foreword was not available, then the net-to-gross ratio defaulted to half way between the possibilities (e.g., (1-0)/2 = 0.5).

If the project would have been done without the program but the program increased the efficiency of the project, then the project was an incremental free rider, and the net-to-gross ratio was calculated as a ratio of the energy savings above what would have been installed divided by the energy savings calculated using the PG&E base case. If the energy savings from the intermediate technology that would have been installed was not known, then the net-to-gross ratio defaulted to half way between the possibilities (e.g., (1-0)/2 = 0.5).

Often incremental free riders involved the addition of an other piece of equipment. For example, one chiller was going to be purchased without the program but a second chiller was purchased to take advantage of the rebate. The net-to-gross ratio was calculated as the average net-to-gross ratio for each of the pieces, weighted by the energy savings (e.g., chiller saved 100,000 kWh with net-to-gross of 0.0 and a cooling tower saved 300,000 kWh with a net-to-gross of 1.0, then the net-to-gross for the project = 0.75).

In some cases, incremental free riders resulted because the initial baseline assumptions used in the gross savings analysis were too inefficient. This occurred when the baseline calculations assumed replacement equipment that was less efficient than the “industry standard” technology or less efficient than a lower cost alternative technology.

By probing for details, the interviewers were able to classify most projects as pure free rider or program induced. For most of the rest of the projects, the interviewer was able to quantify incremental savings or timing-based program impacts. In very few cases was the interviewer unable to make a decisive determination and was required to split the difference between the possibilities.

Aggregation of Savings

Site-specific net-to-gross results were aggregated to program results using avoided cost weighting. First, net-to-gross ratios were determined for each sample segment using a weighted average of the analyzed sites within that segment. Next, the program net-to-gross ratio was developed as a weighted average of the segment net-to-gross ratios.

3 EVALUATION RESULTS

3.1 OVERVIEW

This section presents the 1994 impact results for the industrial HVAC end use in PG&E's energy efficiency program. Overall net electric energy savings are estimated to be 5.6 GWh per year, net summer on-peak demand savings are estimated to be 0.78 MW, and net natural gas savings are estimated to be 34,570 Therms per year.

The following impact results are presented below:

- Gross Program savings;
- Net Program savings; and
- Other findings and recommendations.

3.2 GROSS PROGRAM SAVINGS

Gross savings estimates were based on detailed site-specific engineering analyses for a sample of Program sites. Results from these studies were generalized to the Program using a ratio approach. This section first presents Program-wide results, followed by a more detailed discussion of results for sites analyzed in the study, including a discussion of discrepancies.

3.2.1 Program Results

Table 3-1 presents aggregate energy and demand impacts and realization rates. As these numbers indicate, the realization rate was highest for kWh savings, followed by Therm savings and kW savings.

Table 3-1
Summary of Gross Impact Results

	PG&E Estimates	Gross Realization Rate	90% Conf. Interval	Gross Evaluation Results
Annual kWh	12,751,077	0.87	±0.11	11,031,594
Summer On-Peak kW	3,889	0.39	±0.07	1,522
Annual Therms	118,026	0.57	±0.73	67,784

Prior to Program aggregation, realization rates and savings estimates were developed for the key sample segments developed during the research design. Results for these segments are presented in Table 3-2. The program realization rates are savings-weighted averages of the segment realization rates. The program realization rates were applied to the smaller savings segments that were not directly analyzed (see Table 2-4). The Group A and Group B sites are the "high impact" sites and contribute most to the overall program results.

Table 3-2
Realization Rates for Key Sample Segments

Segment	# of Program Sites	Annual kWh		Summer Peak kW		Annual Therms	
		PG&E Estimate	Realiz Rate	PG&E Estimate	Realiz Rate	PG&E Estimate	Realiz Rate
Group A: Large Sites	4	4,182,033	0.84	1883.5	0.37	67,338	0.24
Group B: Medium - Various	10	2,809,738	0.34	661.2	0.34	22,932	-0.06
Group C: Smaller sites	14	1,805,623	1.24	28.0	-1.13	26,222	1.91
Group CH: Chiller Replacement	8	755,817	2.19	269.1	0.98	1,534	1.67
Group CHT: Chiller and Tower	2	368,276	0.45	265.1	0.18	0	-
Group CT: Cooling Tower	11	577,654	0.77	570.1	0.32	0	-
Group V: VSDs	17	1,317,051	0.97	0		0	-
Program			0.87		0.39		0.57

Primary factors contributing to low kW realization rates include much lower than expected savings for Express Cooling Tower measures (reflected in the Group A, CHT, and CT categories), and lower than expected savings for several customized Group B projects. Therm savings were limited to only nine study projects. Negative secondary impacts[1] at one Group B site and lower than expected savings at one Group A site lower the realization rate. Differences between evaluation results and PG&E estimated impacts are further discussed later in this section.

3.2.2 Study Sites

This subsection focuses on study sites that received site-specific analyses. Overall, 36 sites were included in the study (recall that a site is defined as a PG&E control number).

[1] Secondary impacts are project-related impacts that were not addressed by PG&E. In most cases these were kW impacts (both positive and negative).

Table 3-3 presents realization rates by key measure categories. As the table indicates, the measures with the highest realization rates are chillers and ASDs. Realization rates were lowest for cooling towers and EMSs. For the studied sites, it was determined that EMSs tended to increase summer peak demand, resulting in a negative realization rate.

Table 3-3
Realization Rates for Key Measure Categories

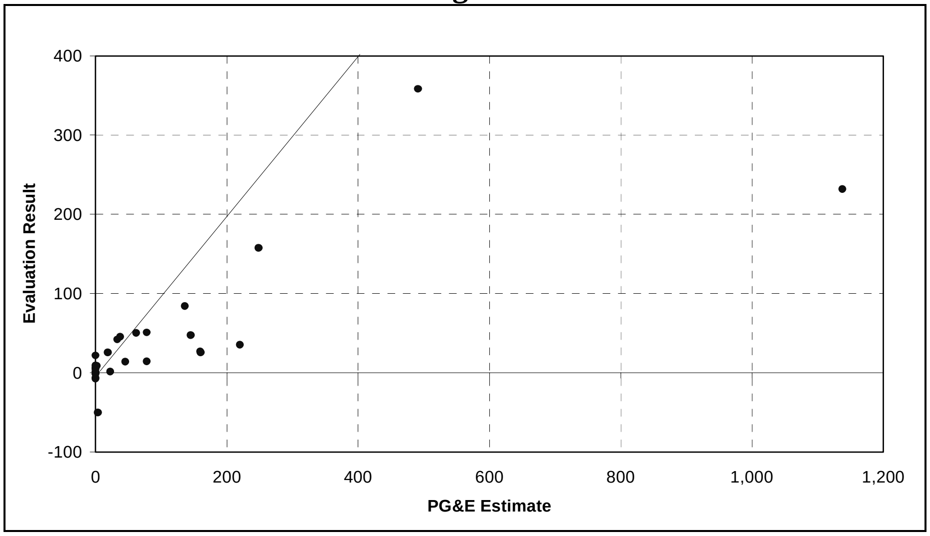
Measure Category	# of Sites**	Annual kWh		Summer Peak kW		Annual Therms	
		PG&E Estimate	Realiz Rate	PG&E Estimate	Realiz Rate	PG&E Estimate	Realiz Rate
Chillers	9	2,925,875	1.34	1023.0	0.85	0	
Cooling Towers	9	1,372,693	0.51	1683.0	0.13	0	
EMS	6	2,334,728	0.47	3.4	-19.20	92,540	0.53
ASD	11	1,147,047	0.97	0.0		0	
Miscellaneous	5	1,146,925	0.50	369.5	0.37	21,857	0.86

** Sites do not sum to 36 due to multiple measure sites.

Figures 3-1 through 3-3 compare evaluation results to PG&E savings estimates for kW, kWh, and Therms, respectively. The diagonal lines represent points where evaluation results and PG&E estimates are equal (realization rates equal to 1.0).

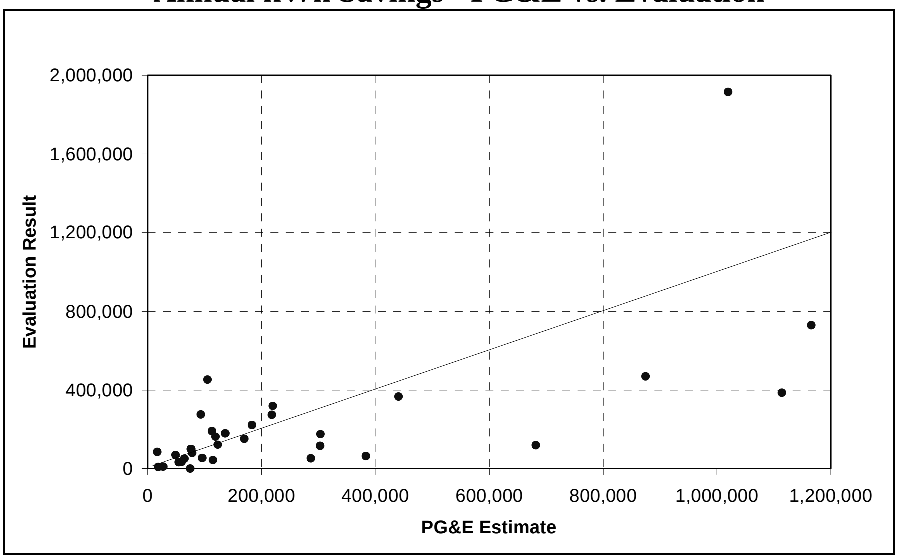
For kW savings (Figure 3-1), most of the points fall below the diagonal line. Evaluation results exceed PG&E estimates in only four of the 18 sites where PG&E estimated kW savings. The evaluation estimated secondary impacts at an additional 13 sites (nine of these site contributed additional savings, while impacts at four sites were negative). Also, most of the large savings sizes have realization rates below 1.0. One very large site has realized savings that are only 20 percent of the PG&E estimate, contributing significantly to the overall kW realization rate of 0.38. This is an Express program chiller/cooling tower site where site specific impacts varied from the assumed average impacts. In addition, the cooling tower savings estimates in the PG&E tracking system overstate what savings should be, based on application of PG&E's savings methodology.

Figure 3-1
Summer Peak kW Savings - PG&E vs. Evaluation



The comparison of annual kWh savings (Figure 3-2) shows a more even distribution of points above and below the diagonal line. Twenty sites have PG&E savings estimates greater than the evaluation result, while evaluation savings exceed PG&E saving at 14 sites. Four of the large impact sites have relatively low evaluation savings relative to PG&E estimates, but one very large site has significantly higher evaluation savings. The low savings sites include two EMS sites and two Express Program chiller/cooling tower sites. The high savings site also is an Express Program chiller/cooling tower site with very high chiller savings due to high process HVAC loads and continuous operation.

Figure 3-2
Annual kWh Savings - PG&E vs. Evaluation



Finally, the annual Therm comparison (Figure 3-3) shows that evaluation results exceed PG&E estimates for three of the six sites at which PG&E impacts were calculated. The largest impact site shows PG&E savings greatly exceed the evaluation result however. This is an EMS site where actual operating conditions differ significantly from those used in the initial impact estimates. Evaluation impacts were determined at an additional three sites where PG&E estimates were zero (one of the three sites had positive savings).

Figure 3-3
Annual Therm Savings - PG&E vs. Evaluation

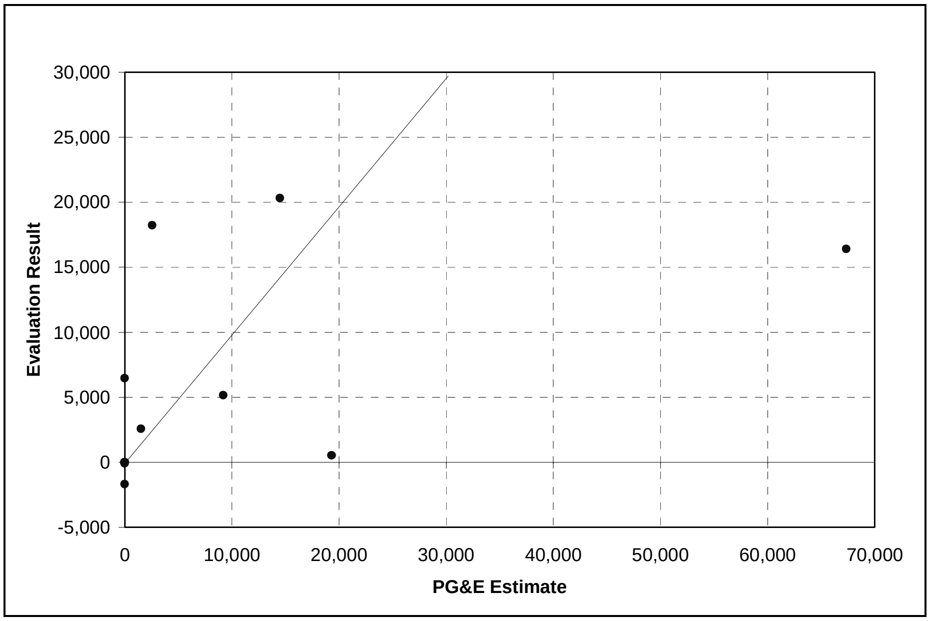


Table 3-4 show distributions of realization rates for the HVAC projects. All projects for which PG&E and/or the evaluation calculated impacts are included. This table summarizes some of the relationships displayed graphically above:

- A significant number of sites had secondary impacts not addressed by PG&E, both for kW and Therm impacts;
- Evaluation impacts for most of the projects were outside the 0.76-1.25 realization rate range, indicating a relatively large deviation between the evaluation results and PG&E's estimated impacts; and
- kWh savings impacts tended to have the highest realization rates.

Table 3-4
Distribution of Realization Rates

Realization Rate	Number of Sites					
	kW	% Sites	kWh	% Sites	Therms	% Sites
> 1.75	1	3%	4	11%	1	11%
1.26 - 1.75	2	6%	7	19%	2	22%
0.76 - 1.25	2	6%	7	19%		
0.25 - 0.75	6	19%	12	33%	1	11%
< 0.25	7	23%	6	17%	2	22%
PG&E Impact=0 / Eval Impact>0	9	29%			1	11%
PG&E Impact=0 / Eval Impact<0	4	13%			2	22%
Totals	31	100%	36	100%	9	100%

Table 3-5 presents the distribution of kWh realization rates by program type. As the table indicates, both Express and Custom programs were subject to inaccuracies in estimating site savings, as indicated by the majority of sites outside the "0.76-1.25" realization rate range. The Express Program significantly underestimated savings for three sites that contributed to about one third of Express Program savings (the three sites in the ">1.75" category.

Table 3-5
Distribution of kWh Realization Rates by Program Type

Realization Rate	Custom	Custom/ Express	Express	Total
> 1.75	1	0	3	4
1.26 - 1.75	5	0	2	7
0.76 - 1.25	4	0	3	7
0.25 - 0.75	6	2	4	12
< 0.25	4	0	2	6
Totals	20	2	14	36

3.2.3 Discussion of Discrepancies

As part of the site-specific analyses, key factors leading to discrepancies between evaluation results and PG&E's estimated impacts were identified. Table 3-6 list key factors causing discrepancies and the number of sites associated with each discrepancy. The PG&E savings impacts for these sites also are shown. (For secondary impacts, the PG&E savings are zero so the evaluation impacts are shown.) These savings impacts are not meant to reflect the magnitude of the discrepancies, rather they provide an indication of the size of the sites (in terms of impact) affected by the discrepancy. Following is a brief discussion of each discrepancy factor.

Table 3-6
Tabulation of Discrepancy Factors

Discrepancy Factor	Sites and Associated Savings Impacts			
	# Sites	kWh	kW	Therms
Equipment/system performance	5	2,272,861	67.4	69,892
Operating conditions	26	8,620,768	3,006	67,338
Methodology inappropriate	5	559,879	98.5	10,729
Secondary impacts	13		32.2	4,705
Reporting system discrepancy	9	3,031,895	2,308.7	1,534

Equipment/ System Performance Different From Projections

PG&E's energy savings estimates are based on projections of the performance of installed equipment and/or systems. These assumptions are typically based on manufacturer's rating of capacity, efficiency, or other measures of efficacy. Equipment may not perform in the field as tested under rating conditions or when operated in the context of their field installation. An example might be the actual kW per ton of a chiller versus the rated value or the inability of an EMS to implement a control strategy due to software or HVAC system limitations. For the Express Program, differences can be exacerbated because the performance assumptions are not site specific.

At many sites, the evaluation was able to collect data on actual post-retrofit performance via metering/monitoring or review of customer data. The evaluation was able to improve on the initial estimates by using actual versus assumed equipment performance in savings calculations/models. Deviations from predicted performance at rating conditions were generally small, but significantly affected impact estimates at a few sites. For one large EMS site, savings were significantly lower than expected because the system performance was different than anticipated.

Different Operating Conditions

Different operating conditions reflect the fact that equipment is being operated at a level or according to an operating strategy that is different from initial PG&E assumptions. These are the most common reasons for discrepancies at these industrial sites, particularly for Express Program measures. Common examples include different chilled water or condenser water temperatures from rating points used in PG&E calculations (for chillers), different water temperature setpoints or control strategies (for cooling towers), different load profiles than initially assumed (for chillers and towers), and different hours of operation from PG&E assumptions (for ASDs, EMSs, chillers, and towers).

At several sites at which Express Program measures were installed, the equipment was installed as part of a system and is operated in parallel or sequentially with other (usually older) equipment. The context of the installation is typically not contemplated in the Express methodology. In many cases, the desired outcome from the equipment does not change (i.e., inside air temperatures), just the operating strategy used to produce that outcome.

Different operating conditions contributed to both under and overestimation of savings impacts.

Inappropriate Methodology

Inappropriate methodologies typically were simplified analyses of complex measures and ranged from not considering all equipment affected by the rebate to inappropriate assumptions about system response to site conditions. (Express Program measures were not included in this category.) The evaluation approach for the five sites in this category was a DOE 2 building simulation, customized to the site.

Secondary Impacts Not Addressed

Thirteen of the 34 sites included impacts that were not addressed in the initial PG&E estimates. All of these sites included additional kW impacts, and three sites included additional Therm impacts. Eight of the 13 sites is this category were ASD sites, and another four sites were EMS sites. Impacts were both positive and negative but generally contributed to increased program savings.

Reporting System Discrepancies

This category mainly includes sites where Express Program calculations could not be reproduced. When savings calculations were performed using the PG&E methodology, savings estimates different from those found in the MDSS tracking system were obtained. (Note: All realization rates are based on PG&E savings estimates in the MDSS database.) The measures affected were all cooling tower measures.

This factor contributed to lower-than expected savings, especially for kW impacts.

3.2.4 Verification Activities at Non-analysis Sites

A total of 91 sites not included in the analysis sample received measure verification audits. For the most part, measures were installed and operating. At four of the 91 sites, a fraction of the measures had been removed. These measures involved programmable thermostats, and they were mainly removed because they were found to be difficult to operate. These measures represented about four percent of the avoided cost of the verification sample and only 0.1 percent of total program avoided cost. Results of the verification study were not integrated into the analysis, because savings were too small to affect overall results.

3.3 NET PROGRAM SAVINGS

This subsection presents net Program savings results. First the results of the net-to-gross analysis are discussed. Next, the net-to-gross ratios are applied to gross program savings to provide estimates of net program savings.

3.3.1 Net-to-Gross Analysis

The objective of the net-to-gross analysis was to determine what would have occurred without the PG&E programs. As discussed in Section 2 of this report, the net-to-gross analysis focused on estimating free ridership. The approach taken was a site-by site assessment of free ridership using data from the program files, information collected during on-site surveys, and most importantly, data from telephone interviews of key participant decision makers.

As a result of the free rider assessment, site-specific net-to-gross ratios were estimated for 28 of the 36 analysis sites included in the gross savings study. One customer did not wish to participate in the follow-up survey, and decision makers at the other seven sites could not be reached to complete the analysis because they had changed jobs (six sites were associated with one customer). As Table 3-7 indicates, these sites accounted for about 65% of the program's first year avoided cost savings.

Table 3-7
First Year Avoided Cost Savings
Program Total vs. Net-to-Gross Sites

Program Total	$603,081
Net-to-Gross Sites	$394,901
% of Total	65%

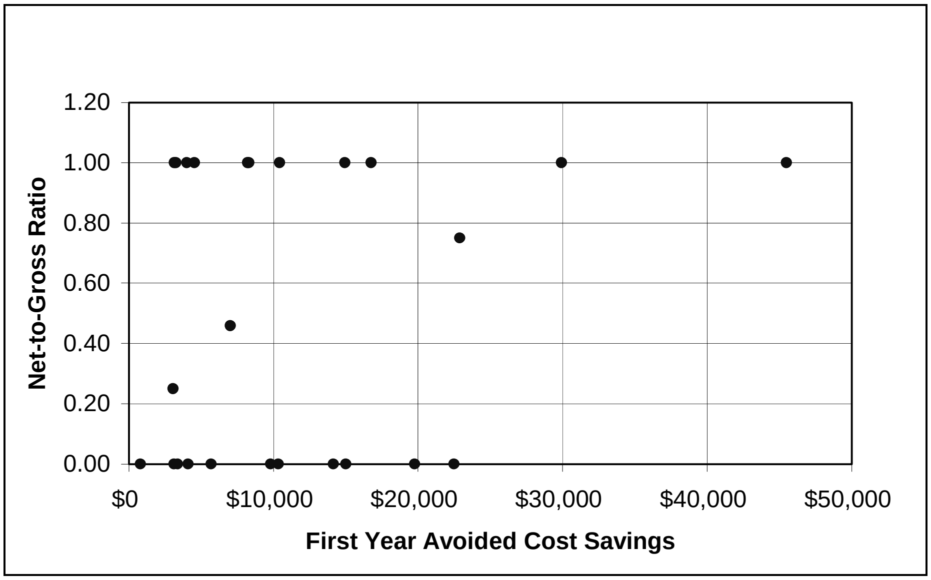
Table 3-8 presents net-to-gross ratios based on a simple average and on a weighted average of study respondents. Weights were based on first-year avoided cost savings to reflect relative project impacts.

Table 3-8
Net-to-Gross Ratios

	Ratio
Unweighted	0.49
Weighted	0.51

As the table indicates, the impact-weighted net-to-gross ratio is 0.51. The table also shows that weighting does not affect the net-to-gross ratios much. This results because the ratios do not vary much by customer "size" as Figure 3-4 (a plot of net-to-gross ratios against avoided cost savings) indicates.

Figure 3-4
Net-to-Gross Ratios versus Avoided Cost Savings



One large site with avoided cost savings of $104,000 and a net-to-gross ratio of 0.25 was omitted from the figure.

Table 3-9 presents a distribution of sites by net-to-gross category. As the table indicates, most of the sites are either pure free riders or program induced participants.

Table 3-9
Site Distribution by Net-to-Gross Category

	# of Sites	Percent
Pure free rider	13	46.4%
Deferred/partial free rider	4	14.3%
Program induced	11	39.3%
Total	28	100%

3.3.2 Net Savings

Evaluation net savings are determined by applying the net-to-gross ratio to evaluation gross savings. Table 3-10 presents the results for annual kWh, summer peak kW, and annual Therms.

Table 3-10
1994 Industrial HVAC Programs
Net Savings Estimates

	Annual kWh	Summer Peak kW	Annual Therms
. PG&E Gross Savings	12,751,077	3,889	118,026
. PG&E Net-to-Gross Ratio	0.67	0.67	0.67
. PG&E Net Savings (1×2)	8,543,222	2,606	79,077
. Evaluation Gross Realization Rate	0.87	0.39	0.57
. Evaluation Gross Savings (1×4)	11,031,594	1,522	67,784
. Evaluation Net-to-Gross Ratio	0.51	0.51	0.51
. Evaluation Net Savings (5×6)	5,626,113	776	34,570
. Net Savings Realization Rate (7÷3)	0.66	0.30	0.44

3.4 OTHER FINDINGS AND RECOMMENDATIONS

During the course of the evaluation, the project team was able to identify several factors that could lead to improvements in the PG&E programs and aid in future evaluations of this type. Key evaluation results indicate that program savings were overestimated, especially for kW impacts. In addition, about half of the program participants appear to be free riders. Recommendations for improving the program follow.

Applicability of Express Measures to Large Sites

For large savings sites, use of the Express Program with its standardized savings estimates and standardized operating estimates can lead to large errors in initial impact estimates. For several large sites, the Express Program estimates were very low, due to higher load factor and increased operating hours at these sites.

Recommendation: Set a savings size limit for the Express Program to ensure that large sites receive Custom applications that are site specific.

Use of Equipment Performance Data

Collection of equipment performance data for some types of equipment, such as chillers, is very difficult during the evaluation, although this information can greatly improve impact estimates. Manufacturers are not inclined to release this information unless one is in the process of purchasing equipment. For larger savings sites, acquisition and use of equipment-specific performance data during the program application process could greatly improve the savings estimates associated with the customized rebate applications.

Recommendation: Require that equipment performance data be obtained and used in rebate application savings calculations for large impact sites.

Monitoring Activities

For sites where pre- and post-retrofit monitoring/metering data exist, evaluation analysis activities often can be greatly simplified. In some cases, the evaluation becomes a verification that the monitoring/metering results are still valid after the equipment has been in the field for some time. Use of monitoring/metering data in the rebate application also can greatly improve the accuracy of the impact estimates.

Recommendation: For larger sites, PG&E should consider guidelines for when monitoring/metering activities for both pre- and post-retrofit periods might be considered or required as part of the application.

Review Express Measure Algorithms

For several measures, particularly cooling towers, the evaluation team could not replicate PG&E savings calculations. There appears to be an error in the Express calculations imbedded in the MDSS database leading to an overestimate of savings in the cases encountered.

Recommendation: Review Express measure calculations and MDSS algorithms to ensure that savings are being estimated correctly.

Free Ridership

The significant number of apparent free riders adversely impact net savings estimates. PG&E customer representatives should work more closely with larger impact customers to determine if they would install the equipment anyway. PG&E should investigate ways to limit the ability of free riders to participate in the programs. In lieu of attempts to limit free ridership, PG&E should incorporate lower net-to-gross ratios into its industrial program design.

Recommendation: Take steps to lower free ridership or incorporate lower net-to-gross ratios in program planning.

A

SITE SPECIFIC RESULTS

This appendix presents gross savings impact results and net-to-gross ratios for the analysis sites included in the study.

Site Specific Savings Results

Sample Group	Site ID	SIC Code	Measure Types	kW Savings			kWh Savings			Therm Savings			Net-to-Gross Ratio
				PG&E	Evaluation	Realization Rate	PG&E	Evaluation	Realization Rate	PG&E	Evaluation	Realization Rate	
H-A	896538	38	EMS	3.4	-50.4	-14.82	1,114,212	385,616	0.35	67,338	16,401	0.24	0.75
H-A	990053	38	Chiller/Cooling Tower	1,137.7	231.9	0.20	1,166,356	728,197	0.62	0	0		1.00
H-A	3750915	36	Chiller/Cooling Tower	491.4	358.1	0.73	1,019,830	1,915,242	1.88	0	0		0.25
H-A	4914633	20	Chiller/Cooling Tower	248.7	157.4	0.63	874,980	467,579	0.53	0	0		1.00
H-B	182725	38	Misc.	160.3	25.3	0.16	286,678	52,776	0.18	19,303	523	0.03	1.00
H-B	5267460	28	Misc.	62.0	50.5	0.81	440,778	365,412	0.83	0	0		0.00
H-B (3)	5324760	35	EMS	0.0	0.5		681,942	119,371	0.18	0	-1,672		1.00
H-B	5914232	35	Misc.	145.2	47.5	0.33	383,540	63,106	0.16	0	0		0.00
H-C	947639	16	EMS	0.0	-6.6		123,634	120,004	0.97	14,473	20,313	1.40	1.00
H-C	1054520	35	Misc.	0.0	4.4		17,152	84,498	4.93	2,554	18,222	7.13	0.00
H-C	4194602	20	Misc.	2.0	8.7	4.35	18,777	7,851	0.42	0	0		0.00
H-C	4537693	27	EMS	0.0	-7.2		220,071	318,128	1.45	0	6,480		1.00
H-C	4833568	15	EMS	0.0	-1.5		169,922	150,226	0.88	9,195	5,165	0.56	1.00
H-CH	4	30	Chiller	33.3	41.9	1.26	93,240	275,266	2.95	0	0		1.00
H-CH	1087449	16	Chiller/EMS	18.8	25.7	1.37	54,947	31,734	0.58	1,534	2,568	1.67	1.00
H-CH	5280685	36	Chiller	37.5	45.5	1.21	105,000	452,086	4.31	0	0		0.00
H-CH	5764782	35	Chiller	78.0	50.8	0.65	218,400	273,459	1.25	0	0		0.00
H-CHT	678075	37	Chiller/Cooling Tower	219.9	35.1	0.16	303,279	114,941	0.38	0	0		0.46
H-CHT	5883953	34	Chiller/Cooling Tower	45.2	13.8	0.31	64,997	51,014	0.78	0	0		1.00
H-CT	1015112	27	Cooling Tower	77.8	14.2	0.18	96,162	53,242	0.55	0	0		0.00
H-CT	3854945	36	Cooling Tower	136.4	84.1	0.62	183,708	220,702	1.20	0	0		0.00
H-CT	4114383	35	Cooling Tower	22.2	1.6	0.07	27,410	8,376	0.31	0	0		
H-CT	6155391	36	Cooling Tower	159.5	26.9	0.17	115,206	42,187	0.37	0	0		0.00
H-V	1043410	33	ASD	0.0	0.6		303,507	174,785	0.58	0	0		1.00
H-V	4380974	35	ASD	0.0	0.0		76,576	98,233	1.28	0	0		
H-V	4382260	36	ASD	0.0	0.0		75,300	0	0.00	0	0		
H-V	4385197	35	ASD	0.0	0.5		136,218	178,269	1.31	0	0		
H-V	4485802	35	ASD	0.0	5.6		59,642	32,764	0.55	0	0		
H-V	4485804	35	ASD	0.0	5.6		59,642	32,757	0.55	0	0		
H-V	4493620	35	ASD	0.0	0.3		119,284	161,420	1.35	0	0		
H-V	4862935	35	ASD	0.0	0.0		76,576	98,251	1.28	0	0		
H-V	4931777	35	ASD	0.0	-0.6		48,945	68,025	1.39	0	-103		0.25
H-V	4973762	23	ASD	0.0	9.0		78,407	79,011	1.01	0	0		0.00
H-V	5817321	36	ASD	0.0	21.7		112,950	189,726	1.68	0	0		0.00

B SAVINGS BY COSTING PERIOD

This appendix presents gross savings by PG&E costing period. Tables are presented in the following order:

- Total industrial HVAC savings
- Sample H-A savings
- Sample H-B savings
- Sample H-C savings
- Sample H-CH savings
- Sample H-CHT savings
- Sample H-CT savings
- Sample H-V savings
- EMS Measures
- Cooling Tower Measures
- Chiller Measures
- ASD Measures
- Miscellaneous Measures

Gross Savings by Costing Period
Total Industrial HVAC Savings

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	1,627	1,522	1.00	1,249,588	0.11
Summer Partial Peak:	1,632	1,881	1.24	1,462,374	0.13
Summer Off Peak:	1,364	1,275	0.84	3,754,955	0.34
Winter Partial Peak:	1,145	708	0.47	1,845,378	0.17
Winter Off Peak:	995	845	0.55	2,719,300	0.25

Annual kWh Savings (6)	11,031,594
Connected load kW Savings (7)	1,341
Summer Therm Savings	23,433
Winter Therm Savings	44,351

Costing Period Definitions

· Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
· Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
· Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
· Winter Partial Peak: Nov. 1 to Apr. 31, 8:30 a.m.-9:30 p.m.
· Winter Off Peak: Nov. 1 to Apr. 30, 9:30 p.m.-8:30 a.m.

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(1) For end-uses limited to either “on” or “off” operation (e.g. lighting):
(Connected load kW savings (7)* number of hours end-use is on in the costing period)/(total number of hours in the costing period)
For end-uses with part-load operating conditions (e.g. HVAC) :
(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E’s system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC Sample H-A

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	655	698	1.00	502,760	0.14
Summer Partial Peak:	627	934	1.34	562,032	0.16
Summer Off Peak:	458	544	0.78	1,260,006	0.36
Winter Partial Peak:	306	211	0.30	493,944	0.14
Winter Off Peak:	250	205	0.29	683,460	0.20

Annual kWh Savings (6)	3,502,202
Connected load kW Savings (7)	610.56
Summer Therm Savings	5,881
Winter Therm Savings	10,520

Costing Period Definitions

· Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
· Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
· Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
· Winter Partial Peak: Nov. 1 to Apr. 31, 8:30 a.m.-9:30 p.m.
· Winter Off Peak: Nov. 1 to Apr. 30, 9:30 p.m.-8:30 a.m.

(1) For end-uses limited to either “on” or “off” operation (e.g. lighting):
(Connected load kW savings (7)* number of hours end-use is on in the costing period)/(total number of hours in the costing period)
For end-uses with part-load operating conditions (e.g. HVAC) :
(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E’s system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC Sample H-B

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	129	223	1.00	99,019	0.11
Summer Partial Peak:	100	218	0.98	89,674	0.10
Summer Off Peak:	98	95	0.43	270,688	0.29
Winter Partial Peak:	90	141	0.63	145,659	0.15
Winter Off Peak:	123	92	0.41	336,278	0.36

Annual kWh Savings (6)	941,318
Connected load kW Savings (7)	148.95
Summer Therm Savings	5
Winter Therm Savings	-1,370

Costing Period Definitions

· Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
· Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
· Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
· Winter Partial Peak: Nov. 1 to Apr. 31, 8:30 a.m.-9:30 p.m.
· Winter Off Peak: Nov. 1 to Apr. 30, 9:30 p.m.-8:30 a.m.

(1) For end-uses limited to either “on” or “off” operation (e.g. lighting):
(Connected load kW savings (7)* number of hours end-use is on in the costing period)/(total number of hours in the costing period)
For end-uses with part-load operating conditions (e.g. HVAC) :
(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E’s system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC Sample H-C

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	31	-32	1.00	23,469	0.01
Summer Partial Peak:	195	1,505	-47.48	175,047	0.08
Summer Off Peak:	287	1,327	-41.85	790,898	0.35
Winter Partial Peak:	285	565	-17.82	459,048	0.21
Winter Off Peak:	288	1,308	-41.27	788,072	0.35

Annual kWh Savings (6)	2,236,535
Connected load kW Savings (7)	-28.05
Summer Therm Savings	16,311
Winter Therm Savings	33,869

Costing Period Definitions

- Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
- Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
- Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
- Winter Partial Peak: Nov. 1 to Apr. 31, 8:30 a.m.-9:30 p.m.
- Winter Off Peak: Nov. 1 to Apr. 30, 9:30 p.m.-8:30 a.m.

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(1) For end-uses limited to either "on" or "off" operation (e.g. lighting):
(Connected load kW savings (7)* number of hours end-use is on in the costing period)/(total number of hours in the costing period)
For end-uses with part-load operating conditions (e.g. HVAC) :
(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E's system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC Sample H-CH

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	227	263	1.00	174,128	0.11
Summer Partial Peak:	240	201	0.76	215,208	0.13
Summer Off Peak:	202	233	0.89	555,711	0.34
Winter Partial Peak:	217	112	0.43	349,326	0.21
Winter Off Peak:	132	178	0.68	360,495	0.22

Annual kWh Savings (6)	1,654,868
Connected load kW Savings (7)	293.25
Summer Therm Savings	1,277
Winter Therm Savings	1,291

Costing Period Definitions

- · Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
- · Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
- · Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
- · Winter Partial Peak: Nov. 1 to Apr. 31, 8:30 a.m.-9:30 p.m.
- · Winter Off Peak: Nov. 1 to Apr. 30, 9:30 p.m.-8:30 a.m.

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(1) For end-uses limited to either "on" or "off" operation (e.g. lighting):
(Connected load kW savings (7)* number of hours end-use is on in the costing period)/(total number of hours in the costing period)
For end-uses with part-load operating conditions (e.g. HVAC) :
(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E's system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC Sample H-CHT

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	43	49	1.00	33,173	0.20
Summer Partial Peak:	35	41	0.83	31,126	0.19
Summer Off Peak:	16	20	0.42	43,233	0.26
Winter Partial Peak:	24	1	0.02	38,514	0.23
Winter Off Peak:	7	17	0.34	19,909	0.12

Annual kWh Savings (6)	165,956
Connected load kW Savings (7)	109.89
Summer Therm Savings	0
Winter Therm Savings	0

Costing Period Definitions

· Summer On Peak:	May 1 to Oct. 31,	Noon-6 p.m. Weekdays
· Summer Partial Peak:	May 1 to Oct. 31,	8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
· Summer Off Peak:	May 1 to Oct. 31,	9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
· Winter Partial Peak:	Nov. 1 to Apr. 31,	8:30 a.m.-9:30 p.m.
· Winter Off Peak:	Nov. 1 to Apr. 30,	9:30 p.m.-8:30 a.m.

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(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC Sample H-CT

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	135	183	1.00	103,315	0.23
Summer Partial Peak:	101	158	0.87	90,694	0.20
Summer Off Peak:	60	64	0.35	166,244	0.37
Winter Partial Peak:	29	7	0.04	46,919	0.11
Winter Off Peak:	13	13	0.07	36,517	0.08

Annual kWh Savings (6)	443,690
Connected load kW Savings (7)	63.50
Summer Therm Savings	0
Winter Therm Savings	0

Costing Period Definitions

· Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
· Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
· Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
· Winter Partial Peak: Nov. 1 to Apr. 31, 8:30 a.m.-9:30 p.m.
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(Connected load kW savings (7)* number of hours end-use is on in the costing period)/(total number of hours in the costing period)
For end-uses with part-load operating conditions (e.g. HVAC) :
(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E's system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC Sample H-V

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	75	66	1.00	57,604	0.05
Summer Partial Peak:	102	72	1.10	91,258	0.07
Summer Off Peak:	142	162	2.47	391,169	0.31
Winter Partial Peak:	159	237	3.60	256,803	0.20
Winter Off Peak:	176	279	4.24	481,405	0.38

Annual kWh Savings (6)	1,278,237
Connected load kW Savings (7)	46.66
Summer Therm Savings	0
Winter Therm Savings	0

Costing Period Definitions

- · Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
- · Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
- · Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
- · Winter Partial Peak: Nov. 1 to Apr. 31, 8:30 a.m.-9:30 p.m.
- · Winter Off Peak: Nov. 1 to Apr. 30, 9:30 p.m.-8:30 a.m.

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(Connected load kW savings (7)* number of hours end-use is on in the costing period)/(total number of hours in the costing period)
For end-uses with part-load operating conditions (e.g. HVAC) :
(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E's system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC - EMS Measures

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	-28	-65	1.00	-21,769	-0.02
Summer Partial Peak:	81	330	-5.09	72,688	0.07
Summer Off Peak:	187	193	-2.98	515,701	0.47
Winter Partial Peak:	36	151	-2.33	58,403	0.05
Winter Off Peak:	175	21	-0.32	476,991	0.43

Annual kWh Savings (6)	1,102,014
Connected load kW Savings (7)	-41.00
Summer Therm Savings	17,854
Winter Therm Savings	31,403

Costing Period Definitions

· Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
· Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
· Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
· Winter Partial Peak: Nov. 1 to Apr. 31, 8:30 a.m.-9:30 p.m.
· Winter Off Peak: Nov. 1 to Apr. 30, 9:30 p.m.-8:30 a.m.

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(1) For end-uses limited to either "on" or "off" operation (e.g. lighting):
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For end-uses with part-load operating conditions (e.g. HVAC) :
(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E's system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC - Cooling Tower Measures

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	193	220	1.00	148,376	0.21
Summer Partial Peak:	157	191	0.87	140,695	0.20
Summer Off Peak:	83	99	0.45	229,378	0.33
Winter Partial Peak:	66	9	0.04	106,735	0.15
Winter Off Peak:	26	42	0.19	72,171	0.10

Annual kWh Savings (6)	697,355
Connected load kW Savings (7)	63.33
Summer Therm Savings	0
Winter Therm Savings	0

Costing Period Definitions

- · Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
- · Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
- · Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
- · Winter Partial Peak: Nov. 1 to Apr. 31, 8:30 a.m.-9:30 p.m.
- · Winter Off Peak: Nov. 1 to Apr. 30, 9:30 p.m.-8:30 a.m.

(1) For end-uses limited to either “on” or “off” operation (e.g. lighting):
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(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E’s system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC - Chiller Measures

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	768	866	1.00	590,041	0.15
Summer Partial Peak:	704	785	0.91	630,340	0.16
Summer Off Peak:	475	553	0.64	1,308,481	0.33
Winter Partial Peak:	435	182	0.21	701,698	0.18
Winter Off Peak:	255	327	0.38	697,443	0.18

Annual kWh Savings (6)	3,928,003
Connected load kW Savings (7)	924.13
Summer Therm Savings	0
Winter Therm Savings	0

Costing Period Definitions

- Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
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- Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
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(2) The kW savings for the targeted end-use at the time of PG&E’s system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

Gross Savings by Costing Period
HVAC - ASD Measures

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	65	43	1.00	50,168	0.05
Summer Partial Peak:	89	47	1.10	79,478	0.07
Summer Off Peak:	124	105	2.47	340,676	0.31
Winter Partial Peak:	139	153	3.60	223,654	0.20
Winter Off Peak:	153	181	4.24	419,264	0.38

Annual kWh Savings (6)	1,113,240
Connected load kW Savings (7)	30.20
Summer Therm Savings	0
Winter Therm Savings	-103

Costing Period Definitions

- · Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
- · Summer Partial Peak: May 1 to Oct. 31, 8:30 a.m.-Noon and 6-9:30 p.m. Weekdays
- · Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
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(1) For end-uses limited to either "on" or "off" operation (e.g. lighting):
(Connected load kW savings (7)* number of hours end-use is on in the costing period)/(total number of hours in the costing period)
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For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW

(2) The kW savings for the targeted end-use at the time of PG&E's system maximum for the costing period.

(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)

(4) Average kW savings (1) * number of annual operating hours in period

(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))

(6) Total annual kWh savings

(7) Connected load kW savings

Gross Savings by Costing Period
HVAC - Miscellaneous Measures

Costing Period	Average kW Savings (1)	kW Savings Coincident with System Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)
Summer On Peak:	95	136	1.00	73,023	0.13
Summer Partial Peak:	67	130	0.95	59,650	0.10
Summer Off Peak:	47	55	0.40	129,442	0.23
Winter Partial Peak:	93	62	0.46	149,775	0.26
Winter Off Peak:	59	96	0.70	161,753	0.28

Annual kWh Savings (6)	573,643
Connected load kW Savings (7)	80.74
Summer Therm Savings	5,619
Winter Therm Savings	13,126

Costing Period Definitions

- Summer On Peak: May 1 to Oct. 31, Noon-6 p.m. Weekdays
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- Summer Off Peak: May 1 to Oct. 31, 9:30 p.m.-8:30 a.m. Weekdays and All Saturdays/Sundays/Holidays
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For end-uses with part-load operating conditions (e.g. HVAC) :
(Summation for all hours in the costing period {full or part load kW savings * number of hours end-use is operating at that full or part load setting}) / (total number of hours in the costing period)
For example, for a chiller for a costing period with 10 hours, if the chiller operates 1 hour with 10 kW savings, 4 hours with 5 kW savings, and 5 hours a 0% load (with no kW savings), the average kW savings would be (1*10+4*5+5*0)/10= 3 kW
(2) The kW savings for the targeted end-use at the time of PG&E’s system maximum for the costing period.
(3) (Coincident kW savings for the costing period)/ (coincident kW savings for the summer on-peak costing period)
(4) Average kW savings (1) * number of annual operating hours in period
(5) (Annual kWh savings in costing period (4)) / (total annual kWh savings (6))
(6) Total annual kWh savings
(7) Connected load kW savings

C PROTOCOLS TABLES 6 AND 7

This appendix presents Tables 6 and 7 of the M&E Protocols for the industrial HVAC evaluation.

M&E PROTOCOLS TABLE 6

Designated Unit of Measurement: LOAD IMPACTS PER PROJECT
ENDUSE: INDUSTRIAL HVAC

1. Average Participant Group and Average Comaprison Group											
A. Pre-install usage:	Pre-install kW	na									
	Pre-install kWh	na									
	Pre-install Therms	na									
	Base kW	na									
	Base kWh	na									
	Base Therms	na									
	Base kW/ designated unit of measurement	na									
	Base kWh/ designated unit of measurement	na									
	Base Therms/ designated unit of measurement	na									
B. Impact year usage:	Impact Yr kW	na									
	Impact Yr kWh	na									
	Impact Yr Therms	na									
	Impact Yr kW/designated unit	na									
	Impact Yr kWh/designated unit	na		**5. A. 90% CONFIDENCE LEVEL**				**5. B. 80% CONFIDENCE LEVEL**			
	Impact Yr Therms/designated unit	na		**LOWER BOUND**	**UPPER BOUND**	**LOWER BOUND**	**UPPER BOUND**	**LOWER BOUND**	**UPPER BOUND**	**LOWER BOUND**	**UPPER BOUND**
2. Average Net and Gross End Use Load Impacts		**AVG GROSS**	**AVG NET**	**AVG GROSS**	**AVG GROSS**	**AVG NET**	**AVG NET**	**AVG GROSS**	**AVG GROSS**	**AVG NET**	**AVG NET**
	A. i. Load Impacts - kW	1,522	776	1,254	1,790	469	1,084	1,313	1,731	759	1,016
	A. ii. Load Impacts - kWh	11,031,594	5,626,113	9,651,928	12,411,260	4,433,272	6,818,954	9,956,377	12,106,811	5,547,035	6,555,732
	A. iii. Load Impacts - Therms	67,784	34,570	-18,605	154,173	-108,937	178,077	458	135,110	-89,612	146,410
	B. i. Load Impacts/designated unit - kW	9	5	7	11	3	6	8	10	4	6
	B. ii. Load Impacts/designated unit - kWh	64,892	33,095	56,776	73,007	26,078	40,111	58,567	71,217	32,630	38,563
	B. iii. Load Impacts/designated unit - Therms	399	203	-109	907	-641	1,048	3	795	-527	861
	C. i. a. % change in usage - Part Grp - kW	na	na	na	na	na	na	na	na	na	na
	C. i. b. % change in usage - Part Grp - kWh	na	na	na	na	na	na	na	na	na	na
	C. i. c. % change in usage - Part Grp - Therms	na	na	na	na	na	na	na	na	na	na
	C. ii. a. % change in usage - Comp Grp - kW	na	na	na	na	na	na	na	na	na	na
	C. ii. b. % change in usage - Comp Grp - kWh	na	na	na	na	na	na	na	na	na	na
	C. ii. c. % change in usage - Comp Grp - Therms	na	na	na	na	na	na	na	na	na	na
D. Realization Rate:	D.A. i. Load Impacts - kW, realization rate	0.39	0.30	0.32	0.46	0.18	0.42	0.34	0.44	0.29	0.39
	D.A. ii. Load Impacts - kWh, realization rate	0.87	0.66	0.76	0.98	0.52	0.80	0.79	0.95	0.65	0.77
	D.A. iii. Load Impacts - Therms, realization rate	0.57	0.44	-0.16	1.30	-1.39	2.27	0.00	1.14	-1.14	1.86
	D.B. i. Load Impacts/designated unit - kW, real rate	0.39	0.30	0.32	0.46	0.18	0.42	0.34	0.44	0.29	0.39
	D.B. ii. Load Impacts/designated unit - kWh, real rate	0.87	0.66	0.76	0.98	0.52	0.80	0.79	0.95	0.65	0.77
	D.B. iii. Load Impacts/designated unit - Therms, real rate	0.57	0.44	-0.16	1.30	-1.39	2.27	0.00	1.14	-1.14	1.86
3. Net-to-Gross Ratios		**RATIO**		**RATIO**	**RATIO**			**RATIO**	**RATIO**		
	A. i. Average Load Impacts - kW	0.51		0.36	0.66			0.39	0.63		
	A. ii. Average Load Impacts - kWh	0.51		0.36	0.66			0.39	0.63		
	A. iii. Average Load Impacts - Therms	0.51		0.36	0.66			0.39	0.63		
	B. i. Avg Load Impacts/designated unit of measurement - kW	0.51		0.36	0.66			0.39	0.63		
	B. ii. Avg Load Impacts/designated unit of measurement - kWh	0.51		0.36	0.66			0.39	0.63		
	B. iii. Avg Load Impacts/designated unit of measurement - Therms	0.51		0.36	0.66			0.39	0.63		
	C. i. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kW	na		na	na			na	na		
	C. ii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - kWh	na		na	na			na	na		
	C. iii. Avg Load Impacts based on % chg in usage in Impact year relative to Base usage in Impact year - Thms	na		na	na			na	na		
4. Designated Unit Intermediate Data				**PART GRP**	**PART GRP**			**PART GRP**	**PART GRP**		
	A. Pre-install average value	1		na	na			na	na		
	B. Post-install average value	1		na	na			na	na		
6. Measure Count Data		**NUMBER**									
	A. Number of measures installed by participants in Part Group	951									
	B. Number of measures installed by all program participants in the 12 months of the program year	23640									
	C. Number of measures installed by Comp Group	na									
7. Market Segment Data											
	B. Distribution of participants by 3 digit SIC code	See next page									

Table 6 (Cont.)
7.B. Market segment data: distribution of participar

SIC3	Percent
131	0.6
138	0.6
152	0.6
153	0.6
154	1.8
161	1.2
171	1.2
173	2.9
174	1.2
201	0.6
203	2.4
204	1.2
206	1.8
207	0.6
208	2.4
233	1.8
239	0.6
251	0.6
265	0.6
267	0.6
271	3.5
272	0.6
275	4.7
278	0.6
281	0.6
283	2.4
284	0.6
289	1.8
291	1.2
295	0.6
301	0.6
308	2.4
322	0.6
327	0.6
331	0.6
334	0.6
335	1.2
341	0.6
342	0.6
344	2.9
347	1.2
351	0.6
352	1.2
353	0.6
356	1.2
357	11.8
363	0.6
366	3.5
367	10.6
369	1.2
371	0.6
372	0.6
373	0.6
376	0.6
381	2.4
382	7.6
384	2.4
386	0.6
399	0.6
652	1.2

M&E PROTOCOLS TABLE 7

A. OVERVIEW INFORMATION

1. Study Title and ID No: Evaluation of 1994 Industrial HVAC Energy-Efficiency Project, #313

2. Program, Program Year, and Program Description: PG&E's Commercial, Industrial, and Agricultural Programs (the CIA Programs): CIA Customized Retrofit Program and CIA Express Retrofit Program; 1994. The Customized Program provides incentives to commercial, industrial, and agricultural customers to install custom-designed energy-efficiency measures. The Express Program provides incentives for commercial, industrial, and agricultural customers to retrofit their facilities with energy-efficient equipment from a pre-specified list of measures.

3. End Uses Covered: Industrial HVAC

4. Methods Used: Site-specific engineering approach

5. Program Participants: Industrial customers who received rebate checks in 1994 for installing HVAC measures

6. Analysis sample size: 36 customers, 46 installations, 951 measures installed, 36 observations (at the site/customer level); these sites accounted for over 70% of the kW, kWh, and therm savings.

B. DATABASE MANAGEMENT

1. Data Flow Chart: See Figure C-1 for a flow chart describing the project data flow.

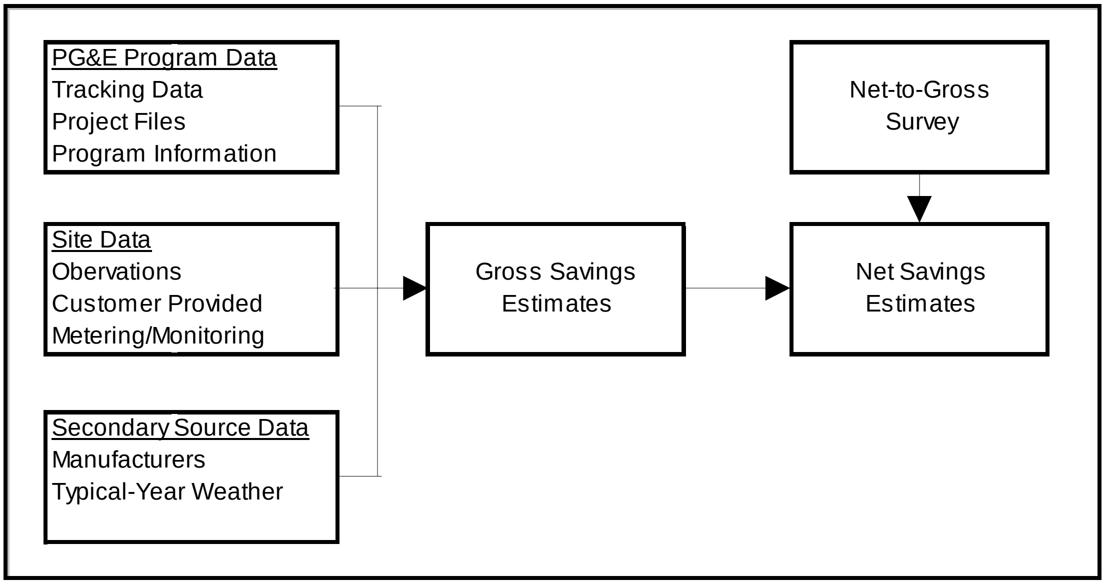
2. Data Sources: See Figure C-1

3. Sample Attrition: 66 sites identified for possible site analyses; 12 customer sites were dropped at PG&E's request for sensitivity reasons not associated with the rebate programs (overcontacting for studies, rate negotiations, reliability problems, etc.); a sample of 36 sites with backups was selected; 2 of these sites refused to participate and were replaced with back-up sites. One of the 36 site analysis sites did not wish to participate in the follow-up net-to-gross phone survey. Seven additional sites were dropped from the net-to-gross analysis because the persons involved in the decision to install measures were no longer with those firms.

4. Quality Checks: Each site analysis was assigned to a senior engineer. This person was responsible for putting together a site analysis plan that made appropriate use of project data.

The plan was reviewed by the lead evaluation engineer and the PG&E project manager. The site analysis was then conducted and a report was produced documenting all site-specific evaluation

Figure C-1



analyses and results. The site report was reviewed by the lead engineer and the PG&E project manager for completeness.

5. Data not used: na

C. SAMPLING

1. Sampling procedures and protocols: Sampling frame - 170 industrial HVAC sites minus 12 sensitive customer sites; Sampling strategy: stratified random sampling with a census of the 4 largest sites; Sampling basis: the site as defined by PG&E control number; Stratification criteria: avoided cost savings and measure type.

2: Survey information: Instrument - see Appendix 4 of this report for the net-to-gross telephone survey guidelines; see Item B3 above for response rates.

3. Statistical descriptions: na

D. DATA SCREENING AND ANALYSIS

1. Outliers: na
2. Background variables: na

3. Data screening: na, all visited sites were included.
4. Regression statistics: na; analysis method was site-specific engineering calculation supported by metering/monitoring.
5. Specification: na; regression model was not used.
6. Error in measuring variables: na, complex site studies made the best use of available data an the analysis approach was chosed to minimize measurement errors.
7: Autocorrelation: na
8: Heteroskedasticity: na
9: Collinerarity: na
10: Influential data points: na
11: Missing data: na
12: Precision: Gross savings - single ratio estimators were utilized; the standard approach for calculating the variance of a ratio estimator was utilized. Net-to-gross: the standard error of the mean net-to-gross ratio was utilized in the precision calculations.

E. DATA INTERPRETATION AND APPLICATION

2. E.1.c was used because the study did not require a comparison group.

D NET-TO-GROSS TELEPHONE SURVEY

This appendix presents the net-to-gross survey guidelines for the follow-up telephone surveys.

Telephone Net-to-Gross Survey Questions
PG&E Retrofit Evaluation Study

Company:	____________________________	Control:	_________________
Call 1:	____________________________	Date:	_________________
Call 2:	____________________________	Interviewer:	_____________
Call 3:	____________________________	Contact Name:	_____________

1. INTRODUCTION/MEASURE IDENTIFICATION

Hello this is <<u>interviewer</u>> of XENERGY. We are working with PG&E to evaluate the performance of PG&E's energy-efficiency programs. This call is a follow-up to earlier on-site work we did on the <<u>name of installed measure(s)</u>>. PG&E provided a rebate for this project.

<<u>Site Contact</u>> provided me with your name in regard to your firm's decision to install:

<<u>Name of installed measure(s)</u>>

I have a few questions to ask you about this project that should take about 5 to 10 minutes of your time.

2. **WHAT WAS YOUR ROLE IN THE DECISION MAKING PROCESS FOR THIS PROJECT?** (IF ROLE OR KNOWLEDGE IS LIMITED, OBTAIN THE NAME AND PHONE NUMBER OF A MORE APPROPRIATE CONTACT.)

3. **DID THE REBATE OR OTHER PG&E ACTIONS INFLUENCE YOUR DECISION TO INSTALL** <<u>NAME OF INSTALLED MEASURE(S)</u>>**? (IF SO, HOW?)**

Company: ___________ Control: _________

4. WHAT WOULD YOU HAVE INSTALLED IF THE PG&E REBATE PROGRAM WERE NOT AVAILABLE?

5. DID THE REBATE OR OTHER PG&E ACTIONS INFLUENCE THE TIMING OF THE PROJECT? THAT IS, WOULD YOU HAVE INSTALLED THE <NAME OF INSTALLED MEASURE(S)> AT SOME LATER DATE ANYWAY? (IF SO, PLEASE EXPLAIN AND GIVE THE APPROPRIATE TIMELINE?)

◊ no influence on timing

would have installed anyway in:

______months or

◊ less than 6 months
◊ 6 months to one year
◊ 1 year to 2 years
◊ more than 2 years

6. CUSTOMIZED QUESTIONS FROM ON-SITE WORK

7. CONSISTENCY CHECKS

a. How did you hear about the <name of installed measure(s)> you installed?

◊ From a PG&E customer representative
◊ From PG&E marketing materials or advertising
◊ Other (please specify)

b. When did you hear about the PG&E rebate programs?

◊ Prior to considering the installation of <name of installed measure(s)>
◊ Prior to determining the cost of installing the <name of installed measure(s)>
◊ Prior to the decision to install the <name of installed measure(s)>
◊ Prior to installation of the <name of installed measure(s)>
◊ Following installation of the <name of installed measure(s)>

c. When did you first talk to PG&E about the project?

◊ Prior to considering the installation of <name of installed measure(s)>
◊ Prior to considering the cost of installing the <name of installed measure(s)>
◊ Prior to the decision to install the <name of installed measure(s)>
◊ Prior to installation of the <name of installed measure(s)>
◊ Following installation of the <name of installed measure(s)>

d. Did PG&E provide you with any project assistance beyond the rebate? (if so, please describe)

◊ no
◊ yes (please describe)

e. Would you have done the <name of installed measure(s)> without the PG&E Rebate?

◊ no
◊ yes
◊ don't know

8. OTHER QUESTIONS

a. Were there any other energy efficiency improvements made at this site during 1994? (If yes, what?)

(1) (If yes) Did PG&E have any influence on your decision to do the project? (if so, Please describe this influence)

Company: ___________ Control: _________

b. What criteria do you use to make decisions about energy efficiency improvements?

(1) What was the [payback[1]] for (the project) including the rebate?

(2) What was the [payback] for (the project) without the rebate?

THIS CONCLUDES THE SURVEY - THANK YOU FOR YOUR TIME.

[1] Use financial criteria from above (e.g. payback, NPV, IRR, etc.)