314

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

Final Report

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314

SECTION E EXECUTIVE SUMMARY E-1
E.1 Background E-1
E.1.1 The Customized Program E-1
E.1.2 The Express Program E-1
E.2 Project Overview E-2
E.2.1 Evaluation Objectives E-2
E.2.2 Gross Savings Analysis E-2
E.2.3 Net-to-Gross Analysis E-2
E.3 Key Findings E-3
E.4 Recommendations E-6

SECTION 1 INTRODUCTION 1-1
1.1 Introduction 1-1
1.2 Project Overview 1-1
1.2.1 Evaluation Objectives 1-1
1.2.2 Description 1-1
1.3 Program Description 1-2
1.3.1 The Customized Program 1-2
1.3.2 The Express Program 1-2
1.3.3 PG&E Savings Estimates 1-3
1.4 Report Organization 1-3

SECTION 2 EVALUATION METHODOLOGY 2-1
2.1 Overview 2-1
2.2 Research Design 2-1
2.2.1 Program Statistics 2-2
2.2.2 Sample Design 2-2
2.3 Estimating Gross Savings 2-5
2.3.1 Site Analysis Procedures 2-5
2.3.2 Analysis Approach 2-8
2.3.3 Aggregation of Site Findings to Program Findings 2-12
2.4 Net-to-Gross Analysis 2-13
2.4.1 Introduction 2-13
2.4.2 Analysis Approach 2-14

SECTION 3 EVALUATION RESULTS 3-1

3.1 Overview 3-1

3.2 Gross Program Savings 3-1

3.2.1 Program Results 3-1

3.2.2 Study Sites 3-2

3.2.3 Discussion of Discrepancies 3-6

3.2.4 Verification Activities at Non-Analysis Sites 3-8

3.3 Net Program Savings 3-8

3.3.1 Net-to-Gross Analysis 3-8

3.3.2 Net Savings 3-11

3.4 Other Findings and Recommendations 3-11

APPENDIX A SITE SPECIFIC RESULTS A-1

APPENDIX B SAVINGS BY COSTING PERIOD B-1

APPENDIX C PROTOCOLS TABLES 6 AND 7 .... C-1

APPENDIX D NET-TO-GROSS TELEPHONE SURVEY D-1

LIST OF FIGURES

Figure E-1 PG&E 1994 Industrial Process Measures Comparison of Annual Energy Impacts E-4
Figure E-2 PG&E 1994 Industrial Process Measures Comparison of Summer Peak Demand Impacts E-4
Figure E-3 PG&E 1994 Industrial Process Measures Comparison of Annual Therm Impacts E-5
Figure 2-1 Site Procedures 2-6
Figure 3-1 Summer Peak kW Savings - PG&E vs. Evaluation 3-4
Figure 3-2 Annual kWh Savings - PG&E vs. Evaluation 3-4
Figure 3-3 Annual Therm Savings - PG&E vs. Evaluation 3-5
Figure 3-4 Net-to-Gross Ratios versus Avoided Cost Savings 3-10

LIST OF TABLES

Table E-1 1994 Industrial Process Measures Gross and Net Savings Estimates E-3
Table E-2 Distribution of Realization Rates E-6
Table 1-1 Sites and Savings Estimates by Category 1994 CIA Programs 1-3
Table 2-1 Size Distribution of Process Savings 2-2
Table 2-2 Industrial Process Energy Savings by End Use 2-2
Table 2-3 Process Research Design Summary 2-3
Table 2-4 Expected Savings: Analysis Sites vs. Program Population 2-5
Table 3-1 Summary of Gross Impact Results 3-1
Table 3-2 Realization Rates for Key Sample Segments 3-2
Table 3-3 Realization Rates for Key Measure Types 3-3
Table 3-4 Distribution of Realization Rates 3-6
Table 3-5 Tabulation of Discrepancy Factors 3-6
Table 3-6 First Year Avoided Cost Savings Program Total vs. Net-to-Gross Sites 3-9
Table 3-7 Net-to-Gross Ratios 3-9
Table 3-8 Site Distribution by Net-to-Gross Category 3-10
Table 3-9 1994 Industrial Process Programs Net Savings Estimates 3-11

E EXECUTIVE SUMMARY

This report presents the 1994 impact evaluation results for the industrial process end use in Pacific Gas and Electric's (PG&E) 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 HVAC, Industrial Miscellaneous measures, and Commercial Miscellaneous measures.

E.1 BACKGROUND

In 1994, PG&E provided retrofit incentives to commercial, industrial, and agricultural customers through two incentive programs:

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

The industrial process measures covered in this evaluation were all installed under the Customized Program. In 1994, a total of 85 sites participated in the Industrial Process portion of the Customized Program. PG&E estimated total impacts at these sites to be 6,286 kW, 42,664,463 kWh, and 8,565,548 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 process 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.

For process measure sites, a site-specific engineering analysis was conducted to determine savings for each site. This approach acknowledged the wide variation in process energy-efficiency measures and the facilities at which these measures were installed.

E.2.3 Net-to-Gross Analysis

To determine net program savings for the industrial process measures, a site-specific net-to-gross analysis was conducted. This analysis 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 site's relative contribution to overall program impacts.

E.3 KEY FINDINGS

Based on the results of the impact evaluation, the 1994 industrial process projects are achieving net electric energy savings of 15.3 GWh per year, net summer peak demand savings of 2.1 MW, and net natural gas savings of 4.8 million therms per year. Table E-1 presents key gross and net evaluation impacts.

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

	Annual kWh	Summer Peak kW	Annual Therms
1. PG&E Gross Savings	42,664,463	6,286	8,565,548
2. PG&E Net-to-Gross Ratio	0.75	0.75	0.75
3. PG&E Net Savings (1×2)	31,998,347	4,715	6,424,161
4. Evaluation Gross Realization Rate	0.76	0.72	1.18
5. Evaluation Gross Savings (1×4)	32,496,113	4,502	10,117,259
6. Evaluation Net-to-Gross Ratio	0.47	0.47	0.47
7. Evaluation Net Savings (5×6)	15,273,173	2,116	4,755,112
8. Net Savings Realization Rate (7÷3)	0.48	0.45	0.74

The table reveals the following key findings:

- Seventy-five percent of gross kWh savings, 72 percent of gross summer peak kW savings, and 118 percent of gross natural gas savings are being realized; and
- The program net-to-gross ratio is estimated to be 0.47, indicating that 47 percent of the realized gross savings can be attributed to the programs.
- Overall, 48 percent of PG&E's net kWh savings estimates, 45 percent of the kW savings estimates, and 74 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 Process Measures
Comparison of Annual Energy Impacts

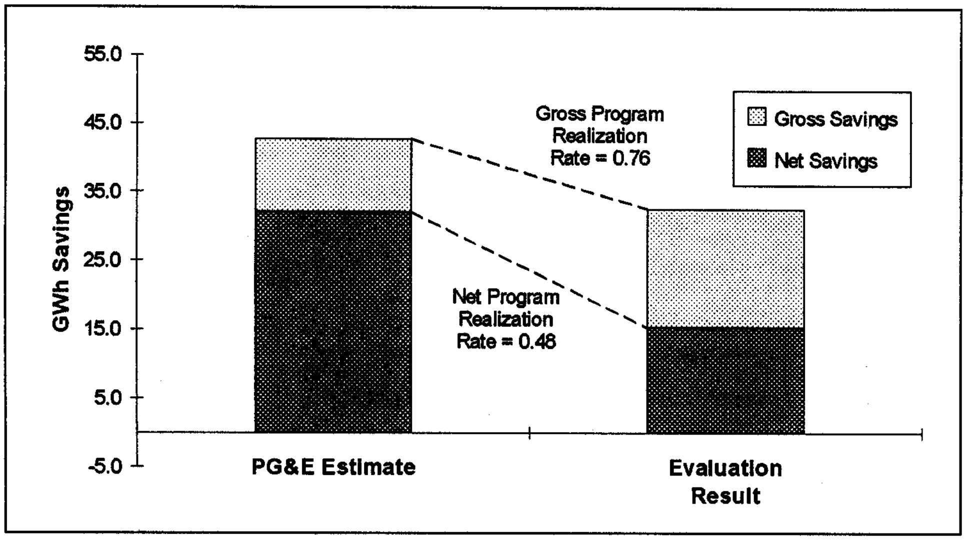


Figure E-2
PG&E 1994 Industrial Process Measures
Comparison of Summer Peak Demand Impacts

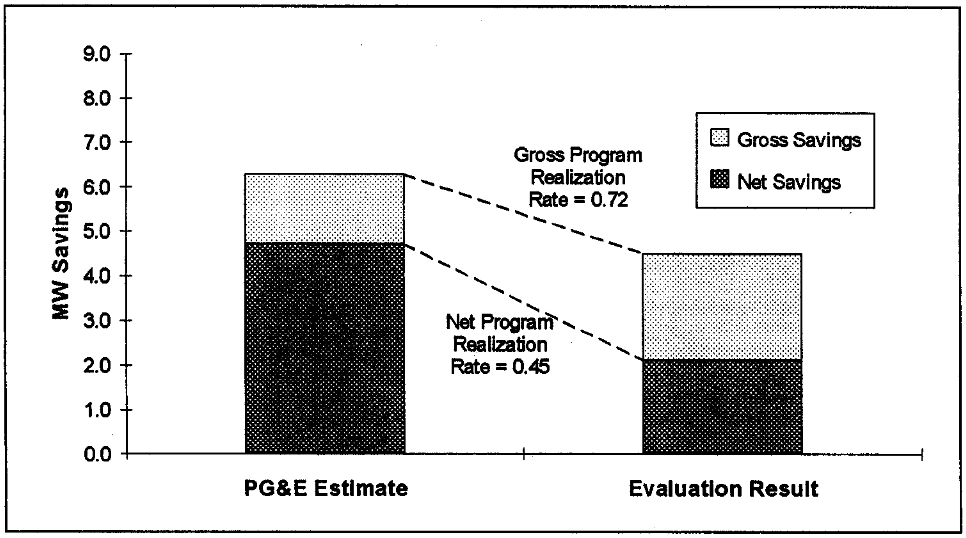
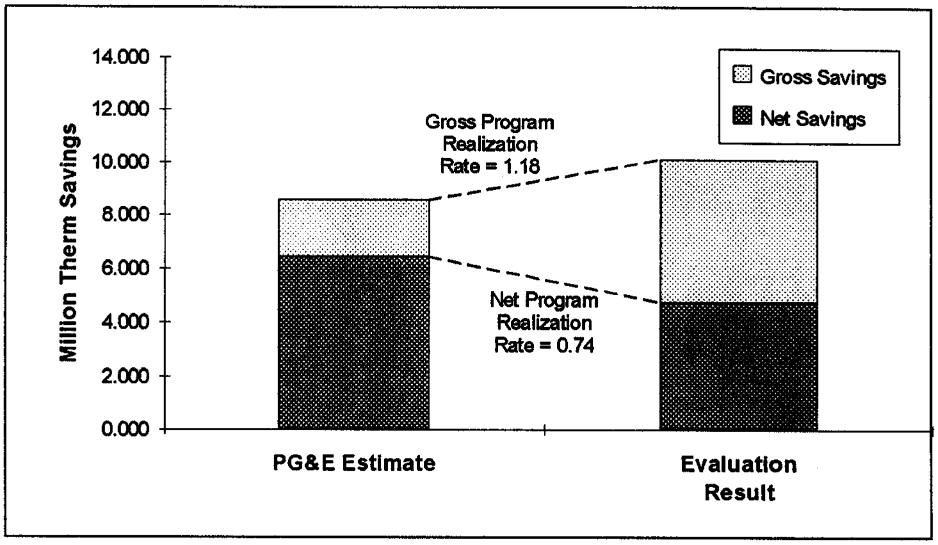


Figure E-3
PG&E 1994 Industrial Process Measures
Comparison of Annual Therm Impacts



Key factors causing realization rates discrepancies include:

- Lower than expected savings for a group of five medium to large electric sites resulting from post-retrofit operation conditions and production levels that are lower than expected;
- Several large natural gas sites with larger than expected savings due to differences in base line assumptions and differences in savings calculation methodologies; and
- A lower than expected net-to-gross ratio that is primarily the result of the largest program project being a free rider.

Overall, boiler projects, compressor projects, and general process modification projects average fairly high realization rate (above 0.90 in most cases). The pumping projects (including the oil pumping projects) achieved lower realization rates on average (in the 0.60 range).

Table E-2 presents the distribution of realization rates for sites analyzed in the evaluation. As the table indicates, about half of the sites were within 0.76-1.25 realization rate range, indicating a reasonably close match between PG&E's ex ante estimates and evaluation results. The table also indicates a number of sites where the evaluation found impacts that PG&E did not estimate.

Table E-2
Distribution of Realization Rates

Realization Rate	Number of Sites					
	kW	% Sites	kWh	% Sites	Therms	% Sites
> 1.75	1	3%	2	7%		
1.26 - 1.75	1	3%	3	10%	3	23%
0.76 - 1.25	[illegible]	48%	15	48%	6	46%
0.25 - 0.75	6	21%	6	19%	2	15%
< 0.25	2	7%	3	10%		
PG&E Impact=0 / Eval Impact>0	2	7%			1	8%
PG&E Impact=0 / Eval Impact<0	3	10%	2	7%	1	8%
Totals	29	100%	31	100%	13	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 (a major contributor to differences between the evaluation and PG&E's results); and
- 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.

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.

Use of Equipment Performance Data

Collection of equipment performance data for some types of equipment, such as chillers or compressors, 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.

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 whether 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 process end use in PG&E's 1994 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 Therm) resulting from industrial process, boiler, refrigeration, 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 to 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 the 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 process end use are discussed in this report.

1.4 REPORT ORGANIZATION

The remainder of the report focuses on the evaluation of industrial process 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.

In the evaluation, "sites" refer to one or more process 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, 26 large sites provide 88 percent of the expected Process avoided cost savings. The remaining 59 sites contribute only 12 percent to savings. Site-specific evaluations were conducted for 22 of the 26 largest sites (a census was attempted) and 24 of the 27 smaller sites; 25 of the remaining 32 smaller sites were subject to verification activities.

Table 2-1
Size Distribution of Process Savings

Size	# Sites	Avoided Cost	Percent of Total
Large	26	46,535,730	88%
Small	59	6,500,962	12%
Total	85	53,036,692	100%

2.2.1 Program Statistics

This section summarizes 1994 PG&E Industrial Process project tracking data as extracted from the PG&E MDSS system. The program savings totaled 42,664 annual MWh, 6,286 peak kW, and 8,565,548 annual Therms. Overall, 93 program measure line items were installed at 85 sites. All measures were installed under the Customized Program.

Table 2-2 presents expected energy and demand savings totals broken down by process boilers and other process measures. As the table indicates, the Process Other category accounts for about 90 percent of the total savings for the process end use. This category consists of measures related to changes in industrial processes, such as modifications to food processing systems, oil pumping systems, compressors, pumps, dryers, and pollution control equipment.

Table 2-2
Industrial Process Energy Savings by End Use

End Use	# of Measures	Annual kWh		Summer Peak kW		Annual Therms	
		Amount	% of Total	Amount	% of Total	Amount	% of Total
Process	82	38,481,558	90%	5,743	91%	7,612,704	89%
Process Boilers	11	4,182,905	10%	543	9%	952,844	11%
TOTAL	93	42,664,463	100%	6,286	100%	8,565,548	100%

2.2.2 Sample Design

The sample design used information on the distribution of savings across sites and across end uses. Sites were categorized by size of savings and by measure category. Avoided cost[1] savings was 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, and 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.

The first step in the sample design was to develop the "Group A" sites. These are the top 26 sites that account for 88 percent of the total avoided costs for the process study.

The next step of the design was to develop sampling segments for the remaining sites. These sites were divided into Process Other and Process Boiler categories. For the Process Other category, a sample of 26 sites was selected for a detailed analysis. The remaining Process Other and Process Boiler sites were targeted for verification activities.

Table 2-3 summarizes the research design and sample plan for the Process evaluation project. A discussion of each measure group follows.

Table 2-3
Process Research Design Summary

		Population			Sample		
End Use	**Measure Group**	**# Sites**	**Avoided Cost**	**%**	**# Sites**	**Avoided Cost**	**%**
Process Other	Group A	19	$40,480,582	76%	16	$35,517,775	67%
Process Other	Remaining Sites	55	$6,123,370	12%	24	$2,976,827	6%
Process Boilers	Group A	7	$6,055,148	11%	6	$5,419,063	10%
Process Boilers	Remaining Sites	4	$377,592	1%	0	$0	0.0%
Total	*Total*	*85*	*$53,036,692*	*100.0%*	*46*	*$43,913,665*	*83%*

Group A - Large Sites

Generally, each site included in the "Large" category contributes significantly to total program savings. These sites each have total avoided costs greater than $350,000.

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

A census of the Group A sites were targeted to receive a detailed site-specific analysis of savings, including detailed on-site surveys, engineering analysis and/or modeling, on-site monitoring where appropriate, and a detailed site report. All but four of the sites were included in the final study.

Remaining Process Other Sites

Nineteen of the Process Other sites are included in Group A, the Large category. The remaining 55 sites are smaller in size and quite diverse in the measures implemented.

A random sample of 27 of these smaller Process sites was selected for site-specific studies, similar in scope to the large sites but somewhat less detailed. Of these, 24 sites were included in the final analysis. (Three sites could not be recruited.) The results from these sample sites then were be applied to the smaller Process group as a whole.

For the 21 of the remaining 28 sites, verification visits were conducted. (We were unable to recruit the remaining seven sites.) In these visits, we verified that the program measures are still installed and are being operated consistent with the energy savings claim that was provided to PG&E with the incentive application.

Remaining Process Boiler Sites

The Process Boiler measures form a more homogeneous group than the other diversified process measures discussed above. The seven largest boiler sites were included in the "Large" Group and were targeted for a detailed analysis. Savings estimates from these Group A boiler sites were applied to the entire boiler measure population in a single-ratio method.

The four remaining Process Boiler sites, representing only one percent of the Process avoided cost received measure verifications similar to the Process Other sites discussed above.

Final Sample

Overall, the final sites included in the analysis account for 70 percent of total kWh savings, 74 percent of total kW savings, and 92 percent of total Therm savings, see Table 2-5.

Table 2-4
Expected Savings: Analysis Sites vs. Program Population

	# Sites	kWh	kW	Therms	Avoided Cost
Program Total	85	42,664,463	6,286	8,565,548	$53,036,692
Analysis Sites	46	29,904,601	4,647	7,846,864	$43,913,665
% of Total	54%	70%	74%	92%	83%

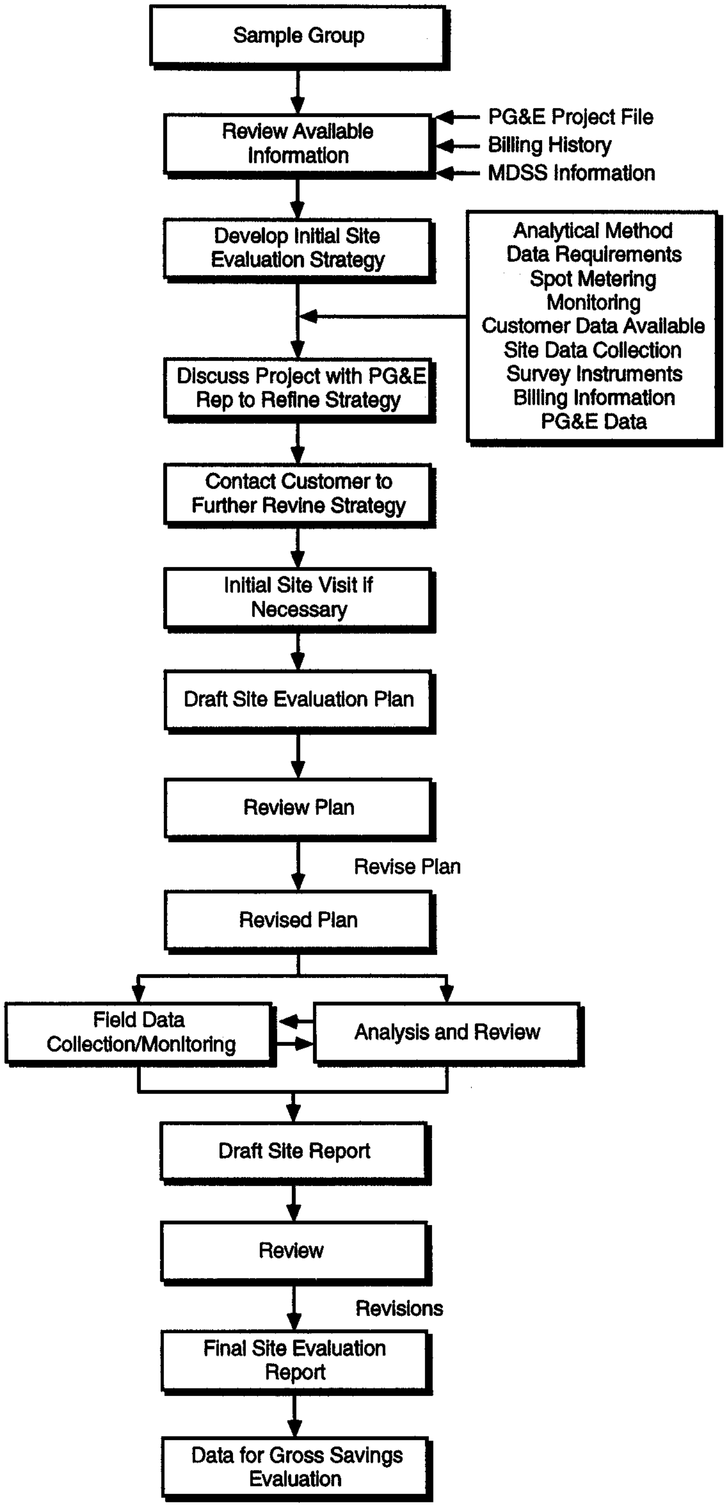
2.3 Estimating Gross Savings

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, however, followed two primary stages: 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.

All of these sites received a Customized Incentive. Each of the Customized measures implemented at these sites have been analyzed individually through engineering procedures identified in the PG&E Customized Incentives Program Manual. As a result, the files for these sites contain a great deal of information about the site, the existing equipment, and the specific retrofit project. Each site has been subjected to a detailed analysis by an engineer. In nearly all cases, the calculations have been reviewed by PG&E at the Division level as well as by General Office Engineering Staff. A careful review of the project files provided a good starting point for the analyses.

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 what type of analysis would probably be required and what types of data collection activities would considered.

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 site 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

From an analytical point of view, two types of evaluations were used for the Process sites:

1. In-depth site-specific engineering evaluations; and
2. Verification surveys.

Detailed Site-Specific Engineering Evaluations

The detailed studies began with a review of the project files and billing records. A site evaluation strategy then was developed and implemented. The final result of this process was a detailed evaluation report.

Several characteristics determined the specific analytical approach for the large and very large sites. Key factors included:

- Measure category: Process Other or Process Boilers;
- Savings Units: kW, kWh, and Therm (kW and kWh savings were more readily monitored);
- Absolute level of savings and level of savings relative to the total metered consumption;
- Pre- and post-project documentation available;
- Site data and information available and customer cooperation;
- Verifiability of pre-and post-project equipment performance and operating assumptions. This relates to the need for spot or short-term measurements to verify pre-and post-project analytical assumptions, and the resources available to take these measurements; and
- Timing/seasonality issues related to production and operating load profiles of the facility or the modified systems.

The site-specific evaluation methodology took all these factors into account. In general, the approach was to review the application documents to identify the technological mechanism through which the savings are achieved, identify an analytical methodology based on accepted engineering principles that would document the savings, identify the key operating assumptions or measurements required to use the methodology with confidence, determine the best way to confirm the measurements or assumptions, conduct the site work to gather the required information, and finally to analyze the results and present the results.

A detailed site-specific summary report for each site was produced. The report included a summary of the measure, a breakout of the savings by PG&E time periods, a description of the PG&E methodology and the evaluation methodology, a description of the results from the two analyses, and an explanation for any discrepancies.

Verification Surveys

Verification surveys were conducted for most Process sites not receiving a full analysis.

The Verification surveys confirmed (or refuted) the installation of the measure at the sample sites and determined if the equipment was being used in a manner consistent with documentation in the Program application.

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 one case, a customer had gone out of business and savings were therefore set to zero.

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.

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-retrofit 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 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 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; and 4) 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. PG&E chose this approach 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.

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. 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.

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 radio transmitter located at the top of a tower.

2.3.3 Aggregation of Site Findings to Program Findings

This section presents the approach for development of 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. 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 results 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 using a self reporting methodology. 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. One site was dropped for this reason.

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 are encountered. These questions examine:

- 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. Often, numerous factors contribute 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, than 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., compressor #1 saved 100,000 kWh with net-to-gross of 0.0 and compressor #2 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 project 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

Sites-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 process end use in PG&E's retrofit energy efficiency programs. Overall net electric energy savings are estimated to be 15.3 GWh per year, net summer on-peak demand savings are estimated to be 2.1 MW, and net natural gas savings are estimated to be 4.8 million 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 therm savings, followed by kWh 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	42,664,463	0.76	±0.08	32,496,113
Summer On-peak kW	6,286	0.72	±0.12	4,502
Annual Therms	8,565,548	1.18	±0.11	10,117,259

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 P-A and P-1, Process Other, sites contribute most to the kWh and kW savings, while the P-A and B-A, Process Boiler, sites contribute most to the therm savings.

Table 3-2
Realization Rates for Key Sample Segments

Segment	# Program Sites	Annual kWh		Summer Peak kW		Annual Therms	
		PG&E Estimate	Realiz Rate	PG&E Estimate	Realiz Rate	PG&E Estimate	Realiz Rate
P-A: Large Process	19	26,382,895	0.90	3,894	0.82	7,569,830	1.19
P-1: Smaller Process	55	12,098,663	0.70	1,849	0.67	42,874	2.72
B- : Process Boilers	11	4,182,905	0.10	543	0.10	952,844	1.06
			0.76		0.72		1.18

Electric kWh and kW realization rates were very low for the Process Boilers, but the overall magnitude of the electric savings was small. This was the result of only one site (the remainder of the Boiler sites were gas impact only). Realization rates were relatively high across the board for the Large Process Other sites.

3.2.2 Study Sites

This subsection focuses on study sites that received site-specific analyses. Overall, 46 sites were included in the study (recall that a site is defined as a PG&E control number).

Table 3-3 presents realization rates for key process measure categories. Process modifications/upgrades was the largest measure category. The pumping measure categories tended to have the lowest realization rates.

Table 3-3
Realization Rates for Key Measure Types

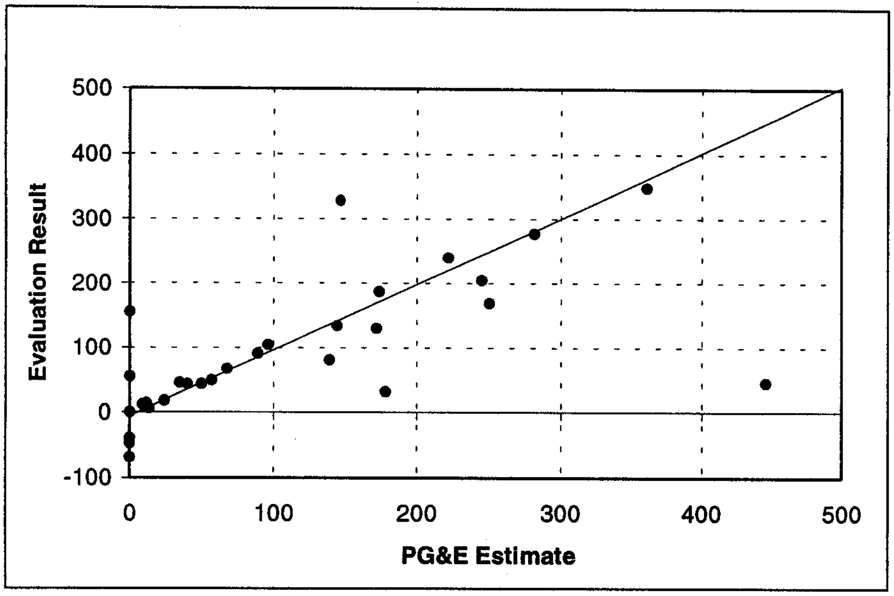
Segment	# Program Sites	Annual kWh		Summer Peak kW		Annual Therms	
		PG&E Estimate	Realiz Rate	PG&E Estimate	Realiz Rate	PG&E Estimate	Realiz Rate
Boilers	4**	0		0		621,356	1.21
Compressors	9	4,274,857	0.86	548	0.90	0	
Oil Pumping	5	8,292,887	0.65	692	0.95	0	
Process Modifications	14	8,776,806	0.96	2,035	0.71	7,225,508	1.17
Pumps/Pumping Systems	6	8,560,051	0.63	1,371	0.59	0	

** Does not match Process Boiler total in Table 2-3 because 2 Process Boiler sites did not install true boiler measures.

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 at which 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 near the diagonal line. Two of the largest impact sites (including the large site not shown on the graph) have evaluation results that are much lower that PG&E estimates. Both sites were found to have significantly lower post-retrofit operating levels that initially anticipated. These two sites contribute most to a lower realization rate of at 0.72.

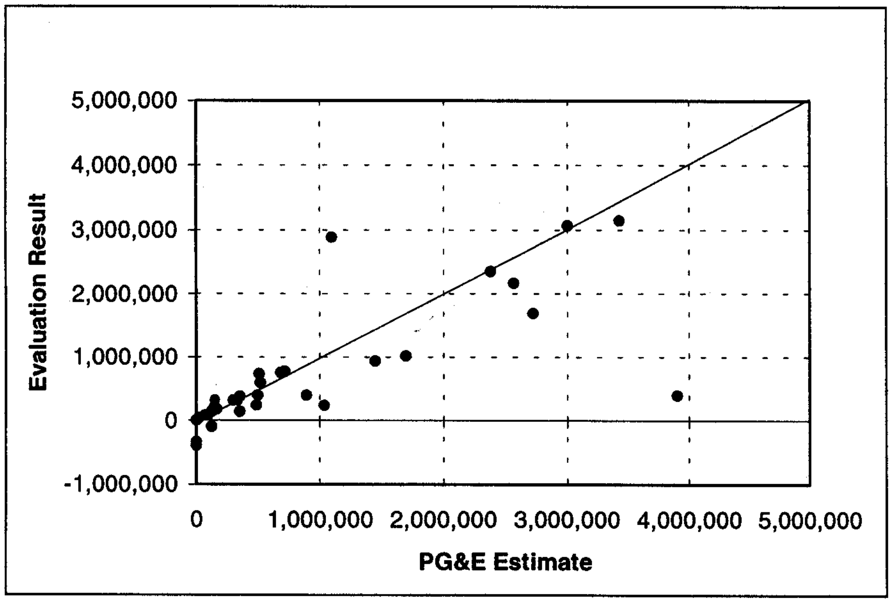
Figure 3-1
Summer Peak kW Savings - PG&E vs. Evaluation



One large impact site with a PG&E estimate of 1,390 kW and an evaluation estimate of 704 kW is excluded from the graph.

The comparison of annual kWh savings (Figure 3-2), shows that a number of medium to large impact sites fall below the diagonal line, indicating that the evaluation result is somewhat lower than the PG&E estimate. This leads to the realization rate estimate of 0.76. The low evaluation savings result for the largest PG&E impact site is again the result of lower than expected post-retrofit operating levels.

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



Finally, the annual therm comparison (Figure 3-3) shows that results are dominated by three large sites. For two of these sites (and the largest site in particular), evaluation results exceed PG&E estimates, leading the 1.21 realization rate.

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

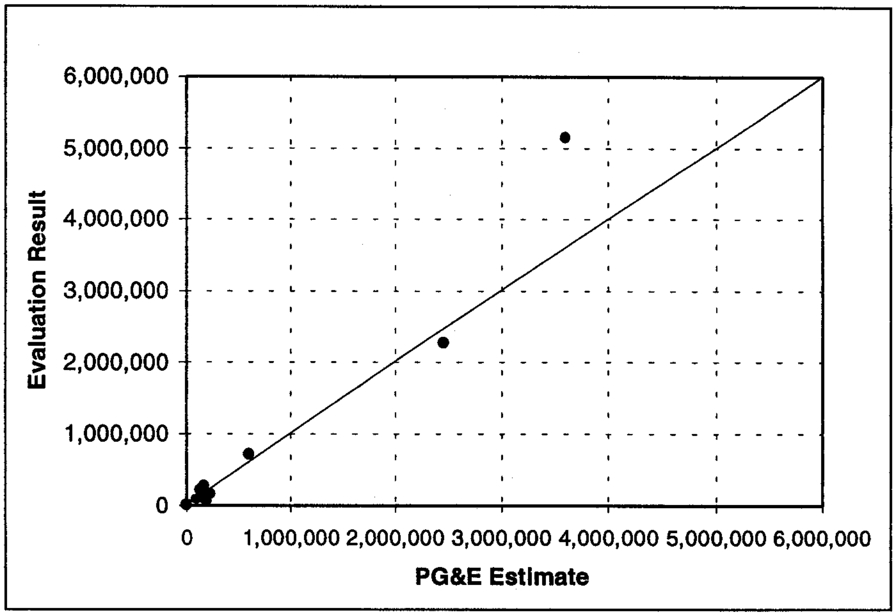


Table 3-4 shows distributions of realization rates for the Process projects. All projects for which PG&E and/or the evaluation calculated impacts are included. This table summarizes some of the relationships displayed graphically above:

- A number of sites had secondary impacts not addressed by PG&E, mainly for kW impacts; sites were split relatively evenly between positive and negative impacts;
- Evaluation impacts for about half of the projects were within the 0.76-1.25 realization rate range, indicating a relatively close match between PG&E and evaluation results; and
- A significant number of kW and kWh impact sites had realization rates less than 0.75.

Table 3-4
Distribution of Realization Rates

Realization Rate	Number of Sites					
	kW	% Sites	kWh	% Sites	Therms	% Sites
> 1.75	1	3%	2	7%		
1.26 - 1.75	1	3%	3	10%	3	23%
0.76 - 1.25	14	48%	15	48%	6	46%
0.25 - 0.75	6	21%	6	19%	2	15%
< 0.25	2	7%	3	10%		
PG&E Impact=0 / Eval Impact>0	2	7%			1	8%
PG&E Impact=0 / Eval Impact<0	3	10%	2	7%	1	8%
Totals	29	100%	31	100%	13	100%

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 3-5 lists 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 3-5
Tabulation of Discrepancy Factors

Discrepancy Factor	Sites and Associated Savings Impacts			
	# Sites	kWh	kW	Therms
Equipment/system performance	15	12,774,061	1,407	495,506
Operating conditions	26	13,836,765	2,894	4,096,073
Methodology inappropriate	5	9,773,585	1,886	188,562
Different Methodology	2	1,704,050	222	3,735,987
Secondary impacts	8	-742,968	52	107,912

Equipment/ System Performance Different From Projections

PG&E's energy savings estimates are assumptions based on how installed equipment will perform at specified operating conditions. Performance factors include such items as operating kW at certain load conditions (motors or pumps/fans), rated efficiency at certain loads (boilers), control system behavior in unloaded or at specified part load conditions (compressors), and the effectiveness of pumping controls to optimize cycling or control strategies (oil well pump controls). At some sites, the evaluation was able to collect data on actual post-retrofit performance via metering/monitoring and review of customer data. The evaluation was able to improve on the initial estimates by using actual versus predicted performance in savings calculations/models.

Different Operating Conditions

Different operating conditions reflect the fact that equipment is being operated in a manner that is different from initial PG&E predictions. This may include total production quantities, production rates, operating schedules, or other factors that affect equipment performance such as operating temperature and pressures.

In some cases, equipment is installed as part of a system and the relationship of the equipment within the system is changed, either as a result of the retrofit project or because of operating changes made subsequent to the retrofit project (such as the new compressor becoming the "lead" compressor when replacing an older "lag" compressor, due to its age). In many cases, the desired outcome from the equipment does not change (i.e., the air flow and pressure in the case of a compressor), but the operating conditions or equipment operating strategy used to produce that outcome does change.

At some sites, operating hours or schedules were different than initially predicted. At a few sites it was found that the systems did not operate during the summer on-peak coincident period, resulting in little or no demand savings. At a number of sites, the evaluation revealed that equipment cycled or experienced a diversity factor that was not considered in the PG&E calculations.

Changes in operating conditions contributed to both over and underpredictions of program savings.

Inappropriate Methodology

Inappropriate methodologies ranged from not considering all equipment affected by the rebate to oversimplification of calculations for complex processes to misunderstanding the performance of equipment in the context of the system.

The inappropriate models consistently overpredicted savings.

Methodology Differences

This category consisted of two sites that used an ex ante savings estimation methodology that was so different from the evaluation methodology that the reasons for saving impact differences were difficult to discern. These were sites where the initial PG&E savings analysis consisted of an engineering approach and the evaluation used a production/measurement method.

Secondary Impacts Not Addressed

Eight sites included impacts that were not addressed in the initial PG&E estimates; these are referred to as secondary impacts. All of these sites included kW impacts and three sites included additional therm impacts. Impacts were both positive and negative but generally contributed to increased program savings.

3.2.4 Verification Activities at Non-Analysis Sites

A total of 32 sites not included in the analysis sample received measure verification audits. For the most part, measures were installed and operating as expected. One of the 38 sites is now out of business. Savings for this site represent about 1.3 percent of total kW and kWh savings. The absence of savings were factored into the calculation of gross evaluation savings.

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 is 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 41 of the 46 analysis sites included in the gross savings study. (The appropriate decision makers at the other five sites could not be reached to complete the analysis.) As Table 3-6 indicates, these sites accounted for about 79% of the program's first year avoided cost savings.

Table 3-6
First Year Avoided Cost Savings
Program Total vs. Net-to-Gross Sites

Program Total	$4,528,887
Net-to-Gross Sites	$3,560,935
% of Total	79%

Table 3-7 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 3-7
Net-to-Gross Ratios

	Ratio
Unweighted	0.68
Weighted	0.47

As the table indicates, the weighted net-to-gross ratio is 0.47 while the unweighted ratio is 0.68. Weighting the results significantly lowers the net-to-gross ratios because the largest site has a net-to-gross ratio of zero and exerts significant influence on the weighed results. (Removal of this site changes the weighted net-to-gross ratio to 0.75.)

Figure 3-4 (a plot of net-to-gross ratios against avoided cost savings) highlights the impact of the large site on the weighted net-to-gross ratio.

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

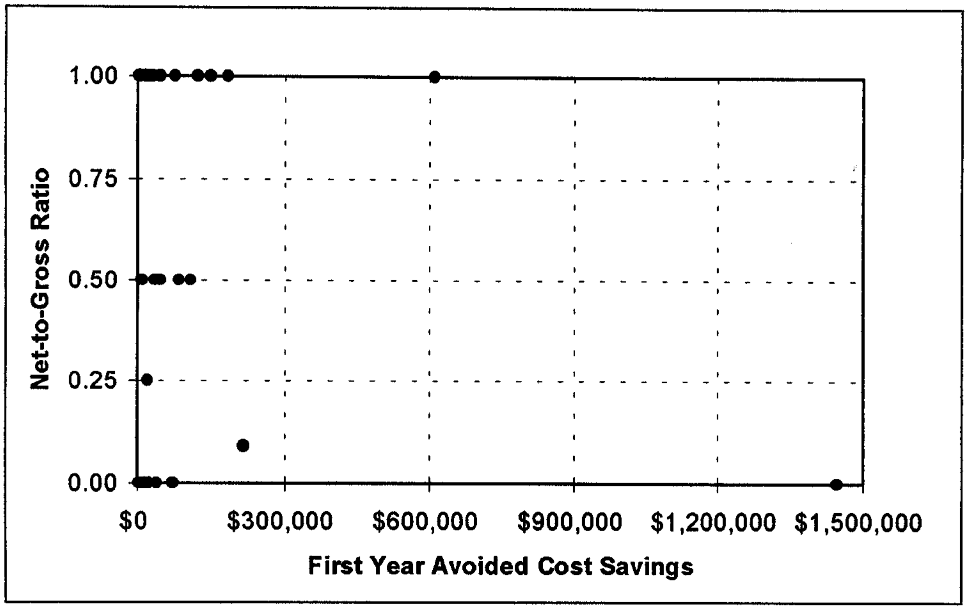


Table 3-8 presents a distribution of sites by net-to-gross category. As the table indicates, most of the sites are either deferred/partial free riders or program induced participants. The larger sites exert a large influence on the overall program totals, however.

Table 3-8
Site Distribution by Net-to-Gross Category

	# of Sites	Percent
Pure free rider	6	15%
Deferred/partial free rider	12	29%
Program induced	23	56%
Total	41	100%

There are a number of reasons why larger projects might tend more towards free-ridership. Large impact projects are commonly initiated by facility personnel as opposed to PG&E representatives. One reason for this is that, because of the potentially larger monetary savings, facility personnel are able to identify the project and develop an interest in it independent of PG&E. A second reason is that the largest impact projects are often very customized to the customer's process (as opposed to projects such as simply adding a variable-frequency drive on a process motor), and the utility simply may not have the expertise to identify these projects for the customer.

3.3.2 Net Savings

Evaluation net savings are determined by applying the net-to-gross ratio to evaluation gross savings. Table 3-9 presents the results for annual kWh, summer peak kW, and annual therms.

Table 3-9
1994 Industrial Process Programs
Net Savings Estimates

	Annual kWh	Summer Peak kW	Annual Therms
1. PG&E Gross Savings	42,664,463	6,286	8,565,548
2. PG&E Net-to-Gross Ratio	0.75	0.75	0.75
3. PG&E Net Savings (1×2)	31,998,347	4,715	6,424,161
4. Evaluation Gross Realization Rate	0.76	0.72	1.18
5. Evaluation Gross Savings (1×4)	32,496,113	4,502	10,117,259
6. Evaluation Net-to-Gross Ratio	0.47	0.47	0.47
7. Evaluation Net Savings (5×6)	15,273,173	2,116	4,755,112
8. Net Savings Realization Rate (7÷3)	0.48	0.45	0.74

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.

Use of Equipment Performance Data

Collection of equipment performance data for some types of equipment, such as chillers or compressors, 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.

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 PG&E	kW Savings Evaluation	kW Savings Realization Rate	kWh Savings PG&E	kWh Savings Evaluation	kWh Savings Realization Rate	Therm Savings PG&E	Therm Savings Evaluation	Therm Savings Realization Rate	Net-to-Gross Ratio
P-A	168380	32	Process Modifications	1,390.0	704.0	0.51	3,433,424	3,138,548	0.91	0	0		0.09
P-A	362052	30	Compressors	282.0	277.0	0.98	2,382,336	2,346,744	0.99	0	0		1.00
P-A	1013574	20	Compressors	172.0	129.2	0.75	891,642	382,092	0.43	0	0		1.00
P-A	1115740	26	Process Modifications	89.0	90.8	1.02	714,620	762,858	1.07	0	-546		0.00
P-A	4387722	13	Oil Pumping	245.0	205.0	0.84	2,570,180	2,167,337	0.84	0	0		0.50
P-A (4)	4481035	13	Oil Pumping	0.0	155.0		2,731,136	1,690,035	0.62	0	0		0.50
P-A	4670922	30	Pumps/Pump Systems	144.7	132.6	0.92	682,312	756,957	1.11	0	0		1.00
P-A	5005804	34	Process Modifications	96.4	102.8	1.07	524,749	593,058	1.13	0	0		0.50
P-A	5589358	13	Pumps/Pump Systems	361.0	348.8	0.97	3,004,242	3,055,222	1.02	0	0		
P-A	5708822	13	Oil Pumping	139.0	80.0	0.58	1,454,216	925,784	0.64	0	0		0.50
P-A	5845025	26	Process Modifications	0.0	-47.6		0	-402,917		2,464,320	2,272,709	0.92	1.00
P-A	5845076	20	Process Modifications	0.0	0.0		0	0		176,041	137,069	0.78	1.00
P-A	5846309	20	Process Modifications	0.0	0.0		0	0		188,562	63,857	0.34	0.00
P-A	5855279	26	Process Modifications	0.0	-39.8		0	-340,051		601,330	726,240	1.21	1.00
P-A	5867280	32	Process Modifications	222.0	240.0	1.08	1,704,050	1,010,793	0.59	3,600,000	5,148,733	1.43	0.00
P-A	6133877	36	Process Modifications	147.0	329.0	2.24	1,095,844	2,884,501	2.63	0	0		1.00
P-1	15938	26	Compressors	24.5	15.5	0.63	358,972	126,643	0.35	0	7,603		0.50
P-1	106816	35	Compressors	13.6	4.6	0.34	25,272	40,574	1.61	0	0		1.00
P-1	163910	28	Process Modifications	40.6	41.9	1.03	350,360	363,115	1.04	0	0		1.00
P-1	549512	34	Compressors	34.9	44.9	1.29	156,173	311,022	1.99	0	0		1.00
P-1	858304	20	Pumps/Pump Systems	178.2	30.2	0.17	150,935	200,191	1.33	0	0		0.50
P-1	891772	24	Compressors	0.0	0.0		164,140	176,888	1.08	0	0		1.00
P-1 (6)	936099	49	Oil Pumping	251.0	168.0	0.67	1,038,845	230,101	0.22	0	0		1.00
P-1	1048685	20	Pumps/Pump Systems	174.0	186.0	1.07	307,545	303,096	0.99	0	0		0.00
P-1	1084877	20	Process Modifications	0.0	-70.1		128,793	-105,991	-0.82	0	0		
P-1	1085884	13	Oil Pumping	57.3	47.4	0.83	498,510	393,142	0.79	0	0		0.25
P-1	3905770	28	Process Modifications	0.0	54.0		330,987	311,972	0.94	0	0		1.00
P-1	3915675	24	Compressors	9.3	10.6	1.14	90,977	79,498	0.87	0	0		0.00
P-1	4619059	24	Compressors	11.9	11.9	1.00	79,031	68,542	0.87	0	0		1.00
P-1	4644167	36	Process Modifications	50.0	42.6	0.85	493,979	237,761	0.48	4,410	4,410	1.00	1.00
P-1	5343667	14	Pumps/Pump Systems	67.9	65.0	0.96	512,062	726,728	1.42	0	0		
P-1	5968696	27	Compressors	0.0	0.0		126,314	132,265	1.05	0	0		1.00
B-A	1091532	28	Boilers	0.0	0.0		0	0		167,131	278,350	1.67	1.00
B-A	4417827	13	Pumps/Pump Systems	445.5	43.6	0.10	3,902,955	381,936	0.10	0	0		
B-A	5845074	20	Boilers	0.0	0.0		0	0		135,987	215,345	1.58	0.00
B-A	5846827	26	Boilers	0.0	0.0		0	0		224,068	174,008	0.78	1.00
B-A	5859576	20	Boilers	0.0	0.0		0	0		94,170	86,183	0.92	
B-A	6083527	20	Process Modifications	0.0	0.0		0	0		190,845	108,458	0.57	1.00

B SAVINGS BY COSTING PERIOD

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

- Total industrial Process savings
- Sample P-A savings
- Sample P-1 savings
- Sample B-A savings
- Boiler Measures
- Compressor Measures
- Oil Pump Measures
- Process Modification Measures
- Pump/Pumping System Measures

Gross Savings by Costing Period
Total Industrial Process 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:	4,463	4,502	1.00	3,427,289	0.11
Summer Partial Peak:	4,467	4,505	1.00	4,002,056	0.12
Summer Off Peak:	3,469	4,450	0.99	9,546,049	0.29
Winter Partial Peak:	4,354	5,156	1.15	7,018,434	0.22
Winter Off Peak:	3,112	5,063	1.12	8,502,284	0.26

Annual kWh Savings (6)	32,496,113
Connected load kW Savings (7)	9,029
Summer Therm Savings	6,408,232
Winter Therm Savings	3,709,027

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
Industrial Process - Sample P-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:	3,379	3,206	1.00	2,595,200	0.11
Summer Partial Peak:	3,329	3,206	1.00	2,982,983	0.13
Summer Off Peak:	2,423	3,070	0.96	6,667,548	0.28
Winter Partial Peak:	3,307	3,926	1.22	5,330,861	0.23
Winter Off Peak:	2,213	3,785	1.18	6,044,805	0.26

Annual kWh Savings (6)	23,621,397
Connected load kW Savings (7)	2210.06
Summer Therm Savings	5,786,122
Winter Therm Savings	3,202,673

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
Industrial Process - Sample P-1

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:	928	1,243	1.00	712,351	0.08
Summer Partial Peak:	1,029	1,247	1.00	921,599	0.11
Summer Off Peak:	1,083	1,387	1.12	2,981,761	0.35
Winter Partial Peak:	883	1,027	0.83	1,423,742	0.17
Winter Off Peak:	888	1,119	0.90	2,425,923	0.29

Annual kWh Savings (6)	8,465,376
Connected load kW Savings (7)	1429.36
Summer Therm Savings	52,353
Winter Therm Savings	64,438

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
Industrial Process - Sample B-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:	47	53	1.00	35,887	0.09
Summer Partial Peak:	47	53	1.00	41,869	0.10
Summer Off Peak:	47	53	1.00	128,596	0.31
Winter Partial Peak:	47	53	1.00	75,326	0.18
Winter Off Peak:	47	53	1.00	127,661	0.31

Annual kWh Savings (6)	409,339
Connected load kW Savings (7)	5126.10
Summer Therm Savings	542,448
Winter Therm Savings	469,225

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
Industrial Process - Boiler 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:	0	0	0.00	0	0.00
Summer Partial Peak:	0	0	0.00	0	0.00
Summer Off Peak:	0	0	0.00	0	0.00
Winter Partial Peak:	0	0	0.00	0	0.00
Winter Off Peak:	0	0	0.00	0	0.00

Annual kWh Savings (6)	0
Connected load kW Savings (7)	0.00
Summer Therm Savings	372,936
Winter Therm Savings	380,950

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
Industrial Process - Compressor 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:	419	494	1.00	322,118	0.09
Summer Partial Peak:	443	494	1.00	397,363	0.11
Summer Off Peak:	443	541	1.09	1,220,128	0.33
Winter Partial Peak:	397	398	0.81	640,348	0.17
Winter Off Peak:	397	461	0.93	1,084,311	0.30

Annual kWh Savings (6)	3,664,268
Connected load kW Savings (7)	354.36
Summer Therm Savings	4,458
Winter Therm Savings	3,145

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
Industrial Process - Oil Pump 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:	614	655	1.00	471,812	0.09
Summer Partial Peak:	616	655	1.00	552,134	0.10
Summer Off Peak:	618	655	1.00	1,699,632	0.31
Winter Partial Peak:	616	655	1.00	993,246	0.18
Winter Off Peak:	618	655	1.00	1,689,575	0.31

Annual kWh Savings (6)	5,406,399
Connected load kW Savings (7)	99.00
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):
(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
Industrial Process - Process Modification 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:	1,423	1,448	1.00	1,092,816	0.13
Summer Partial Peak:	1,394	1,448	1.00	1,249,441	0.15
Summer Off Peak:	755	1,333	0.92	2,077,446	0.25
Winter Partial Peak:	1,426	2,210	1.53	2,298,922	0.27
Winter Off Peak:	635	2,091	1.44	1,735,022	0.21

Annual kWh Savings (6)	8,453,647
Connected load kW Savings (7)	1634.62
Summer Therm Savings	5,464,050
Winter Therm Savings	2,996,880

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
Industrial Process - Pump/Pumping System 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:	695	806	1.00	533,573	0.10
Summer Partial Peak:	700	809	1.00	627,276	0.12
Summer Off Peak:	634	835	1.04	1,744,123	0.32
Winter Partial Peak:	635	634	0.79	1,023,835	0.19
Winter Off Peak:	547	621	0.77	1,495,324	0.28

Annual kWh Savings (6)	5,424,131
Connected load kW Savings (7)	4737.50
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.
- 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

C PROTOCOLS TABLES 6 AND 7

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

M&E PROTOCOLS TABLE 6

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

				5. A. 90% CONFIDENCE LEVEL				5. B. 80% CONFIDENCE LEVEL			
				LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND	LOWER BOUND	UPPER BOUND
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									
	Impact Yr Therms/designated unit	na									
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	4,502	2,116	3,770	5,234	1,601	2,631	3,932	5,072	2,089	2,517
	A. ii. Load Impacts - kWh	32,496,113	15,273,173	28,924,822	36,067,404	10,225,404	20,320,942	29,712,894	35,279,332	14,893,799	19,207,057
	A. iii. Load Impacts - Therms	10,117,259	4,755,112	9,153,088	11,081,430	2,708,979	6,801,244	9,365,851	10,868,667	4,446,442	6,349,727
	B. i. Load Impacts/designated unit - kW	53	25	44	62	19	31	46	60	25	30
	B. ii. Load Impacts/designated unit - kWh	382,307	179,684	340,292	424,322	120,299	239,070	349,563	415,051	176,221	225,965
	B. iii. Load Impacts/designated unit - Therms	119,027	55,942	107,683	130,370	31,870	80,015	110,186	127,867	52,311	74,703
	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	0.72	0.45	0.60	0.84	0.34	0.56	0.63	0.81	0.44	0.54
	D.A. ii. Load Impacts - kWh, realization rate	0.76	0.48	0.68	0.84	0.32	0.64	0.69	0.83	0.47	0.60
	D.A. iii. Load Impacts - Therms, realization rate	1.18	0.74	1.07	1.29	0.42	1.06	1.09	1.27	0.69	0.99
	D.B. i. Load Impacts/designated unit - kW, real rate	0.72	0.45	0.60	0.84	0.34	0.56	0.63	0.81	0.44	0.54
	D.B. ii. Load Impacts/designated unit - kWh, real rate	0.76	0.48	0.68	0.84	0.32	0.64	0.69	0.83	0.47	0.60
	D.B. iii. Load Impacts/designated unit - Therms, real rate	1.18	0.74	1.07	1.29	0.42	1.06	1.09	1.27	0.69	0.99
3. Net-to-Gross Ratios		RATIO		RATIO	RATIO			RATIO	RATIO		
	A. i. Average Load Impacts - kW	0.47		0.34	0.60			0.37	0.57		
	A. ii. Average Load Impacts - kWh	0.47		0.34	0.60			0.37	0.57		
	A. iii. Average Load Impacts - Therms	0.47		0.34	0.60			0.37	0.57		
	B. i. Avg Load Impacts/designated unit of measurement - kW	0.47		0.34	0.60			0.37	0.57		
	B. ii. Avg Load Impacts/designated unit of measurement - kWh	0.47		0.34	0.60			0.37	0.57		
	B. iii. Avg Load Impacts/designated unit of measurement - Therms	0.47		0.34	0.60			0.37	0.57		
	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	59									
	B. Number of measures installed by all program participants in the 12 months of the program year	93									
	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 participants by SIC code

SIC3	Percent
131	18.8
142	2.4
144	1.2
154	1.2
201	1.2
203	15.3
204	1.2
206	1.2
208	1.2
209	2.4
242	8.2
249	1.2
262	2.4
263	1.2
265	1.2
267	3.5
271	2.4
275	1.2
281	4.7
287	1.2
291	2.4
308	3.5
323	1.2
324	1.2
331	1.2
341	1.2
342	1.2
344	1.2
347	2.4
349	1.2
352	1.2
357	1.2
367	2.4
497	5.9

M&E PROTOCOLS TABLE 7

A. OVERVIEW INFORMATION

1. Study Title and ID No: Evaluation of 1994 Industrial Process Energy-Efficiency Projects, #314

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 Process

4. Methods Used: Site-specific engineering approach

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

6. Analysis sample size: 46 customers, 59 installations, 59 measures installed, 46 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.

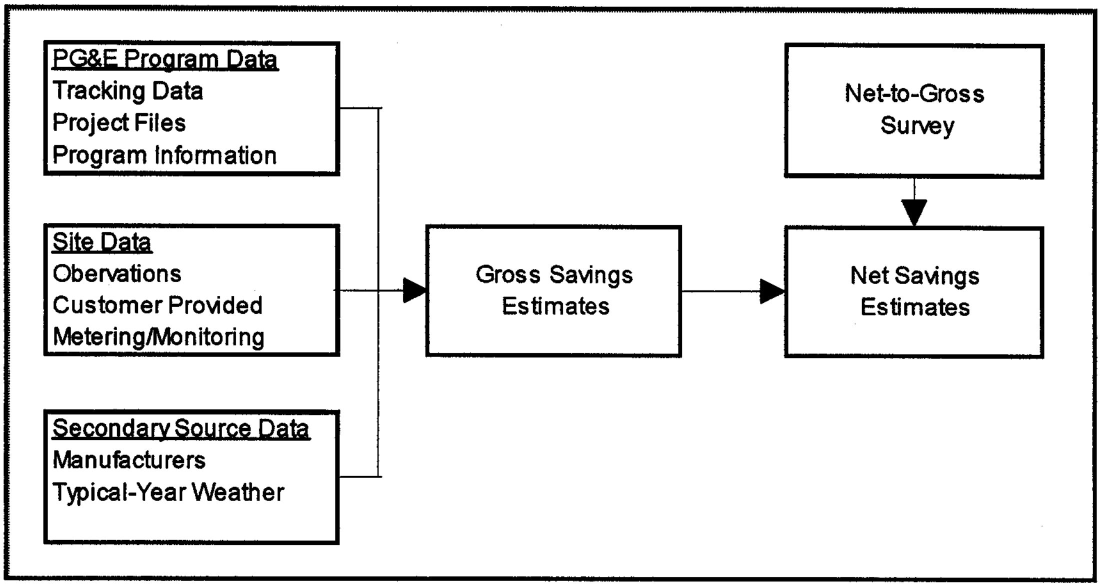
2. Data Sources: See Figure C-1

3. Sample Attrition: 53 sites identified for possible site analyses; 6 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.); 1 additional site refused to participate; 46 sites were analyzed. Four of the 46 site analysis sites did not wish to participate in the follow-up net-to-gross phone survey. One additional site was dropped from the net-to-gross analysis because the person involved in the decision to install measures was no longer with the firm.

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: N/A

C. SAMPLING

1. Sampling procedures and protocols: Sampling frame - 85 industrial process sites; Sampling strategy: a census was attempted for the 26 largest sites - 4 sites were eventually dropped (1 customer refused to participate and 3 sensitive customers were removed from the study by PG&E); a random sample of 27 sites was taken of the remaining sites (3 sensitive customers were removed from the sample by PG&E); 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.