PRE-1998 NON-RESIDENTIAL NEW CONSTRUCTION IMPACT EVALUATION CARRYOVER

PG&E Study ID number: 400

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PACIFIC GAS & ELECTRIC COMPANY

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Purpose of Study

This study was conducted in compliance with the requirements specified in "Protocols and Procedures for the Verification of Costs, Benefits, and Shareholders Earnings from Demand-Side Management Programs", as adopted by California Public Utilities Commission Decision 93-05-063, revised January, 1997, pursuant to Decisions 94-05-063, 94-10-059, 94-12-021, 95-12-054, and 96-12-079.

This study measures the carryover net and gross energy and demand savings of the Pre-1998 nonresidential new construction program for the commercial and industrial program.

Methodology

The goal of this evaluation was to estimate the carryover net and gross energy and demand savings of the Pre-1998 nonresidential new construction program for the commercial and industrial program.

The primary deliverables of this evaluation were:

1. Gross savings estimates of annual energy and summer peak demand
2. Net savings estimates of annual energy and summer peak demand
3. Parametric runs to isolate the influences of various measures and end-uses. These parametric runs were for the lighting, HVAC, refrigeration, motors, and shell measures.

The evaluation relied on the use of model-based statistical sampling (MBSS), on-site engineering surveys, short term metering of end uses, DOE2.1e building simulation models, and statistical analysis to develop the findings presented. The basic approach for the commercial projects relied on engineering models to develop gross savings estimates and difference of differences analysis to determine the net-to-gross ratio. This methodology conforms to the CADMAC protocols[1], with the important exception that statistical sampling was used in the place of an attempted census of program participants.

The Pre-1998 NRNC program included seven industrial sites. These industrial sites contributed less than 3% of the total number of commercial and industrial sites or 16% of the total program savings. The gross savings

[1] 1999 AEAP decision number D.99-06-052 revised M&E protocols.

were determined from on-site surveys of all seven projects. Following the methodology usually used for industrial retrofit evaluations, a measure by measure self-report was used to determine the net-to-gross ratio of each of the seven projects.

Study Results

Program participants saved 135,543 MWh of energy and 20.8 MW of power in their first year of operation. This is a gross realization rate of 147.9% and 82.4% of the verified savings estimate previously filed by PG&E respectively. Energy and demand net-to-gross ratios using difference of difference econometrics are 41.4% and 36.7% respectively, compared to the program estimate of 75%. Net energy savings attributable to the program are 7.6 MW and 56,157 MWh. The resulting net realization rate for energy is 47.3% and 30.3% for demand.

Pre-1998 Non-residential New Construction Program Carryover						
End Use 1	Gross Savings	Gross Realization Rate	Net-To-Gross		Net Savings	Net Realization Rate
			1-FR	SO		
EX ANTE						
kW	25,221	100%	75%	-	18,916	75%
kWh	91,657,513	100%	75%	-	68,743,135	75%
Therms	NA	NA	NA	NA	NA	NA
EX POST						
kW	20,783	82.4%	36.7%	-	7,631	30.3%
kWh	135,543,161	147.9%	41.4%	-	56,157,436	47.3%
Therms	NA	NA	NA	NA	NA	NA

Regulatory Waivers and Filing Variances

Two retroactive waivers were filed in conjunction with this study. The waivers requesting deviation from CADMAC rules are summarized below:

Waiver #1

- Achieve requisite precision and confidence levels with a reduced sample size
- Permit the use of short-term whole premise metering in addition to or instead of billing data for calibration of building simulation models (DOE-2) and eliminate the requirement for a minimum of 9 months of billing data.

Waiver #2

- Analyze the gross savings for the new construction industrial projects using a methodology that is consistent with the industrial retrofit methodology using measure-specific analysis instead of whole-building analysis.
- Analyze the net savings for the new construction industrial projects using a methodology that is consistent with the industrial retrofit methodology using a self-reported net-to-gross analysis instead of a nonparticipant sample.

The filed retroactive waivers can be found in the appendix of the final report on pages 15-23.

There were No E-Table variances.

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Executive Summary

Introduction

This is the final impact report for the Pre-1998 Non-Residential New Construction (Pre-98 NRNC) Program Carryover evaluation. The evaluation was conducted by RLW Analytics and Architectural Energy Corporation from June 1999 through January 2000. Field data collection assistance was provided by Eskinder Berhanu Associates, ASW Engineering, and GeoPraxis.

This report details findings of energy and demand savings at the whole building level and for lighting, HVAC, refrigeration, motors, and shell measures. Both net and gross savings are presented.

Approach

The goal of this evaluation was to estimate the net and gross energy and demand savings of the Pre-1998 nonresidential new construction program for the commercial and industrial program.

The primary deliverables of this evaluation were:

1. Gross savings estimates of annual energy and summer peak demand
2. Net savings estimates of annual energy and summer peak demand
3. Parametric runs to isolate the influences of various measures and end-uses. These parametric runs were for the lighting, HVAC, refrigeration, motors, and shell measures.

The RLW Analytics/AEC team used a methodology similar to the 1994 and 1996 NRNC studies. The evaluation relied on the use of model-based statistical sampling (MBSS), on-site engineering surveys, short term metering of end uses, DOE2.1e building simulation models, and statistical analysis to develop the findings presented. The basic approach for the commercial projects relied on engineering models to develop gross savings estimates and difference of differences analysis to determine the net-to-gross ratio. This methodology conforms to the CADMAC protocols with the important exception that statistical sampling was used in the place of an attempted census of program participants.

A sample of 139 participant buildings from the commercial projects and 144[2] matching non-participant buildings were surveyed and modeled to estimate energy and demand savings. An additional telephone survey was conducted with decision-makers to collect data to estimate free-ridership and spillover. Net savings were developed using a difference of differences approach to compare the energy efficiency of the participants to that of the matching non-participants.

The Pre-1998 NRNC program included seven industrial sites. These industrial sites contributed less than 3% of the total number of commercial and industrial sites or 16% of the total program savings. The gross savings were determined from on-site surveys of all seven projects. Following the methodology usually

[2] 35 of the non-participant sites and 5 of the participant sites used in this study were existing models that were developed for the 1998 CA NRNC Baseline Study.

used for industrial retrofit evaluations, a measure by measure self-report was used to determine the net-to-gross ratio of each of the seven projects.

A brief overview of the findings follows.

Findings

This section presents gross and net savings estimates for the population of commercial and industrial program participants. Table 1 summarizes the overall evaluation findings. The 'ex ante' values in the top part of the table are the PG&E preliminary estimates, and the 'ex post' values in the lower portion of the table are the results of the program evaluation. The net savings reported in Table 1 are based on the difference of differences analysis.

Program participants saved 135,543 MWh of energy and 20.8 MW of power in their first year of operation. This is a gross realization rate of 147.9% and 82.4% of the verified savings estimate previously filed by PG&E respectively. Energy and demand net-to-gross ratios using difference of difference econometrics are 41.4% and 36.7% respectively, compared to the program estimate of 75%. Net energy savings attributable to the program are 7.6 MW and 56,157 MWh. The resulting net realization rate for energy is 47.3% and 30.3% for demand.

			Net-to-Gross			
Whole Building	**Gross Savings**	**Gross Realization Rate**	**1-FR**	**SO**	**Net Savings**	**Net Realization Rate**
ex ante						
kW	25,221	100%	75.0%	-	18,916	75.0%
kWh	91,657,513	100%	75.0%	-	68,743,135	75.0%
ex post						
kW	20,783	82.4%	36.7%	-	7,631	30.3%
kWh	135,543,161	147.9%	41.4%	-	56,157,436	47.3%

Table 1: Summary of Evaluation Findings

Gross Savings

Program participants saved 135,543 MWh of energy in their first year of operation. This is a realization rate of 147.9% of the verified savings estimate previously filed by PG&E. The relative precision of the estimate is ±3.3% at the 90% confidence level, meaning that the gross program savings is estimated to be between 131,050 MWh and 140,037 MWh.

The summer on-peak demand savings is 20.78 MW. The realization rate is 82.4% of the verified program savings. The relative precision is ±3.9% at the 90% confidence level, meaning that the gross program demand savings is between 20.0 MW and 21.6 MW. Table 2: Participant Energy and Demand Savings by Costing Period

below shows the energy and demand savings by PG&E costing period. The winter costing periods have greater energy savings because they consist of more hours than the summer periods.

Period	Energy Savings (MWh)	Energy Relative Precision	Demand Savings (MW)	Demand Relative Precision
Annual	**135,543**	**± 3.3%**	-	-
Summer On-Peak	12,989	± 3.3%	20.78	± 3.9%
Summer Mid-Peak	14,657	± 3.2%	14.49	± 3.9%
Summer Off-Peak	23,255	± 3.6%	15.79	± 4.7%
Winter Mid-Peak	41,996	± 3.2%	19.61	± 3.8%
Winter Off-Peak	42,645	± 4.0%	14.03	± 4.5%

Table 2: Participant Energy and Demand Savings by Costing Period

To compare participants and non-participants, the savings of each group relative to their own baseline is plotted in Figure 1[3]. The figure clearly shows much higher levels of energy efficiency among participants than among non-participants. The participants' energy use was 26.4% better than baseline, while the non-participants' energy use was only 17.9% better than baseline. "Better than baseline" means that the buildings are more energy efficient than the baseline efficiency levels established for this study. Numerically, a building that is for example20% better than baseline uses 20% less energy than it would have used if built to baseline efficiency levels. For summer on-peak demand, the participant group was 25.3% better than baseline while the non-participant group was 15.9% better than baseline.

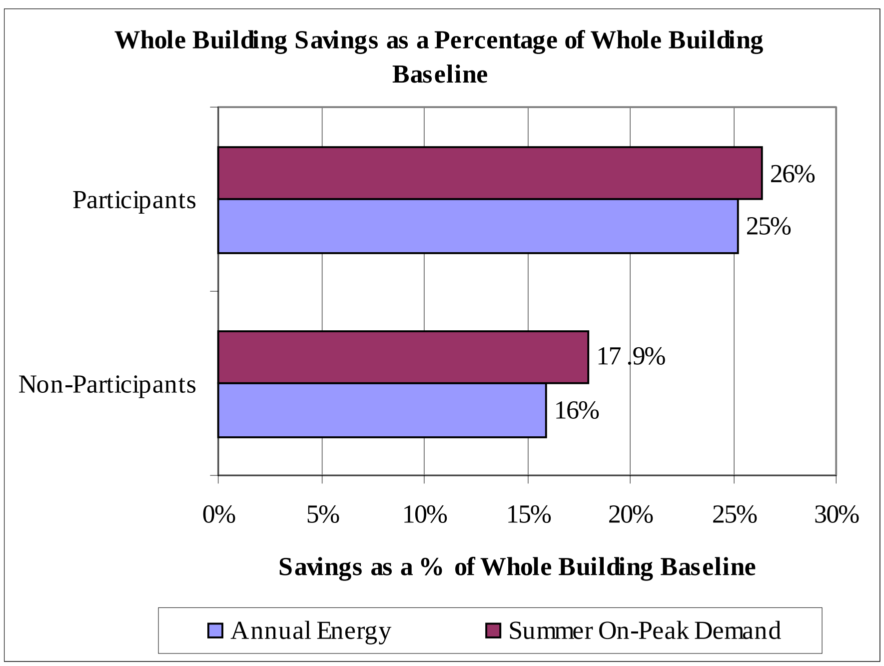

Figure 1: Gross Energy and Demand Savings Relative to Baseline

[3] The industrial sites are excluded from this table since no industrial non-participants were studied.

Savings by End-Use Measure Category

Energy and demand savings were also estimated for lighting, HVAC, refrigeration, motor, and shell measures. Figure 2 and Figure 3 show the composition of the annual energy savings and the summer on-peak demand savings for commercial and industrial program participants, respectively. The shell measures did not produce any statistically significant savings. As expected, HVAC savings contributed more to the summer peak demand savings than to annual energy due to the seasonal nature of the end-use.

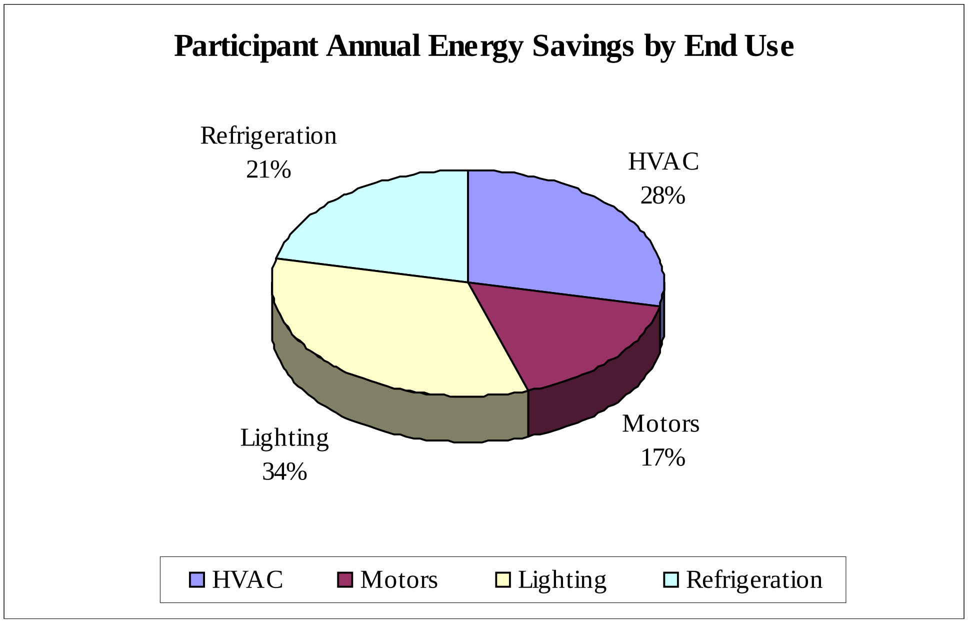

Figure 2: Annual Energy Savings by End-use

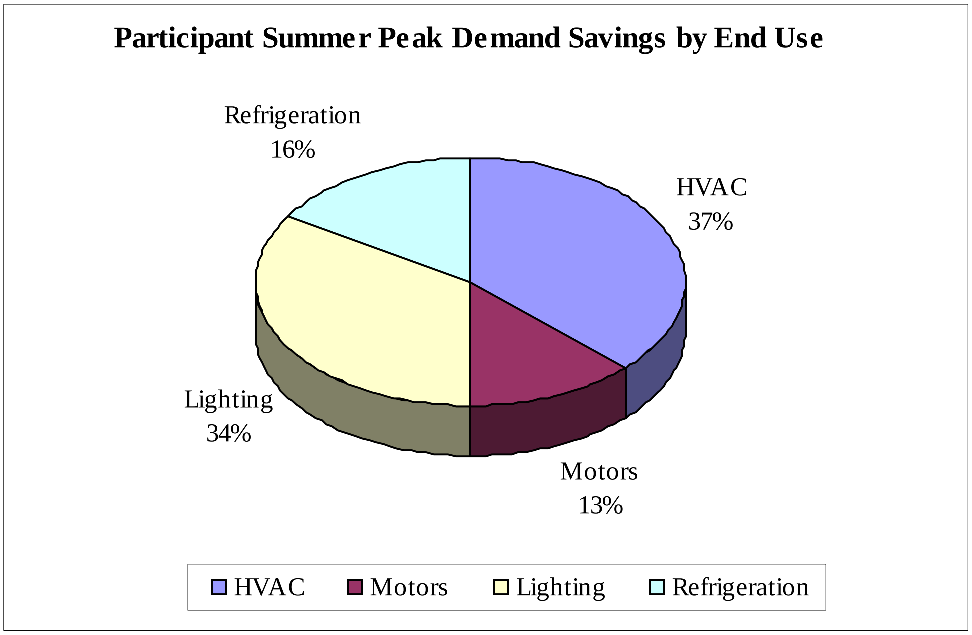

Figure 3: Summer Peak Demand Savings by End-use

Table 3 shows the energy savings by end-use measure category for each of the costing periods. Table 4 shows the summer on-peak demand savings for each end-use category. Shell savings are not included because no statistically significant savings were found.

	Lighting (MWh)	Refrigeration (MWh)	Motors (MWh)	HVAC (MWh)
Annual	**45,632**	**29,011**	**22,697**	**38,383**
Summer On-Peak	4,691	1,701	1,675	4,699
Summer Mid-Peak	4,892	2,530	2,069	5,125
Summer Off-Peak	5,986	5,195	4,321	7,765
Winter Mid-Peak	17,531	7,474	6,089	11,024
Winter Off-Peak	12,533	12,110	8,543	9,770

Table 3: Participant End-Use Gross Energy Savings by Costing period

	Lighting (MW)	Refrigeration (MW)	Motors (MW)	HVAC (MW)
Summer On-Peak	6.88	3.30	2.58	7.57
Summer Mid-Peak	3.85	3.30	2.67	14.49
Summer Off-Peak	3.29	3.34	2.18	15.79
Winter Mid-Peak	6.98	3.33	2.71	19.61
Winter Off-Peak	2.94	3.45	2.27	14.03

Table 4: Participant End-Use Gross Demand Savings by Costing period

Net Savings

Net savings is that part of the observed energy savings that can be attributed to the efforts of PG&E. The results reported here were developed from the difference-of-differences analysis for the commercial projects and from the self-report methodology for the industrial projects.

Table 5 summarizes the findings. The table shows the estimated net savings and net-to-gross ratio for both annual energy and summer peak demand savings.

	Net Savings (MWh)	Net-to-Gross Ratio	Relative Precision (+/-)
Annual Energy	56,157	41.4%	± 47.3%
Summer Peak Demand	7.6	36.7%	± 47.7%

Table 5: Net Savings and Net-to-gross Ratio

The table also shows the relative precision of each estimate.[4] For example, in the case of annual energy, the net-to-gross ratio was estimated to be 41.4% with a relative precision of ±47.3%. The error bound for the 90% confidence interval for the true net-to-gross ratio is equal to 47.3% of the estimate, i.e. to ±19.6%. The 90% confidence interval for the true net-to-gross ratio can be calculated using the equation:

$$0.414 \pm (0.414 * 0.473) = (0.218, 0.610)$$

We can be quite confident that this interval contains the true net-to-gross ratio that would have been obtained by developing on-site surveys and building engineering simulation models for all program participants and a very large sample of non-participants using the methodology of this study and then analyzing the resulting data using the difference of differences methodology.

The confidence interval reflects sampling variability and random measurement error but does not reflect any possible systematic measurement error that might be repeated throughout the data collection and engineering simulation or that might arise by neglecting explicit estimation of free ridership and spillover.

Other Observations about the Program

The primary objective of this study was to obtain an independent, objective assessment of the actual savings of the program. In the course of the study, we have made some important observations about the program and about our approach to the evaluation. Regarding the program itself, we have observed:

- Comparing 1996 to 1998, there has been a substantial improvement in energy efficiency in the non-residential new construction market. Using essentially the same baseline, the gross savings among the non-participants has risen from 10.3% of baseline energy use in 1996 to 15.9% of energy use in 1998.

[4] Some definitions: The standard error reflects the standard deviation of an estimate in repeated sampling. The error bound at the 90% level of confidence is 1.645 times the standard error. The confidence interval is the estimate plus or minus the error bound. The relative precision is the error bound divided by the estimate itself. The relative precision was determined using a Jackknife procedure described in the Commercial Net Savings section of the report.

- During the same period, the program participants kept pace with the non-participants. The gross savings among the participants has risen from 19.2% of baseline energy use in 1996 to 25.3% of energy use in 1998.
- As the non-residential new construction market has grown more efficient relative to the baseline, the net-to-gross ratio of the program has necessarily dropped. This is an artifact of the baseline and is *not* a reflection of the program itself. With the 1999 modifications to Title 24 lighting requirements, future evaluations should find an improved net-to-gross ratio.
- The program has moved away from lighting into HVAC and motors. In the 1996 program, lighting was responsible for 55% of all savings, but in the 1998 program, lighting was only 38% of all savings. By contrast, HVAC rose from 9% in 1996 to 20% in 1998 and motors rose from 4% to 17%. This is an important shift in the program.
- The annual savings due to lighting measures are about 37% of the lighting baseline use for participants and about 31% for non-participants. These results indicate that participants have about 19% more savings from lighting measures than non-participants.
- The fact that non-participants are achieving such high lighting savings reflects the wide acceptance of T-8 lamps and electronic ballasts. The lighting component of the program will need to focus on more aggressive measures such as daylighting, dimming ballasts, and compact fluorescent lamps.
- By contrast with lighting, the 1998 participants are much more efficient than the 1998 non-participants in the motors, refrigeration and HVAC end uses. The annual savings due to the motor measures are about 20% of the motor baseline use for participants, and about 4% for non-participants. The annual savings due to the HVAC measures are about 14% of the HVAC baseline use for participants, and about 8% for non-participants. The annual savings due to the refrigeration measures are about 45% of the refrigeration baseline use for participants, and about 12% for non-participants.
- The participant savings percentages are smaller for HVAC and motors than for refrigeration and lighting. This suggests that as the program matures, it may more difficult to attain the savings achieved in past years. In other words, as the bar gets higher, success will be more difficult.

Data Collection

A major portion of this project was the collection of the building and decision-maker data necessary to determine the program impacts. Overall, the data collection process ran quite smoothly - no problems were encountered that had an adverse impact on the overall quality of the data.

The data collection process was designed to collect the highest quality data in the most efficient manner possible. This process relied on several people working together to ensure a seamless information flow. Figure 4 shows a graphical representation of the data collection process.

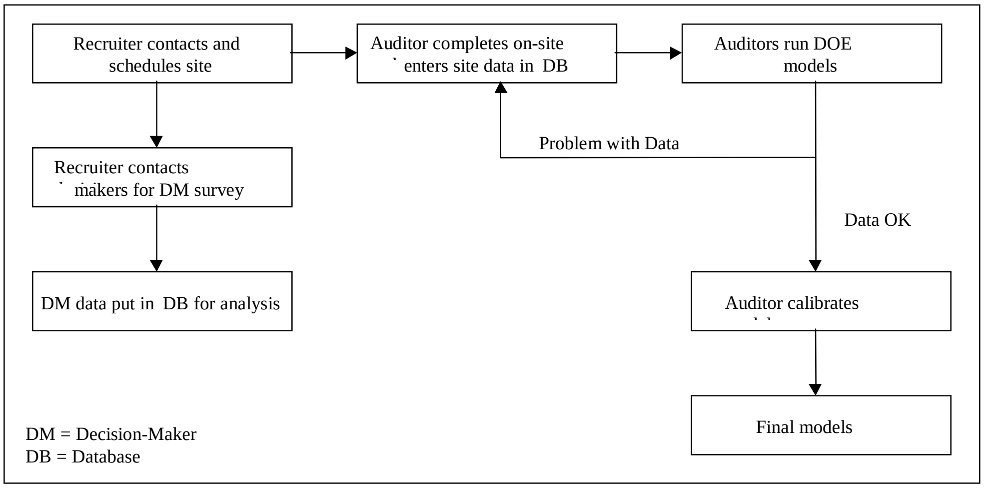

Figure 4: Data Collection Process

The recruiter was responsible for making contact with the site representative and securing their participation in the study. Once that was accomplished, the recruiter scheduled the on-site visit and provided the information to the field surveyors. The recruiter then completed the decision-maker survey with the initial site contact and any additional contacts that were necessary to answer the decision-maker questions.

The on-site surveyor collected building description and operation information from the site and entered the data into a database. Automated modeling software was used to create DOE-2 input files. The surveyors were responsible for checking the models created from the field data, and correcting the data if necessary. The on-site surveyor was also responsible for calibrating the model to billing data or short-term metered data, if available for the site. Senior staff engineers of AEC and RLW checked the final model results for reasonableness.

The calibrated models were delivered to AEC, who produced all of the required parametric runs of the engineering models.

Engineering Models

Engineering models were developed for each building in the on-site survey sample using the DOE-2.1E building simulation program. A series of models was developed for each sample site, including:

- An as-built model representing the building as found by the surveyors.
- A “baseline” model representing the building with minimally compliant equipment and envelope efficiencies.
- A series of parametric runs to isolate the impact of motors, refrigeration, HVAC, lighting, and shell end-uses.

The models were developed using an automated BDL[5] generator, developed by AEC and RLW Analytics. This method ensured that all of the models were consistent, thus eliminating a potential source of bias in the results.

Analysis Baseline and Gross Savings Calculations

The estimates of gross program savings were made by comparing the as-built simulated building energy consumption to a baseline level of energy consumption[6]. The baseline energy consumption for all buildings was defined to be the energy consumption of the building as if all of the equipment and envelope characteristics were specified to be minimally compliant with Title 24 and the building was operated on the schedule found during the on-site survey.

A gross savings estimate was calculated for each building in the sample. The savings estimates were projected to the population of participants using model-based statistical sampling procedures. Gross savings estimates were developed for both the participant and the non-participant population.

Measures-only gross savings estimates were also developed for the participant population. Measures-only gross savings were calculated for each end use as the savings from the incented end-uses in each end use relative to the baseline consumption or demand of that particular end use.

Net Savings Methodologies

Net program savings estimates are the savings that directly result from program participation. Effects of free-ridership, or what the customer would have done in the absence of the program, have been factored out. Three different net savings methodologies were used in this evaluation. In the case of the commercial projects, a “difference-of-differences” approach was used to determine the final results and an econometric approach was used for verification. In the case of the industrial projects a simple self-reporting method was used to determine the net-to-gross ratio. Net-to-gross ratios from all three methods are presented in this report.

Difference of Differences

This method estimated net savings by comparing the savings of the participants in the sample to a “matched” sample of non-participants. The savings of the non-participant group is assumed to be the savings of the participants in the absence of the program. In this methodology, spillover among the non-participants is assumed to be offset by free-ridership among the participants but no attempt is made to measure either spillover or free-ridership.

Econometric Modeling

The estimates obtained from the difference-of-differences method were validated using an econometric approach. The econometric model sought to explicitly

[5] BDL is DOE-2’s Building Description Language

[6] Because the default Title 24 operating schedules were not used to develop the baseline and because the area category method was used for each building regardless of the Title 24 compliance path actually elected, the savings calculated relative to the baseline in this study cannot be interpreted as the degree of compliance with Title 24

measure both free-ridership and spillover, and controlled for self-selection and other decision-making factors affecting the efficiency choice of each sample site. Figure 5 shows the overall flow of data for the econometric modeling. In this methodology, a logistic regression was performed to create a participation model. This model estimated Mills' ratios for correcting self-selection bias. A second linear regression model was built to estimate the savings of participants in the absence of the program.

The econometric approach incorporated the relationship between PG&E's influence on the design of projects and the energy efficiency of the current project. This component of the model was used to estimate the spillover effect, i.e., the effect of the program on non-participant savings.

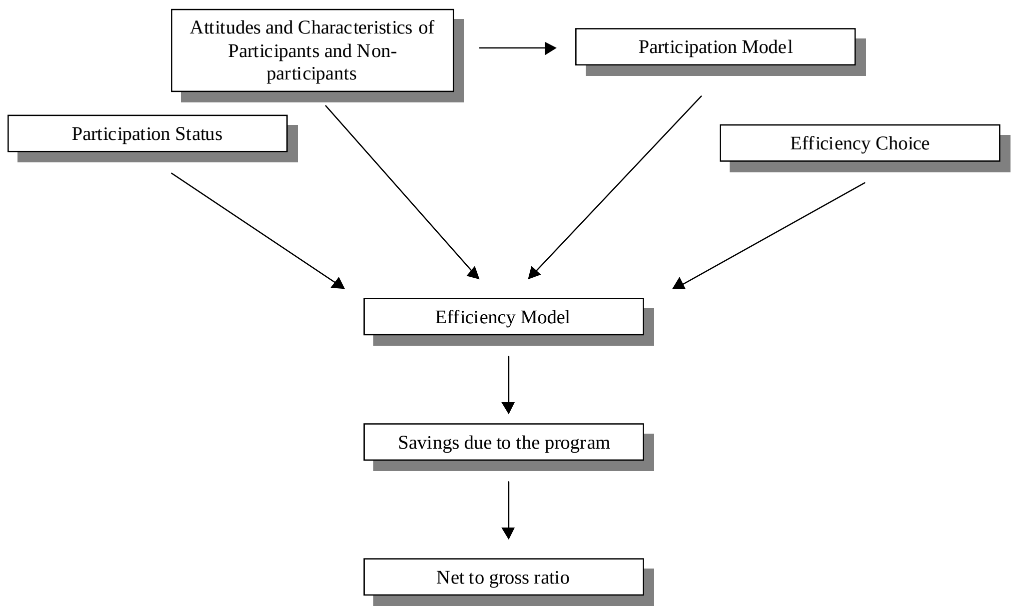

Figure 5: Econometric Modeling Overview

Industrial Projects

In the case of the seven industrial projects in the program, both of the preceding approaches were felt to be inappropriate due to the difficulty of obtaining a suitably matched sample of non-participants. Instead, a simple self-reporting method was used to determine the net-to-gross ratio following the guidelines of the CADMAC Protocols for industrial projects. For each industrial measure, the auditor directly assessed the impact of the program on the decision to install the measure using a fraction from 0 to 1 to reflect the measure-specific net to gross ratio. The results were weighted by the tracking estimate of savings for the measures at each site and then averaged across sites using the measured savings.

Sample Design

Introduction

The key to effective sample design is to take advantage of the association between the target variables to be measured in the study and any supporting variables already known from the sampling frame. For example, the savings of each program participant measured in this project can be associated with the estimate of savings recorded in the program tracking system. Stratified sampling is used to ensure that the sample has the best mix of small and large sites. Ratio estimation is used to expand the sample data to the target population, taking advantage of the supporting information. Both stratified sampling and ratio estimation are well known and widely used in load research and DSM evaluation.

The principal questions addressed in sample design are:

- How big should the sample be, both overall and within different subsets of the target population?
- How much statistical precision can we expect from the sample?
- How should the sample be stratified to get the best statistical precision?

The usual approach is to estimate the variance of the estimated savings in the program tracking system. This approach is not appropriate for stratified ratio estimation since the statistical precision depends not on the variance of estimated savings but on the strength of the association between the measured savings and the tracking estimate of savings. The Model-Based Statistical Sampling (MBSS) approach is to develop a statistical model describing the relationship between these variables, and then use the parameters of this model to develop the sample design. In this project the parameters of the MBSS model were estimated in our prior evaluation of the 1996 program.

Using this approach, RLW Analytics designed the participant sample to achieve ±10 percent precision at the 90 percent confidence level for the participants' annual measured energy savings. This analysis indicated that the participant sample size should be 148 sites, stratified by the tracking estimate of savings. The non-participant sample was matched to the participant population in terms of square footage and building type. A sample of 148 non-participant sites was selected from F.W. Dodge New Construction data.

Participants

RLW Analytics used the sites that received incentive checks dated in 1997 and 1998 as a participant sample frame. A sample of 148 sites was drawn from a population of 236. The sample was stratified into five sampling strata and one certainty strata for a total of six strata by estimated annual energy savings. The sample sites were then compared to the existing models from the Baseline study. Five of the sample sites had been surveyed and modeled recently for the 1998 CA NRNC Baseline study, and the models for those five sites were used in this study. Sample size, population size, and stratum cutpoints are indicated in the Table 6 below.

Stratum	Population Size	Max kWh Savings	Program kWh Savings	Sample Size
1	63	55,800	1,667,793	17
2	41	111,600	3,296,978	20
3	32	194,852	4,649,448	20
4	27	273,000	6,289,814	20
5	22	425,232	7,618,148	20
6	51	4,542,678	68,135,332	51
Totals	**236**		**91,657,513**	**148**

Table 6: Stratified Sampling Plan for Participants

The total tracking savings for the 236 program participants was 91,658 MWH. The anticipated precision from this sample design was ± 3 percent at 90 percent confidence. The estimated precision for participants was based on the model parameters used in the sample design, which are shown in Table 7.

Model Parameter	Value
β	1.00
error ratio	0.62
γ	0.60

Table 7: Model-Based Sampling Parameters for Participant Sample

The error ratio and γ were taken from the actual model parameters found in the 1996 NRNC study. The analysis variable is the actual energy saved and the explanatory variable is the tracking estimate of energy saved. The error ratio is a measure of the spread of the data around the trend line. It is analogous to the coefficient of variation. γ is a measure of the heteroskedastisity of the data. Heteroskedastisity is the tendency for the variation around the trend line to increase as the value of the stratification variable increases.

Non-participants

For the non-participant sample design, the *participant* population was re-stratified on building type and square footage. This two-way stratification defined the cells in the sample design, which was then filled with non-participant sites from the Dodge database. This procedure ensures that the non-participant sample that is produced is matched to the participant sample as closely as possible. Later in this section, a comparison between the participant and non-participant population is shown.

The sample frame for the non-participants was taken from the F.W. Dodge new construction database of projects started in 1996 and 1997. The database was screened to eliminate program participants, out-of-scope, and out-of-territory projects. The Dodge project was considered in scope if the building type was eligible for NRNC incentives.

The non-participant sample was developed using the method outlined in the flowchart below. This led to a non-participant sampling frame of 3,601 sites.

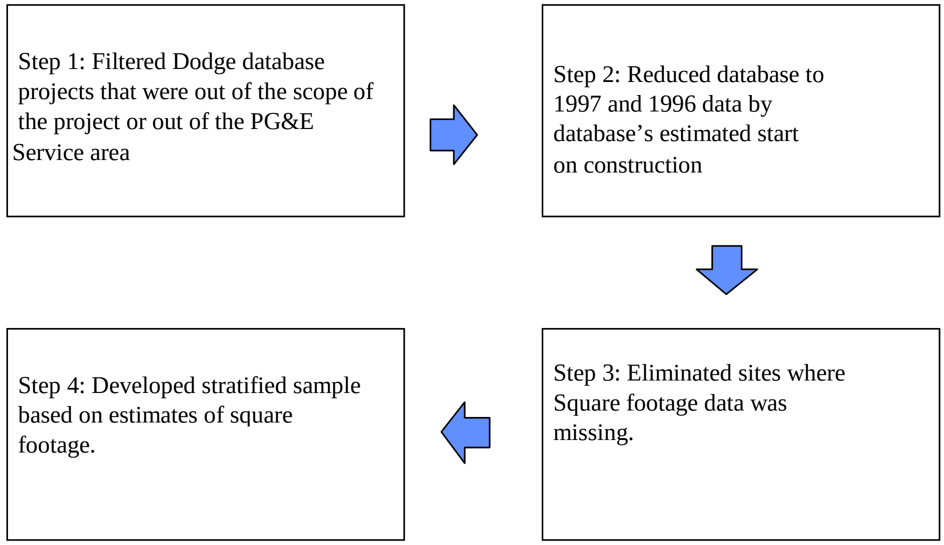

Figure 6: Non-Participant Sample Frame Development

The non-participant sample size was chosen to be 148 sites to match the participant sample size. The non-participant sample was stratified by building type and by square footage. Thirty-five of the sample sites had recently been surveyed and modeled for the Baseline study, and the models for those thirty-five sites were used in this study.

Table 8 below summarizes the sample design used to select the 151 non-participants. For example, in the case of grocery stores, 4 sites were selected from each of 3 size strata. The number of sites from each building type and the allocation of the sample to the size strata was selected to match the participant population. In Table 8 and Table 9, a dash in the cell indicates that the data element is not applicable to that building type. For example, there were only 2 theater strata, therefore there was no strata 3 or strata 4 sample (Table 8) and there were no strata 2 or strata 3 cutpoints.

Building Type	**Stratum 1**	**Stratum 2**	**Stratum 3**	**Stratum 4**	**Stratum 5**	**Total**
C&I Storage	4	3	3	3	3	**16**
Fire/Police/Jails	1	1	--	--	--	**2**
General C&I Work	4	4	4	4	5	**21**
Grocery Store	2	1	1	1	1	**6**
Libraries	1	--	--	--	--	**1**
Medical/Clinical	2	1	1	1	1	**6**
Office	14	14	14	14	13	**69**
Rel. Wor., Aud., Conven.	1	1	1	1	1	**5**
Retail and Wholesale Store	2	1	1	1	1	**6**
School	4	4	3	3	3	**17**
Theater	1	1	--	--	--	**2**
Total	**36**	**31**	**28**	**28**	**28**	**151**

Table 8: Stratified Sampling Plan for Non-Participants

The square footage cutpoints for the non-participant strata are shown in Table 9. For example, in the medical/clinical category, stratum 1 consists of sites with square footage less than 49,643 square feet, and stratum 2 of sites between 49,643 and 76,725 square feet.

Building Type	Stratum 1 Maximum Sq. Footage	Stratum 2 Maximum Sq. Footage	Stratum 3 Maximum Sq. Footage	Stratum 4 Maximum Sq. Footage	Stratum 5 Maximum Sq. Footage
C&I Storage	36,818	48,650	61,429	289,305	436,098
Fire/Police/Jails	844,296	1,664,592	--	--	--
General C&I Work	41,920	73,378	97,620	247,580	395,000
Grocery Store	51,589	55,715	59,967	62,459	118,000
Gymnasium	--	--	--	--	--
Libraries	60,000	--	--	--	--
Medical/Clinical	49,643	76,725	104,452	191,258	251,675
Office	57,751	87,125	138,889	232,674	800,000
Rel. Wor., Aud., Conven.	29,436	44,788	58,524	138,992	213,713
Retail and Wholesale Store	8,851	16,311	22,766	31,190	86,838
School	16,761	44,738	67,113	82,711	236,708
Theater	61,644	104,830	--	--	--

Table 9: Strata Cutpoints

Sample design vs. actual sample

Table 10 shows a summary of the study population, sample design, and achieved sample. Although metered sites are shown in Table 10, they were not part of a nested sample. Short-term metering was targeted primarily at industrial sites, as a means of better characterizing the process loads and measure performance at these sites. Short term metering was also installed at selected sites as a proxy for billing data. See the Short-term metering section later in this report for more information.

		Sample Design			Actual Final Sample		
	Population	Phone	On-Site	Meter	Phone	On-site	Meter
Participants	236	151	151	15	148	148	11
Non-Participants	3,600	151	151		144	144	4

Table 10: Sample Summary

Table 11 shows the participant sample design and the actual participant sample. As the table shows, in the certainty stratum, (stratum 6), 50 of the 51 projects were included in the final sample. The slight shortfall in the sample occurred among the smallest projects in the population. Three projects were not used in the analysis due to the fact that they were thermal energy storage load shifting projects.

Stratum	Design	Actual
1	20	17
2	20	19
3	20	21
4	20	21
5	20	20
6	51	50
Total	**151**	**148**

Table 11: Participant Sample Design and Actual Sample

There was no stratification of the participant sample by building type. Figure 7 shows the expected distribution of the participant sample by building type and the actual distribution of the participant sample. The distributions have been weighted by their inclusion probability to reflect the sample design. Figure 7 shows that the participant sample accurately reflects the distribution of building types among the program participants.

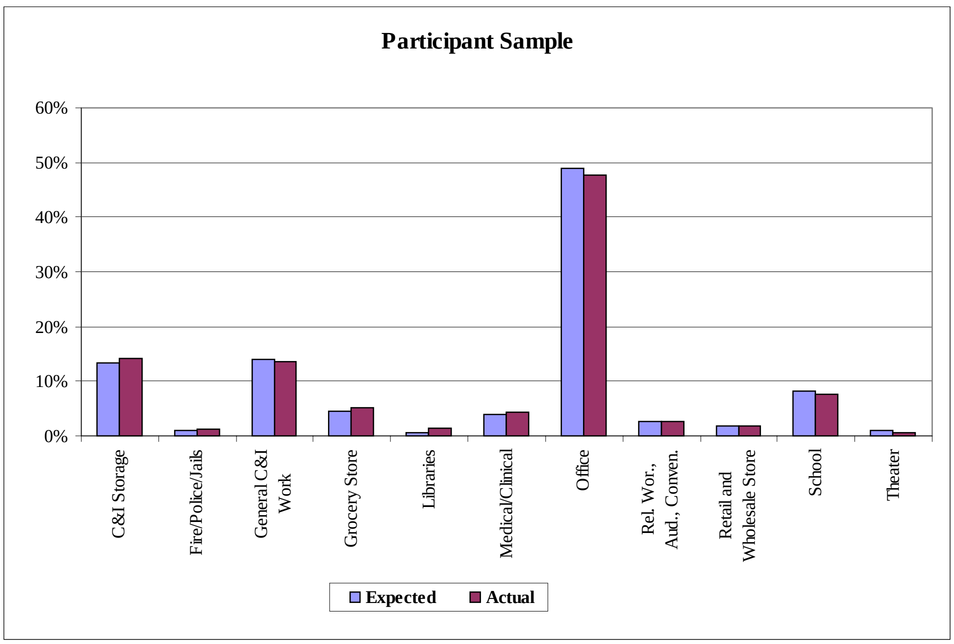

Figure 7: Participant Sample by Building Type

The non-participant sample was designed to be comparable to the participant population. The participant population was stratified by building type and square footage. Non-participant sites were selected from the Dodge new construction database to fill that sample design.

Figure 8 shows the non-participant sample design and the actual non-participant sample by building type. This shows that in terms of number of buildings, the actual sample was very close to the planned sample.

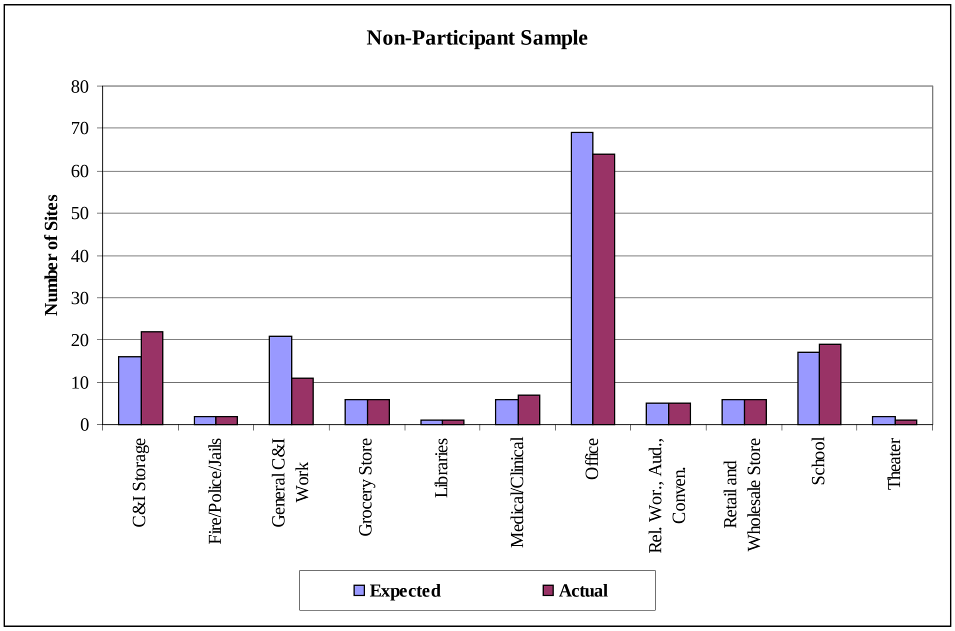

Figure 8: Non-participant Sample by Building Type

Table 12 shows the sample design and the actual non-participant sample by building type and square footage. Stratum 1 consists of the smallest buildings. Each successive stratum consists of progressively larger buildings. The specific cutpoints differ by building category, as shown previously in Table 9. In the table, the first number is the actual number of sites surveyed and the second number is the design for the cell. For example, in stratum 1 of C&I Storage, seven sites were surveyed whereas the original sample design called for four sites. There were a total of 10 participant refrigerated warehouses surveyed, and 3 non-participants. A matching sample of refrigerated warehouses was not surveyed due to the fact that the PG&E NRNC program targeted refrigerated warehouses, leaving a small number in our non-participant population.

In several of the building types, the final sample was more concentrated in the smaller strata than originally planned. The primary reason for the lack of larger buildings was the absence in the population of non-participants comparable in size to the participants. In other words, the program was generally very successful in targeting the largest projects in the population.

Building Type	Stratum 1	Stratum 2	Stratum 3	Stratum 4	Stratum 5	Total
C&I Storage	7 of 4	4 of 3	3 of 3	7 of 3	1 of 3	**22 of 16**
Fire/Police/Jails	2 of 1	0 of 1	--	--	--	**2 of 2**
General C&I Work	2 of 4	2 of 4	4 of 4	2 of 4	1 of 5	**11 of 21**
Grocery Store	1 of 2	0 of 1	1 of 1	2 of 1	2 of 1	**6 of 6**
Libraries	1 of 1	--	--	--	--	**0**
Medical/Clinical	5 of 2	2 of 1	0 of 1	0 of 1	0 of 1	**7 of 6**
Office	24 of 14	15 of 14	11 of 14	6 of 14	8 of 13	**64 of 69**
Rel. Wor., Aud., Conven.	4 of 1	0 of 1	0 of 1	1 of 1	0 of 1	**5 of 5**
Retail and Wholesale Store	2 of 2	1 of 1	1 of 1	2 of 1	0 of 1	**6 of 6**
School	2 of 4	7 of 4	3 of 3	2 of 3	5 of 3	**19 of 17**
Theater	1 of 1	0 of 1	--	--	--	**1 of 2**

Table 12: Non-participant Sample by Building Type and Size Strata

All of the preceding sample design tables contained the participant and non-participant sites that were used in the gross commercial and industrial analyses. The number of sites used in the net savings analysis for the commercial sites varied by the method used. The following table shows the number of participants and non-participants that were used in the difference of differences method of calculating net savings.

The seven industrial sites were excluded from the difference of differences analysis. In addition, two sites that were sampled combined into two sites for the analysis. That accounts for the nine fewer sites in the difference of differences analysis.

	Participants	Non-Participants
C&I Storage	17	22
Fire/Police/Jails	2	2
General C&I Work	17	11
Grocery Store	6	6
Libraries	2	1
Medical/Clinical	6	7
Office	62	64
Rel. Wor., Aud., Conven.	5	5
Retail and Wholesale Store	5	6
School	16	19
Theater	1	1
Total	**139**	**144**

Table 13: Difference of Differences Analysis Sample by Building Type-Commercial

Table 14 shows the econometric analysis sample. The same sites used in the difference of differences analysis were also used in the econometric analysis, with the exception of six sites for which no decision maker surveys were completed, thus they were excluded from the econometric analysis.

	Participants	Non-Participants
C&I Storage	17	22
Fire/Police/Jails	2	2
General C&I Work	17	11
Grocery Store	5	6
Libraries	2	1
Medical/Clinical	6	7
Office	62	60
Rel. Wor., Aud., Conven.	5	5
Retail and Wholesale Store	5	5
School	16	19
Theater	1	1
Total	**138**	**139**

Table 14: Econometric Analysis Sample by Building Type

Data Collection

Overview

A major portion of this project was the collection of the building and decision-maker data necessary to determine the program impacts. This section discusses the effectiveness of the data collection effort.

Overall, the data collection process ran quite smoothly. This was due to the use of highly qualified staff for recruiting, surveying, and modeling. The data collection process used in this study was similar to the process used in the 1996 NRNC study.

The data collection process was designed to collect the highest quality data in the most efficient manner possible. This process relied on several people working together to ensure a seamless information flow. Figure 9 shows a graphical representation of the data collection process.

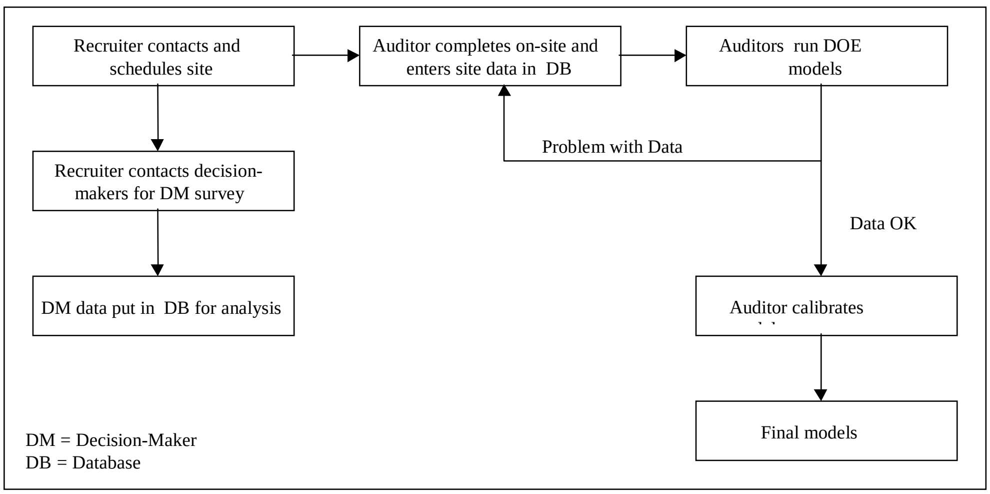

Figure 9: Data Collection Process

The recruiter was responsible for making contact with the site representative and securing their participation in the study. Once that was accomplished, the recruiter scheduled the on-site visit and provided the information to the field auditor. The recruiter then completed the decision-maker survey with the initial site contact and any additional contacts that were necessary to answer the decision-maker questions.

The on-site auditor collected building description and operation information from the site and entered the data into a database. Automated modeling software was used to create DOE-2 input files. The auditors were responsible for checking the models created from the field data, and correcting the data if necessary. The on-site auditor was also responsible for calibrating the model to billing data or short-term meter data, if available for the site. AEC and RLW senior staff checked the final model results.

The calibrated models were returned to AEC, who produced all of the required parametric model runs.

Recruiting

The recruiting process included the use of staff experienced in construction and development. This ensured that the professionals being contacted did not feel that they were speaking with someone who did not understand the basic issues in the field.

Table 15 summarizes the recruiting effort. A total of 292 of the 441 customers RLW (66.2%) attempted to recruit for the study agreed to participate. Only 7.7% refused to participate in the study.

In the table, "completed" means that the site was successfully recruited and audited. "No contact" means that attempts to contact a decision-maker at the site failed. "Dropped" indicates that the site was eliminated because it was found to be outside the scope of the study or the strata that a particular building fell into was filled before the recruiting process could be completed for a building. Participant buildings were typically dropped for the latter reason. Buildings found to be outside the scope of the project – typically non-participants – were those buildings that were not completed in 1998 or performed work that would not have been eligible for participation in the program (e.g. cosmetic renovations).

Disposition	Participants	Non-Participants	Total
Completed	148	144	292
Refused	6	28	34
No Contact	0	4	4
Dropped	11	100	111

Table 15: Recruiting Disposition

Decision-Maker Surveys

1. The recruiters completed decision-maker surveys for each audited site.
2. Recruiters made an average of 3.7 calls to complete each survey.
3. Figure 10 shows the number of calls made to all sites, including all dropped sites, and to only the sites that were ultimately surveyed[7].
4. Fewer than 1% of all sites required more than 1.0 individual decision-makers to complete each survey.

[7] The following graphs and tables in the recruiting section do not include information from the 40 sites that were used from the Baseline study due to the fact that they were recruited during a different study. The only calls made to the 40 Baseline sites were made in order to ask the few questions from the NRNC 98 decision-maker survey that were worded differently from, or added to the questions on the decision-maker survey from the Baseline study.

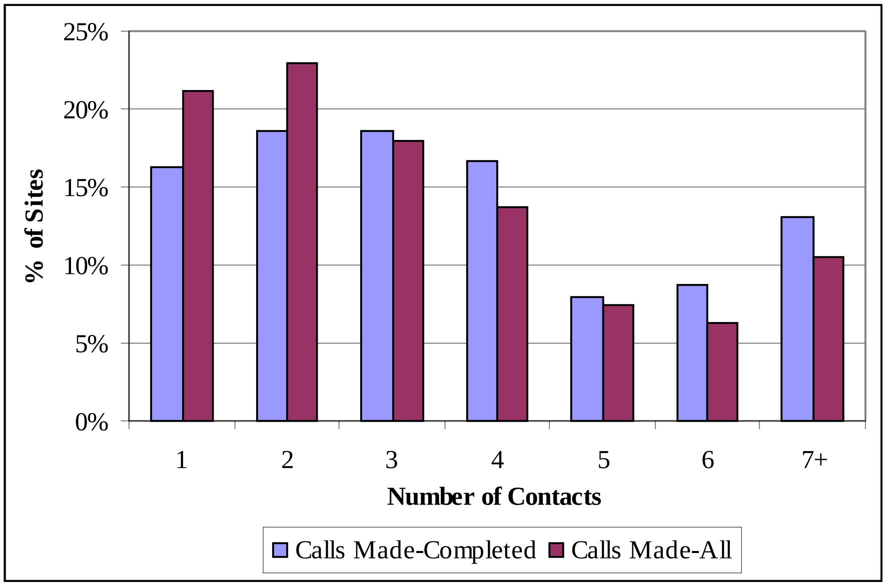

Figure 10: Number of Calls to Complete Each Decision-maker Survey

Figure 11 shows the number of calls made to complete each decision-maker survey by participant and non-participant. Notice that the majority of the sites were scheduled for an on-site and the decision-maker survey completed within 4 contacts for both participants and non-participants.

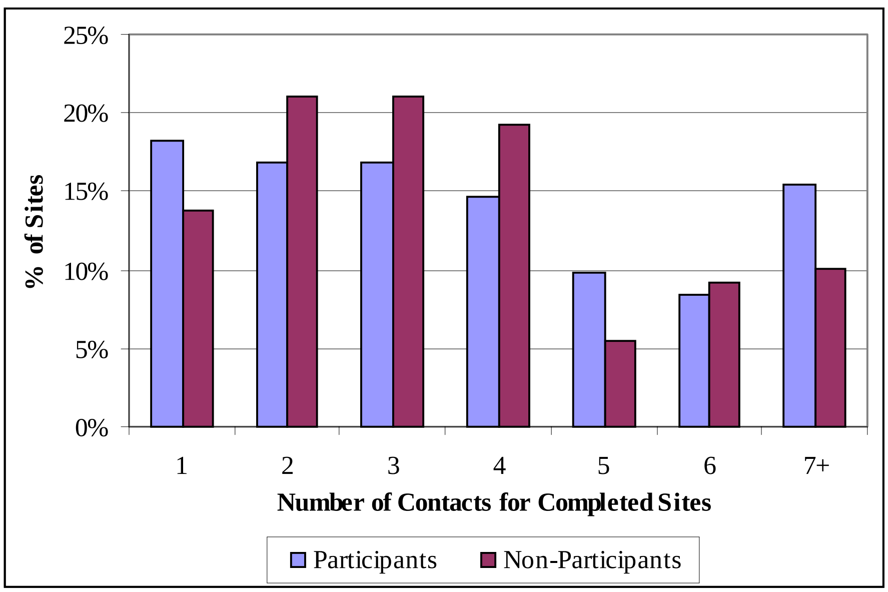

Figure 11: Number of Calls to Complete Each Decision-maker Survey by Participation Status

Table 16 summarizes the minimum, maximum, median, and average number of people contacted and calls made.

	Decision-Makers	Calls – Surveyed Sites	Calls – All Sites
Average	1.008	3.7	5.3
Median	1	3	3
Minimum	1	1	1
Maximum	2	12	12

Table 16: Summary of Telephone Contacts

On-Site Surveys

The primary data source for the DOE-2 models used to develop gross savings estimates were the on-site surveys. The survey form was designed so that key modeling decisions on model zoning and equipment/space association were made by the surveyors in the field. The form was designed to follow the logical progression of an on-site survey process. The form started out with a series of interview questions. Conducting the interview first helped orient the surveyor to the building and allowed time for the surveyor to establish a rapport with the customer. Once the interview was completed, an inventory of building equipment and all physical characteristics was conducted. The survey started with the HVAC systems, and progressed from the roof and/or other mechanical spaces into the conditioned spaces. This progression allowed the surveyor to establish the linkages between the HVAC equipment and the spaces served by the equipment. The incented measures were verified during the on-site survey.

Interview Questions

The surveyor used the interview questions to identify building characteristics and operating parameters that were not observable during the course of the on-site survey. The interview questions covered the following topics:

Building functional areas. Functional areas were defined on the basis of operating schedules. Subsequent questions regarding occupancy, lighting, and equipment schedules, were repeated for each functional area.

Occupancy history. The occupancy history questions were used to establish the vacancy rate of the building during 1998. The questions covered occupancy, as a percent of total surveyed floor space, and HVAC operation during the tenant finish and occupancy of the space. Responses to these questions were used to understand building start-up behavior during the model calibration process.

Building occupancy schedules. For each functional area in the building, a set of questions was asked to establish the building occupancy schedules. First, the surveyor assigned each day of the week to one of three daytypes: full occupancy, partial occupancy, and unoccupied. This was done to cover buildings that did not operate on a normal Monday through Friday workweek. Holidays and monthly variability in occupancy schedules were identified.

Daily schedules for occupants, interior lighting, and equipment/plug loads. A set of questions were used to establish hourly occupancy, interior lighting, and miscellaneous equipment and plug load schedules for each functional area in the building. During the on-site survey, the surveyor defined hourly schedules for each day type. A value, which represents the fraction of the maximum occupancy and/or connected load, was entered for each hour of the day. The entry of the schedule on to the form was done graphically.

Daily schedules of kitchen equipment. A set of questions was asked to establish hourly kitchen equipment schedules for each functional area in the building for each daytype. A value which represented the equipment-operating mode (off, idle, or low, medium or high volume production) was entered for each hour of the day. The entry of the schedule onto the form was done graphically.

Operation of other miscellaneous systems. General questions on the operation of exterior lighting systems, interior lighting controls, window shading, swimming pools, and spas were covered in this section.

Operation of the HVAC systems. A series of questions was asked to construct operating schedules for the HVAC systems serving each area. The surveyors entered fan operating schedules and heating and cooling setpoints. A series of questions was used to define the HVAC system controls. These questions were intended to be answered by someone familiar with the operation of the building mechanical systems. The questions covered operation of the outdoor air ventilation system, supply air temperature controls, VAV system terminal box type, chiller and chilled water temperature controls, cooling tower controls, and water-side economizers.

Building-wide water use. A series of questions was used to help calculate the service hot water requirements for the building.

Refrigeration system. The operation of refrigeration systems utilizing remote condensers, which are common in groceries and restaurants, was covered in this section. Surveyors divided the systems into three temperature classes, (low, medium and high) depending on the compressor suction temperature. For each system temperature, the refrigerant, and predominant defrost mechanism was identified. Overall system controls strategies were also covered.

Building Characteristics

The next sections of the on-site survey covered observations on building equipment inventories and other physical characteristics. Observable information on HVAC systems, building shell, lighting, plug loads, and other building characteristics were entered, as described below:

Built-up HVAC systems. Make, model number, and other nameplate data were collected on the chillers, cooling towers, heating systems, air handlers, and pumps in the building. Air distribution system type, outdoor air controls, and fan volume controls were also identified.

Packaged HVAC systems. Equipment type, make, model number, and other nameplate data were collected on the packaged HVAC systems in the building.

Zones. Based on an understanding of the building layout and the HVAC equipment inventory, basic zoning decisions were made by the surveyors according to the following criteria:

- ***Unusual internal gain conditions***. Spaces with unusual internal gain conditions, such as computer rooms, kitchens, laboratories were defined as separate zones.

- ***Operating schedules***. Different operating schedules (e.g. occupancy, lighting, HVAC) within a building were defined by zone. For example, retail establishments in a strip retail store may have different operating hours. Multiple office tenants within one office building may also have different hours of operation. These varying schedules were identified, recorded and input into the model.
- ***HVAC system type and zoning***. When the HVAC systems serving a particular space were different types, the surveyors sub-divided the spaces according to HVAC system type. If the space was zoned by exposure, the space was surveyed as a single zone, and a "zone by exposure" option was selected on the survey form.

For each zone defined, the surveyor recorded the floor area and occupancy type. Enclosing surfaces were surveyed, in terms of surface area, construction type code, orientation, and observed insulation levels. Window areas were surveyed by orientation. The surveyor also identified and inventoried basic window properties, interior and exterior shading devices, lighting fixtures and controls, and miscellaneous equipment and plug loads. Finally, the surveyor identified and entered zone-level HVAC equipment, such as baseboard heaters, fan coils, and VAV terminals.

Refrigeration systems. The surveyor inventoried the refrigeration equipment separately, and associated the equipment with a particular zone in the building. Refrigerated cases and stand-alone refrigerators were identified by case type, size, product stored, and manufacturer. Remote compressor systems were inventoried by make, model number, and compressor system type. Each compressor or compressor rack was associated with a refrigerated case temperature loop and heat rejection equipment such as a remote condenser, cooling tower, and/or HVAC system air handler. Remote condensers were inventoried by make, model number, and type. Nameplate data on fan and pump hp were recorded. Observations on condenser fan speed controls were also recorded.

Cooking Equipment. The surveyor recorded the cooking equipment separately and associated with a particular zone in the building. Major equipment was inventoried by equipment type (broiler, fryer, oven, and so on), size, and fuel type. Kitchen ventilation hoods were inventoried by type and size. Nameplate data on exhaust flow rate and fan horse power were recorded and each piece of kitchen equipment was associated with a particular ventilation hood.

Hot Water/Pools. Water heating equipment was inventoried by system type, capacity, and fuel type. The surveyor recorded observations on delivery temperature, heat recovery, and circulation pump horsepower. Solar water heating equipment was inventoried by system type, collector area, and collector tilt and storage capacity. The surveyor inventoried pools and spas by surface area and location (indoor or outdoor). The filter pump motor horsepower was recorded, along with the surface area, collector type, and collector tilt angle data for solar equipment serving pools and/or spas.

Miscellaneous exterior loads. Connected load, capacity, and other descriptive data on elevators, escalators, interior transformers, exterior lighting, and other miscellaneous equipment were recorded.

Meter Numbers. Additional utility meter data was collected in the field to assist in the billing data account matching and model calibration process. This section served as the primary link between the on-site survey and billing data for non-participants. The surveyor recorded meter numbers for each meter serving the surveyed space. If the meter served space in addition to the surveyed space, the surveyor made a judgment on the ratio of the surveyed space to the space served by the meter.

Establishing Component Relationships

In order to create a DOE-2 model of the building from the various information sources contained in the on-site survey, relationships between the information contained in the various parts of the survey needed to be established. In the interview portion of the form, schedule and operations data were cataloged by building functional area. In the equipment inventory section, individual pieces of HVAC equipment: boilers, chillers, air handlers, pumps, packaged equipment and so on were inventoried. In the zone section of the survey, building envelope data, lighting and plug load data, and zone-level HVAC data were collected. The following forms provided the information needed by the software to associate the schedule, equipment, and zone information.

System/Zone Association Checklist. The system/zone association checklist provided a link between each building zone and the HVAC equipment serving that zone. Systems were defined in terms of a collection of packaged equipment, air handlers, chillers, towers, heating systems, and pumps. Each system was assigned to the appropriate thermal zones in accordance with the observed building design.

Interview "Area" / Survey "Zone" Association Checklist. Schedule and operations data gathered during the interview phase of the survey were linked to the appropriate building zone. These data were gathered according to the building functional areas defined previously. Each building functional area could contain multiple zones. This table facilitated the association of the functional areas to the zones, and thereby the assignment of the appropriate schedule to each zone.

Refrigerated Warehouses

Models of each refrigerated warehouse facility were constructed from a combination of program documents and on-site surveys. Hard-copy program documents were obtained from PG&E for each participant. The program documentation generally included application forms, facility plans, building load calculations, equipment specification sheets, system operations manuals and proof of purchase documents. The refrigerated warehouse on-site survey was used to obtain the following information:

1. ***Verify facility design information***. Facility physical dimensions, equipment nameplate data, and other design parameters provided in the program file were field-verified. Additional facility description data required to develop the engineering model was collected.

2. ***Verify the installation of incented measures***. The surveyor identified all incented measures using the program files. The surveyor then physically counted the measures and compared nameplate data to program records.

3. ***Determine facility operation***. The facility operations data necessary to construct the engineering model was also collected. Interview questions identified facility operations parameters such as:

- Current operating hours
- Current operating months
- Future production and/or construction plans
- Product types received, receiving schedule, and product receiving temperature
- Product shipping schedule
- Process water flow schedules, temperature, and source (when heat recovery is used)
- Number and size of forklifts or other vehicles used, operating schedules
- Vehicle recharging schedules

During the facility walk-through portion of the on-site survey, additional equipment and facility operating parameters were observed. Such as:

- Space temperatures for coolers, freezers, loading vestibules, etc.
- Defrost schedules
- Suction pressures
- Minimum head pressure setpoints

These data were combined with the program information to construct a description of the design and operation of each participating refrigerated warehouse facility. Once the on-site surveys were conducted, an as-built TRNSYS model of each facility was constructed.

Short-term Metering

Short-term metering was targeted primarily at industrial sites, as a means of better characterizing the process loads and measure performance at these sites. Short term metering was also installed at selected sites as a proxy for billing data. The short-term metered data were gathered using a combination of battery-powered data loggers and existing site energy management system (EMS) trend logs. It was initially determined that 15 sites would be metered, with 2 meters installed at each site, for a total of 30 installed meters. The actual number of sites metered was in fact 15, but a total of 56 meters were installed at those 15 sites, almost doubling the proposed number of meters. A summary of the metering activities is shown in Table 17 below:

Site Description	Objective	Data Logger Channels	EMS Channels	Metering Summary
Church	Billing meter proxy	6		Four panels + two HVAC units serving new bldg
Industrial site with thermal energy storage	Billing meter proxy, TES operation		5	Whole bldg power plus chiller plant w/ TES
Lumber yard	Billing meter proxy	9		Four 208V panels serving new bldg
Industrial clean room site with desiccant dehumidifier	Process load characterization, measure performance	4	6	Two desiccant AHUs
Biotechnology laboratory	Process load characterization, measure performance	12	21	Combination of loggers and EMS trending on central plant and lab AHUs
Crude oil pumping facility	Process load characterization	3		One 2000 HP motor w/ VFD
Grain processing facility	Process load characterization, measure performance	16		Selected process motors
Biotechnology laboratory and manufacturing facility	Process load characterization, measure performance	7	18	Combination of loggers and EMS trending on central plant and AHUs
Refrigerated warehouse – salad processing plant	Billing meter proxy	4		Meter at whole bldg level
Refrigerated warehouse – carrot processing plant	Billing meter proxy	7		Logging pulse output meters on each of three buildings
University library addition	Billing meter proxy	2		Meter at whole bldg level
Medical office building	Billing meter proxy	7		Meter at whole bldg level
Office/laboratory	Billing meter proxy	2		Whole bldg
Hospital central chilled water plant	Process load characterization	32		Chiller plant
Industrial air compressor plant	Process load characterization	3		VSD air compressor
Total		**114**	**50**	

Table 17: Short-Term Metering Summary

Example data plots from the short-term metering of industrial sites can be found in the appendix. Short-term total load data were collected as a billing meter proxy in sites where there was not a good match between the surveyed space and the space served by the PG&E meter. An example of such a mismatch is a major tenant improvement or tenant finish in a multi-tenant building, where the PG&E revenue meter serves the entire space. Short-term metering equipment was installed on the circuits feeding only the surveyed space. These data were then used to calibrate the DOE-2 model for the site, instead of billing data. An example of model calibration using short-term data is shown below. In order to get sufficient data points for calibration, the models are calibrated to daily rather than monthly consumption. The response of the measured data and the model results to average ambient temperature is compared, and the model inputs are adjusted to within ±10% of the measured daily consumption, as shown in Figure 12 below:

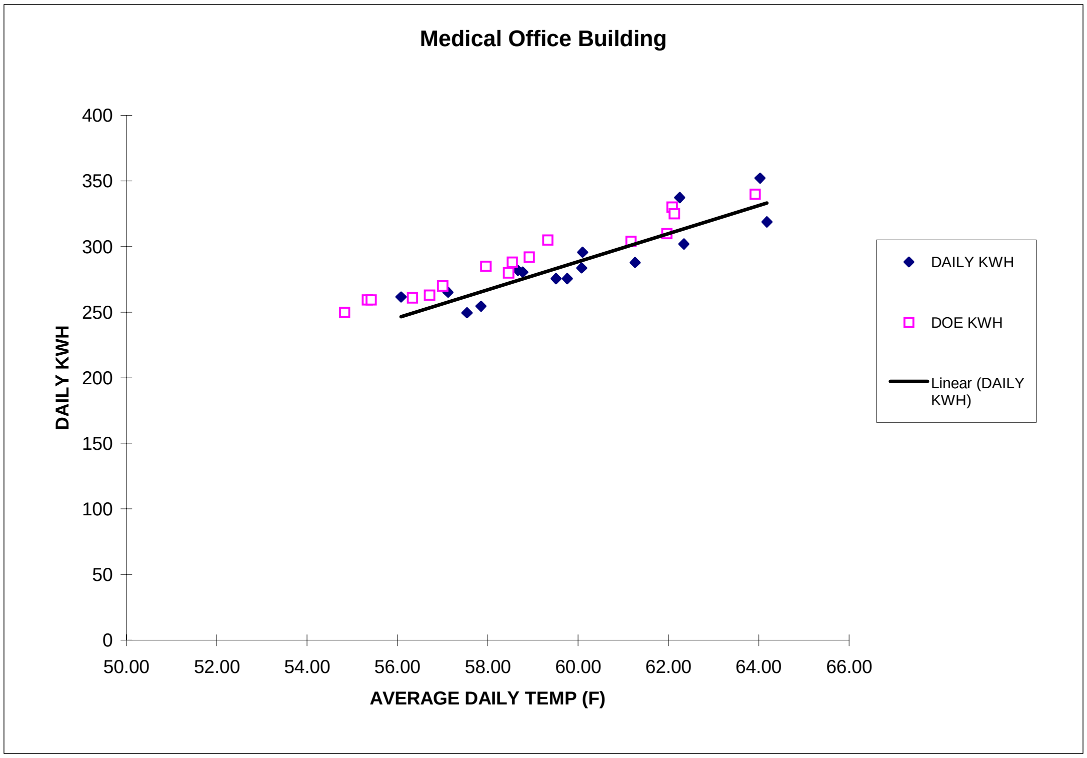

Figure 12: Model Calibration to Short Term Data

Engineering Models

An automated process was used to develop basic DOE-2 models from data contained in the on-site surveys, Title 24 compliance forms, program information and other engineering data. The modeling software took information from these data sources and created a DOE-2 model. The data elements used, default assumptions, and engineering calculations are described for the Loads, Systems, and Plant portions of the DOE-2 input file as follows.

Loads

Schedules were created for each zone in the model by associating the zones defined in the on-site survey with the appropriate functional area, and assigning the schedule defined for each functional area to the appropriate zone. Hourly schedules were created by the software on a zone-by-zone basis for:

- Occupancy
- Lighting
- Electric equipment
- Gas equipment (primarily kitchen equipment)
- Solar glare
- Window shading
- Infiltration

Occupancy, lighting, and equipment schedules. Each day of the week was assigned to a particular daytype, as reported by the surveyor. Hourly values for each day of the week were extracted from the on-site database according to the appropriate daytype. These values were modified on a monthly basis, according to the monthly building occupancy history.

Solar and shading schedules. The use of blinds by the occupants was simulated by the use of solar and shading schedules. The glass shading coefficient values were modified to account for the use of interior shading devices.

Infiltration schedule. The infiltration schedule was established from the fan system schedule. Infiltration was scheduled "off" during fan system operation, and was scheduled "on" when the fan system was off.

Shell materials. A single-layer, homogeneous material was described which contains the conductance and heat capacity properties of the composite wall used in the building. The thermal conductance and heat capacity of each wall and roof assembly was taken from the Title 24 documents, when available. If the Title 24 documents were not available, default values for the conductance and heat capacity were assigned from the wall and roof types specified in the on-site survey, and the observed R-values. If the R-values were not observed during the on-site survey and the Title 24 documents were not available, an "energy-neutral" approach was taken by assigning the same U-value and heat capacity for the as-built and baseline simulation runs.

Windows. Window thermal and optical properties from the building drawings or Title 24 documents (when available) were used to develop the DOE-2 inputs. If these documents were not available, default values for the glass conductance were assigned according to the glass type specified in the on-site survey. Solar radiation pyranometers were used during the on-site survey when possible to measure the as-built solar transmission of the glazing. The glass shading coefficient was calculated from the glass type and measured solar transmittance. The results of these tests were input into the model. If the glass properties were not measurable during the on-site survey and the Title 24 documents were not available, an "energy-neutral" approach was taken by assigning the same U-value and shading coefficient for the as-built and baseline simulation runs.

Lighting kW. Installed lighting power was calculated from the lighting fixture inventory reported on the survey. A standard fixture wattage was assigned to each fixture type identified by the surveyors. Lighting fixtures were identified by lamp type, number of lamps per fixture, and ballast type as appropriate.

Lighting controls. The presence of lighting controls was identified in the on-site survey. For occupancy sensor and lumen maintenance controls, the impact of these controls on lighting consumption was simulated as a reduction in connected load, according to the Title 24 lighting control credits. Daylighting controls were simulated using the "functions" utility in the load portion of DOE-2. Since the interior walls of the zones were not surveyed, it was not possible to use the standard DOE-2 algorithms for simulating the daylighting illuminance in the space. A daylight factor, defined as the ratio of the interior illuminance at the daylighting control point to the global horizontal illuminance was estimated for each zone subject to daylighting control. Typical values for sidelighting applications were used as default values. The daylight factor was entered into the function portion of the DOE-2 input file. Standard DOE-2 inputs for daylighting control specifications were used to simulate the impacts of daylighting controls on lighting schedules. The default daylight factors were adjusted during model calibration.

Equipment kW. Connected loads for equipment located in the conditioned space, including miscellaneous equipment and plug loads, kitchen equipment and refrigeration systems with integral condensers were calculated. Input data were based on the "nameplate" or total connected load. The nameplate data were adjusted using a "rated-load factor," which is the ratio of the average operating load to the nameplate load during the definition of the equipment schedules. This adjusted value represented the hourly running load of all equipment surveyed. Equipment diversity was also accounted for in the schedule definition.

For the miscellaneous equipment and plug loads, equipment counts and connected loads were taken from the on-site survey. To reduce audit time, the plug load surveys were done as a subset of the total building square footage. When the connected loads were not observed, default values based on equipment type were used.

For the kitchen equipment, equipment counts and connected loads were taken from the on-site survey. Where the connected loads were not observed, default values based on equipment type and "trade size" were used. Unlike the miscellaneous plug load schedules, the kitchen equipment schedules were defined by operating regime. An hourly value corresponding to "off", "idle", or "low," "medium," or "high" production rates was assigned by the surveyor. The hourly schedule was developed from the reported hourly operating status and the ratio of the hourly average running load to the connected load for each of the operating regimes.

For the refrigeration equipment, refrigerator type, count, and size were taken from the on-site survey. Equipment observed to have an "integral" compressor/condenser that is, equipment that rejects heat to the conditioned space, were assigned a connected load per unit size.

Source input energy. Source input energy represented all non-electric equipment in the conditioned space. In the model, the source type was set to natural gas, and a total input energy was specified in terms of Btu/hr. Sources of internal heat gains to the space that were not electrically powered include kitchen equipment, clothes dryers, and other miscellaneous process loads. The input rating of the equipment was entered by the surveyors. As with the electrical equipment, the ratio of the rated input energy to the actual hourly consumption was calculated by the rated load factor assigned by equipment type and operating regime.

Heat gains to space. The heat gains to space were calculated based on the actual running loads and an assessment of the proportion of the input energy that contributed to sensible and latent heat gains. This in turn depended on whether or not the equipment was located under a ventilation hood.

Spaces. Each space in the DOE-2 model corresponded to a zone defined in the on-site survey. In the instance where the "zoned by exposure" option was selected by the surveyor, additional DOE-2 zones were created. The space conditions parameters developed on a zone by zone basis were included in the description of each space. Enclosing surfaces, as defined by the on-site surveyors, were also defined.

Systems

This section describes the methodology used to develop DOE-2 input for the systems simulation. Principal data sources include the on-site survey, Title 24 documents, manufacturers' data, and other engineering references as listed in this section.

Fan schedules. Each day of the week was assigned to a particular daytype, as reported by the surveyor. The fan system on and off times from the on-site survey were assigned to a schedule according to daytype. These values were modified on a monthly basis, according to the monthly HVAC operating hour adjustment. The on and off times were adjusted equally until the required adjustment percentage was achieved. For example, if the original schedule was "on" at 6:00 hours and "off" at 18:00 hours, and the monthly HVAC adjustment indicated that HVAC operated at 50% of normal in June, then the operating hours were reduced by 50% by moving the "on" time up to 9:00 hours and the "off" time back to 15:00 hours.

Setback schedules. Similarly, thermostat setback schedules were created based on the responses to the on-site survey. Each day of the week was assigned to a particular daytype. The thermostat setpoints for heating and cooling, and the setback temperatures and times were defined according to the responses. The return from setback and go to setback time was modified on a monthly basis in the same manner as the fan-operating schedule.

Exterior lighting schedule. The exterior lighting schedule was developed from the responses to the on-site survey. If the exterior lighting was controlled by a time clock, the schedule was used as entered by the surveyor. If the exterior lighting was controlled by a photocell, a schedule, which follows the annual variation in daylength was used.

System type. The HVAC system type was defined from the system description from the on-site survey. The following DOE-2 system types were employed:

- Packaged single zone (PSZ)
- Packaged VAV (PVAVS)
- Packaged terminal air conditioner (PTAC)
- Water loop heat pump (HP)
- Evaporative cooling system (EVAP-COOL)
- Central constant volume system (RHFS)
- Central VAV system (VAVS)
- Central VAV with fan-powered terminal boxes (PIU)
- Dual duct system (DDS)
- Multi-zone system (MZS)
- Unit heater (UHT)
- Four-pipe fan coil (FPFC)

Packaged HVAC system efficiency. Manufacturers' data were gathered for the equipment surveyed based on the observed make and model number. A database of equipment efficiency and capacity data was developed from an electronic version of the ARI rating catalog. Additional data were obtained directly from manufacturers' catalogs, or the on-line catalog available on the ARI website (www.ari.org). Manufacturers' data on packaged system efficiency is a net efficiency, which considers both fan and compressor energy. DOE-2 requires a specification of packaged system efficiency that considers the compressor and fan power separately. Thus, the manufacturers' data were adjusted to prevent "double-accounting" of fan energy, according to the procedures described in the 1995 Alternate Compliance Method (ACM) manual.

Pumps and fans. Input power for pumps, fans and other motor-driven equipment was calculated from motor nameplate hp data. Motor efficiencies as observed by the surveyors were used to calculate input power. In the absence of motor efficiency observations, standard motor efficiencies were assigned as a function of the motor hp. A rated load factor was used to adjust the nameplate input rating to the actual running load. For VAV system fans, custom curves were used to calculate fan power requirements as a function of flow rate in lieu of the standard curves used in DOE-2, as described in the 1995 ACM manual.

Refrigeration systems. Refrigeration display cases and/or walk-ins were grouped into three systems defined by the evaporator temperature. Ice cream cases were assigned to the lowest temperature circuit, followed by frozen food cases, and all other cases. Case refrigeration loads per lineal foot were taken from manufacturers' catalog data for typical cases. Auxiliary energy requirement data for evaporator fans, anti-sweat heaters, and lighting were also compiled from manufacturers' catalog data. Model inputs were calculated based on the survey responses. For example, if the display lighting was surveyed with T-8 lamps, lighting energy requirements appropriate for T-8 lamps were used to derive the case auxiliary energy input to DOE-2.

Compressor EER data were obtained from manufacturers' catalogs as a function of the suction temperatures corresponding to each of the three systems defined above. These data were used to create default efficiencies for each compressor system. Custom part-load curves were used to simulate the performance of parallel-unequal rack systems.

Total heat of rejection (THR) data at design conditions were obtained for refrigeration system condensers from manufacturers' data. These data were used to calculate hourly approach temperatures and fan energy using the enhanced refrigeration condenser algorithms in DOE-2.1 E version 119.

Service hot water. Service hot water consumption was calculated based on average daily values from the 1995 ACM for various occupancy types. Equipment capacity and efficiency were assigned based on survey responses.

Exterior lighting. Exterior lighting input parameters were developed similarly to those for interior lighting. The exterior lighting connected load was calculated from a fixture count, fixture identification code and the input wattage value associated with each fixture code.

Plant

This section describes the methodology used to develop DOE-2 input for the plant simulation. Principal data sources included the on-site survey, Title 24 documents, manufacturers' data, program data, and other engineering references.

Chillers. The DOE-2 input parameters required to model chiller performance included chiller type, full-load efficiency and capacity at rated conditions, and performance curves to adjust chiller performance for temperature and loading conditions different from the rated conditions. Chiller type was assigned based on the type code selected during the on-site survey. Surveyors also gathered chiller make, model number, and serial number data. These data were used to develop performance data specific to the chiller installed in the building. Program data and/or manufacturers' data were used to develop the input specifications for chiller efficiency.

Cooling towers. Cooling tower fan and pump energy was defined based on the nameplate data gathered during the on-site survey. Condenser water temperature and fan volume control specifications were derived from the on-site survey responses.

Refrigerated Warehouses

A combination of engineering techniques was used to calculate the energy performance and energy savings of refrigerated warehouses. The DOE-2.2 and TRNSYS transient simulation programs were used in tandem to create the engineering models. The DOE-2.2 program was used to calculate hourly facility refrigeration loads. The TRNSYS program was used to simulate the performance of specialized refrigeration equipment such as industrial refrigeration evaporators, defrost systems, evaporative condensers, and industrial refrigeration compressor systems.

Models of each facility were constructed from a combination of design documents and on-site surveys. Hard-copy program documents were obtained from PG&E, which included application forms, facility plans, building load calculations, equipment specification sheets, system operations manuals and proof of purchase documents. Similar information was obtained for non-participants during the on-site survey and subsequent interviews with facility designers.

An on-site survey was conducted for each sampled site. The on-site survey was used to obtain the following information:

1. ***Verify facility design information***. Facility physical dimensions, equipment nameplate data, and other design parameters were field-verified. Additional facility description data required to develop the engineering model were collected.
2. ***Verify the installation of incented measures***. All incented measures were identified, and the physical count and nameplate data were compared to program records.
3. ***Determine facility operation***. The facility operations data necessary to construct the engineering model were collected. Interview questions identified facility operations parameters such as:
    - Operating hours
    - Operating months
    - Product types received, receiving schedule, and product receiving temperature
    - Product shipping schedule
    - Process water flow schedules, temperature, and source (when heat recovery is used)
    - Number and size of forklifts or other vehicles used, operating schedules
    - Vehicle recharging schedules

    During the facility walk-through portion of the on-site survey, additional equipment and facility operating parameters were observed such as:

    - Space temperatures for coolers, freezers, loading vestibules, etc.
    - Defrost schedules
    - Suction pressures
    - Minimum head pressure setpoints

These data were used to construct a description of the design and operation of each refrigerated warehouse facility. Once the on-site surveys were conducted, an engineering model of each facility was constructed.

Gross savings calculations

The as-built performance of the facility was calculated from the facility characteristics verified during the on-site survey. Since there are no energy standards for refrigerated warehouses, the PG&E program baseline equipment specifications as reported in the Advice Filings served as the baseline or reference point for the gross impact calculations. Gross savings for each participant and non-participant warehouse were calculated from the difference in the energy consumption between the facility modeled with the baseline specifications and the facility modeled with the as-built efficiency specifications. The refrigerated warehouse baseline specifications are summarized in Table 18. The baseline specifications were defined based upon the Advice Filings for the PG&E/SCE 1994 NRNC Evaluation, and heavily reviewed by PG&E program engineers. The PG&E program minimum requirements for pipe insulation were less stringent than the baseline level established for the study. In other words, a refrigerated warehouse that only installed the minimum required pipe insulation would have negative savings.

Attribute	Application	Baseline Characteristics	Program Minimum	Incentive Levels	Comments	Reference
Lighting	All refrigerated space	Not addressed	0.6 W/SF	none	Since no incentives paid, installed lighting will be held energy-neutral.	
Roof Insulation	Cooler	R-30	R-30	R-40 - R-50	Baseline = program minimum	Advice Filing NRNC- A - A7
	Freezer	R-45	R-45	R-50 - R-100	Baseline = program minimum	Advice Filing NRNC- A - A7
Wall Insulation	Cooler	R-25	R-25	R-35 - R-45	Baseline = program minimum	Advice Filing NRNC- A - A7
	Freezer	R-35	R-35	R-40 - R-60	Baseline = program minimum	Advice Filing NRNC- A - A7
Vessel insulation	Cooler	R-10	R-11	R-16		Advice Filing NRNC- A - 40
	Freezer	R-17	R-14	R-24	Baseline higher than program minimum	Advice Filing NRNC- A - 41
Pipe insulation	Cooler - pipe dia .5 - 1.5 in. pipe dia 2 - 5 in. pipe dia 6 - 12 in.	R-6 R-9 R-10	R-3.5 R-5.5 R-5.5	R-5 R-8 R-11	Baseline higher than incentive levels Baseline higher than incentive levels Baseline higher than program minimum	Advice Filing NRNC- A - 40
	Freezer - pipe dia .5 - 1.5 in. pipe dia 2 - 5 in. pipe dia 6 - 12 in.	R-9 R-14 R-15	R-5 R-8 R-8	R-8 R-11 R-16	Baseline higher than incentive levels Baseline higher than incentive levels Baseline higher than program minimum	Advice Filing NRNC- A - 40
Doors	Forklift doors - open to ambient	Slow-closing automatic door, 14 second cycle time.	None	Quick-close door		Advice Filing NRNC- A - 42
	Forklift doors - open to adjacent space	Open door with strip curtain	None	Quick-close door		Pers comm, Stan Tory
	Material pass-through doors	Open door with strip curtain	None	Quick-close door	50% reduction in door use and infiltration	Pers comm, Stan Tory
Evaporators	Fan control	One-speed	None	Two speed, VSD		Advice Filing NRNC- A - 44
	Fan power	0.39 hp/ton	None	0.3 hp/ton		Advice Filing NRNC- A - 44
	Motor efficiency	Standard efficiency	None	High efficiency		Advice Filing NRNC- A - 44
	Approach temperature	20 °F	None	8 °F		Advice Filing NRNC- A - 44

Table 18: Refrigerated Warehouse Baseline Specifications

Attribute	Application	Baseline Characteristics	Program Minimum	Incentive Levels	Comments	Reference
Low temperature piping design	Systems with loads at different temperatures	Lowest value for all evaporators	None	Separate low temp suction line	Second system < -25°F SST, > 10°F below initial system	
Pipe sizing	Suction line pressure drop	0.5 psi/100 ft, max of 2.0 total	None	Upsize one pipe diameter		Advice Filing NRNC-A-F12
	Discharge line pressure drop	1.5 psi/100 ft, max of 3 total	None	Upsize one pipe diameter		Advice Filing NRNC-A-F12
Liquid sub-cooling	High pressure liquid	No sub-cooling	None	5 °F difference between refrigerant and cooling water		
Evaporative condensers	Approach temperature	20 °F	10 °F	Same as program minimum		Advice Filing NRNC - A56
	Minimum condensing temperature	75 °F	60 °F	Same as program minimum		Advice Filing NRNC - A56
	Condensing temperature control	Pressure control	Wet-bulb control for systems > 300 T	Same as program minimum	Program minimum and incentive level is press control for systems < 300 T	
	Motor efficiency	Standard	Energy-efficient	Same as program minimum		Advice Filing NRNC - A55
	Fan control	One-speed	Two speed	Same as program minimum		Advice Filing NRNC - A55
	Fan and pump power	0.09 hp/ton	0.11 hp/ton	Same as program minimum	Lower condensing temp makes up for higher fan hp	Pers comm., Stan Tory
Compressors	Efficiency	Stock compressor bhp/ton from manufacturer.	None	4% improvement over stock compressor efficiency		
	Motor efficiency	Standard efficiency	None	Premium efficiency		
	Oil cooling	Liquid-injection	Thermo-syphon oil cooling > 300 T	Thermo-syphon oil cooling all sizes T	Must use thermosyphon oil cooling to get compressor incentive	
Battery chargers		Ferro-resonant battery charger with manual timer	None	Select from list of qualifying models		

Table 18 (con't): Refrigerated Warehouse Baseline Specifications

Model Review and Quality Control

The on-site survey data entry program contained numerous quality control (QC) checks designed to identify invalid building characteristics data during data entry. Once the data were entered, the models were run and the results were reviewed by the surveyor/modeler and senior engineering staff. A building characteristics and model results summary report was created for each site. The model results were compared to a set of QC criteria as shown in Table 19. Data falling outside of the QC range were validated during the QC process.

Building Parameter	Range	Definition
Lighting Power Density	0.9 - 1.9	building wide average
Equipment Power Density	0.1 - 5	building wide average
Cooling Ratio	95 - 200%	capacity from annual run / capacity from sizing run
Cooling EER	8 - 14	capacity weighted cooling efficiency
Wall-U	0.5 - 0.033	area weighted average, includes air film
Roof-U	0.5 - 0.033	area weighted average, includes air film
Win-U	0.3 - 0.88	area weighted average, includes air film
Win-Shading Coefficient	0.35 - 0.88	area weighted average
Win Area	0 - 70%	Percentage of gross wall area associated w/windows, expressed as a true percentage 0 –100
Sky-U	0.3 - 0.9	area weighted average of glazing contained in roof
Sky-Shading Coefficient	0.35 - 0.88	area weighted SC for all horizontal glazing
Sky-Area	0 - 10%	Percentage of gross roof area associated with sky light, expressed as a true percentage 0 –100
LTG Occ	0 - 50%	Percentage of lighting watts controlled by occupancy sensors, expressed as a true percentage 0 –100
LTG DayL	0 - 50%	Percentage of lighting watts controlled by daylighting sensors, expressed as a true percentage 0 –100
Measures only savings relative to program expectations (participants only)	50% - 150%	measures-only savings / program expectations
Total savings (all sites)	0% - 50%	Savings expressed as a percentage of baseline energy consumption

Table 19: Model Quality Control Criteria

Model Calibration

An integral part of DOE-2 model development was the model calibration process. Monthly energy consumption and demand from the DOE-2 models were compared to billing data for the same period to assess the reasonableness of the models. Changes were made to a fixed set of calibration parameters until the models matched the billing data. The goal of the calibration process was to match billing demand and energy data within ± 10 percent on a monthly basis. The overall model calibration process consisted of the following steps:

1. Review and format billing data. Billing data as received from PG&E were reformatted as required by the model calibration software.
2. Select relevant accounts. For many of the sites, a number of accounts were provided. Account information such as customer name, address, business type, and meter number was compared to the on-site survey information. The list of accounts that seemed to best match the surveyed space was selected.
3. Assign surveyed to metered space percentage. During the on-site survey, the surveyors were asked to assess the ratio of the space surveyed to the space served by the building meter(s). Billing data records were adjusted to reflect the portion of the metered data that applied to the modeled space.
4. Run model. The as-built model was run with actual 1998 and 1999 weather data applicable to the particular site, using the occupancy as reported by the surveyors. Annual simulations for both years were done, and the modeled consumption and demand were aggregated to correspond to the meter read dates from the billing data. The 1999 calibration covered billing data and simulated energy consumption for the first six months of the year.
5. Review kWh and kW comparison. The modeled and metered consumption and demand for each billing period were compared using a graphical data visualization tool. An example output screen from the calibration tool is shown in Figure 13.
6. Reject unreasonable or faulty billing data. Some of the billing data received was incomplete or not well matched to the modeled space. In these cases, the billing data were rejected, and the models were not calibrated.
7. Make adjustments to calibration variables. A fixed set of calibration variables was provided to the modeling calibration team. The calibration parameters, and the range of acceptable adjustments are shown in Table 20. The modelers adjusted the calibration parameters until the modeled results matched the metered results within ± 10 percent for each billing period. This was an iterative process, involving changing the model inputs, repeating the simulation, and reviewing the results. At each iteration, the changes made to the model and the impacts of the change on the model vs. billing data comparison were entered into a calibration log file.

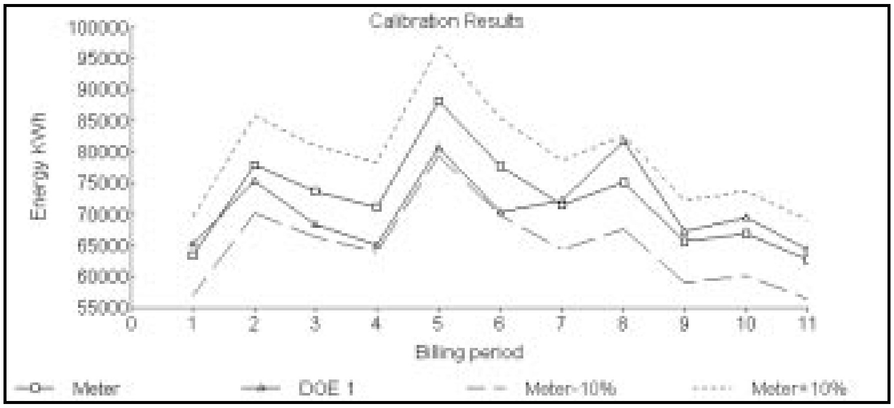

Figure 13: Example Calibration Tool Screen

Calibration Parameter	Adjustment range
Monthly schedule multiplier	.2 – 2
Lighting diversity multiplier	.2 – 2
Plug load diversity multiplier	.2 – 5
Plug load internal heat gains multiplier	.2 – 5
Heating thermostat setpoint	± 5°F
Cooling thermostat setpoint	± 5°F
DHW water use multiplier	.1 – 10
Minimum outside air ratio	.1 - .7, if no additional information
Refrigeration compressor efficiency	± 20%
Heating supply air temp control	discrete choices
Direct evaporative system effectiveness	0.2 - 0.8
Indirect evaporative system effectiveness	0.2 - .07
Heat pump defrost control	discrete choices
Daylight factor	look at hourly reports to verify correct operation
Building azimuth	± 45 degrees

Table 20: Model Calibration Parameters and Acceptable Adjustment Range

In some cases, it was not possible to calibrate the models. When billing or short-term metering data were not available, the modeled results were examined for reasonableness, in terms of annual energy consumption (kWh/SF) by building type and measure percentage of total consumption. Even when billing data were available, some of the models resisted reasonable attempts to achieve calibration. Rather than making unreasonable adjustment to the models, the models were left un-calibrated or partially calibrated. During calibration, the models were run with actual year weather data provided by PG&E from 32 local weather stations located throughout their service territory.

The results of the model calibration process are shown in Figure 14. The modelers were able to successfully calibrate 41% of the models. We were unable obtain billing data for 36% of the sites, due primarily to lack of access to the meter during the on-site survey or lack of access to billing data for non-PG&E

customers. The surveyed space was less than 80% of the space served by the meter in 16% of the sites. A total of 7% of the models resisted reasonable attempts at calibration. In other words, for 7% of the sites, billing data were available but the model could not be brought into agreement with the data by making reasonable modifications to the model. Overall, when valid billing data that matched the surveyed space was obtained, the modelers were able to successfully calibrate 85% of the possible models.

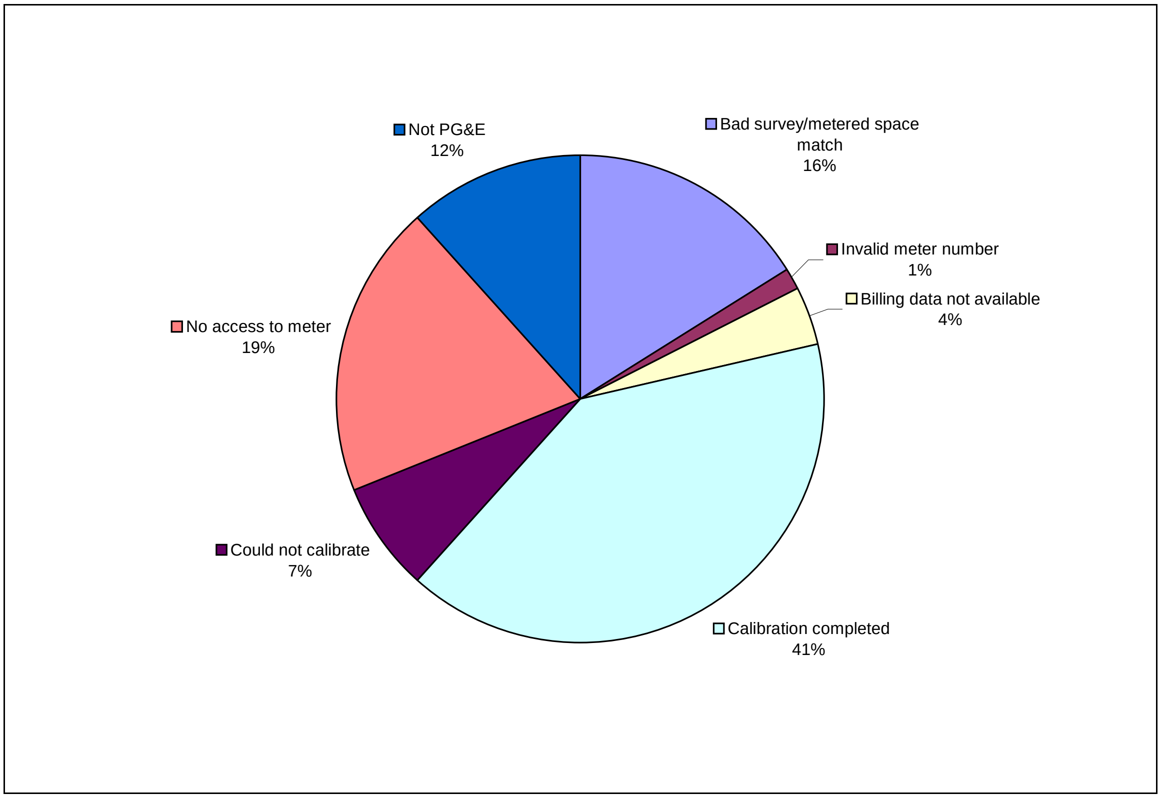

Figure 14: Model Calibration Results

The frequency of calibration actions taken by the modelers is shown in Figure 15. A total of 127 buildings were successfully calibrated. Note that plug load diversity multiplier adjustments were the most common changes made during the calibration process.

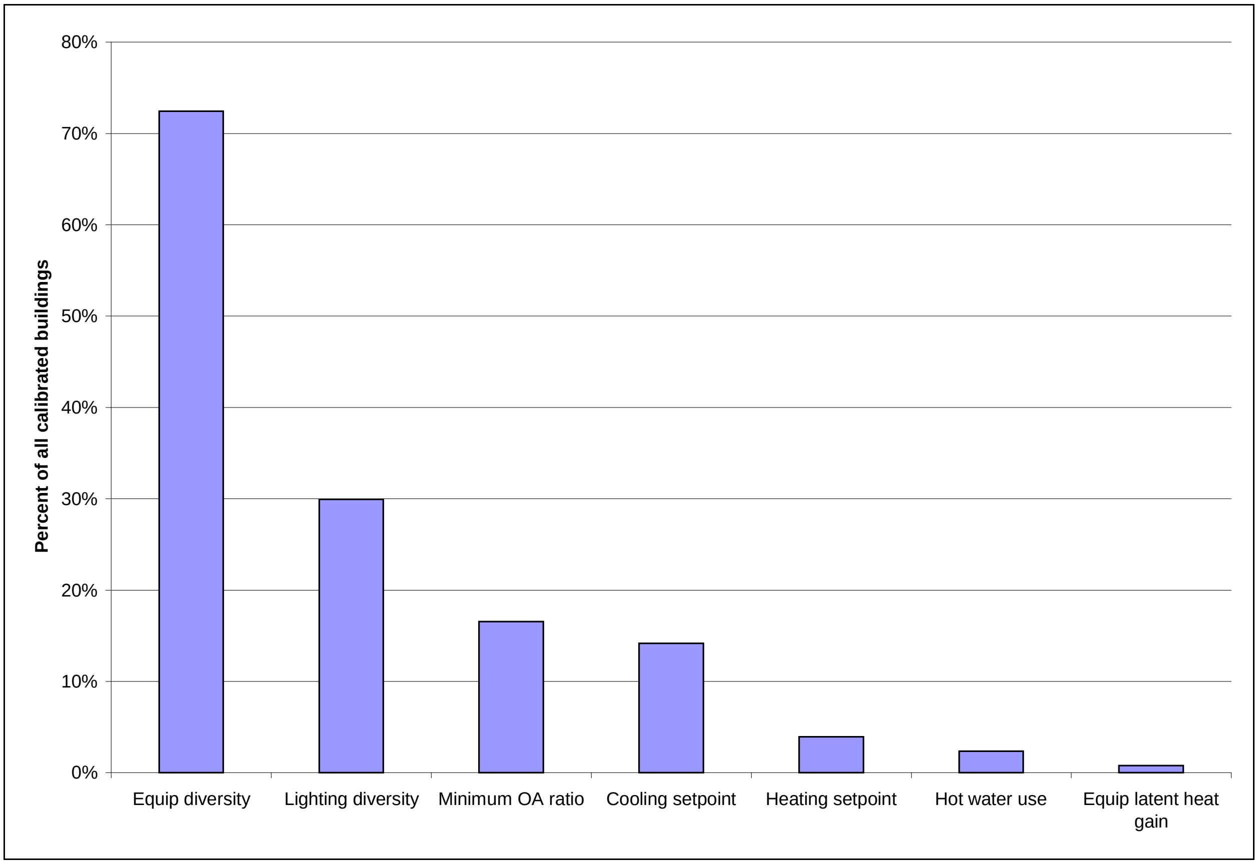

Figure 15: Frequency of Calibration Actions

The average initial and final values for the most common calibration variables are shown in Table 21.

Calibration Variable	Average Initial Value	Average Final Value
Plug load diversity multiplier	1	2.75
Lighting diversity multiplier	1	2.40
Outdoor air fraction	0.207	0.248
Cooling setpoint (°F)	72.6	71.6
Heating setpoint (°F)	65.4	62.6
Hot water consumption (gallons/person/day)	13.2	3.1

Table 21: Initial and Final Calibration Variables

The plug load diversity multiplier showed the largest average change (275%) of the set of most common calibration variables shown in Table 21. Plug loads were not extensively surveyed, since plug load energy consumption was not addressed by the program or Title 24. The uncertainty in the calculated plug load density and schedule diversity was high, as was the influence of plug loads on total building consumption and demand. However, the impact of plug loads on calculated energy savings was minor, thus the impact of calibration on the total program savings is relatively small.

Parametrics

Once the models were quality checked and calibrated, a batch process was used to create a series of parametric simulation runs. These runs were used to simulate gross savings for participants and non-participants on a whole-building and end-use-measure basis. The parametric runs performed for this study are listed below:

As-Built Parametric Run

Once the models were completed, checked for reasonableness, and/or calibrated, the as-built parametric runs were done. Monthly schedule variations resulting from partial occupancy and building startup were eliminated, and the models were run using long-term average weather data from the California Energy Commission.

Baseline Parametric Run

Key building performance parameters were reset to a baseline condition to calculate gross energy savings for participants and non-participants. The California Building Energy Efficiency Standard (Title 24) was the primary reference for establishing baseline performance parameters. Title 24 specifies minimum specifications for building attributes such as:

- Opaque shell conductance
- Window conductance
- Window shading coefficient
- HVAC equipment efficiency
- Lighting power density

Title 24 applied to most of the building types covered in the programs covered under this evaluation, with the exception of:

- Hospitals
- Unconditioned space (including warehouses)

Incentives were also offered by the programs for building attributes not addressed by Title 24. In situations where Title 24 does not address building types or equipment covered under the program, baseline parameters equivalent to those used for the program baseline efficiencies were used.

Envelope

Opaque shell U-values were assigned based on Title 24 requirements as a function of climate zone and heat capacity of the observed construction. For windows, Title 24 specifications for maximum relative solar heat gain were used to establish baseline glazing shading coefficients. Fixed overhangs were not modeled for the baseline building. Glass conductance values as a function of climate zone were applied. For skylights, shading coefficients and overall conductance were also assigned according to climate zone.

Mechanical

Baseline specifications for HVAC equipment efficiency were derived from the Title 24 requirements as a function of equipment type and capacity. Maximum power specifications for fans were established based on Title 24 requirements, which address fan systems larger than 25 hp. Specific fan power was held energy neutral (as built W/CFM = baseline W/CFM) for fan systems under 25 hp. Additionally, all systems larger than 2500 CFM (except for hospitals) were simulated with economizers in the baseline run. All VAV fan systems larger than 50 hp were simulated with inlet vane control. All variable-volume pumps were simulated with throttling valve control.

HVAC System Sizing

HVAC system sizing for the as-built case was determined by direct observation of the nameplate capacities of the HVAC equipment. The installed HVAC system capacity was compared to the design loads imposed on the system to determine a sizing ratio for the as-built building. Once established, the sizing ratio was held constant for each subsequent DOE-2 run. A separate sizing run was done prior to the baseline and parametric runs. The peak cooling system size was calculated using the equipment sizing algorithms in DOE-2. The system capacity was reset using the calculated peak cooling capacity, and the as-built sizing ratio. A new system size was calculated for the baseline run and each parametric run.

Lighting

The Title 24 area category method was used to set the baseline lighting power for each zone as a function of the observed occupancy. Task lighting was not included in the baseline lighting calculation, and exit signs were reset to the program baseline (40 W/exit sign). A lighting power density appropriate for corridor/restroom/support areas was assigned according to the portion of each space allocated to these areas. All lighting controls were turned off for the baseline simulation.

Additional Parametric Runs

Once the as-built and baseline building models were defined, an additional set of parametric runs were done to estimate the program impact on the lighting, HVAC, shell end-uses. The baseline model was returned to the as-built design in a series of steps outlined as follows:

1. Shell, incented measures only – Baseline envelope properties (glazing U-value and shading coefficient; and opaque surface insulation) for incented measures only were returned to their as-built condition.
2. All Shell – All baseline envelope properties were returned to their as-built condition.
3. Lighting, incented measures only – Run 2 above, plus baseline lighting power densities and controls for spaces in the building that received incentives were returned to their as-built condition.
4. All Lighting – Run 2 above, plus all baseline lighting power densities and controls were returned to their as-built condition.

5. Motors and Air Distribution, incented measures only – Run 4 above, plus baseline motor efficiency and fan power indices (W/CFM) for incented measures only returned to their as-built condition.
6. All Motors and Air Distribution – Run 4 above, plus all baseline motor efficiency and fan power indices (W/CFM) returned to their as-built condition.
7. HVAC, incented measures only. Run 6 above, plus HVAC parameters for incented measures only returned to their as-built condition.
8. All HVAC – Run 6 above, plus all HVAC parameters returned to their as-built condition.
9. All Refrigeration – Run 8 above, plus all refrigeration parameters in buildings eligible for the grocery store refrigeration and refrigerated warehouse programs returned to their as-built condition. This run is equivalent to the full as-built run. Note: refrigeration parameters in buildings not eligible for the grocery store refrigeration and refrigerated warehouse programs remained at the as-built level for all parametric runs.

Several model variables are held "energy neutral" during the parametric run process. Energy neutral is defined as keeping specific model variables equal to baseline model runs so as not to effect energy consumption. For example, operating schedules for a rebated lighting system remain unchanged in the as-built and baseline runs so that only the delta in connected lighting load between the two models is used to estimate energy and demand impacts.

Commercial Projects - Gross Savings

This section presents the gross energy and demand savings estimates of participants. Savings findings for the whole building as well as for shell, lighting, motors, HVAC, and refrigeration end-uses are reported.

Some definitions will be helpful to clarify the discussion.

Baseline	A consistent standard of energy efficiency against which all buildings were measured. This was defined as the output of a DOE-2.1E simulation of a building using Title 24 required equipment efficiencies (where applicable) run using the operating schedule found by the on-site surveyor. Where Title 24 did not apply (e.g. hospitals), the baseline that was defined by the program for estimating the program savings was used.
As Built	A DOE-2.1E simulation of a building using all equipment and operating parameters as found by an on-site surveyor.
Whole-Building Savings	The difference between the whole-building energy use under the baseline and as-built simulations. Positive savings indicate that the building was more efficient – used less energy – than its baseline case.
End-Use Savings	The difference between the whole-building energy use under the baseline and as-built measures associated with a particular end use. For example, the lighting savings are the whole-building savings associated with the lighting measures. Both direct and interactive savings are included in the lighting end use savings.
"Better than baseline"	The as built simulation showed less energy consumption than the baseline simulation – more efficient than the base case. Positive savings.
"Worse than baseline"	The as built simulation showed more energy consumption than the baseline simulation – less efficient than the base case. Negative savings.
Costing period	PG&E defined time periods for reporting energy usage. See Table 22 for description of each period.

Period	Dates	Days / Times
Summer On-peak	May 1 to October 31	Weekdays 12 pm to 6 pm
Summer Part-peak	May 1 to October 31	Weekdays 8:30 am to 12 pm and 6 pm to 9:30 pm
Summer off-peak	May 1 to October 31	Weekdays 9:30 pm to 8:30 am. All day weekends and holidays
Winter part-peak	November 1 to April 30	Weekdays 8:30 am to 9:30 pm
Winter Off-peak	November 1 to April 30	Weekdays 9:30 pm to 8:30 am. All day weekends and holidays.

Table 22: Costing Periods

Methodology

This project used a statistical methodology called Model-Based Statistical Sampling or MBSS™. MBSS has been used for many evaluation studies to select the sites or projects to be studied and to extrapolate the results to the target population. MBSS has been used for NEES, Northeast Utilities, Consolidated Edison, The New York Power Authority, Wisconsin Electric, Sierra Pacific Power Company, and Washington Power and Light among others. MBSS was used in the end-use metering component of the 1992 evaluation of PG&E's CIA program, the 1994 and 1996 NRNC evaluations for PG&E and Southern California Edison, and the 1998 NRNC Baseline Study for the CBEE. A complete description of MBSS methodology is available if further discussion of the methodology is required.[8]

The Sample design discussion in an earlier chapter described the sample designs used in this study. Therefore this section will describe the methods used to extrapolate the results to the target population. Three topics will be described:

- Case weights
- Balanced stratification to calculate case weights
- Stratified ratio estimation using case weights.

Case Weights

We will use the following example problem to develop the idea of case weights[9]. Given observations of a variable y in a stratified sample, estimate the population total Y.

Note that the population total of y is the sum across the H strata of the subtotals of y in each stratum. Moreover each subtotal can be written as the number of cases in the stratum times the mean of y in the stratum. This gives the equation:

---

[8] *Methods and Tools of Load Research, The MBSS System, Version V*. Roger L. Wright, RLW Analytics, Inc. Sonoma CA, 1996.

[9] This example is provided only to demonstrate the statistical concepts used in the study. The numbers presented have no relevance to the 1998 NRNC study findings.

$$Y = \sum_{h=1}^{H} N_h \mu_h$$

Motivated by the preceding equation, we estimate the population mean in each stratum using the corresponding sample mean. This gives the conventional form of the stratified-sampling estimator, denoted $\hat{Y}$, of the population total *Y:*

$$\hat{Y} = \sum_{h=1}^{H} N_h \bar{y}_h$$

With a little algebra, the right-hand side of this equation can be rewritten in a different form:

$$\begin{aligned}\hat{Y} &= \sum_{h=1}^{H} N_h \bar{y}_h \\ &= \sum_{h=1}^{H} N_h \left(\frac{1}{n_h} \sum_{k \in s_h} y_k \right) \\ &= \sum_{k=1}^{n} \left(\frac{N_h}{n_h} \right) y_k\end{aligned}$$

Motivated by the last expression, we define the ***case weight*** of each unit in the sample to be $w_k = \frac{N_h}{n_h}$. Then the conventional estimate of the population total can be written as a simple weighted sum of the sample observations:

$$\hat{Y} = \sum_{k=1}^{n} w_k y_k$$

The case weight w_k can be thought of as the number of units in the population represented by unit *k* in the sample. The conventional sample estimate of the population total can be obtained by calculating the weighted sum of the values observed in the sample.

Table 23 shows an example. In this example, the population of program participants has been stratified into five strata based on the annual savings of each project shown in the tracking system. For example, the first stratum consists of all projects with annual savings less than 101,978 kWh. The maximum kWh in each stratum is called the stratum cut point. There are 339 projects in this stratum and they have a total tracking savings of 8,038,527 kWh. The estimate of gross impact was obtained from the measured savings found in a sample of 85 projects. Column 5 of Table 23 shows that the sample contains 62 projects from the first stratum. Each of these 62 projects can be given a case weight of 339 / 62 = 5.47.

Stratum	Max kWh	Population Size	Total KWh	Sample Size	Case Weight
1	101,978	339	8,038,527	62	5.47
2	278,668	61	10,949,421	9	6.78
3	441,916	35	12,598,315	8	4.38
4	816,615	22	13,654,171	3	7.33
5	4,000,000	12	17,469,244	3	4.00
Total		469	62,709,678	85	

Table 23: Stratification Example

Balanced Stratification

Balanced stratification is another way to calculate case weights. In this approach, the sample sites are sorted by the stratification variable, tracking kWh, and then divided equally among the strata. Then the first stratum cutpoint is determined midway between the values of the stratification variable for the last sample case in the first stratum and the first sample case in the second stratum. The remaining strata cutpoints are determined in a similar fashion. Then the population sizes are tabulated within each stratum. Finally the case weights are calculated in the usual way.

Table 24 shows an example. In this case the sample of 85 sites has been equally divided among five strata, so there are 17 sites per stratum. Then the stratum cutpoints shown in column two were calculated from the tracking estimates of kWh for the sample sites. Next the population sizes shown in column three were calculated from the stratum cutpoints. The final step was to calculate the case weights shown in the last column. For example, the case weight for the 17 sites in the first stratum is 136 / 17 = 8.

Stratum	Max kWh	Population Size	Total KWh	Sample Size	Case Weight
1	7,948	136	417,368	17	8.00
2	22,361	84	1,211,832	17	4.94
3	63,859	84	3,605,867	17	4.94
4	202,862	73	8,146,886	17	4.29
5	2,883,355	92	49,327,725	17	5.41
Total		469	62,709,678	85	

Table 24: Balanced Stratification

Stratified Ratio Estimation

Ratio estimation is used to estimate the population total Y of the target variable y taking advantage of the known population total X of a suitable explanatory variable x. The ratio estimate of the population total is denoted $\hat{Y}_{ra}$ to distinguish it from the ordinary stratified sampling estimate of the population total, which is denoted as $\hat{Y}$.

Motivated by the identity $Y = BX$, we estimate the population total *Y* by first estimating the population ratio *B* using the sample ratio $b = \bar{y}/\bar{x}$, and then estimating the population total as the product of the sample ratio and the known population total *X*. Here the sample means are calculated using the appropriate case weights. This procedure can be summarized as follows:

$$
\begin{aligned}
\hat{Y}_{ra} &= b\,X \quad \text{where} \\
b &= \frac{\bar{y}}{\bar{x}} \\
\bar{y} &= \frac{1}{\hat{N}} \sum_{k=1}^{n} w_k\, y_k \\
\bar{x} &= \frac{1}{\hat{N}} \sum_{k=1}^{n} w_k\, x_k \\
\hat{N} &= \sum_{k=1}^{n} w_k
\end{aligned}
$$

The conventional 90 percent confidence interval for the ratio estimate of the population total is usually written as

$$
\begin{aligned}
\hat{Y}_{ra} &\pm 1.645\sqrt{V\left(\hat{Y}_{ra}\right)} \quad \text{where} \\
V\left(\hat{Y}_{ra}\right) &= \sum_{h=1}^{H} N_h^2 \left(1 - \frac{n_h}{N_h}\right) \frac{s_h^2(e)}{n_h} \\
s_h^2(e) &= \frac{1}{n_h - 1} \sum_{k \in s_h} \left(e_k - \bar{e}_h\right)^2 \\
e_k &= y_k - b\,x_k
\end{aligned}
$$

We can calculate the relative precision of the estimate $\hat{Y}_{ra}$ using the equation

$$
rp = \frac{1.645\sqrt{V\left(\hat{Y}_{ra}\right)}}{\hat{Y}_{ra}}
$$

MBSS theory has led to an alternative procedure to calculate confidence intervals for ratio estimation, called model-based domains estimation. This method yields the same estimate as the conventional approach described above, but gives slightly different error bounds. This approach has many advantages, especially for small samples, and has been used throughout this study.

Under model-based domains estimation, the ratio estimator of the population total is calculated as usual. However, the variance of the ratio estimator is estimated from the case weights using the equation

$$V\left(\hat{Y}_{ra}\right) = \sum_{k=1}^{n} w_k \left(w_k - 1\right) e_k^2$$

Here w_k is the case weight discussed above and e_k is the sample residual $e_k = y_k - b\,x_k$. Then, as usual, the confidence interval is calculated as

$$\hat{Y}_{ra} \pm 1.645\sqrt{V\left(\hat{Y}_{ra}\right)}$$

and the achieved relative precision is calculated as

$$rp = \frac{1.645\sqrt{V\left(\hat{Y}_{ra}\right)}}{\hat{Y}_{ra}}$$

The model-based domains estimation approach is often much easier to calculate than the conventional approach since it is not necessary to group the sample into strata. In large samples, there is generally not much difference between the case-weight approach and the conventional approach. In small samples the case-weight approach seems to perform better. For consistency, we have come to use model-based domains estimation in most work.

This methodology generally gives error bounds similar to the conventional approach. Equally, the model-based domains estimation approach can be derived from the conventional approach by making the substitutions:

$$\begin{aligned} \bar{e}_h &\approx 0 \\ s_h^2(e) &\approx \frac{1}{n_h}\sum_{k \in s_h} e_k^2 \end{aligned}$$

In the first of these substitutions, we are assuming that the within-stratum mean of the residuals is close to zero in each stratum. In the second substitution, we have replaced the within-stratum variance of the sample residual *e*, calculated with $n_h - 1$ degrees of freedom, with the mean of the squared residuals, calculated with n_h degrees of freedom.

Model-based domains estimation is appropriate as long as the expected value of the residuals can be assumed to be close to zero. This assumption is checked by examining the scatter plot of *y* versus *x*. It is important to note that the assumption affects only the error bound, not the estimate itself. $\hat{Y}_{ra}$ will be essentially unbiased as long as the case weights are accurate.

Gross Savings Expansions

Baseline, as-built, and savings estimates were developed for each building in the sample. The sample of baseline, as built, and savings estimates was projected to the participant population using model-based statistical methods described above.

Whole Building Impact Findings

The whole-building energy and demand savings are defined to be the difference between the whole-building energy use or demand under the baseline and as-built simulations. The results were determined for each sample site and then extrapolated to the population using the methodology discussed in the preceding section. Positive savings indicate that the building was more efficient – used less energy or demanded less– than its baseline case.

The whole-building gross energy savings were estimated to be 116,317 MWh for all commercial program participants. The relative precision of the estimate was ±3.9%. This represents a gross realization rate of 147.6% of verified annual savings. Table 25 shows the estimated energy savings by costing period.

Period	Energy Savings (MWh)	Error Bound (MWh)	Relative Precision (+/-)
Annual	**116,317**	**± 4,494**	**± 3.9%**
Summer On-Peak	11,418	± 431	± 3.8%
Summer Mid-Peak	12,657	± 470	± 3.7%
Summer Off-Peak	19,362	± 840	± 4.3%
Winter Mid-Peak	36,619	± 1,338	± 3.7%
Winter Off-Peak	36,260	± 1,698	± 4.7%

Table 25: Whole Building Energy Savings by Costing Period

The participant group was more energy efficient than the non-participant comparison group. Figure 16 shows the savings of both participants and non-participants expressed as a percentage of each group's whole-building baseline usage. As Figure 16 shows, the participant group was 25% better than baseline on average. The non-participant comparison group was 16% better than baseline. The level of efficiency relative to the baseline remains fairly constant throughout the costing periods.

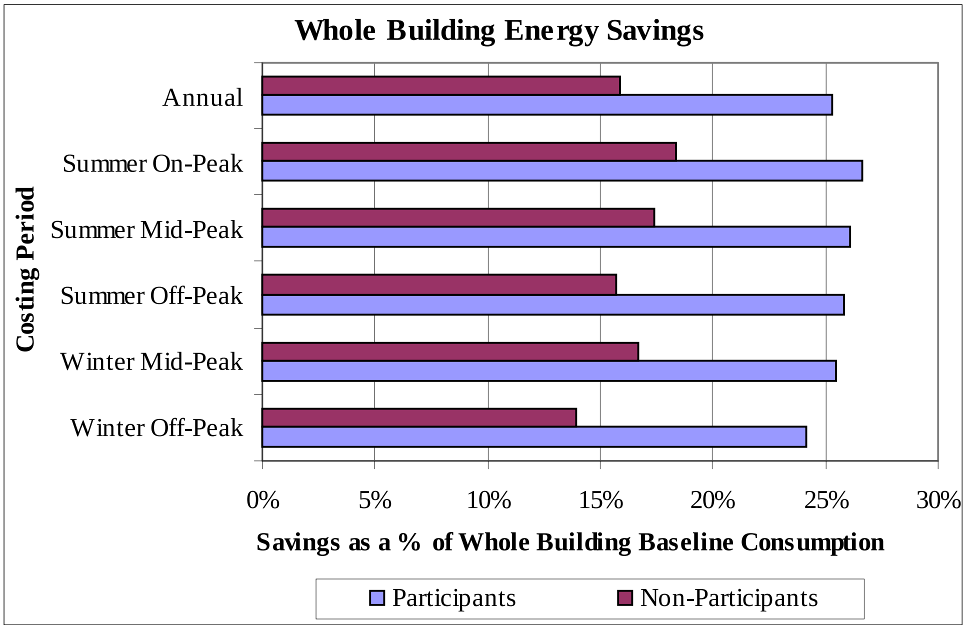

Figure 16: Participant and Non-participant Energy Savings as a Percentage of Baseline

PG&E's whole building gross demand savings were 18.41 MW. The relative precision of the estimate was ±4.4%. This represents a gross realization rate of 80.0% of verified summer on-peak demand savings. Table 26 shows the estimated savings by costing period.

Period	Demand Savings (MW)	Error Bound (MW)	Relative Precision (+/-)
Summer On-Peak	18.41	± 0.80	± 4.4%
Summer Mid-Peak	12.73	± 0.58	± 4.6%
Summer Off-Peak	13.71	± 0.74	± 5.4%
Winter Mid-Peak	17.58	± 0.76	± 4.3%
Winter Off-Peak	12.30	± 0.64	± 5.2%

Table 26: Whole Building Demand Savings by Costing Period

The demand savings of participant compared to the non-participants are similar to the energy savings results. Figure 17 shows that the participant group was 26% better than baseline on average. The non-participant comparison group was 18% better than baseline. The level of efficiency relative to the baseline remains fairly constant throughout the costing periods.

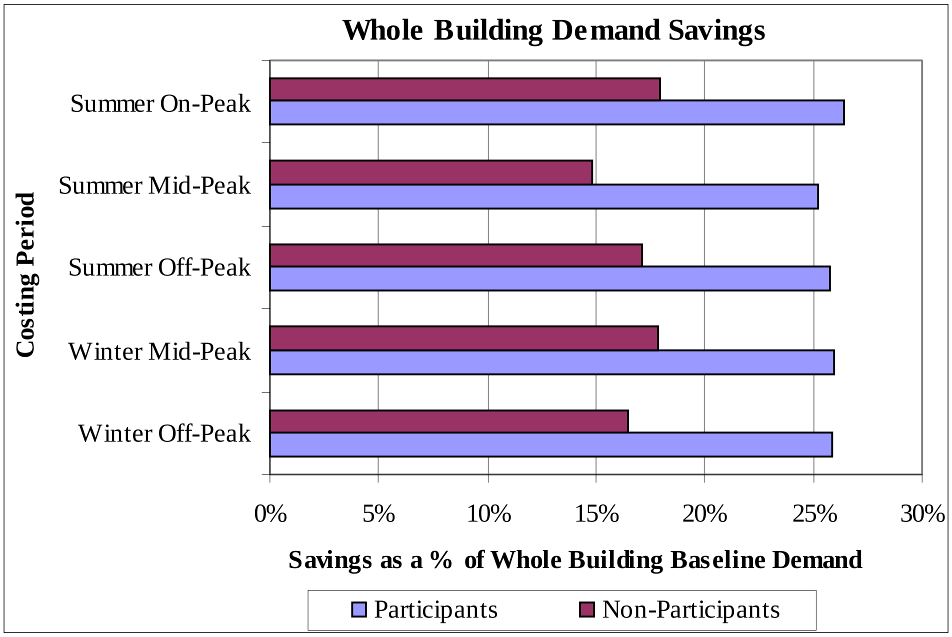

Figure 17: Participant and Non-participant Savings as a Percentage of Baseline Demand

As Figure 17 shows, the summer on-peak demand of the participant group was 26.4% better than baseline. The non-participant comparison group was 17.9% better than baseline. The level of efficiency relative to the baseline remains fairly constant throughout the year.

End-use Impact Findings

The following section presents the energy impact findings by end-use. The end-use savings are the difference between the whole-building energy use under the baseline and as-built measures associated with a particular end-use category of measures. Five end-use-measure groups were examined as part of this study:

- Shell – High performance glass
- Lighting – Lamps, ballasts, controls
- Motors – All energy efficient motors, including HVAC fans. Also overall air distribution system design end-uses such as efficient cooling coils and oversized ducts.
- HVAC – Compressor efficiency, VSDs, oversized cooling towers
- Refrigeration – Commercial refrigeration systems (condensers, compressors, cases)

The end-use savings were determined from the whole-building energy consumption under the parametric runs discussed in the preceding chapter. The starting point was the baseline parametric. Then the following special parametric runs were used.

1. Shell, incented measures only – Baseline envelope properties (glazing U-value and shading coefficient; and opaque surface insulation) for incented measures only were returned to their as-built condition.
2. All Shell – All baseline envelope properties were returned to their as-built condition.
3. Lighting, incented measures only – Run 2 above, plus baseline lighting power densities and controls for spaces in the building that received incentives were returned to their as-built condition.
4. All Lighting – Run 2 above, plus all baseline lighting power densities and controls were returned to their as-built condition.
5. Motors and Air Distribution, incented measures only – Run 4 above, plus baseline motor efficiency and fan power indices (W/CFM) for incented measures only returned to their as-built condition.
6. All Motors and Air Distribution – Run 4 above, plus all baseline motor efficiency and fan power indices (W/CFM) returned to their as-built condition.
7. HVAC, incented measures only. Run 6 above, plus HVAC parameters for incented measures only returned to their as-built condition.
8. All HVAC – Run 6 above, plus all HVAC parameters returned to their as-built condition.
9. All Refrigeration – Run 8 above, plus all refrigeration parameters in buildings eligible for the grocery store refrigeration and refrigerated warehouse programs returned to their as-built condition. This run is equivalent to the full as-built run. Note: refrigeration parameters in buildings not eligible for the grocery store refrigeration and refrigerated warehouse programs remained at the as-built level for all parametric runs.

Specifically, the shell savings were estimated as the difference in the whole-building energy use under the baseline simulation less the whole-building energy use under run 2. The lighting end-use savings were estimated as the difference in the whole-building energy use under runs 2 and 4. The motors end-use savings were estimated as the difference in the whole-building energy use under runs 4 and 6. The HVAC end-use savings were estimated as the difference in the whole-building energy use under runs 6 and 8. The refrigeration end-use savings were estimated as the difference in the whole-building energy use under runs 8 and 9.

Under this approach, the lighting savings are the whole-building savings associated with all lighting measures, both incented and non-incented. Both direct and interactive savings are included in the lighting end use savings.

As with the whole-building saving, the savings associated with each end-use measure category were projected to the population to arrive at the total savings estimate. The end-use savings were reported in two ways. First, the savings for each end-use measure category were reported as a percentage of the whole building baseline consumption. Under this approach, the sum of the percentage savings of each end-use category is equal to the whole-building savings as a percentage of the whole building baseline consumption. These results indicate the contribution of each measure category to overall savings.

The second approach takes advantage of the fact that the output of the DOE-simulations includes not only the whole-building energy consumption but also the consumption of each of the major end uses in the building, including lighting, motors, and HVAC. Using these results, the savings for the lighting, motors, and HVAC end-use measure categories was calculated as a percentage of the consumption of the corresponding end-use in the baseline simulation. For example, the lighting savings were calculated as a percentage of the baseline lighting consumption. This analysis is most appropriate for comparing participants to non-participants since it controls for the potential difference in other measures at the non-participant vs. participant sites.

This section also reports an analysis of savings for the incented measures in the lighting, motors and HVAC measure categories. The incented-measures-only savings was calculated for each category as the difference between the whole-building energy use in the parametric DOE-2 simulations with and without the specific measures incented by the program. For example the lighting incented-measures-only savings were estimated as the difference in the whole-building energy use under runs 2 and 3.

The incented-measures-only savings were calculated as a percentage of the consumption of the corresponding end-use in the baseline simulation. For example, the incented-measures-only lighting savings were calculated as a percentage of the baseline lighting consumption. The baseline lighting consumption included all lighting in the building, both incented and non-incented. This analysis can be used to assess the direct effect of the program on these measures.

Figure 18 shows the breakdown of annual energy savings by the end-use measure category. The savings associated with the shell (glazing) end-use were not statistically significant and will not be discussed further in this section. Glazing was not a significant portion of the program. Only 25 sites in the total sample received and incentive for glazing. In addition to the small number of sites with incented glazing, there tends to be a systematic overprediction of glazing savings by the program due to the fact that the program savings ignored the use of interior blinds. In all of the sites that were scrutinized during the engineering review at PG&E for low glazing savings, interior blinds and/or significant exterior shading were the causes of underperformance.

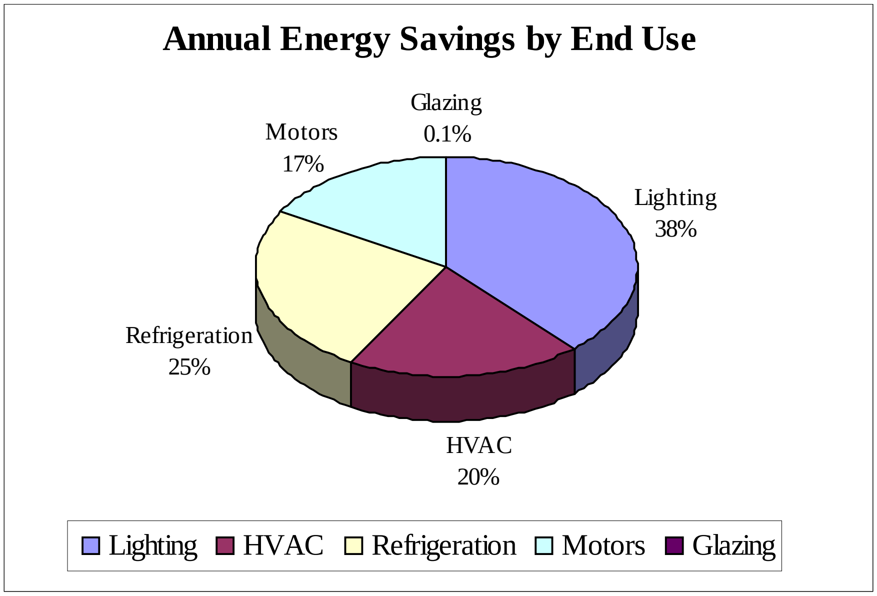

Figure 18: Composition of Annual Energy Savings

Figure 19 compares the end-use energy percentages in the 1998 program to the 1996 program. Lighting savings have fallen dramatically, from 55% of the total savings in 1996 to 38% in 1998. Refrigeration savings have also fallen, from 32% to 25%. HVAC and motors have both increased as a percentage of the total savings. This indicates that the NRNC program is adjusting to the increased acceptance of energy efficient lighting by emphasizing the other measures.

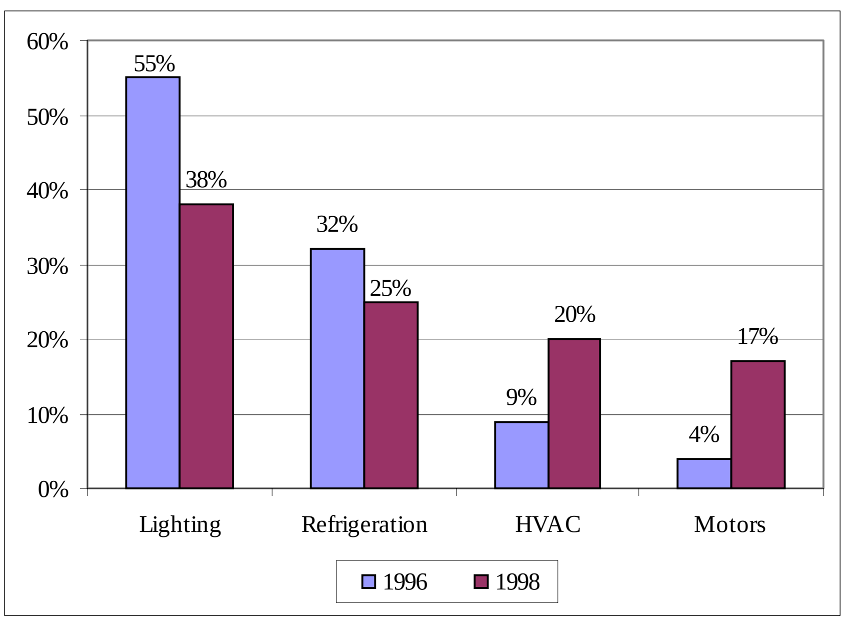

Figure 19: End Use Composition by Program Year for Participants

Although demand savings will not be presented by end use, the Figure 20 is included to show the breakdown of annual demand savings by end-use. The HVAC end-use has a larger impact on summer peak demand savings than it does on annual energy because of its seasonal nature.

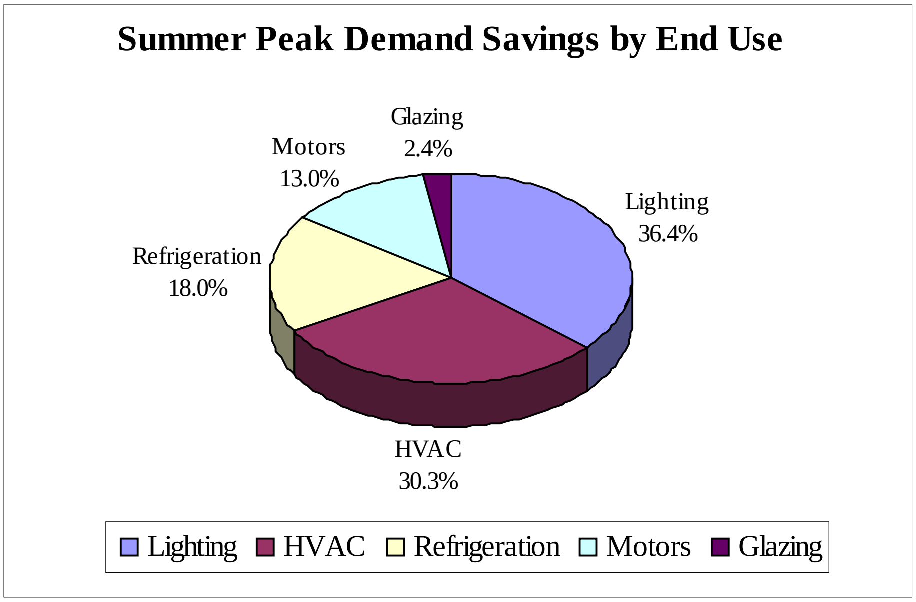

Figure 20: Summer Peak Demand Savings by End-use

Lighting

The lighting end-use measures accounted for 44,472 MWh of annual energy savings among program participants. This was 38.2% of the total annual energy savings. Table 27 shows the savings and relative precision by costing period.

Period	Energy Savings (MWh)		Error Bound (MWh)		Relative Precision (+/-)
Annual	**44,472**	±	**3,177**	±	7.1%
Summer On-Peak	4,586	±	292	±	6.4%
Summer Mid-Peak	4,779	±	328	±	6.9%
Summer Off-Peak	5,825	±	517	±	8.9%
Winter Mid-Peak	17,102	±	1,056	±	6.2%
Winter Off-Peak	12,181	±	1,116	±	9.2%

Table 27: Energy Savings of All Lighting Measures

Figure 21 shows the participant and non-participant lighting savings relative to baseline consumption by costing period. Interestingly, the lighting energy efficiency of non-participants was actually slightly *higher* than that of participants. By contrast, in 1996 we found that the lighting of participants was over 10% more efficient than baseline whereas the lighting of non-participants was less than 6% more efficient than baseline. So, in terms of lighting efficiency, the gap between the participants and non-participants has disappeared since 1996. However, the results for lighting savings relative to lighting use will provide a better comparison of participants and non-participants.

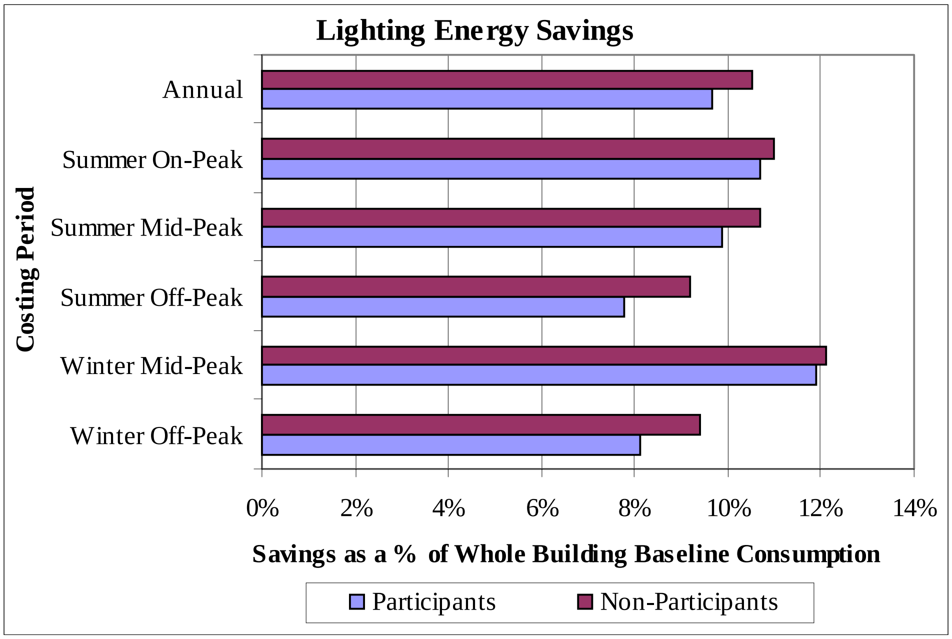

Figure 21: Energy Savings of Lighting as a Percentage of Baseline Use

Figure 22 shows the lighting energy savings relative to lighting baseline consumption. With this way of looking at the data, participants are saving more relative to lighting baseline consumption than non-participants. In terms of annual savings, the savings due to the lighting measures are about 37% of the lighting baseline use for participants, and about 31% for non-participants. These results indicate that participants have about 19% more savings from lighting measures than non-participants.

The fact that non-participants are achieving such high lighting savings reflects the wide acceptance of T-8 lamps and electronic ballasts. As these measures become commonplace, the lighting component of the program will need to focus on more aggressive measures such as daylighting, dimming ballasts, and compact fluorescent lamps.

A word of explanation is needed about why these findings differ from the results for lighting relative to whole-building energy use. When we compare the participants to the non-participants in terms of baseline use, we find that the participants have more energy use than the non-participants in total, but about the same energy use for lighting. In other words, participants have relatively more use in other end uses. This distorts the results relative to whole-building energy use.

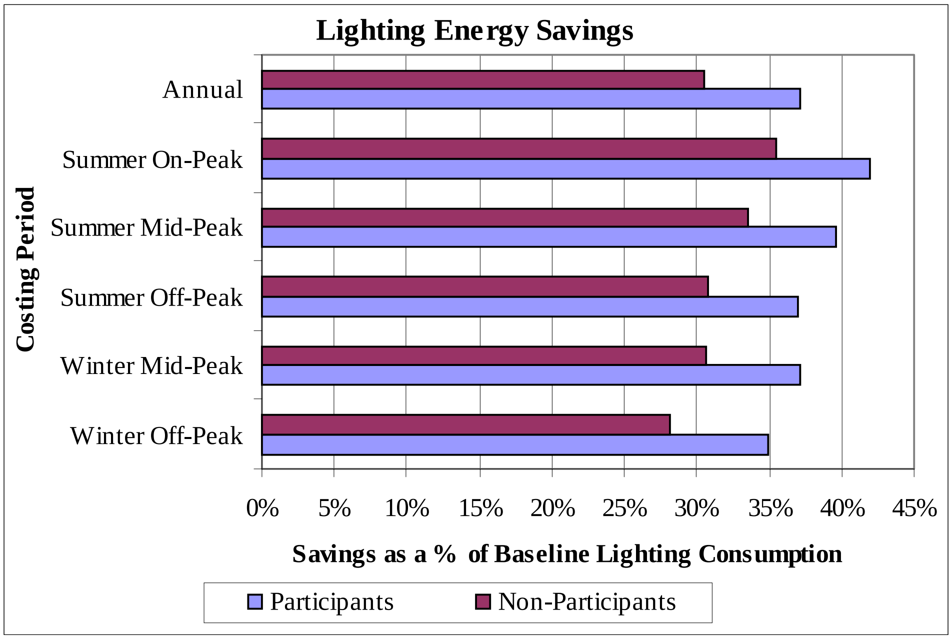

Figure 22: Energy Savings of Lighting Relative to Lighting Baseline Use

Table 28 shows the results for the incented lighting measures. The table shows the savings, the relative precision, and the measures-only savings relative to the lighting baseline consumption. Comparing these results with Table 27, the incented measures account for almost 75% of all lighting measures. These results show that the savings from the incented lighting measures are 36% of the lighting baseline use. These results understate the savings since the lighting baseline use includes both incented and non-incented lighting.

Period	**Energy Savings (MWh)**	**Relative Precision (+/-)**		**Savings as % of Lighting Baseline**
Annual	**33,069**	±	**5.4%**	**35.8%**
Summer On-Peak	3,395	±	5.8%	39.5%
Summer Mid-Peak	3,578	±	5.9%	38.1%
Summer Off-Peak	4,274	±	5.4%	36.1%
Winter Mid-Peak	12,826	±	5.7%	35.3%
Winter Off-Peak	8,997	±	5.4%	34.2%

Table 28: Energy Savings of Incented Lighting Measures

Motors

The motor measures made a contribution to savings of 19,310 MWh. This was 16.6% of total savings. This percentage is much higher than the amount of motor savings found in the 1996 program[10]. Table 29 shows the motor energy savings by costing period.

Period	Energy Savings (MWh)	Error Bound (MWh)	Relative Precision (+/-)
Annual	**19,310**	± **2,255**	± **11.7%**
Summer On-Peak	1,391	± 132	± 9.5%
Summer Mid-Peak	1,727	± 193	± 11.2%
Summer Off-Peak	3,316	± 415	± 12.5%
Winter Mid-Peak	5,434	± 569	± 10.5%
Winter Off-Peak	7,441	± 958	± 12.9%

Table 29: Energy Savings of All Motor Measures

Figure 23 shows the participant and non-participant savings relative to the whole-building baseline. The participants had a much higher savings relative to whole-building baseline than the non-participant comparison group. However, as in the case of lighting, it is more meaningful to look at the savings relative to the motors use.

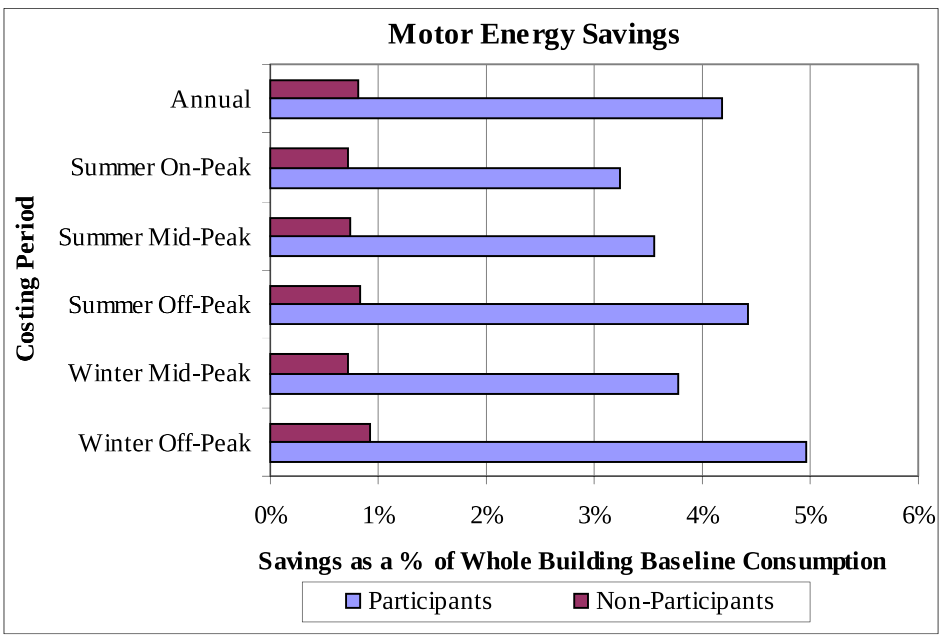

Figure 23: Energy Savings of Motors as a Percentage of Total Baseline Use

Figure 24 shows the motors energy savings relative to motors baseline consumption. In terms of annual savings, the savings due to the motor measures are about 20% of the motor baseline use for participants, and about 4% for non-

[10] 1996 Program year motor savings were 3,539 MWh.

participants. This implies that participants have about five times more savings from motor measures than non-participants.

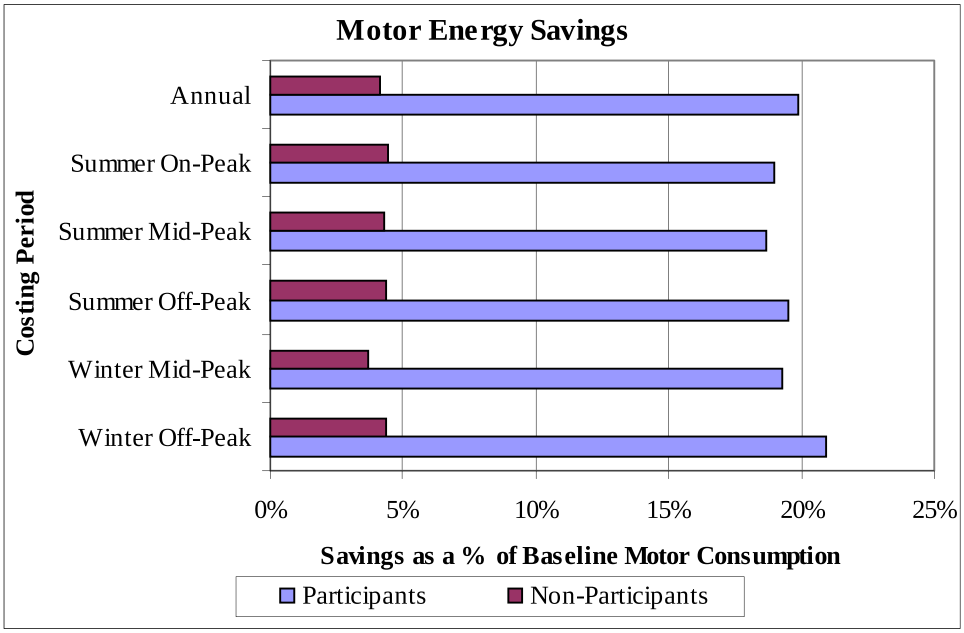

Figure 24: Energy Savings of Motors Relative to Motors Baseline Use

Table 30 shows the results for the incented motor measures. The table shows the savings, the relative precision, and the measures-only savings relative to the lighting baseline consumption. Comparing these results with Table 29, the incented measures account for almost 52% of all motor measures.

Period	Energy Savings (MWh)	Relative Precision (+/-)		Savings as % of Motors Baseline
Annual	**10,019**	±	**15.9%**	**18.9%**
Summer On-Peak	793	±	11.8%	19.8%
Summer Mid-Peak	906	±	15.0%	18.2%
Summer Off-Peak	1,671	±	17.6%	17.9%
Winter Mid-Peak	2,954	±	13.6%	19.6%
Winter Off-Peak	3,695	±	18.4%	18.7%

Table 30: Energy Savings of Incented Motors Measures

HVAC

The HVAC end-use measure categories accounted for 23,463 MWh of energy savings, or 20.2% of total annual energy savings. Table 31 shows the savings and relative precision by costing period.

Period	Energy Savings (MWh)	Error Bound (MWh)	Relative Precision (+/-)
Annual	**23,463**	± **1,811**	± **7.7%**
Summer On-Peak	3,426	± 201	± 5.9%
Summer Mid-Peak	3,547	± 240	± 6.8%
Summer Off-Peak	4,999	± 425	± 8.5%
Winter Mid-Peak	6,674	± 510	± 7.6%
Winter Off-Peak	4,817	± 507	± 10.5%

Table 31: Energy Savings of All HVAC Measures

Figure 25 shows the participant and non-participant HVAC savings relative to whole-building baseline consumption. The participants enjoyed annual savings from these measures of over 5% of their whole-building baseline use whereas the non-participants experienced about 3% savings. However, as in the case of lighting, it is more meaningful to look at the savings relative to the HVAC use.

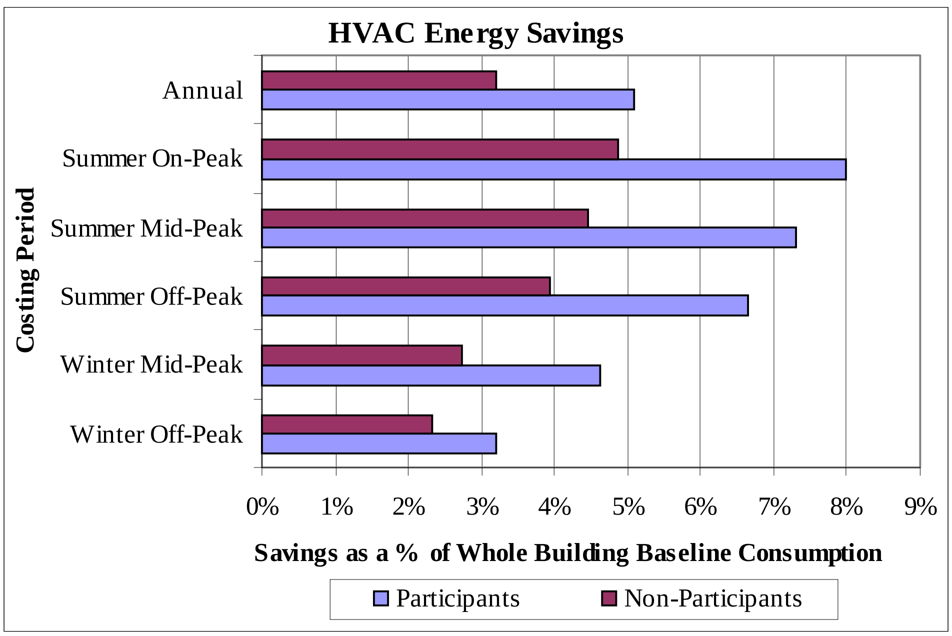

Figure 25: Energy Savings of HVAC as a Percentage of Baseline Use

Figure 26 shows the HVAC energy savings relative to HVAC baseline consumption. In terms of annual savings, the savings due to the HVAC measures are about 14% of the HVAC baseline use for participants, and about 8% for non-participants. This implies that participants have about 75% more savings from HVAC measures than non-participants.

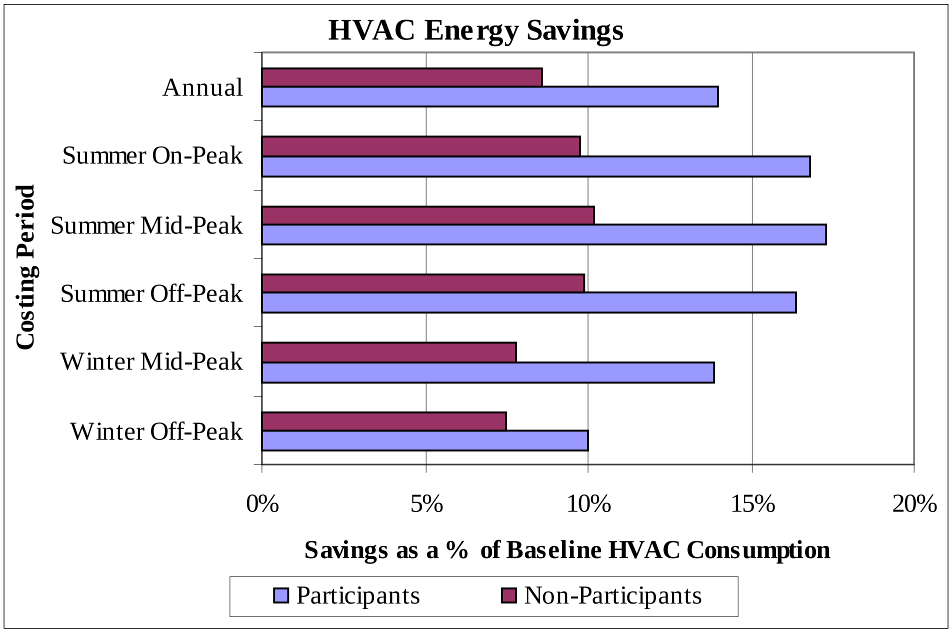

Figure 26: Energy Savings of HVAC Relative to HVAC Baseline Use

Table 32 shows the results for the incented HVAC measures. The table shows the savings, the relative precision, and the measures-only savings relative to the lighting baseline consumption. Comparing these results with Table 31, the incented measures account for almost 73% of all HVAC measures.

Period	Energy Savings (MWh)	Relative Precision (+/-)	Savings as % of HVAC Baseline
Annual	**17,098**	± **6.1%**	**12.1%**
Summer On-Peak	2,321	± 6.3%	13.5%
Summer Mid-Peak	2,266	± 6.6%	13.1%
Summer Off-Peak	3,291	± 7.3%	12.7%
Winter Mid-Peak	4,882	± 5.9%	12.0%
Winter Off-Peak	4,338	± 6.5%	10.8%

Table 32: Energy Savings of Incented HVAC Measures

Refrigeration

The refrigeration end-uses accounted for 28,972 MWh, or 24.9%, of the participant group energy savings. Table 33 shows the savings and relative precision by costing period.

Period	Energy Savings (MWh)	Error Bound (MWh)		Relative Precision (+/-)	
Annual	**28,972**	±	**3,288**	±	**11.3%**
Summer On-Peak	1,703	±	202	±	11.8%
Summer Mid-Peak	2,529	±	295	±	11.6%
Summer Off-Peak	5,190	±	579	±	11.2%
Winter Mid-Peak	7,466	±	861	±	11.5%
Winter Off-Peak	12,084	±	1,362	±	11.3%

Table 33: Energy Savings of All Refrigeration Measures

Figure 27 shows the participant and non-participant refrigeration savings relative to whole-building baseline consumption for each costing period. The participants enjoyed annual savings from these measures of over 6% of their whole-building baseline use whereas the non-participants experienced less than 1% savings. However, as in the case of lighting, it is more meaningful to look at the savings relative to the refrigeration use.

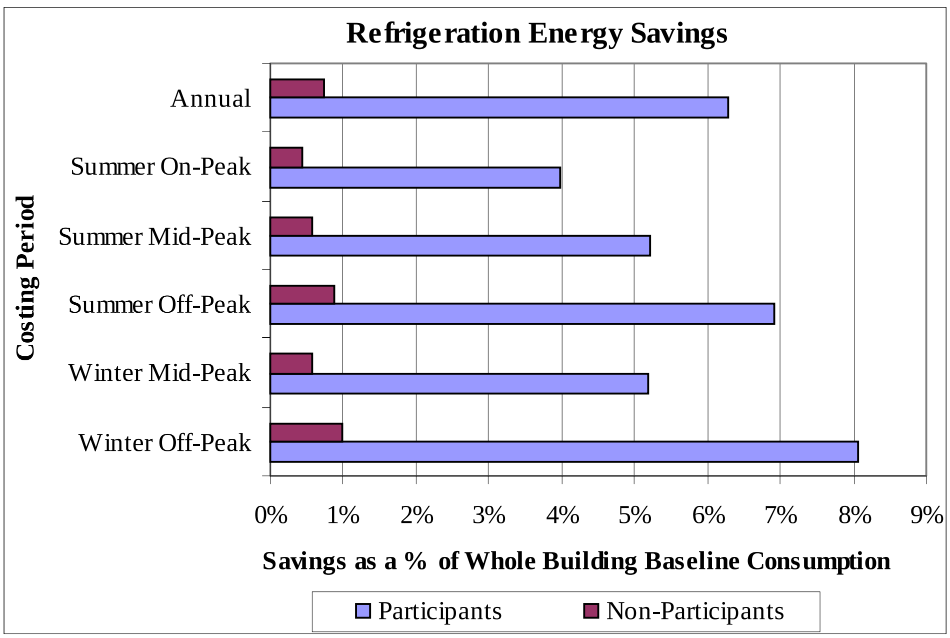

Figure 27: Energy Savings of Refrigeration as a Percentage of Baseline Use

Almost 88% of the unweighted refrigeration savings for participants and non-participants are from refrigerated warehouses. The remaining 12% include savings from retail and other refrigeration.

Figure 28 shows the refrigeration energy savings relative to refrigeration baseline consumption. In terms of annual savings, the savings due to the refrigeration measures are about 45% of the refrigeration baseline use for participants, and about 12% for non-participants. This implies that participants have about 3.75 times more savings from refrigeration measures than non-participants.

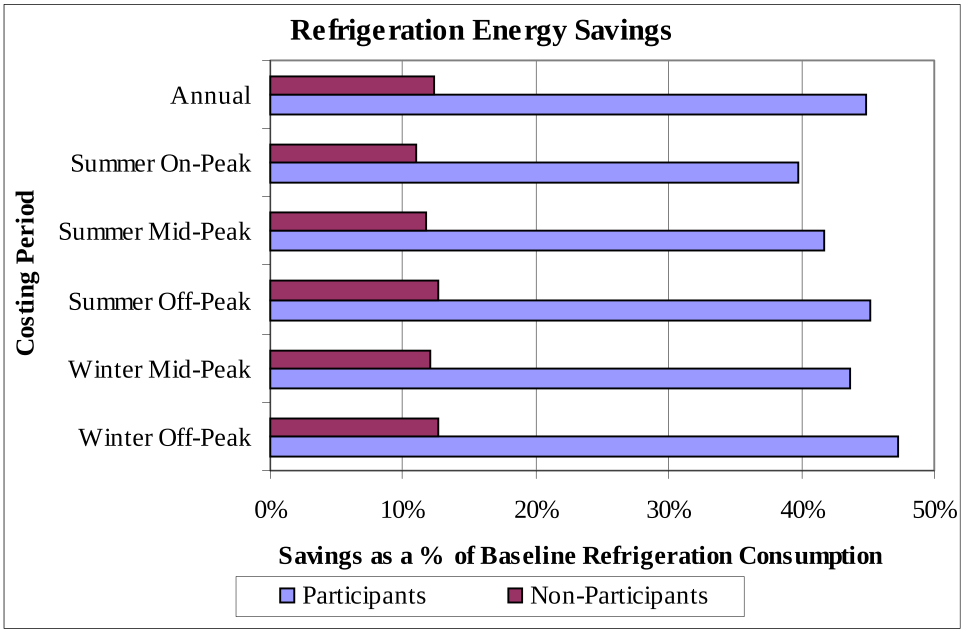

Figure 28: Energy Savings of Refrigeration Relative to Refrigeration Use

The incented-measures-only savings are not available for refrigeration because the refrigeration measures in building types other than grocery and warehouse were treated as energy-neutral in the models. Thus, there is no true measures only parametric run.

Commercial Projects - Net Savings

Two different methodologies were followed to estimate the net savings for the commercial sites: a relatively simple difference of differences approach and a more complex econometric approach. In the difference-of-differences methodology, the net-to-gross ratio was calculated by comparing the gross savings relative to baseline of the program participants to the gross savings relative to baseline of the non-participants. In the econometric approach, the net-to-gross ratio was calculated using regression modeling techniques to estimate the net savings due to the program for each of the program participants.

Table 34 compares the results of the two procedures. Both procedures start with the gross savings and realization rate found by expanding the engineering simulations to all program participants. The regression approach gave two separate components of savings, the direct net savings among the program participants and the spillover savings among the non-participants. As shown in Table 34, the participant net savings was estimated to be 39,158 MWh. The spillover savings was estimated to be 8,916 MWh, giving a total net savings of 48,074 MWh. The net realization rate corresponding to this estimate was 61% and the net-to-gross ratio was 41%.

By contrast the difference of differences approach yielded an estimate of 43,076 for the total net savings of the program. The net realization rate corresponding to this estimate was 54% and the net-to-gross ratio was 37%.

	Regression Estimate (MWh)	**Difference of Difference Estimate (MWh)**
Tracking Savings	78,798	78,798
Gross Savings	116,317	116,317
Gross Realization Rate	147.6%	147.6%
Net Participant Savings	39,158	43,076
Participant Net Realization Rate	49.7%	54.7%
Participant Net-to-Gross Ratio	33.7%	37.0%
NP Spillover Savings	8,916	-
Total Net Savings	48,074	43,076
Net Realization Rate	61.0%	54.7%
Net-to-Gross Ratio	41.3%	37.0%

Table 34: Comparison of the Net Savings Estimates for the Commercial Projects

A Jackknife methodology was used to assess the statistical precision of the two approaches. The Jackknife technique is a computationally intensive but well-regarded method for evaluating the statistical precision of a complex statistical procedure. The basis idea is to drop one case at a time from the sample and recalculate each estimate of savings using the remaining data. The variance of the resulting estimates is used to calculate their relative precision and error bounds.[11]

These results indicate that the difference of differences result has a standard deviation of about 15,000 MWh and a relative precision of about ±62%. The direct participant savings from the econometric analysis was found to have a similar standard deviation and relative precision. Therefore the two methods do not yield statistically different results.

However, several factors in the econometric model were contrary to expectation. For example, the significance of energy costs on design decisions was negatively related to the energy efficiency of the site. Similarly, the lowest first cost decision criteria was positively related to energy efficiency. These findings suggest that the econometric model may not be correctly specified, perhaps due to the absence of information about additional factors relevant to the decision process.

Difference of Differences Methodology

This section describes the difference-of-differences methodology. For simplicity we will discuss the methodology used to analyze annual energy savings. An analogous approach was used to analyze summer peak demand savings.

Table 35 summarizes the derivation of the net-to-gross ratio for annual energy. The analysis starts with the baseline and as-built energy consumption of the participants and non-participants. All of these results are reported in MWh and were obtained by statistically expanding the sample data to the population of 1998 program participants. For example, the table shows that we would estimate that all program participants would have an aggregate annual consumption of 344,062 MWh, based on the as-built simulation runs developed for the sites in the participant sample. By contrast, if we expand the as-built simulation runs of the non-participants to the same participant population, we would expect an aggregate annual consumption of 265,792 MWh.

	Participants	**Non-Participants**	**Net Savings**
Baseline (MWh)	460,378	316,076	-
As-Built (MWh)	344,062	265,792	-
Savings (MWh)	116,317	50,284	43,076
Savings (% of baseline)	25.3%	15.9%	9.4%
Net-to-Gross Ratio	-	-	37.0%

Table 35: Summary of Difference of Differences Calculation

Expanding both samples to the population of program participants, the preceding table shows that the savings were 116,317 MWh using the participant sample and 50,284 MWh using the non-participant sample. Thus, considering only the savings results, the participants would appear to have over twice as much savings as the non-participants.

[11] See, for example, Sarndal, C.E., Swensson, B., and Wretman, J. Model-Assisted Survey Sampling, Springer-Verlag, 1992, Equation 11.5.7 and accompanying discussion.

However, this fails to control for differences between the two samples. The preceding table shows that the baseline results were 460,378 MWh using the participant sample and 316,076 MWh using the non-participant sample. Both samples were designed to be representative of the population of 1998 program participants. However we would expect differences in the baseline results from the two samples due to normal sampling variability. Moreover, difficulty in obtaining large non-participant sample sites to match the large participants in the program may have led to some systematic difference between the participant and non-participant samples.

For a more meaningful comparison, the as-built energy use should be considered relative to the baseline. The table shows the gross savings, calculated as the difference between the baseline and the as-built energy use. Calculated this way, the gross savings relative to baseline were 116,317 MWh for the participant sample and 50,284 MWh for the non-participant sample. In proportion to the respective baseline energy use of each sample, the gross savings were 25.3% for the participant sample and 15.9% for the non-participant sample.

In the difference-of-differences approach, the net savings can be estimated as the difference between the percentage savings of the participants and non-participants. In this case the net savings is 9.4% of baseline use. Multiplying 460,378 MWh by 9.4%, the net savings of the population of 1998 program participants can be estimated to be 43,076 MWh.

The net savings of the program participants can also be calculated using the following equation.

$$\left(\frac{265{,}792}{316{,}076}\right)\cdot 460{,}378 - 344{,}062 = 43{,}076$$

Here the first factor is the as-built energy use relative to the baseline energy use using the non-participants. This is used to adjust the baseline energy use of the participants. Then the net savings is calculated by subtracting the as-built energy use of the participants. Finally, the net savings is found to be 9.4% of the baseline energy use of the participants. The two approaches for calculating net savings are mathematically equivalent.

The net-to-gross ratio can also be calculated two equivalent ways. One is to divide the participants' net savings (43,076 MWh) by their gross savings (116,317 MWh). The other is to divide the participants' net percent savings (9.4%) by their gross percent savings (25.3%). Either approach gives the difference of differences estimate of 37.0% for the net-to-gross ratio for annual energy.

Comparison to the 1996 Findings

Table 36 compares the difference-of-difference results found in this study to the comparable results from the 1996 PG&E program evaluation. The table shows that the gross savings among the participants has risen from 19.2% of baseline energy use in 1996 to 25.3% of energy use in 1998. However, during the same period the gross savings among the non-participants has risen from 10.3% of baseline energy use to 15.9% of energy use.

In other words, the gap between the participants and non-participants is about the same in the two years, but both participants and non-participants have grown more efficient relative to the Title 24 baseline. Recall from the preceding section that the net-to-gross ratio is equal to the net percent savings divided by the participant's gross percent savings. Consequently, as the NRNC market has grown more efficient relative to the baseline, the net-to-gross ratio of the program has necessarily dropped. This is an artifact of the baseline and is not a reflection of the program itself. With the 1999 modifications to Title 24 lighting requirements, future evaluations should find an improved net-to-gross ratio.

1996	**Participants**	**Non-Participants**	**Net Savings**	**Net-to-Gross Ratio**
Baseline (MWh)	437,800	613,100		
As-Built (MWh)	353,830	550,200		
Savings (MWh)	83,970	62,900	39,055	
Savings (% of Baseline)	19.2%	10.3%	8.9%	46.5%
1998	**Participants**	**Non-Participants**	**Net Savings**	**Net-to-Gross Ratio**
Baseline (MWh)	460,378	316,076		
As-Built (MWh)	344,062	265,792		
Savings (MWh)	116,317	50,284	43,076	
Savings (% of Baseline)	25.3%	15.9%	9.4%	37.0%

Table 36: Comparison to 1996 Results

Rationale for the Econometric Net-to-Gross Methodology

The econometric methodology can be regarded as an extension of a simple comparison of the efficiency choice of non-participant and participants through the difference of difference methodology. A coefficient of the participation indicator variable reflects the difference in efficiency choice between a participant and a non-participant. Other variables are included in the model to control for other factors that are associated with efficiency choice.

The inclusion of these variables can improve the statistical model in two ways:

1. Reduce potential bias, and

2. Provide improved statistical precision.

The potential bias arises if the model omits an explanatory variable that (a) is related to efficiency choice, and (b) is correlated with participation. For example, suppose a particular type of builder or designer tends to build a more efficient building and also tends to participate in the program. Then the difference of difference approach would tend to overestimate the actual impact of the program. This is sometimes called self-selection bias.

As another example, suppose that some of the non-participants have incorporated efficiency measures into the current building that they learned from participating in the program in prior years. In this case the difference of difference approach would underestimate the actual impact of the program. This can be called bias due to spillover.

Therefore, under most circumstances the difference of difference approach might be expected to provide a biased estimate of the actual program impact. The size of the bias depends on the balance between any positive bias due to self-selection and related factors versus any negative bias due to spillover and similar factors.

The econometric methodology seeks to obtain an unbiased estimate of net savings by including both program variables and other explanatory variables in a multivariate regression model. If the model is accurately specified and if the program variables and other explanatory variables are not multicollinear, then the model will provide an unbiased estimate of the net program savings among the participants as well as the spillover impact among the non-participants. This is the primary motivation for a multivariate regression analysis.

The econometric approach can also improve statistical precision by including explanatory variables that significantly affect efficiency choice. If an explanatory variable has a significant relationship with efficiency, then its inclusion in the model may significantly decrease the residual variance, or unexplained variance, of the model, and in turn, provide more statistically reliable estimates of net savings and spillover impacts.

Conversely, there are reasons for excluding all variables that do not have a significant relationship with efficiency. The inclusion of such variables needlessly tends to reduce the statistical precision of the results and makes the models unnecessarily complex and difficult to interpret. Therefore, we seek to include all truly relevant variables but drop the irrelevant variables. Necessarily, this is an iterative process, but a well-defined and objective procedure can be followed to obtain the final model and resulting estimates of net savings and spillover impacts.

Explanatory Variables

The following table summarizes the data elements used to develop the potential explanatory variables for the econometric analysis. The table shows the source of each data element and gives a brief description of the relevance of each data element to the econometric analysis.

Data Element	*Collection*	*Rationale*
Building Type	On-site	Different types of buildings may be built to different efficiency standards. This was seen in the 1994 study.
Participant Status	Phone	Participants in the utility program may be more concerned with efficiency and be more willing to install efficient measures than non-participants.
Project Type	Phone	New construction may be built more efficiently than additions or renovations
Building ownership	Phone	Owner occupants may be more concerned with efficiency than developers / landlords.
Construction circumstances	Phone	Same as above
Owner input	Phone	More owner input makes owner attitudes more important with respect to efficiency choices.
Pre-existing plans	Phone	Standard designs reduce the likelihood of efficiency measures in response to the program.
Investment Criteria	Phone	Investment criteria may affect willingness to install efficiency measures
Signif. Of energy costs	Phone	Significance of energy costs may influence efficiency choice.
Signif. Of energy eff	Phone	Significance of energy efficiency may influence decision to install higher eff. equipment
Awareness of program	Phone	Awareness may lead to spillover.
Interaction with utility on this project	Phone	Interaction with PG&E may lead to spillover
Influence of utility on this project	Phone	Influence of PG&E may lead to spillover.
Interaction with utility on previous projects	Phone	Previous interaction with PG&E may lead to spillover
Influence of utility on previous projects	Phone	Previous influence of PG&E may lead to spillover

Table 37: Variables Considered for Econometric Analysis

General Methodology for Data Screening and Analysis

A systematic process was followed to specify the final logistic and efficiency choice models. The present section summarizes how each of the following issues were addressed. Additional details will be found in other sections of the report, especially the following sections of this chapter.

- Weather adjustment
- Background variables such as economic activity
- Missing data points
- Missing or unusable billing data
- Missing responses to questions
- Outliers and data screens
- Model specification
- Cross sectional variation
- Time series variation
- Participant self selection
- Omitted factors
- Estimation of net impacts
- Errors in measuring variables
- Autocorrelation
- Heteroscedasticity
- Collinearity
- Influential data points
- Statistical Precision

Weather adjustment

This was handled in the engineering modeling. The model calibration used actual weather concurrent with the available billing data. Then all models were run using typical meteorological weather data. In this way the gross savings determined by the engineering models reflected normal weather conditions expected in each climate zone.

Background variables such as economic activity

This was also handled in the engineering modeling. The schedules used in the models were based on the levels of building use observed in the on-site survey. The schedules were held fixed in calculating the gross savings. Therefore the savings can be regarded as representing the actual savings obtained under the economic activity found at the time of the on-site surveys.

Missing data points

Sites that refused to participate in the study were replaced using a randomly drawn sample of backup sites. The level of refusal was rather low, as discussed earlier in this report.

Missing or unusable billing data

Whenever possible, the engineering models were calibrated to the available billing data. However, many of the projects studied in this evaluation were actually renovations or additions to existing buildings. In many of these cases, the available billing data described the whole building rather than the actual space that was renovated or added. In these cases, when it was practical we installed special metering equipment to collect load data for use in calibration. When this was not practical, the models were used without calibration.

Missing responses to questions

When a decision-maker did not know or refused to answer a particular question, we tried to identify a more appropriate respondent. If this failed, we recorded the response as 'don't know' or 'refused'. In the case of questions with categorical answers, we treated all such answers as a distinct category of response and created a corresponding indicator variable. In the case of the questions that were answered on a seven-point scale, we coded the response as 0 and created a corresponding indicator variable.

Outliers and data screens

The full sample was retained throughout the analysis. Studentized residuals were used to identify outliers. A site was considered to be an outlier if its studentized residual was greater than three in absolute value. A separate indicator variable was used to represent each such outlier in the model. The coefficient of this indicator variable indicated how much the dependent variable deviated from its expected value for the particular outlier. The statistical significance of these indicator variables was used to identify outliers that were statistically significant.

Model specification

A systematic approach was followed so that each model would be properly specified. The primary concern was to avoid bias arising from specification error – omitted variables, outliers, omitted statistical interactions, etc. We also sought to obtain a parsimonious final model that included only statistically significant variables. The following sections trace the approach, indicate some of the tests and graphical displays that were used to examine intermediate models, and compare the models that were examined. The entire process of refining the models is documented in SPSS command files.

Cross sectional variation

Cross-sectional variation was addressed throughout the sample design and experimental approach as well as in the modeling. The sample design was based on the experience of the 1994 evaluation study and sought to represent the full diversity of participants in the program, and a matched sample of non-participants. The sample size and stratification were chosen to yield statistically reliable estimates of the overall savings of the program. The experimental approach was built around engineering surveying and modeling techniques that were designed to capture the full range of actual building equipment types and schedules found in the population. The gross analysis was designed to determine the actual gross savings of each site, controlled for the actual equipment and use of the site. The net-to-gross analysis was designed to control for additional factors affecting the decision making process.

Time series variation

In the gross analysis, time series variation was controlled by the simulation methodology. The gross savings were calculated by simulating the building with and without the energy efficiency measures but holding other equipment and schedules fixed as observed. Time-series variation was not an issue in the net-to-gross regression analysis since all observations reflected the same time period. In other words, the regression modeling addressed variation from one same site to another, but not from one time point to another.

Participant self selection

Self selection was addressed in the net-to-gross analysis by developing a logistics model for the probability of participating, and then using the resulting double inverse Mills ratios as added explanatory variables in the efficiency choice models. The statistical significance and effect of the inverse Mills ratios were estimated and reported.

Omitted factors

Two factors might be discussed: the use of Title 24 documentation and billing data. The study sought to use both Title 24 documentation and billing data to the extent practical. When either Title 24 documentation or billing data was available, it was used to improve the accuracy of the engineering models. This approach allowed us to maintain the full sample even when these data were unavailable.

The evaluation of the 1994 NRNC program clearly demonstrated the difficulty of obtaining Title 24 documentation, especially for the non-participants. In order to avoid high refusal rates and the concomitant risk of nonresponse bias, we only insisted on Title 24 documentation for sites that used the tailored lighting approach or the performance-based approach to Title 24 compliance.

Billing data was used to calibrate each individual engineering model whenever possible. However, as described elsewhere, the available billing data did not always reflect the space affected by the new construction. In some of these cases, we sought to supplement the billing data with our own metering. Nevertheless, some of the sites did not have actual usage data. In such cases, the uncalibrated model was used.

Estimation of net impacts

The combination of statistical sampling, on-site surveys, site-specific engineering models, econometric analysis, and statistical expansion was carefully designed to provide an unbiased and statistically reliable estimate of net program savings. In particular, the decision-maker survey was designed to isolate self-selection bias and the long-run impact of the program on design practice. The model was specified to include any observable and statistically significant effects of the program on the energy efficiency of both participants and non-participants.

Errors in measuring variables

In the on-site surveys and engineering modeling we sought to obtain an accurate representation of each individual sample site. Past experience suggested that serious errors could arise from failing to model the space in the building actually affected by the new construction, or by failing to accurately describe some of the equipment and schedules of use. The present study addressed these problems by improved training and communication with the auditors, earlier retrieval and review of program files, having the auditors themselves responsible for the data entry and modeling, and having the auditors develop the model for a site soon after completing its survey. The engineering team met with PG&E's program managers and reviewed the site-specific models in detail. We also redesigned the decision-maker survey, streamlined the process used to recruit each site and complete the decision maker survey. All of these measures resulted in much more accurate data going into the econometric analysis than in the prior study.

Autocorrelation

Autocorrelation was not an issue since, as explained above, the analysis was cross sectional.

Heteroscedasticity

Heteroscedasticity – the tendency of larger projects to have greater variation – was addressed in both the sample design and efficiency-choice regression models.

The MBSS methodology used in the sample design addressed heteroscedasticity by modeling the variation in savings as a function of the tracking estimate of savings or the square footage of each site and then using an efficiently stratified sampling plan to increase the probability of selecting large sites. This ensures that the sample is effectively focused where the savings are greatest, while retaining an unbiased representation of small and large projects alike.

The efficiency-choice regression models were specified to minimize the danger of heteroscedasticity by defining the dependent variable as the gross savings as a fraction of the baseline energy use. This specification is closely related to the weighted-least-square methodology resulting from the assumption that the residual variation in gross savings is proportional to the baseline energy use of each site. Graphical scatter plots of the studentized residuals were examined to confirm the absence of heteroscedasticity.

Collinearity

Multicollinearity is generally a less serious problem in a cross sectional analysis than in a time series analysis. Our methodology was designed to protect against the type of problem that might arise in a cross sectional analysis. Extreme multicollinearity can cause computational problems. Several of the indicator variables used in the regression models were perfectly collinear. This occurred, for example, if a respondent who failed to answer a given question also failed to answer a second question. In this case the missing-response indicators would be perfectly collinear. The SPSS software used in the analysis identifies and reports these instances and automatically drops one of the variables from the analysis. The software also provides a warning if the multicollinearity is strong enough to affect the numerical accuracy of the estimated coefficients. In practice there was no indication of a serious problem with numerical accuracy.

When explanatory variables have strong but not extreme multicollinearity, it is important to guard against obtaining biased results. Omitted-variable bias can arise if one of the correlated variables is dropped from the model. We guarded against this possibility by systematically comparing the estimated coefficients of our various models and looking for other indicators such as large shifts in statistical significance.

Influential data points

We followed diagnostic procedures recommended by Belsley, Kuh and Welsh.[12] Our key indicator of an influential observation was the studentized residual, which can be related to the t-distribution. We also examined normal probability plots, partial-regression leverage plots for each explanatory variable, and other case-specific measures of influence.

Statistical Precision

In each regression model, we used standard logistics or least-squares techniques to calculate the standard error and statistical precision of each coefficient. We used the standard MBSS statistical techniques described in the Gross Savings chapter to expand to the econometric estimates for each sample site to the population and to measure the statistical precision of the results.

Overview of the Econometric Net-to-Gross Methodology

Under the econometric approach, the net-to-gross ratio was calculated in the following seven steps. For simplicity we will discuss the methodology used to analyze annual energy savings. An analogous approach was used to analyze summer peak demand savings.

1) **Dependent Variable:** For each site in the combined participant/non-participant sample, calculate the efficiency choice of each site; this is the difference between the baseline and as-built energy use as a fraction of the baseline energy use. The efficiency choice was the dependent variable, i.e., the *y*-variable, in the regression analysis.

2) **Analysis Data Base:** For each site in the combined participant-non-participant sample, create an indicator variable for program participation, and indicator variables reflecting the responses to the categorical questions in the decision-maker survey. Create indicator variables to identify missing data to each of the decision-maker questions. Create indicator variables to identify the building-type categories. Include the scale response variables from the decision-maker survey as additional potential explanatory variables.

3) **Logistic Regression Model:** Develop a logistic regression model to estimate the probability that each sample site is a participant. Use the preceding indicator variables as well as the scale response variables as possible explanatory variables in the model. Examine the model for outliers and other violations of the assumptions of logistics regression. Drop explanatory variables that are not statistically significant. Use the simplified logistics model to calculate the predicted probability that each site in the combined sample is a participant. Then use the predicted probabilities to calculate double Inverse Mills ratios in order to correct for possible self-selection bias.

[12] D. A. Belsley, E. Kuh and R. E. Welsch, *Regression Diagnostics*, Wiley, 1980.

4) **Efficiency choice Regression Model:** Formulate a regression model explaining the variation in efficiency choice as a function of various variables describing the participants and non-participants. The explanatory variables included the following:

   (a) The indicator variable for program participation,

   (b) Indicators describing the type of building,

   (c) Indicators for the decision makers planning process and priorities, concern about energy, etc.

   (d) Scale variables measuring the degree of interaction with PG&E and the amount of influence PG&E had on the design of this project, and

   (e) The inverse Mills and double inverse Mills ratios, and

   (f) Indicators for potential outliers.

5) **Model Diagnostics and Simplification:** Examine suitable graphs and statistics to determine the adequacy of the regression model. Simplify the regression model by dropping statistically insignificant variables. Add statistically significant interaction variables.

6) **Net Savings:** Use the simplified regression model to estimate the net savings attributable to the program for each sample participant, after statistically controlling for the efficiency choice of non-participants, any significant differences between participants and non-participants in the other explanatory variables, and self selection via the inverse Mills and double inverse Mills ratios. Then use the statistical sampling methods to expand the net savings attributable to the program for each sample participant to the population of 1998 program participants, as described in the Gross Savings chapter. Finally, calculate the error bound and relative precision of the results using the jackknife technique.

7) **Spillover:** Use the simplified regression model to estimate the spillover effect of the program for each sample non-participant. Then use standard statistical sampling methods to expand the net savings attributable to the program for each sample non-participant to the population of 1998 non-participants, using Dodge new construction data. Next, use standard statistical sampling methods to expand the sample spillover to the participant population. To ensure a conservative estimate of spillover, the participant population spillover was subtracted from the new construction population spillover estimate. Finally, calculate the error bound and relative precision of the results using the jackknife technique.

Database for the Econometric Analysis

The analysis database consisted of 277 sample observations with sixteen variables. Thirty-seven additional indicator variables were created to reflect the building types, categorical survey information and missing responses to specific questions. Several additional indicator variables were created to represent individual sample sites that appeared to be outliers in the preliminary residual analysis. Additional variables were created within the analysis for statistical interactions, for the Mills ratios, and for various diagnostic tests.

Logistic Regression Model

As previously indicated, the objective of this task was to develop a logistic regression model to estimate the probability that each sample site is a program participant.

Table 38 summarizes the final logistic model. The column labeled B is the regression coefficient for each explanatory variable. A positive value indicates a higher probability of being a program participant whereas a negative value indicates a lower probability. For example, a building built by the owner for his/her own business was more likely to be a program participant, whereas a renovation project was relatively unlikely to be a program participant.

Explanatory Variable	B	S.E.	Sig.
Renovation Project	-1.67	0.43	0.00
Built by Owner for Own Business	0.83	0.37	0.03
Lowest First Cost	-1.52	0.47	0.00
Financial Criteria Missing	-2.04	0.52	0.00
Awareness of PG&E Program	0.47	0.08	0.00
Input in Design Process	-0.21	0.10	0.03
Interaction with PG&E on Current Project	0.37	0.09	0.00
Constant	-1.00	0.71	0.16

Table 38: Logistic Regression Model

The preceding model was developed in the following steps.

1. Estimate a logistic regression model relating the dependent variable – the indicator of program participation – to all of the potential explanatory variables. Measure the fit, save the diagnostic statistics, and examine the diagnostic graphs. This analysis indicated that there were no outliers or other observable problems with the model.

2. Use backward stepwise logistic regression to eliminate the statistically insignificant variables from the preceding model. Use a p-value of 0.05 for adding variables and 0.10 for deleting variables.

3. Estimate the simplified model shown above, measure its fit, save its diagnostic statistics, and examine its diagnostic graphs.

Figure 29 shows a normal probability plot for the studentized residuals of the model. This is a tool to assess the hypothesis of a normal probability distribution that is the basis of the logistics analysis. If the hypothesis of a normal probability distribution is valid, then the plotted points should lie along the straight line. A failure of the residuals to be normally distributed may be indicated if the plotted points deviate substantially from the line. The figure supports the hypothesis of a normal probability distribution.

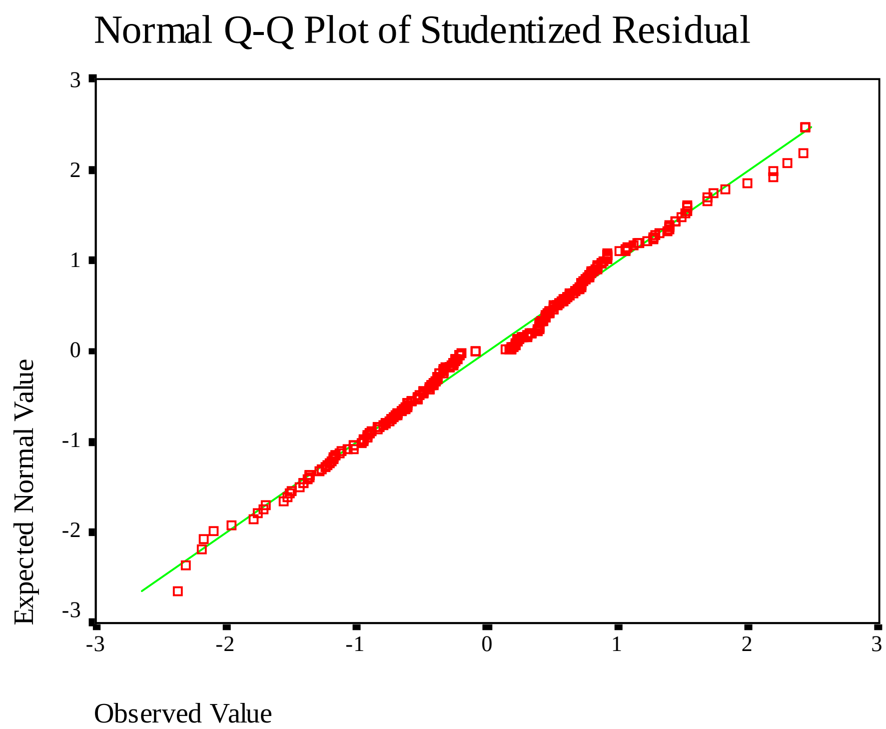

Figure 29: Normal Q-Q Plot of Studentized Residuals

The following classification table provides a common measure of the goodness of fit of the final model. Of the 139 non-participants in the sample, the model correctly predicted that 113 were non-participants, for a score of 81.3% correct. Of the 138 participants, the model correctly predicted that 112 were participants, for a score of 81.2% correct. The overall score was 81.2%.

	Predicted		**Percent Correct**
Observed	**Non-participant**	**Participant**	
Non-participant	113	26	81.3%
Participant	26	112	81.2%
Overall			81.2%

Table 39: Logistic Model Participation Prediction

Two other measures were calculated reflecting the goodness of fit of the logistics model. The Nagelkerke R-squared statistic was 56% - indicating that the model explained 56% of the total variation. The statistical significance of the model was .0000 – indicating that the model was statistically very significant.

Another way to assess the simplified model is to compare its goodness of fit to the full model developed in step 1 of the analysis. This analysis indicated that the variables that were deleted from the full model were not statistically significant as a group. This suggests that the simplified model is an adequate summary of the relationship between program participation and the variables developed from the decision-maker survey. From all of the preceding analysis, we can conclude that the simplified model is a good predictive model for program participation.

The simplified logistic model was then used to estimate the probability that each site in the sample might have been a participant as a function of the characteristics of the site and the information about the decision-making process. For each site, let *Z* represent the numerical result of substituting the values of the explanatory variables into the logistic equation. Then the estimated probability is calculated using the equation

$$\hat{p} = \frac{e^Z}{1+e^Z}$$

The inverse Mills ratio was calculated as

$$C = \left[\frac{(1-\hat{p})\times\ln(1-\hat{p})}{\hat{p}} + \ln(\hat{p})\right] \qquad \text{for participants, and}$$

$$C = -1\left[\frac{\hat{p}\times\ln(\hat{p})}{1-\hat{p}} + \ln(1-\hat{p})\right] \qquad \text{for non-participants.}$$

The double inverse Mills ratio was calculated by multiplying *C* by the indicator variable for program participation.[13] These variables were labeled *Mills ratio* and *Double Mills ratio*, respectively.

Annual Energy Regression Model

The objective of this task was to develop a regression model to estimate the efficiency choice of each sample site, participant and non-participant. The efficiency choice of each sample site was measured as the difference between as built and baseline use as a fraction of baseline use.

Table 40 summarizes the final efficiency choice model. The column labeled B is the regression coefficient for each explanatory variable. A positive value indicates a higher efficiency choice whereas a negative value indicates a lower efficiency choice. For example, the model indicates that a program participant tended to have a 0.011 higher efficiency choice than a non-participant. The econometric standard error of this estimate was 0.027 indicating that the error bound at the 90% level of confidence was 1.645 * 0.027 = 0.044. The 90% confidence interval for the true value is 0.011 ± 1.645 * 0.027 = (-0.033, 0.055). The column labeled t is the value of the t-statistic for each explanatory variable calculated when testing the hypothesis that the regression coefficient is equal to zero. The column labeled sig. provides the significance level associated with the t-statistic for each explanatory variable. In other words, the column labeled sig. is the probability that the regression coefficient is statistically different from zero.

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[13] Net Savings Estimation: *An Analysis of Regression and Discrete Choice Approaches*, Prepared for the CADMAC Subcommittee on Base Efficiency, Prepared by Xenergy, Inc. Madison WI, by M. Goldberg and K. Train, Revised March 1996.

Three other explanatory variables based on seven-point scale variables were used in the calculation of energy efficiency. The variable labeled level of PGE's influence on this project measured the level of influence of PG&E on the respondent's decisions regarding design and equipment choices for this project, coded 0 (not at all) to 7 (very significant). The positive coefficient means that the efficiency choice was greater for a decision-maker who reported a significant level of influence compared to a decision-maker who reported very little influence by PG&E. In addition to calculating participant savings, this variable is used to compute non-participant spillover savings and is significant at the 0.05 level of significance. The 'participant C & I Storage' variable indicated if the site was of building type C & I Storage and participated in the program. This variable was also equal to 0 for a non-participant and for non- C & I Storage buildings. The positive coefficient means that the efficiency choice was greater for a participating C & I Storage building. This variable was highly significant with a significance level of 0.000. The variable 'participant office' indicated if the building was an office that had participated in the program. This variable was also equal to 0 for a non-participant and for buildings other than offices. The positive coefficient indicates that offices that participated in the program had higher efficiency choices.

We will discuss the role of these variables in detail in a later section.

The remaining variables represent other factors that were found to have a statistically significant effect on efficiency choice. The variable labeled level of input in design process measured the decision-makers level of input in the design process regarding decisions about energy efficiency, coded 1 (not at all) to 7 (very significant). The positive coefficient means that the efficiency choice was greater for a decision-maker who reported a significant level of input compared to a decision-maker who reported a low level of input.

A number of the coefficients did not have the expected signs. The variable labeled sig. of energy costs on design decisions measured the significance of energy costs on design decisions, coded 1 (not at all) to 7 (very significant). The negative coefficient means that the efficiency choice was lower for a decision-maker who reported energy costs as being very significant in design decisions compared to a decision-maker who reported a low level of significance. The model indicates that addition projects were more efficient, as were decision-makers who used the financial criteria of lowest first cost. The fact that these variables did not come out as expected detracts from the credibility of the model. The most likely cause is that the model may be misspecified due to the omission of information on important factors in the decision process.

The model indicates that Sites 201, 225, 230, 241, 1071, 1239, and 3827 had a significantly higher efficiency choice than expected based on other factors and were treated as outliers. The model also indicates that Sites 317, 670, 1218, 1555, 2601, and 3789 had a significantly lower efficiency choice than expected based on other factors and were deemed outliers.

The inverse Mills ratio was not statistically significant, indicating that there was no statistically significant correction for self selection. The double Mills variable was also not statistically significant and was not included in the model.[14]

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.116	.030		3.881	.000
	Participant	.011	.027	.030	.412	.681
	Level of PG&E's influence on this project	.008	.004	.101	2.125	.035
	Level of Input in Design Process	.013	.004	.136	3.075	.002
	Sig. of Energy Costs on Design Decisions	-.009	.005	-.087	-1.963	.051
	C & I Storage	-.022	.033	-.041	-.652	.515
	Participant C & I Storage	.174	.049	.228	3.543	.000
	Office	.015	.022	.039	.658	.511
	Participant Office	.047	.031	.107	1.536	.126
	Addition	.122	.037	.140	3.291	.001
	Lowest First Cost	.030	.015	.079	1.962	.051
	MILLS	.001	.012	.003	.057	.955
	Outlier Site 201	.603	.122	.197	4.954	.000
	Outlier Site 1071	.717	.121	.234	5.939	.000
	Outlier Site 1555	-.674	.118	-.220	-5.729	.000
	Outlier Site 3789	-1.174	.126	-.384	-9.283	.000
	Outlier Site 225	.503	.118	.165	4.279	.000
	Outlier Site 241	.579	.122	.189	4.735	.000
	Outlier Site 670	-.526	.117	-.172	-4.477	.000
	Outlier Site 230	.483	.122	.158	3.964	.000
	Outlier Site 1218	-.426	.126	-.139	-3.377	.001
	Outlier Site 1239	.437	.120	.143	3.628	.000
	Outlier Site 3827	.425	.120	.139	3.545	.000
	Outlier Site 317	-.389	.118	-.127	-3.303	.001
	Outlier Site 2601	-.348	.121	-.114	-2.883	.004

a. Dependent Variable: KWH

Table 40: Annual Energy Regression Model

The coefficient of the variable ‘participant’, 0.011, indicates that program participants tended to have efficiency choices 0.011 higher than non-participants and is lower than might be expected. Also, this variable is not statistically significant. One explanation for the low coefficient and significance level is that most of the program related efficiency effects were captured in the coefficient of the variable ‘level of PG&E’s influence on this project’ since responses varied dramatically between program participants and non-participants. Figure 30 presents the percentage of decision-makers mentioning each response by

[14] The inclusion or deletion of the two Mills ratio variables had very little effect on the remaining coefficients of the model.

participation status. As shown, significantly more non-participants indicated that PG&E had no influence on the current project. This suggests that most of the program related effects were captured in this variable. This helps explain the low coefficient and significance level for the participation variable.

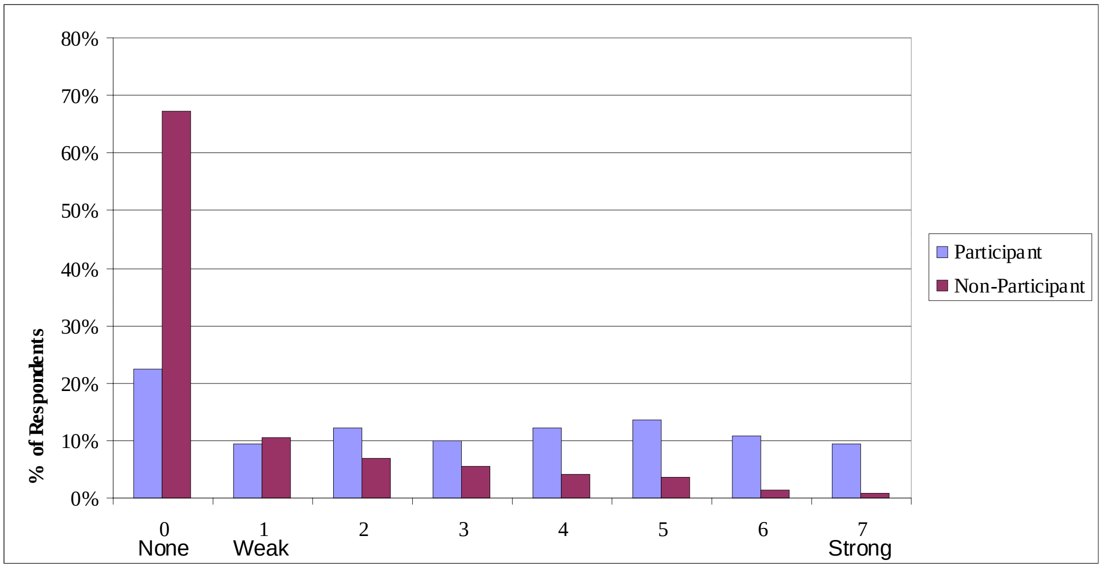

Figure 30: Level of PG&E's Influence on Design Decisions in Current Project

The following table provides several measures of the goodness of fit of the final model. The adjusted R square was .602 indicating that the model explains about 60% of the total variation in efficiency choice. The F-statistic was 18.379, corresponding to a statistical significance of 0.000, indicating that the model as a whole was highly significant.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.798	.636	.602	.116

Table 41: Annual Energy Model Summary

The figure below shows a normal probability plot for the deviancies of the final model. This is a tool to assess the hypothesis of a normal probability distribution that is the basis of the efficiency-choice regression analysis. If the hypothesis of a normal probability distribution is valid, then the plotted points should lie along the straight line. The figure suggests that this assumption is generally valid.

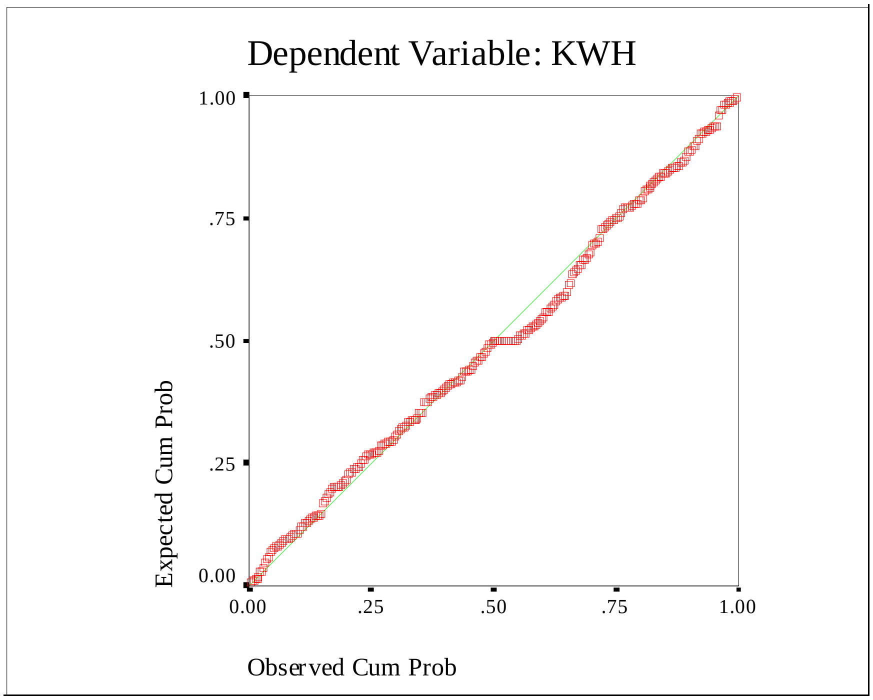

Figure 31: Normal P-P Plot of Annual Energy Residuals

The following figure shows a more conventional histogram of the standardized residuals of the model. Again the assumption of a normal distribution appears to be generally satisfactory. This evidence, together with the relatively large size of the sample, indicates that standard measures of statistical significance should be valid.

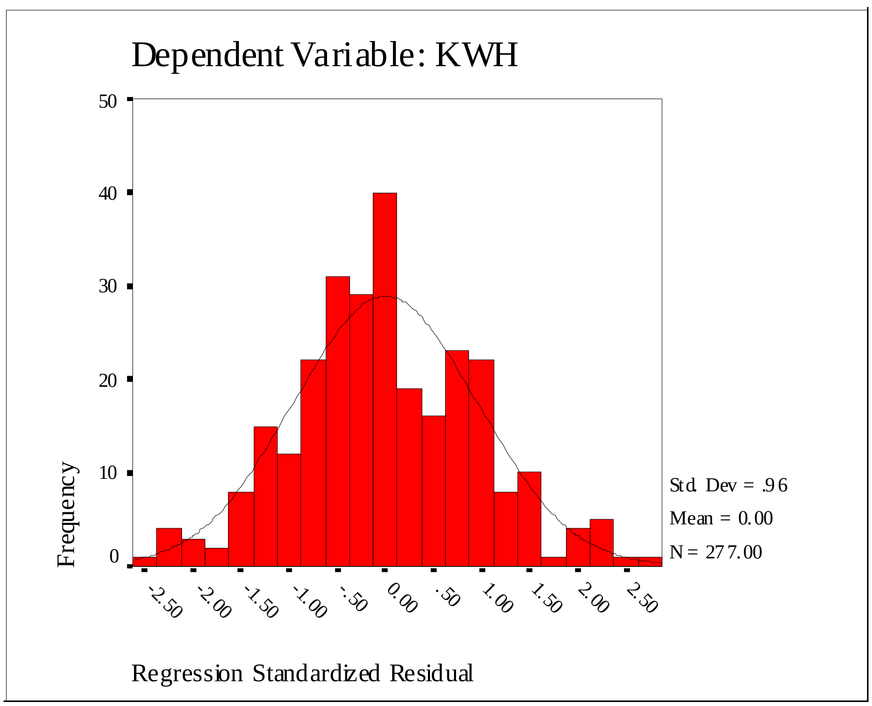

Figure 32: Annual Energy Model Residual Histogram

The remaining graph shows a scatter plot of the residuals compared to predicted values. The important issue is not the range of predicted values on the horizontal axis, but rather the range of the residuals on the vertical axis. Again this graph shows that the residuals are randomly distributed. Moreover, it shows that the residuals are homoscedastic. In other words, the variance of the residuals seems to be independent of the predicted values.

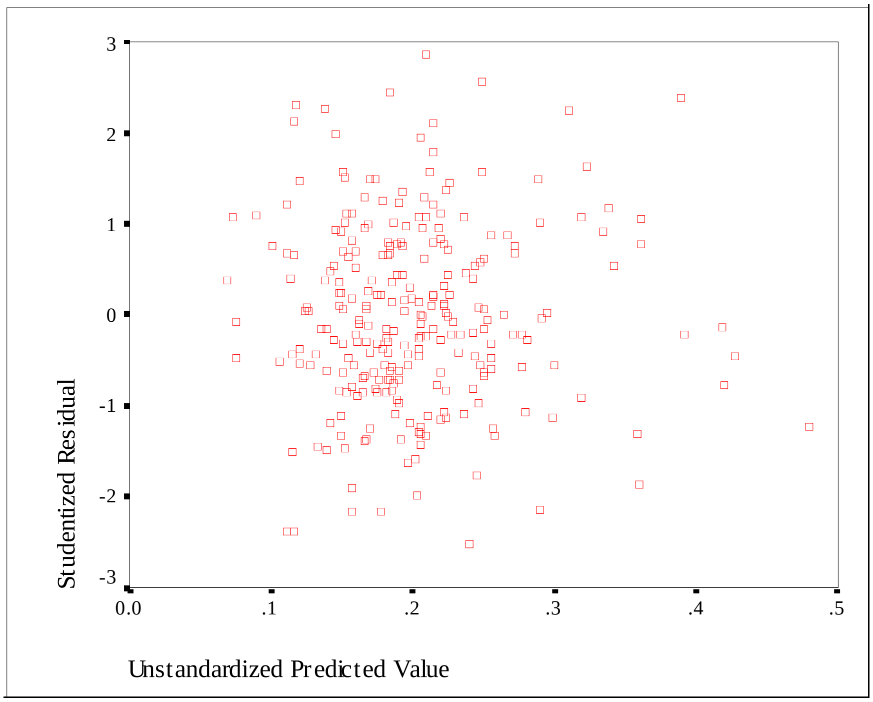

Figure 33: Scatter Plot of Predicted Values and Residuals

Another way to assess the simplified model is to compare its goodness of fit to the full model developed in the first step of the analysis. This analysis indicated that the variables that were deleted from the full model were not statistically significant as a group. This suggests that the simplified model is an adequate summary of the relationship between efficiency choice and the variables developed from the decision-maker survey. From all of the preceding analysis, we can conclude that the simplified model is a good predictive model for efficiency choice.

Comparison of Models

In seeking the most complete and parsimonious model for the energy efficiency choice, a sequence of regression models were examined. The following general steps were followed to obtain the final efficiency-choice model.

1. Estimate a linear regression model relating the dependent variable – the efficiency choice of each site – to all of the potential explanatory variables. Measure the fit, save the diagnostic statistics, and examine the diagnostic graphs. This analysis suggested that sites 201, 225, 230, 241, 670, 1071, 1555, and 3789 might be outliers.

1B. Rerun the preceding model with indicator variables for the outliers. Observe the statistical significance of these indicator variables, measure the fit, save the diagnostic statistics, and examine the diagnostic graphs. This analysis indicated that the model was well specified.

2. Use backward stepwise regression to eliminate the statistically insignificant variables from the preceding model. Use a p-value of 0.05 for adding variables and 0.10 for deleting variables.

3. Estimate the simplified model from the stepwise regression, adding variables interacting building type and participation status, adding significant variables and dropping variables that were not statistically significant. Measure its fit, save its diagnostic statistics, and examine its diagnostic graphs. This analysis suggested that sites 317, 1218, 1239, 2601, and 3827 might be outliers.

4. Use backward stepwise regression to eliminate the statistically insignificant variables from the preceding model with the outlier sites added in. Use a p-value of 0.05 for adding variables and 0.10 for deleting variables.

5. Estimate the simplified model from the stepwise regression. Measure its fit, save its diagnostic statistics, and examine its diagnostic graphs. The results indicated that the model was well specified. This analysis gave the final regression reported above.
6. Add Mills to the previous simplified model get the final model.

7. Add Mills 2.

Table 42 shows the coefficients of the program participant and participant interaction variables and their standard errors for each of the models that were estimated. These coefficients are important because they determine the net savings estimated from the regression model. In other words, any bias in estimating these regression coefficients may produce a bias in the final estimate of net savings.

The table traces how the value of the coefficient changed as various variables were added or dropped. All of the models were based on the same underlying data. Models 1 through 5 trace the steps that were taken to obtain the final model. Model 6 is the final model itself.

In Models 1-5 we were seeking (a) to identify and deal with outliers that might bias the results, and (b) to simplify the model. The approach was to start with a full model reflecting all candidate explanatory variables, look at the various diagnostic statistics and graphs to check the validity of the model, and introduce corrections to any problems that are indicated. Our objective was to get a good model that passes the diagnostic statistics before working to refine the model.

The first model included all of the candidate explanatory variables. The studentized residuals of this model indicated that eight sites were potential outliers, using 3.0 as the critical value. Model 1B was similar to Model 1 but included indicator variables for these added outliers. Both of these models suffered from multicolinearity. The results indicated that the model was well specified. Model 2 was the backward stepwise regression with the outliers identified in Model 1 added in. Model 3 was the simplified model obtained from the backward stepwise regression. The studentized residuals of Model 3 indicated that five more sites were potential outliers, using 3.0 as the critical value. Model 4 was a second backward stepwise regression with indicator variables added in for the potential outliers identified in Model 3. Model 5 was the simplified model obtained from the second backward stepwise regression.

Model 6 was obtained by adding the Mills ratio and became the final model. Model 7 was obtained by adding the double Mills ratio to model 6. These models show that the Mills and Double Mills ratios have very little effect on the coefficients.

Model	Participant		PG&E Influence		Part. C&I Storage		Part. Office		Description
	B	SE	B	SE	B	SE	B	SE	
E1	0.089	0.03	0.006	0.005	-	-	-	-	Multicollinearity and Outliers
E1B	0.046	0.022	0.01	0.004	-	-	-	-	Multicollinearity
E2	0.051	0.021	0.01	0.004	-	-	-	-	Stepwise Regression Model
E3	0.006	0.029	0.01	0.004	0.134	0.052	0.054	0.033	Simplified Model from E2
E4	0.016	0.023	0.007	0.004	0.175	0.049	0.039	0.03	2nd Stepwise With Added Outliers
E5	0.016	0.023	0.007	0.004	0.175	0.049	0.039	0.03	Simplified Model from E4
E6	0.011	0.027	0.008	0.004	0.174	0.049	0.047	0.031	New Final Model (Mills Added)
E7	0.009	0.028	0.008	0.004	0.175	0.049	0.048	0.031	Mills 2 added

Table 42: Model Development Summary

Analysis of Program Impact and Spillover, Annual Energy

The final energy efficiency model was described in an earlier section. The efficiency choice regression model can be written as follows:

Expected efficiency = .116 + .011 * participant

+ .008 * level of influence on current project

+ .013 * level of input in design process

- .009 * significance of energy costs on design decisions

- .022 * C&I storage + .174 * participant C&I storage

+ .015 * office + .047 * participant office

+ .122 * addition + .030 * lowest first cost

+ .001 * mills + other factors

Here, the participant variable was 1 for a participant and 0 for a non-participant. The level of influence was measured on a seven point scale, with 0 indicating no influence and 7 indicating very strong influence. The participant C&I storage variable was a 0 /1 indicator variable, with 0 indicating that the site was not a participant or a C&I storage, and 1 indicating that the site was a participant and a C&I storage site. The participant office variable was a 0 / 1 indicator variable, with 0 indicating that the site was not a participant or an office building, and 1 indicating that the site was a participant and an office.

The energy efficiency model can be used to estimate the impact of the program on any particular sample site. This is done by calculating the difference between the expected energy efficiency predicted by the model and the energy efficiency that would be expected for the site in the absence of the program. In the absence of the program, the participant variable would be equal to 0. Under these assumptions, the impact of the program on expected energy efficiency can be calculated for a program participant as

Added Efficiency = 0.011 + .008 * (level of influence on current project)

+.174 * (participant C&I storage) + .047 * (participant office)

In other words, for a participant, the program increased the expected building efficiency by 0.011 plus 0.008 times the level of influence on the current plus 0.174 times the participant C&I storage indicator variable, plus 0.047 times the participant office indicator.

For a non-participant, the energy efficiency model implies that the program increased the expected energy efficiency by:

Added Efficiency = 0.008 * (level of influence on current project)

In other words, for a non-participant, the program increased the expected building efficiency by 0.008 times the level of influence of PG&E on non-participants.

Table 43 shows the added efficiency due to the program for both participants and non-participants. The top portion of the table represents the impact of the program on expected energy efficiency for a program participant. Levels of participant influence are horizontal, and the vertical rows represent the building type of the participant. The bottom portion of the table represents the influence of the program on expected energy efficiency for non-participants. The values in the table show the increase in expected efficiency due to the program, for both participants and non-participants, evaluated using the preceding two equations.

	Participant Influence							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Participant C&I Storage	0.185	0.193	0.201	0.209	0.217	0.225	0.233	0.241
Participant Office	0.058	0.066	0.074	0.082	0.09	0.098	0.106	0.114
Other Participant Building Types	0.011	0.019	0.027	0.035	0.043	0.051	0.059	0.067
	Non-Participant Influence							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**
	0	0.008	0.016	0.024	0.032	0.04	0.048	0.056

Table 43: Added Efficiency Due to Program

The top portion of Table 43 shows that for a participant building of type other than C&I Storage or Office with no influence by PG&E, the program increased the expected efficiency by .011. In other words, the percent efficiency of the site relative to baseline was .011 higher than in the absence of the program. If the participant building was strongly influenced by PG&E and was an office, the program increased the expected efficiency by .114.

The bottom portion of Table 43 indicates that for a non-participant that was not influenced by PG&E, there was no increased efficiency due to the program, but for a non-participant that was very strongly influenced by PG&E, the program increased the expected efficiency by .056.

This suggests that the program has two impacts. First the program has a direct net impact on the participants. Second, the program appears to have an indirect or spillover impact on the non-participants.

The next step was to use the energy-efficiency regression model to estimate the net direct impact of the program. For each participant we calculated the net annual kWh savings due to the program by multiplying the base annual energy use of the site by the estimated increase in efficiency due to the program, calculated from the preceding equation. Then these results were expanded to the population of program participants.

The final step was to use the energy-efficiency regression model to estimate the spillover impact of the program. In this analysis, we worked with the non-participants in the sample. For each non-participant, we calculated the net annual kWh savings due to the program by multiplying the base annual energy use of the site by the estimated increase in efficiency due to the program, calculated from the preceding non-participant equation. Then we used the Dodge database to expand the sample non-participants to the population of new construction. To ensure a conservative estimate of spillover, we made an adjustment to factor out any participant sites that may have been present in the non-participant population. To accomplish this, the sample spillover was projected to both the participant and new construction populations and the participant population estimate was subtracted from the new construction population estimate.

Table 44 shows the net savings estimate for the commercial population and the estimate of spillover. The econometric approach estimated the direct net savings to be 39,158 MWh among participants and the spillover savings to be 8,916 MWh among non-participants, for a total net savings of 48,074 MWh. The difference-of-differences net savings was 43,076 MWh. The difference between the two estimates was not statistically significant.

We have considered carefully whether to take the final estimates of net savings from the econometric or difference of differences analysis. Because of the unexpected coefficients of several of the decision factors in the model as well as several other problems with the econometric analysis, we have concluded that the difference of differences estimate may be the most suitable estimate of the true program savings. We have presented the econometric results in such detail because we feel that they add validity to the difference of difference results.

	Estimate	**Net-to-Gross Ratio**
Net Savings of Participants	39,158 MWh	33.7%
Spillover in Dodge population	11,232 MWh	--
Spillover in particpant population	2,316 MWh	--
Net non-participant spillover	8,916 MWh	--
Total Net Savings	48,074 MWh	61.0%

Table 44: Net Energy Savings and Spillover Estimates

Industrial Projects

The seven sites classified as industrial were a small subset of the NRNC population. These seven sites covered a wide variety of projects, including new facilities built from the ground up, retrofits and expansions. The evaluations of these sites are summarized below.

Site ID	Measures	Analysis	Monitoring	Tracking Savings
93	New air compressor with integrated VSD	Spreadsheet	On rebated compressor	103,358. kWh 0.0 kW
118	High efficiency and premium efficiency motors for grain conveyance	Spreadsheet	Sample of Motors	113,371 kWh 18.6 kW
205	Desiccant dehumidification for cleanroom expansion	DOE2	Various HVAC related	908,206 kWh 243.4 kW
210	VSDs on glass furnace tempering fans	NA	NA	768,399 kWh 184 kW
223	VSD on oil pipeline pump motor	Spreadsheet	On pump	3,807,138 kWh 0.0 kW
229	New manufacturing facility with six incented measures	DOE2	Extensive	4,542,678 kWh 85.9 kWh
257	New pharmaceutical production facility with 22 incented measures	DOE2	Extensive	4,018,129 kWh 1,628 kW

Table 45: Summary of Industrial Projects

As can be seen from the above table the industrial projects represent a diverse and unique set of projects. Finding a suitably matched sample of non-participants would be extremely difficult if not impossible. Hence, no non-participant sample is utilized for statistical comparison for the industrial project.

The industrial projects were of two distinct types, sites with temperature dependent loads that required simulation, and sites with a single non-temperature dependent measure that were evaluated with spreadsheet analysis. The sites for which energy simulation models were constructed were evaluated by use of the same methods as the commercial projects. Special emphasis was placed upon estimation of the process loads. Short-term monitoring was employed primarily for this purpose. The results of the monitoring were used to modify the models with regards to both process load and hours of operation. Note that site 210 did not have either analysis because the measure was no longer in operation.

All of the sites that were evaluated by spreadsheet were surveyed and three out of the four underwent short term monitoring. From on-site inspections and monitoring data, yearly as-built load profiles were constructed consisting of 8760 average hourly values. Baseline profiles were generated from basecase information found in PG&E project files, on-site equipment inspection and usage patterns gleaned from the monitored data and site personnel interviews. The savings were then calculated from the difference of the two profiles.

Each of these sites were surveyed and evaluated on individual basis. Site specific reports for each of the industrial project are included in the appendix. These reports detail each incented measure, short term monitoring, and site savings calculations.

Gross Savings

This section presents the gross energy and demand savings estimates from all seven sites classified as industrial. Each of the seven sites were surveyed and six of the seven underwent short term monitoring to some degree. Four of the sites were evaluated for a single specific measure with spreadsheet analysis. For the other three, a DOE2 model of the facility was constructed and utilized for the evaluation. The three industrial sites evaluated with a DOE2 energy model were analyzed in the same manner as the commercial sites.

Whole Building

For the industrial sites, total premise is probably a more accurate term to describe the totality of the evaluation for a given facility. A majority of the projects, four out of the seven, involved the evaluation of a single incented measure and some of these measures were outside the confines of any building. The total premise (whole building) gross energy savings is estimated at 19,226 MWh. This represents a gross realization rate of 134.8% of verified annual energy savings. The summer on peak demand savings for the industrial sites is estimated at 2.4 MW, which represents a gross realization of 107.4% of verified summer on-peak demand savings. Since all industrial sites were evaluated, the relative precision of the estimates is ±0.0% with no error bound. Table 48 shows the breakdown of gross energy and demand savings for the industrial sites by costing period.

Gross Period	Energy Savings (MWh)	Demand Savings (MW)
Annual	**19,226**	
Summer On-Peak	1,571	2.37
Summer Mid-Peak	2,000	2.19
Summer Off-Peak	3,893	2.12
Winter Mid-Peak	5,377	2.29
Winter Off-Peak	6,385	1.93

Table 46: Gross Energy and Demand Savings of Industrial Sites

The total gross savings for the industrial projects of 19,226 MWh was 35.4% of total baseline usage. The estimated summer on-peak demand savings of 2.37 MW was 30.3% of the baseline demand. Table 47 shows the percentage of total energy and demand savings as a percentage of baseline usage for the industrial projects.

Gross Savings as a % of Baseline Period	**Energy (MWh)**	**Demand (MW)**
Annual	35.4%	
Summer On-Peak	35.2%	30.3%
Summer Mid-Peak	36.2%	38.2%
Summer Off-Peak	34.9%	32.2%
Winter Mid-Peak	37.3%	32.4%
Winter Off-Peak	34.1%	32.9%

Table 47: Total Industrial Site Gross Savings as a Percentage of Baseline

End-use Composition of Savings

The industrial sites had significant savings in three of the five end uses that were examined as part of this study. The percentage breakdown of industrial site whole building energy savings by end use is shown in Figure 34. The HVAC measures account for 77% of the savings, and motors another 17% of the savings. Lighting accounted for the remaining 6%.

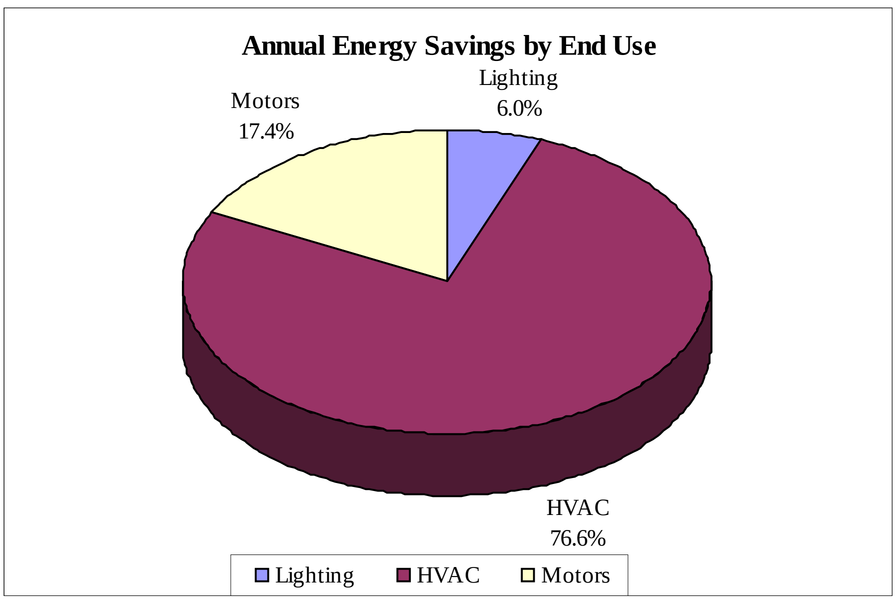

Figure 34: End-Use Energy Savings as a Percentage of Total Savings

The industrial program had only one incented measure for the shell end use and one incented measure for refrigeration. The refrigeration end-use showed savings of no statistical significance and the shell end use showed small negative savings. This was the case for both energy and demand. The percentage breakdown of summer on peak demand savings by statically significant end uses in shown in Figure 35.

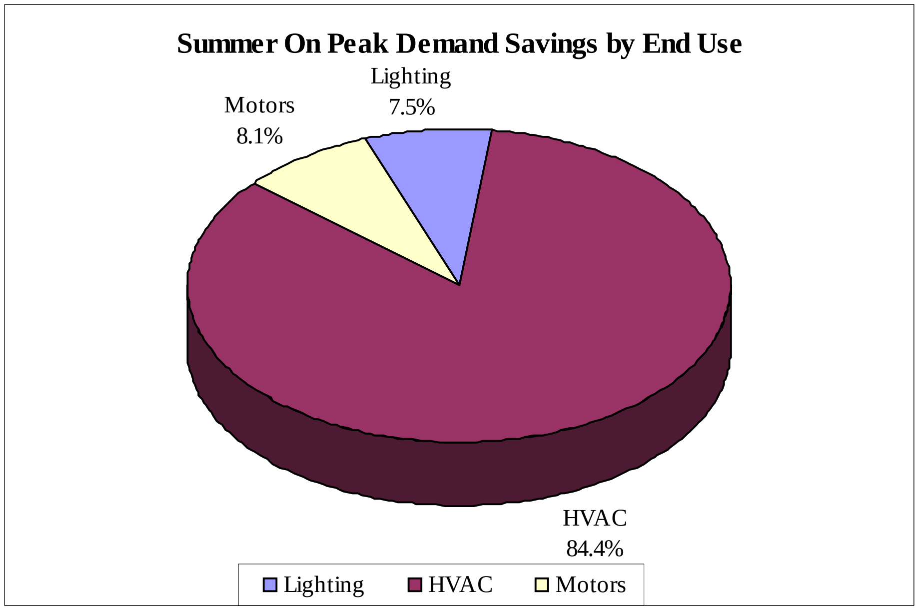

Figure 35: Demand Savings by End Use Measure Category

Lighting

Three of the seven industrial sites were evaluated for lighting savings using DOE2. One of these sites had an incented measure for the lighting end use. The total annual energy savings for the industrial sites are estimated at 1,160 MWh, this represent 6.0% of the total annual energy savings. The summer on-peak demand savings for the lighting end use are estimated at 0.2 MW, which is 7.5% of the total summer on-peak demand savings for the industrial sites.

HVAC

Three of the seven industrial sites were evaluated for HVAC savings using DOE2. All three of these sites received incentives for HVAC related measures. HVAC energy savings at these sites are estimated at 14,920 MWh, which is 76.6% of the annual whole building energy savings for the industrial sites. The estimated summer on-peak demand savings for the lighting end use are estimated at 1.99 MW, representing 84.4% of the whole building summer on-peak demand savings.

Motors

At six of the seven industrial sites, evaluations for motor savings were performed. All six of these sites had incented measures related to the motor end use. The annual motor end use energy savings are estimated at 3,387 MWh. This accounts for 17.4% of total energy savings. The summer on-peak demand savings are estimated at 0.2 MW, accounting for 8.1% of the whole building (total premise) summer on-peak demand savings.

Table 48 shows the savings for the three statistically significant end uses broken down by costing periods.

Energy Savings Period	**End Use** Lighting (MWh)	HVAC (MWh)	Motors (MWh)
Annual	**1,160**	**14,920**	**3,387**
Summer On-Peak	106	1,273	284
Summer Mid-Peak	113	1,578	342
Summer Off-Peak	161	2,766	1,005
Winter Mid-Peak	429	4,350	655
Winter Off-Peak	352	4,954	1,102
Demand Savings	**End Use**		
Period	**Lighting (MW)**	**HVAC (MW)**	**Motors (MW)**
Summer On-Peak	0.18	1.99	0.19
Summer Mid-Peak	0.09	1.38	0.71
Summer Off-Peak	0.08	1.81	0.24
Winter Mid-Peak	0.18	1.76	0.36
Winter Off-Peak	0.08	1.70	0.35

Table 48: Industrial End Use Energy and Demand Savings by Costing Period

Table 49 shows the industrial site gross savings as a percentage of baseline broken down by costing period for the statistically significant end uses.

	Energy Savings		
Period	**Lighting**	**HVAC**	**Motors**
Annual	2.1%	27.5%	6.2%
Summer On-Peak	2.4%	28.5%	6.4%
Summer Mid-Peak	2.0%	28.5%	6.2%
Summer Off-Peak	1.4%	24.8%	9.0%
Winter Mid-Peak	3.0%	30.2%	4.5%
Winter Off-Peak	1.9%	26.5%	5.9%
	Demand Savings		
Period	**Lighting**	**HVAC**	**Motors**
Summer On-Peak	2.2%	25.4%	2.5%
Summer Mid-Peak	1.6%	30.3%	12.3%
Summer Off-Peak	1.2%	32.8%	3.7%
Winter Mid-Peak	2.5%	31.7%	5.0%
Winter Off-Peak	1.3%	35.3%	6.0%

Table 49: Industrial Project End Use Gross Savings as a Percentage of Baseline.

Savings of Incented Measures

This section contains the results for the incented measures for the industrial projects. The analysis was conducted for all five end-use measure categories:

shell, lighting, HVAC, refrigeration, and motors. However, shell and refrigeration end uses had only one measure each for all of the industrial sites, both of which failed to produce savings of statistical significance.

Table 50 shows the energy savings of the incented measures broken down by costing period. The relative precision for each estimate by end use is 0.0%, as all of the seven sites were evaluted. Table 51 shows the demand savings.

Energy Savings			
Measures Only	**Lighting (MWh)**	**HVAC (MWh)**	**Motors (MWh)**
Annual	425	8,343	2,896
Summer On-Peak	22	680	256
Summer Mid-Peak	35	846	299
Summer Off-Peak	79	1,673	906
Winter Mid-Peak	107	2,046	537
Winter Off-Peak	182	3,098	899

Table 50: Energy Savings of Incented Measures for Industrial Projects

Demand Savings			
Measures Only	**Lighting (MW)**	**HVAC (MW)**	**Motors (MW)**
Summer On-Peak	0.05	1.35	0.19
Summer Mid-Peak	0.06	0.92	0.71
Summer Off-Peak	0.05	1.22	0.24
Winter Mid-Peak	0.05	1.09	0.36
Winter Off-Peak	0.05	1.14	0.35

Table 51: Measures Only Demand Savings by End Use

Table 52 and Table 53 show the energy and demand savings of the incented measures for each end-use measure category relative to the corresponding end-use baseline usage. The percentage scale indicates the savings attributed to incented measures for each end use category compared to the entire baseline usage for that end use for all of the industrial sites.

	Lighting (MWh)	**HVAC (MWh)**	**Motors (MWh)**
Annual	12.1%	19.3%	10.7%
Summer On-Peak	6.9%	18.7%	12.8%
Summer Mid-Peak	10.4%	18.9%	11.5%
Summer Off-Peak	16.1%	17.8%	14.4%
Winter Mid-Peak	8.3%	18.7%	8.6%
Winter Off-Peak	16.9%	21.1%	9.1%

Table 52: Energy Savings of Incented Measures Relative to End Use Baseline Use

	Lighting (MW)	HVAC (MW)	Motors (MW)
Summer On-Peak	10.7%	28.4%	5.7%
Summer Mid-Peak	21.4%	18.8%	23.3%
Summer Off-Peak	19.7%	22.3%	7.9%
Winter Mid-Peak	10.8%	20.5%	10.7%
Winter Off-Peak	20.1%	22.4%	11.5%

Table 53: Demand Savings of Incented Measures Relative to End Use Baseline Demand

Net Savings

As discussed previously, the net savings are that part of the observed energy savings that can be directly attributed to the efforts of PG&E. There were two primary reasons why a different net-to-gross methodology needed to be used for the industrial customers than the did the commercial customers:

1. Difficulty in finding a non-participant to match to the participant group. Some of the industrial participants were industry leading high-tech and bio-tech facilities that are “one of a kind” projects.
2. All of the industrial sites were evaluated.

During the interview, decision-makers for the facility were asked about the influence of PG&E for each individual measure. Based upon that response, a net-to-gross ratio was assigned for each measure. A value zero for free riders, 0.25 for those who were influenced but were already leaning towards implementation in the absence of the program, and 0.5 was assigned to those measures where the decision-maker was somewhat influenced by the program. A 0.75 for those were considering implementation and felt greatly influenced by the program and a 1.0 was assigned to those measures whose decision-makers’ proclaimed that they would not have implemented the measure in the absence of the program. A default value 0.75 was assigned to all measures where the question of PG&E’s influence went unanswered.

Five of the seven sites had only a single measure. For those sites, the net-to-gross ratio was simply the net-to-gross ratio for that measure.

For the two sites with multiple measures, the net-to-gross ratio for each individual measure was multiplied by the tracking savings for that measure. The value for each measure was used to calculate an average net-to-gross ratio for each site. This was an average net-to-gross ratio weighted by tracking savings of each individual measure.

The resulting net to gross ratio for each site was then used to calculate net savings for that site. The industrial project energy savings net-to-gross ratio was calculated to be 68.0%. The summer on peak demand ratio was calculated to be 72.9%. Table 54 and Table 55 show the generation of the program net-to-gross ratios for estimated annual energy and summer on peak demand savings from savings and net to gross ratios from each individual site

Site ID	Gross Energy Savings (MWh)	Net-to-Gross Ratio	Net Energy Savings (MWh)
93	-	0.0%	-
118	44	0.0%	-
205	1,271	75.0%	953
210	-	0.0%	-
223	2,896	25.0%	724
229	5,736	77.0%	4,416
257	9,280	75.3%	6,988
Total	**19,226**	**68.0%**	**13,081**

Table 54: Industrial Project Net Annual Energy Savings

Site ID	Gross Summer On-Peak Demand Savings (MW)	Net-to-Gross Ratio	Net Summer On-Peak Demand Savings (MW)
93	-	0.0%	-
118	-	0.0%	-
205	0.13	75.0%	0.10
210	-	0.0%	-
223	0.14	25.0%	0.04
229	0.85	77.0%	0.66
257	1.25	75.3%	0.94
Total	**2.37**	**72.9%**	**1.73**

Table 55: Industrial Project Net Summer On Peak Demand Savings

The results from analysis of the seven industrial sites are summarized below in Table 56.

	Annual Energy Savings (MWh)	Summer On-Peak Demand Savings (MW)
Tracking Savings	14,261	2.21
Gross Savings	19,226	2.37
Gross Realization Rate	134.8%	107.4%
Net Savings	13,081	1.73
Net Realization Rate	91.7%	78.4%
Net to Gross Ratio	68.0%	72.9%

Table 56: Summary of Results for Industrial Projects

Overall Program Savings

The preceding sections of this report contain the separate gross and net savings estimates for the commercial and industrial projects, respectively. This section contains the combined savings estimates from the two categories of projects. These combined results are also shown in the executive summary of this report.

Gross Program Savings

Whole Building

PG&E's whole building gross energy savings was 135,543 MWh. The relative precision of the estimate was ±3.3%. This represents a gross realization rate of 147.9% of verified annual savings. Table 57 shows the estimated energy savings by costing period.

Period	Energy Savings (MWh)	Error Bound (MWh)	Relative Precision (+/-)
Annual	**135,543**	± **4,494**	± **3.3%**
Summer On-Peak	12,989	± 431	± 3.3%
Summer Mid-Peak	14,657	± 470	± 3.2%
Summer Off-Peak	23,255	± 840	± 3.6%
Winter Mid-Peak	41,996	± 1,338	± 3.2%
Winter Off-Peak	42,645	± 1,698	± 4.0%

Table 57: Whole Building Energy Savings by Costing period

End-use Savings

Figure 36 shows the breakdown of annual energy savings by end-use. The savings associated with the shell measures was not statistically significant and is omitted in Figure 36. The shell measures will not be discussed further in this section.

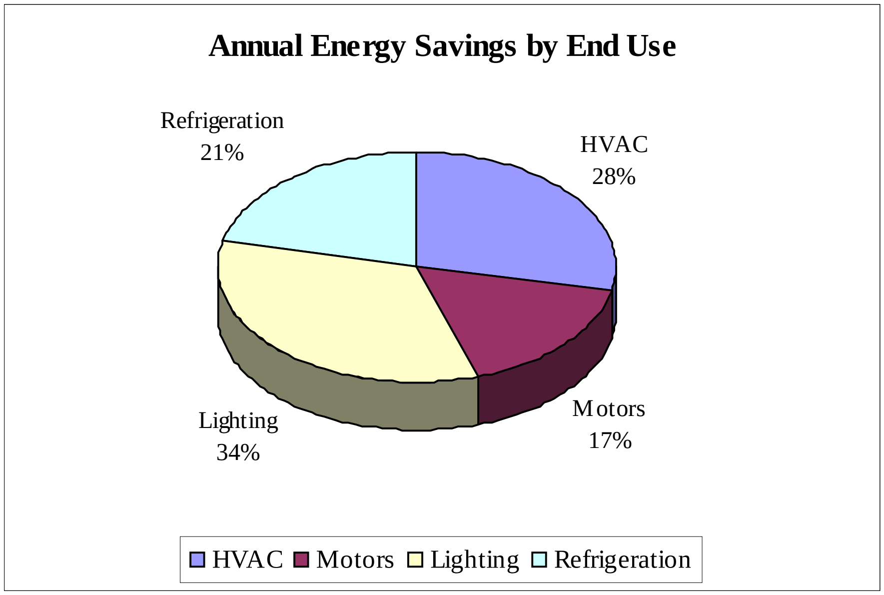

Figure 36: Composition of Annual Energy Savings

Lighting

The lighting end-use accounted for 45,632 MWh of annual energy savings. This was 33.6% of the total annual energy savings. Table 58 shows the savings, error bounds and relative precision by costing period.

Period	Energy Savings (MWh)	Error Bound (MWh)	Relative Precision (+/-)
Annual	**45,632**	± **3,177**	± **7.0%**
Summer On-Peak	4,691	± 292	± 6.2%
Summer Mid-Peak	4,892	± 328	± 6.7%
Summer Off-Peak	5,986	± 517	± 8.6%
Winter Mid-Peak	17,531	± 1,056	± 6.0%
Winter Off-Peak	12,533	± 1,116	± 8.9%

Table 58: Lighting Energy Savings by Costing Period

HVAC

The HVAC end-use accounted for 38,383 MWh of energy savings, or 28.3% of annual energy savings. Table 59 shows the savings, error bounds and relative precision by costing period.

Period	Energy Savings (MWh)		Error Bound (MWh)		Relative Precision (+/-)
Annual	**38,383**	±	**1,811**	±	**4.7%**
Summer On-Peak	4,699	±	201	±	4.3%
Summer Mid-Peak	5,125	±	240	±	4.7%
Summer Off-Peak	7,765	±	425	±	5.5%
Winter Mid-Peak	11,024	±	510	±	4.6%
Winter Off-Peak	9,770	±	507	±	5.2%

Table 59: HVAC Energy Savings by Costing period

Refrigeration

The refrigeration end-use accounted for 29,011 MWh, or 21.4%, of the total energy savings. Table 60 shows the savings, error bounds and relative precision by costing period.

Period	Energy Savings (MWh)		Error Bound (MWh)		Relative Precision (+/-)
Annual	**29,011**	±	**3,288**	±	**11.3%**
Summer On-Peak	1,701	±	202	±	11.8%
Summer Mid-Peak	2,530	±	295	±	11.6%
Summer Off-Peak	5,195	±	579	±	11.1%
Winter Mid-Peak	7,474	±	861	±	11.5%
Winter Off-Peak	12,110	±	1,362	±	11.2%

Table 60: Refrigeration Energy Savings by Costing period

Motors

The motor end-use made the smallest contribution to savings at 22,697 MWh. This was 16.7% of total savings. Table 61 shows the motor energy savings by costing period.

Period	Energy Savings (MWh)		Error Bound (MWh)		Relative Precision (+/-)
Annual	**22,697**	±	**2,255**	±	**9.9%**
Summer On-Peak	1,675	±	132	±	7.9%
Summer Mid-Peak	2,069	±	193	±	9.3%
Summer Off-Peak	4,321	±	415	±	9.6%
Winter Mid-Peak	6,089	±	569	±	9.3%
Winter Off-Peak	8,543	±	958	±	11.2%

Table 61: Motor Energy Savings by Costing Period

Demand Impact Findings

Whole Building

PG&E's whole building gross demand savings was 20.78 MW. The relative precision of the estimate was ±3.9%. This represents a gross realization rate of 82.4% of verified summer on-peak demand savings. Table 62 shows the estimated savings by costing period.

Period	Demand Savings (MW)	Error Bound (MW)	Relative Precision (+/-)
Summer On-Peak	20.78	± 0.80	± 3.9%
Summer Mid-Peak	14.49	± 0.57	± 3.9%
Summer Off-Peak	15.79	± 0.74	± 4.7%
Winter Mid-Peak	19.61	± 0.75	± 3.8%
Winter Off-Peak	14.03	± 0.63	± 4.5%

Table 62: Whole Building Demand Savings by Costing period

End-use Demand Savings

Figure 37 shows the breakdown of annual energy savings by end-use. The HVAC end-use has a larger impact on summer peak demand savings than it does on annual energy because of its seasonal nature.

The shell measures did not produce statistically significant savings and is not discussed in this section.

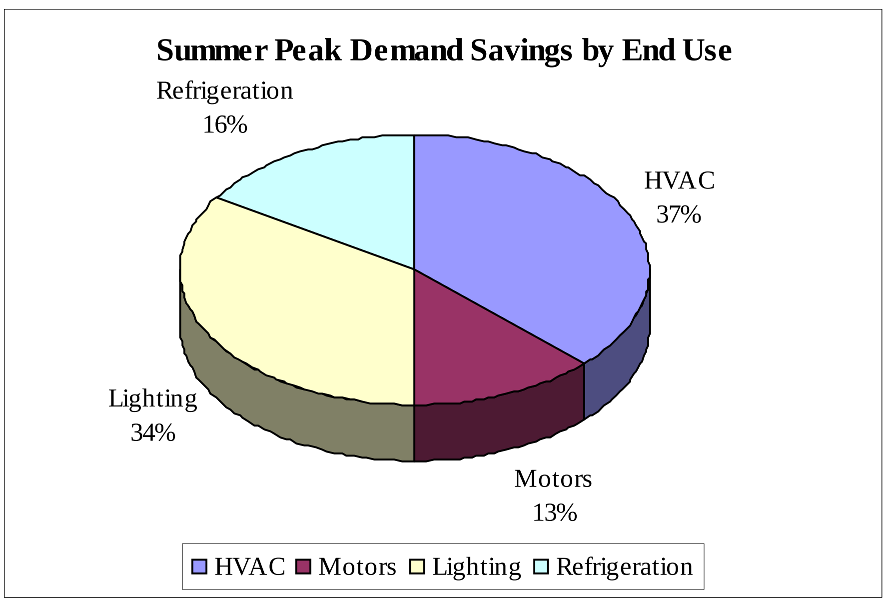

Figure 37: Summer Peak Demand Savings by End-use

Lighting

PG&E's lighting end-use summer on-peak gross demand savings was 6.88 MW. This was 33.9% of the summer on-peak demand savings. The relative precision of the estimate was ±7.1%. Table 63 shows the estimated savings by costing period.

Period	Demand Savings (MW)	Error Bound (MW)	Relative Precision (+/-)
Summer On-Peak	6.88	± 0.49	± 7.1%
Summer Mid-Peak	3.85	± 0.37	± 9.7%
Summer Off-Peak	3.29	± 0.40	± 12.1%
Winter Mid-Peak	6.98	± 0.51	± 7.2%
Winter Off-Peak	2.94	± 0.33	± 11.3%

Table 63: Lighting Demand Savings by Costing Period

HVAC

PG&E's HVAC end-use gross demand savings was 7.57 MW, or 37.2% of summer on-peak demand savings. The relative precision of the estimate was ±5.5%. Table 64 shows the estimated savings by costing period.

Period	Demand Savings (MW)	Error Bound (MW)	Relative Precision (+/-)
Summer On-Peak	7.57	± 0.41	± 5.5%
Summer Mid-Peak	14.49	± 0.89	± 6.1%
Summer Off-Peak	15.79	± 1.02	± 6.4%
Winter Mid-Peak	19.61	± 1.05	± 5.4%
Winter Off-Peak	14.03	± 0.85	± 6.0%

Table 64: HVAC Demand Savings by Costing Period

Refrigeration

PG&E's refrigeration end-use gross demand savings was 3.30 MW. This was 16.2% of summer on-peak demand savings. The relative precision of the estimate was ±11.8%. Table 65 shows the estimated savings by costing period.

Period	Demand Savings (MW)	Error Bound (MW)	Relative Precision (+/-)
Summer On-Peak	3.30	± 0.39	± 11.8%
Summer Mid-Peak	3.30	± 0.38	± 11.6%
Summer Off-Peak	3.34	± 0.40	± 11.9%
Winter Mid-Peak	3.33	± 0.39	± 11.6%
Winter Off-Peak	3.45	± 0.42	± 12.3%

Table 65: Refrigeration Demand Savings by Costing Period

Motors

The motor end use had a summer on-peak demand savings of 2.58 MW, or 10.2% of the total demand savings. Table 66 shows the savings by costing period.

Period	Demand Savings (MW)	Error Bound (MW)	Relative Precision (+/-)
Summer On-Peak	2.58	± 0.26	± 10.2%
Summer Mid-Peak	2.67	± 0.26	± 9.7%
Summer Off-Peak	2.18	± 0.26	± 11.9%
Winter Mid-Peak	2.71	± 0.26	± 9.7%
Winter Off-Peak	2.27	± 0.26	± 11.5%

Table 66: Motor Demand Savings by Costing Period

Net Program Savings

Table 67 shows the total program net savings for annual energy and summer on-peak demand. The table also contains the net-to-gross ratio and the relative precision for each estimate.

	Net Savings	Net-to-Gross Ratio	Relative Precision (+/-)
Annual Energy	56,157	41.4%	± 47.3%
Summer Peak Demand	7.6	36.7%	± 47.7%

Table 67: Energy and Demand Net Savings, Net-to-Gross, and Relative Precision

Table 68 shows the energy savings, realization rates, and net-to-gross ratio. The realization rates for each estimate is also reported in the table below.

	Estimate (MWh)	Relative Precision (+/-)
Tracking Savings	91,658	NA
Gross Savings	135,543	± 3.3%
Gross Realization Rate	147.9%	± 3.3%
Net Savings	56,157	± 47.3%
Net Realization Rate	61.3%	± 47.3%
Net-to-Gross Ratio	41.4%	-

Table 68: Energy Savings, Realization Rates, and Net-to-Gross Ratio

Table 69 shows the demand savings, realization rates, and net-to-gross ratio. The realization rates for each estimate is also reported in the table below.

	Estimate (MW)	Relative Precision (+/-)
Tracking Savings	25.2	NA
Gross Savings	20.8	± 3.9%
Gross Realization Rate	82.4%	± 3.9%
Net Savings	7.6	± 47.7%
Net Realization Rate	30.3%	± 47.7%
Net-to-Gross Ratio	36.7%	-

Table 69: Demand Savings, Realization Rates, and Net-to-Gross Ratio

Added Observations and Recommendations

The Program

The primary objective of this study was to obtain an independent, objective assessment of the actual savings of the program. In the course of the study, we have made some important observations about the program and about our approach to the evaluation. Regarding the program itself, we have observed:

- Comparing 1996 to 1998, there has been a substantial improvement in energy efficiency in the non-residential new construction market. Using essentially the same baseline, the gross savings among the non-participants has risen from 10.3% of baseline energy use in 1996 to 15.9% of energy use in 1998.
- During the same period, the program participants kept pace with the non-participants. The gross savings among the participants has risen from 19.2% of baseline energy use in 1996 to 25.3% of energy use in 1998.
- As the non-residential new construction market has grown more efficient relative to the baseline, the net-to-gross ratio of the program has necessarily dropped. This is an artifact of the baseline and is *not* a reflection of the program itself. With the 1999 modifications to Title 24 lighting requirements, future evaluations should find an improved net-to-gross ratio.
- The program has moved away from lighting into HVAC and motors. In the 1996 program, lighting was responsible for 55% of all savings, but in the 1998 program, lighting was only 38% of all savings. By contrast, HVAC rose from 9% in 1996 to 20% in 1998 and motors rose from 4% to 17%. This is an important shift in the program.
- The annual savings due to lighting measures are about 37% of the lighting baseline use for participants and about 31% for non-participants. These results indicate that participants have about 19% more savings from lighting measures than non-participants.
- The fact that non-participants are achieving such high lighting savings reflects the wide acceptance of T-8 lamps and electronic ballasts. The lighting component of the program will need to focus on more aggressive measures such as daylighting, dimming ballasts, and compact fluorescent lamps.
- By contrast with lighting, the 1998 participants are much more efficient than the 1998 non-participants in the motors, refrigeration and HVAC end uses. The annual savings due to the motor measures are about 20% of the motor baseline use for participants, and about 4% for non-participants. The annual savings due to the HVAC measures are about 14% of the HVAC baseline use for participants, and about 8% for non-participants. The annual savings due to the refrigeration measures are about 45% of the refrigeration baseline use for participants, and about 12% for non-participants.
- The participant savings percentages are smaller for HVAC and motors than for refrigeration and lighting. This suggests that as the program matures, it may more difficult to attain the savings achieved in past years. In other words, as the bar gets higher, success will be more difficult.

The Evaluation Methodology

The methodology used for this study has proven to be generally successful. RLW Analytics and AEC were able to collect and analyze large amounts of detailed data quickly using this methodology. To be sure, this was not an inexpensive endeavor, but it has produced characteristic and energy use information that is also very valuable for studies of market transformation, building characteristics, and other market research.

The key characteristics of the approach were retained from 1996 PG&E and SCE evaluations:

- **The use of the same staff to survey buildings and build engineering models**. This approach allowed the project team to build much better models because the data was collected with a full understanding of the needs of the models. Also, because the person who developed the model was on-site, they could do a much better "reality check" on the model results.
- **Building the engineering model shortly after the site visit**. In the 1994 study, several months passed before the modeling staff could review the field data, greatly increasing the chance that errors could not be adequately corrected. In this study, the initial models were built within days or weeks of the site visit. This, combined with the point above, greatly improved the quality of the models because the building was much fresher in the mind of the modeler.
- **The use of scale variables in the econometric models**. In the 1994 study, a binary variable was used to indicate "partial participation" (a non-participant with spillover). This crude approach to a subtle issue contributed to the econometric model's inability to identify non-participant spillover. In this study, a series of scale variables were used to isolate spillover. This more sensitive approach was successful in measuring "partial participation."
- **Experienced construction professionals were used to recruit and survey design professionals and building owners**. The use of staff who understood the industry was the primary reason that such a high participation rate was observed. This also helped with survey completion and data quality because the respondents felt as though the surveyor understood the subject matter and could speak on their level.

Most of the cost and effort in this study involved the data collection and engineering model-building tasks. To the extent that impact evaluation studies like this one continue, there are several steps that could be taken in those areas to improve the cost effectiveness of the study:

- **Electronic data entry**. Related to the above point, the use of handheld computers to record survey data would streamline data entry and move quality control checks to the survey site, where the errors could most easily and accurately be corrected.
- **"Codify" engineering judgement**. A major factor in the data collection cost was the use of experienced engineers to collect the data. To the extent that some of the engineering judgement could be captured in the software, lower cost staff could be used in the data collection. This is a fine line to walk, as

reductions in surveyor experience and skill could contribute to degradation in the quality of data.

- **Capture decision-maker data as the program runs.** One of the biggest challenges in this type of study is to ask a decision-maker about events that occurred as long as two years prior. The data collected for the econometric analysis could be significantly improved by collecting this data at the time the project is done. This would require a standard survey to be developed by CADMAC and administered by the utility sponsoring the program.
- **Revision of the CADMAC protocols on sampling**. A revision of the sampling protocols would benefit future studies. The CADMAC committee approved this variance from the protocols on this study as well as the 1996 Southern California Edison NRNC study and the combined 1994 PG&E/SCE NRNC study. The results of the study show that this sampling approach is effective in capturing the required information at a significantly lower cost than would be required by a sample complying with the current protocol.

PRE-1998 NON-RESIDENTIAL NEW CONSTRUCTION IMPACT EVALUATION CARRYOVER

APPENDIX

PG&E Study ID number: 400

March 1, 2000

Measurement and Evaluation
Customer Energy Efficiency Policy & Evaluation Section
Pacific Gas and Electric Company
San Francisco, California

Disclaimer of Warranties and Limitation of Liabilities

All inquiries should be directed to:

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San Francisco, CA 94177

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CADMAC PROTOCOLS TABLE 6

Pacific Gas & Electric

Study ID # 400

	Energy		Demand	
	Participant Group	Comparison Group	Participant Group	Comparison Group
	(per sqft in kwh/sqft/year)		*(per sqft in w/sqft)*	
Energy Usage				
Base Usage	514,630,913	316,075,974	77,642	50,341
Base usage per sqft	24.15	13.76	3.64	2.36
Impact Year Usage	379,087,982	265,792,182	56,861	41,311
Impact Year Usage per sqft	17.79	11.57	2.67	1.80
Gross Load Impact	135,542,931	50,283,794	20,781	9,029
Gross Load Impact per sqft	6.36	2.19	0.98	0.39
Net Load Impact	56,157,156	na	7,628	na
Net Load Impact per sqft	2.63	na	0.36	na
% Load Impact	26.3%	15.9%	26.8%	17.9%
% Load Impact per sqft	26.3%	15.9%	26.8%	16.6%
Gross Realization Rate	147.9%	na	82.4%	na
Net Realization Rate	61.3%	na	30.3%	na
Net-to-Gross Ratios				
Load Impacts	41.4%	na	36.7%	na
Load Impact per sqft	41.4%	na	36.7%	na
Square Footage				
Pre-Installation	21,312,820	22,978,563	21,312,820	22,978,563
Post-Installation	21,312,820	22,978,563	21,312,820	22,978,563
90% Precision				
Base Usage	3.9%	19.5%	5.0%	22.7%
Base usage per sqft	3.9%	19.5%	5.0%	22.7%
Impact Year Usage	4.8%	19.0%	6.0%	23.5%
Impact Year Usage per sqft	4.8%	19.0%	6.0%	23.5%
Gross Load Impact	3.3%	20.5%	3.9%	24.6%
Gross Load Impact per sqft	3.3%	20.5%	3.9%	24.6%
Net Load Impact	47.3%	na	47.7%	na
Net Load Impact per sqft	47.3%	na	47.7%	na
80% Precision				
Base Usage	3.0%	15.2%	3.9%	17.7%
Base usage per sqft	3.0%	15.2%	3.9%	17.7%
Impact Year Usage	5.3%	14.8%	4.7%	18.3%
Impact Year Usage per sqft	5.3%	14.8%	4.7%	18.3%
Gross Load Impact	2.6%	16.0%	3.0%	19.2%
Gross Load Impact per sqft	2.6%	16.0%	3.0%	19.2%
Net Load Impact	36.9%	na	37.2%	na
Net Load Impact per sqft	36.9%	na	37.2%	na

Measure Counts	Measure counts are not applicable to the design of this program

TABLE 6 CONTINUED

Population by Building Type	
Category	**Total**
C&I Storage	8.9%
Fire/Police/Jails	2.0%
General C&I Work	14.6%
Grocery Store	3.7%
Gymnasium	0.4%
Libraries	0.8%
Medical/Clinical	4.1%
Office	41.1%
Religious Worship, Auditorium, Convention	3.3%
Retail and Wholesale Store	4.1%
School	16.3%
Theater	0.8%
Grand Total	**100.0%**

CADMAC PROTOCOLS TABLE 7

Pacific Gas & Electric

Study ID# 400

A. OVERVIEW INFORMATION

1. Study title and study ID number

Impact Evaluation of Pacific Gas & Electric 1998 Non-residential New Construction Programs. Study ID Number 400.

2. Program and year

PG&E 1998 Non-residential New Construction Programs.

3. End uses measures

The study was directed primarily to the total load of the affected space. Lighting, Refrigeration, motor, shell measures, and HVAC were also examined.

4. Methods and models used

This study used an integrated combination of model-based statistical sample design, onsite audits, site-specific DOE-2 engineering models calibrated to billing data, short-term metering, econometric analysis and statistical expansion. See report body for methodological discussion.

5. Participant and comparison group definitions

Participants were sites that received a rebate during the 1997 and 1998 program year. Non-participants were completed new construction in 1997 and 1998 that did not receive a rebate.

6. Analysis sample sizes

Commercial gross analysis: 283 buildings. Net to gross analysis: 277 buildings.

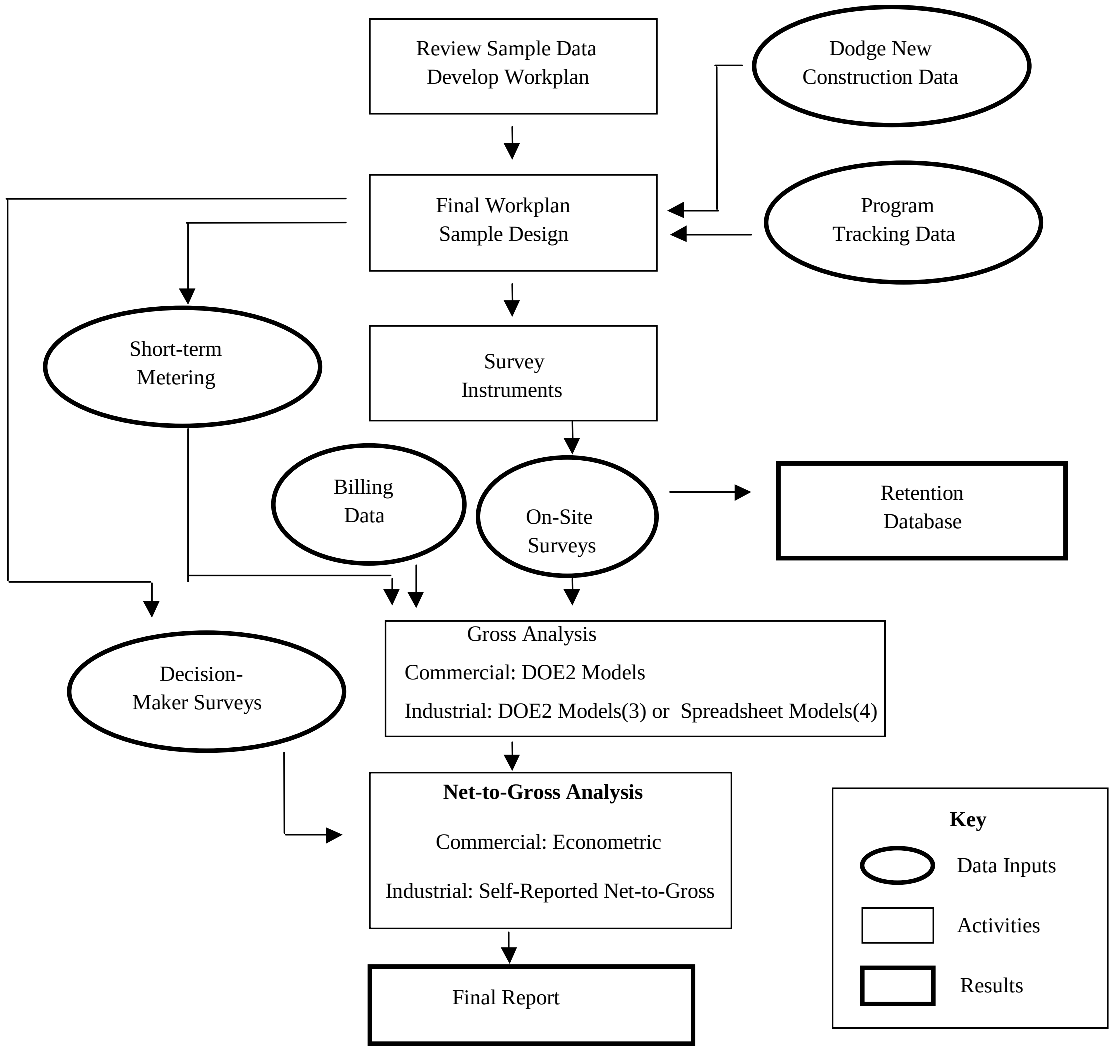
Industrial gross analysis: 7 buildings. Net to gross analysis: 7 buildings.

B. DATABASE MANAGEMENT

1. Data elements

The following figure shows the relationship between the data elements and major tasks used in the study. The principle data elements were the Decision Maker Survey, the on-site audits, the short-term monitoring, the billing data used to calibrate the DOE-2 models used in the gross analysis, the program tracking systems, and the Dodge data base describing new construction. Additional instruments were used for recruiting.

The short-term metering, onsite audits and billing data support the DOE-2 modeling which supports the gross analysis. The primary purpose of the Decision-Maker Survey was to support the net to gross analysis. The Dodge database and the program tracking systems were used in the sample design and in the statistical expansion of the sample findings. The relationship between these elements is described in the report.



2. Specific data sources

The Decision-Maker Survey collected data regarding:

- The degree of program participation
- The specific nature of influences on key design decisions
- Whether their design decisions would have been taken in the absence of the program.

The on-site survey was used to obtain an independent, realistic, observation of the ECM conditions and performance. The on-site survey instrument was designed to provide the information needed to simulate energy use and demand for each building by a minimum of five different scenarios. For maximum validity, the field data collection was aimed at directly observable data. Special attention was paid to Title 24 specifications and program measures throughout the building. The on-site visits also helped to assess the suitability of each site for potential short-term metering.

For details, see the report body.

3. Data attrition process

Please see D3 below.

See report section on net impact findings.

4. Data quality checks

Strict quality control measures were carried out throughout the data collection phase of the project. They consisted of a number of range, consistency, and sanity checks on the collected data, as well as random spot-checks on auditors in the field. These procedures are discussed in detail in the report section on engineering models and data collection.

5. Data collected but not used

None.

C. SAMPLING

1. Sampling procedures and protocols

The primary sampling frame was the Dodge database of new construction in California in 1996 and 1997. This sample was screened for service area and building type and matched to the participant tracking database. The participant sample was stratified by the program estimate of savings, the non-participant sample was stratified by estimated square footage and building type. Model based statistical sampling (MBSS™) methods were used to construct the strata and choose the sample sizes. See the report section on sample design.

2. Survey information

See report text and answer D 3 below.

3. Statistical descriptions

Standard descriptive statistics are misleading for a stratified ratio estimation since weighting is necessary to obtain meaningful results and the methods described in the report are needed to evaluate statistical precision. The report provides statistical results for all key variables that are properly expanded to the population, together with suitable error bounds at the 90% level of confidence.

D. DATA SCREENING AND ANALYSIS

1. Outliers, missing data, and weather adjustment

The full sample was retained throughout the analysis. Studentized residuals were used to identify outliers. A site was considered to be an outlier if its studentized residual was greater than three in absolute value. A separate indicator variable was used to represent each such outlier in the model. The coefficient of this indicator variable indicated how much the dependent variable deviated from its expected value for the particular outlier. The statistical significance of these indicator variables were used to identify outliers that were statistically significant.

Sites that refused to participate in the study were replaced using a randomly drawn sample of backup sites. The level of refusal was rather low, as discussed earlier in this report.

Weather adjustment was handled in the engineering modeling. The model calibration used actual weather concurrent with the available billing data. Then all models were run using typical meteorological weather data. In this way the gross savings determined by the engineering models reflected normal weather conditions expected in each climate zone.

2. Control for background variables

The experimental design provided two types of control: (a) engineering models which provided 'same-building' comparisons, and (b) the net-to-gross analysis which compared the results of the engineering models for the participant and non-participant subsamples. The engineering models provided the first 'line of defense' against biased findings. The engineering models were used to compare the 'as-built' building to the 'baseline' building. Here the baseline referred to a building that just complied with Title 24 code. The engineering models were normalized for weather. The occupancy schedules were based on the onsite information describing the normal occupancy of the building on a daily and monthly basis.

This led to our estimates of weather-normalized gross savings. The net-to-gross analysis, in turn, compared the gross savings found from the engineering models for the participant and non-participant subsamples. The net to gross analysis used econometric techniques to estimate the naturally occurring level of efficiency that would have been built in the absence of the program. The econometric analysis included additional explanatory variables to control for self-selection bias and other differences between participants and non-participants.

All of these procedures were designed to get a reliable, unbiased estimate of the net impact of the programs. In particular, the experimental approach was designed to control for the effect of changes in economic or political activity. Increased operating hours would increase the gross savings for both the participants and non-participants but be controlled for in the net savings.

3. Screening procedures

The tables below summarize the screening procedures used to arrive at the final analysis datasets. In the case of the onsite audits, 292 buildings were recruited for the audit. Two sites were listed as two sites each in the original dataset. The four sites were combined into 2 sites, resulting in a total of 290 sites. See the report section on the gross impact findings.

OnSite Audits		
Recruited	293	buildings
Audited	293	buildings
Final Data	290	buildings
Models	283	buildings
Used	283	buildings

Decision Maker Surveys		
Recruited	290	buildings
Completed	277	buildings
Used	277	buildings

The above table also shows the disposition of the Decision-Maker surveys. The objective of the Decision-Maker survey was to interview one or more key decision-makers for each building. Six of the surveys were dropped from the analysis because of missing survey data or because the building was dropped from the gross analysis. This left 277 buildings in the final net-to-gross analysis. See the report section on the net impact findings.

4. Regression statistics

The following table shows the participation decision model.

Explanatory Variable	B	S.E.	Sig.
Renovation Project	-1.67	0.43	0.00
Built by Owner for Own Business	0.83	0.37	0.03
Lowest First Cost	-1.52	0.47	0.00
Financial Criteria Missing	-2.04	0.52	0.00
Awareness of PG&E Program	0.47	0.08	0.00
Input in Design Process	-0.21	0.10	0.03
Interaction with PG&E on Current Project	0.37	0.09	0.00
Constant	-1.00	0.71	0.16

The following table shows the annual energy efficiency choice model.

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.116	.030		3.881	.000
	Participant	.011	.027	.030	.412	.681
	Level of PG&E's influence on this project	.008	.004	.101	2.125	.035
	Level of Input in Design Process	.013	.004	.136	3.075	.002
	Sig. of Energy Costs on Design Decisions	-.009	.005	-.087	-1.963	.051
	C & I Storage	-.022	.033	-.041	-.652	.515
	Participant C & I Storage	.174	.049	.228	3.543	.000
	Office	.015	.022	.039	.658	.511
	Participant Office	.047	.031	.107	1.536	.126
	Addition	.122	.037	.140	3.291	.001
	Lowest First Cost	.030	.015	.079	1.962	.051
	MILLS	.001	.012	.003	.057	.955
	Outlier Site 201	.603	.122	.197	4.954	.000
	Outlier Site 1071	.717	.121	.234	5.939	.000
	Outlier Site 1555	-.674	.118	-.220	-5.729	.000
	Outlier Site 3789	-1.174	.126	-.384	-9.283	.000
	Outlier Site 225	.503	.118	.165	4.279	.000
	Outlier Site 241	.579	.122	.189	4.735	.000
	Outlier Site 670	-.526	.117	-.172	-4.477	.000
	Outlier Site 230	.483	.122	.158	3.964	.000
	Outlier Site 1218	-.426	.126	-.139	-3.377	.001
	Outlier Site 1239	.437	.120	.143	3.628	.000
	Outlier Site 3827	.425	.120	.139	3.545	.000
	Outlier Site 317	-.389	.118	-.127	-3.303	.001
	Outlier Site 2601	-.348	.121	-.114	-2.883	.004

a. Dependent Variable: KWH

5. Specification of Models

The "Engineering Models" section of the report describes the DOE-2 engineering models used to estimate the gross savings. The "Commercial-Net Savings" section of the report describes the econometric models that were used in the net to gross analysis.

Heterogeneity:	The DOE-2 engineering models were designed to represent the heterogeneity of sites in the program. The models were designed to represent all building types, functional zones and equipment types encountered in the sample sites. The econometric models were designed to explain the variation in efficiency choice from one site to another.
Time series variation:	In the gross analysis, time series variation was controlled by the simulation methodology. The gross savings were calculated by simulating the building with and without the energy efficiency measures but holding other equipment and schedules fixed as observed. Time-series variation was not an issue in the net-to-gross regression analysis since all observations reflected the same time period. In other words, the regression modeling addressed variation from one same site to another, but not from one time point to another.
Self selection:	Self selection was addressed in the net-to-gross analysis by developing a logistics model for the probability of participating, and then using the resulting double inverse Mills ratios as added explanatory variables in the efficiency choice models. The statistical significance and effect of the inverse Mills ratios were estimated and reported.
Omitted factors:	Two factors might be discussed: the use of Title 24 documentation and billing data. The study sought to use both Title 24 documentation and billing data to the extent practical. When either Title 24 documentation or billing data was available, it was used to improve the accuracy of the engineering models. This approach allowed us to maintain the full sample even when these data were unavailable. The evaluation of the 1994 program clearly demonstrated the difficulty of obtaining Title 24 documentation, especially for the non-participants. In order to avoid high refusal rates and the concomitant risk of nonresponse bias, we only insisted on Title 24 documentation for sites that used the tailored lighting approach or the performance-based approach to Title 24 compliance. Billing data was used to calibrate each individual engineering model whenever possible. However, as described elsewhere, the available billing data did not always reflect the space affected by the new construction. In some of these cases, we sought to supplement the billing data with our own metering. Nevertheless, some of the sites did not have actual usage data. In such cases we trusted that the engineering models were accurate without calibration. To confirm this assumption, we compared the gross savings determined before and after calibration for the sites with billing data or our metering. This analysis confirmed that the pre-calibration models were very accurate.
Net impacts	The combination of statistical sampling, onsite surveys, site-specific engineering models, econometric analysis, and statistical expansion was carefully designed to provide an unbiased and statistically reliable estimate of net program savings. In particular, the decision-maker survey was designed to isolate self-selection bias and the long-run impact of the program on design practice. The model was specified to include any

observable and statistically significant effects of the program on the energy efficiency of both participants and non-participants.

6. Errors in measuring variables

In the onsite surveys and engineering modeling we sought to obtain an accurate representation of each individual sample site. Past experience suggested that serious errors could arise from failing to model the space in the building actually affected by the new construction, or by failing to accurately describe some of the equipment and schedules of use. The present study addressed these problems by improved training and communication with the auditors, earlier retrieval and review of program files, having the auditors themselves responsible for the data entry and modeling, and having the auditors develop the model for a site soon after completing its survey. The engineering team met with PG&E's program managers and reviewed the site-specific models in detail. We also redesigned the decision-maker survey, streamlined the process used to recruit each site and complete the decision maker survey, and assigned the responsibility for the whole process to a single, very competent person. All of these measures resulted in much more accurate data going into the econometric analysis than in the prior study.

7. Autocorrelation

Does Not Apply. All regression analysis was cross-sectional.

8. Heteroscedasticity

Heteroscedasticity – the tendency of larger projects to have greater variation – was addressed in both the sample design and efficiency-choice regression models.

The MBSS methodology used in the sample design addressed heteroscedasticity by modeling the variation in savings as a function of the tracking estimate of savings or the square footage of each site and then using an efficiently stratified sampling plan to increase the probability of selecting large sites. This ensures that the sample is effectively focused where the savings are greatest, while retaining an unbiased representation of small and large projects alike.

The efficiency-choice regression models were specified to minimize the danger of heteroscedastisity by defining the dependent variable as the gross savings as a fraction of the baseline energy use. This specification is closely related to the weighted-least-square methodology resulting from the assumption that the residual variation in gross savings is proportional to the baseline energy use of each site. Graphical scatter plots of the studentized residuals were examined to confirm the absence of Heteroscedasticity. In addition, a statistical test of homogeneity of variance was carried out to measure the statistical significance of differences in the variance of the residuals grouped by building type and by the level of efficiency predicted by the model..

9. Collinearity

Multicollinearity is generally a less serious problem in a cross sectional analysis than in a time series analysis. Our methodology was designed to protect against the type of problem that might arise in a cross sectional analysis. Extreme multicollinearity can cause computational problems. Several of the indicator variables used in the regression models were perfectly collinear. This occurred, for example, if a respondent who failed to answer a given question also failed to answer a second question. In this case the missing-response indicators would be perfectly collinear. The SPSS software used in the analysis identifies and reports these instances and automatically drops one of the variables from the analysis. The software also provides a warning if the multicollinearity is strong enough to affect the numerical accuracy of the estimated coefficients. In practice there was no indication of a serious problem with numerical accuracy.

When explanatory variables have strong but not extreme multicollinearity, it is important to guard against obtaining biased results. Omitted-variable bias can arise if one of the correlated variables is dropped from the model. We guarded against this possibility by systematically comparing the estimated coefficients of our various models and looking for other indicators such as large shifts in statistical significance.

10. Influential data points

We followed diagnostic procedures recommended by Belsley, Kuh and Welsh.[1] Our key indicator of an influential observation was the studentized residual, which can be related to the t-distribution. We also examined normal probability plots, partial-regression leverage plots for each explanatory variable, and other case-specific measures of influence. When an influential observation was identified, we included an indicator variable in the analysis that was 1 for the influential observation and 0 for all other cases in the sample. We retained this variable if it was statistically significant in the final model.

11. Missing data

See answer D.1. above.

12. Precision

In each regression model, we used standard logistics or least-squares techniques to calculate the standard error and statistical precision of each coefficient. We used the standard MBSS statistical techniques described in the Gross Savings chapter to expand to the econometric estimates for each sample site to the population and to measure the statistical precision of the results.

E. DATA INTERPRETATION AND APPLICATION

1. Method of net to gross analysis

The net impact was calculated as the participant gross impact less the naturally occurring impact predicted by the econometric model. The econometric model in turn was estimated by comparing the efficiency choice of the participants to the control group. Thus the approach was essentially equivalent to comparing the participants to the control group and adjusting for any uncontrolled differences between the two groups. We also estimated spillover impacts, which are discussed in the "Net Impact Findings" section of the report.

2. Process and rational used in net to gross analysis

The econometric analysis was designed to isolate the naturally occurring efficiency choice by comparing the efficiency choice found in the participant and non-participant samples, and adjusting the results for uncontrolled differences between the participants and non-participants, as well as for self-selection.

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[1] D. A. Belsley, E. Kuh and R. E. Welsch, *Regression Diagnostics*, Wiley, 1980.

CADMAC PROTOCOLS TABLE 11

LOAD IMPACT RESULTS FOR USE IN PLANNING AND FORECASTING

For Non-Residential New Construction Incentives Program

First Year Load Impact Evaluation – Whole Building Savings

Pacific Gas & Electric

PG&E Study No. 400

1.	**Base Energy Usage:** The primary purpose of both the engineering and statistical models was to produce estimates of energy savings in kWh and kW due to the non-residential new construction programs. Base energy usage was arbitrarily defined by the researchers for purposes of this study. Therefore, no estimates of base energy use are provided for forecasting.
2.	**Determination of Net Program Impacts:** The applicability of net-to-gross estimates derived in this study to forecasts of future program impacts depends on several factors, including: 1) the differences in characteristics between the general population and the study sample; 2) the generalizability of the net-to-gross statistical models; 3) market changes that affect net-to-gross ratio determinants. Net-to-gross estimates were developed at the whole building level and reported in Tables 6 & 7. The estimates were produced using weights that were specific to the population of 1998 non-residential new construction. To the extent that any of the characteristics of the new construction population changes from year to year or the new construction population differs from the general building population, the results are not transferable. Changes in program design and general construction practice can influence the types of customers who participate and the types of technologies that are covered by the programs. The estimates were developed for a population with a given program structure and state of building practice. To the extent that either of these things change, the results are not transferable. Long-term market changes were beyond the scope of this study. Due to the probable changes in market conditions over time, specific net impact results developed for the 1998 Non-residential new Construction programs are not transferable for use in long-term forecasting.
3.	**Load Impacts:** Gross kWh per ft2 per year is 6.36 kWh; gross kW per ft2 is 0.000975. The study found an energy net-to-gross ratio of 0.414 and a summer peak demand net-to-gross ratio of 0.367. The load impacts were calculated from a mix of prescriptive and custom incentive packages. These savings estimates cannot be applied to other program forecasts where the mix of custom and prescriptive incentive packages is different from the 1998 Non-Residential New Construction sample or where the prescriptive requirements are different from the 1998 program.

EXHIBIT 1

kW and kWh Savings by Costing Period

Costing Period	Avg. kW Savings (1)	Avg. kW Savings Coincident with system Maximum in Period (2)	kW Adjustment Factor (3)	kWh Savings (4)	kWh Adjustment Factor (5)	Annual kWh Savings (6)	Average Load kW
Summer On Peak : May 1 to Oct. 31 Noon-6 p.m. Weekdays	16,525.22	20,785	1.00	12,988,822	0.10	12,988,822	56,857
Summer Part. Peak: May 1 to Oct. 31 8:30 a.m. - Noon & 6-9:30 p.m. Weekdays	16,212.96	14,492	0.70	14,656,513	0.11	14,656,513	41,306
Summer Off Peak: May 1 to Oct. 31 9:30 p.m. - 8:30 a.m. Weekdays & All Saturday/Sunday	8530.860602	15,788	0.76	23,255,126	0.17	23,255,126	43,932
Winter Part. Peak: Nov. 1 to Apr. 30 8:30 a.m. - 9:30 p.m. Weekdays	23,983.89	19,614	0.94	41,995,794	0.31	41,995,794	54,961
Winter Off Peak: Nov. 1 to Apr. 30 9:30 p.m. - 8:30 a.m. Weekdays & All Saturday/Sunday	16,446.18	14,032	0.68	42,644,951	0.31	42,644,951	39,149

PACIFIC GAS AND ELECTRIC COMPANY
RETROACTIVE WAIVER FOR
PRE-98 NONRESIDENTIAL NEW CONSTRUCTION PROGRAM CARRYOVER
(STUDY ID# 400)

DATE SUBMITTED: 10/19/99

Summary of PG&E Request

This waiver requests deviations from the Protocols by Pacific Gas & Electric Co. (PG&E) for its Pre-98 Nonresidential New Construction Impact Study. This Study will cover participants who made commitments (i.e., submitted applications) in program years 1994, 1995, 1996, and 1997 and were paid rebates in 1998. PG&E seeks approval to:

1. Achieve requisite precision and confidence levels with a reduced sample size
2. Permit the use of short-term whole premise metering in addition to or instead of billing data for calibration of building simulation models (DOE-2) and eliminate the requirement for a minimum of 9 months of billing data

In the remainder of this waiver, items (1) and (2) above are referenced by their item number.

PROGRAM SUMMARY Nonresidential New Construction Program

Number of Participants (coupons)	245
Administrative Costs	$1,328,616
Incentive Costs	$9,187,215
Total Program Costs	$14,132,550
Net Resource Benefits	$48,939,802
Earnings	$10,349,044

Proposed Waiver

PG&E seeks CADMAC approval to: (see Table A for summary)

(1) Achieve requisite precision and confidence levels with a reduced sample size

Parameter

Table C-8, Item #1 Sample design, which refers to Table 5, Section C Sample Design for First Load Impact Year, which specifies minimum sample sizes for nonresidential impact evaluations. (Similar requirements for Participant and Comparison Groups)

Protocol Requirement

The Protocols specify that if there are less than 350 program participants, sample size will attempt a census. If there are more than 350 program participants, sample size for participants will be sufficiently large to achieve a minimum precision of plus/minus 10% at 90% confidence level, based on total annual energy use. In any case, samples must have at least 150.

Waiver Alternative

For Nonresidential New Construction programs which use site-specific survey information and individual DOE-2 models of buildings in the sample, allow sample sizes to be smaller, provided samples are designed to target a minimum precision of plus/minus 10% at the 90% confidence level, based on annual gross energy savings.

Rationale

The approach of collecting detailed, site-specific survey information and developing individual DOE-2 models of the sampled buildings provides highly detailed engineering data on the performance of the whole building and its efficiency measures. The approach also has high costs per site, but this is felt to be justified because of the high quality of information it provides about building performance. The required numbers of buildings in the Protocols is arbitrary for this approach. If the sample size is sufficiently large to achieve the required precision, then it should be allowable to use a smaller number of buildings.

The draft sample design for this project indicates that PG&E can achieve plus/minus 3% precision at a 90% confidence level on annual gross energy savings with a participant sample size of 150 cases. PG&E proposes to use a nonparticipant sample size of 150 cases and feels that similar precision/confidence levels can be achieved. Given that annual energy savings is the variable of interest in the evaluation, and given that the prior study provided information about the variation in annual energy savings, it is more appropriate that energy *savings* rather than energy *consumption* be used as the basis of precision/confidence levels in determining sample size.

In the 1996 Nonresidential New Construction Impact Evaluation, PG&E had 405 program participants. The sample was stratified into six strata, five sampling strata and one certainty strata. The certainty strata inlcuded the 13 largest sites in the population. The sampling plan was stratified such that the majority of the program savings were captured. The sample design achieved 90/10 precision with 138 participant buildings.

In the 1994 Nonresidential New Construction Impact Evaluation, PG&E had 484 program participants. The sample was stratified into eleven building types (including refrigerated warehouses) with from two to five size strata per building type. The sample design achieved 90/10 precision with 109 participant buildings. A comparable, somewhat larger non-participant sample of 124 buildings was drawn. In both evaluations, the sampling methodology was statistically rigorous, and provided a reasonable balance between sample size, study cost and precision. Based on this experience, PG&E feels that reduced sample sizes are justified.

(2) Combine the use of short-term whole premise metering with billing data for calibration of building simulation models (DOE-2)

Parameter

Table C-8, Item #3 The End Use Consumption and Load Impact Model, option (b). Also, Table C-8, Item #2 Billing data requirements, which refers to Table 5, Section D Billing Data Protocols, which specifies minimum months of billing data. (Similar requirements for Participant and Comparison Groups)

Protocol Requirement

Under option (b), when a Building Simulation Model is used, billing data is used as the primary determinant of usage.

Waiver Alternative

Under option (b), when site-specific survey information and a Building Simulation Model (DOE-2) is used for each building in the sample, PG&E is requesting to use billing data for calibration when the metered area corresponds well to the area affected by the program measure(s). When billing data are not available or there is not a good correspondence between the two areas, PG&E proposes to use short-term (2 to 4 weeks) whole premise metering to develop representative operating schedules for the affected areas.

Rationale

For Nonresidential New Construction Impact Evaluations using detailed DOE-2 models to determine whole building energy use and measure savings (option (b)), billing data are used to check the accuracy of the models through a calibration process. The billing data are not used in the traditional sense of a billing analysis.

Experience has shown that the usefulness of billing data for calibration purposes is often limited because:

- The building area served by the billing meter and the participant area of the building often do not coincide.
- Billing data are often difficult to match to customer sites, even with meter numbers from the site.
- There are typically other energy uses in the building, such as escalators or outdoor lighting, which have little impact on energy savings but which show up on the billing meter.
- Occupancy of the building may vary substantially from month to month during the initial years of its life, leading to erratic billing meter readings.

In the 1994 Nonresidential New Construction Program Impact Evaluation, heroic efforts were made to obtain billing data for surveyed sites. Even so, billing data could not be located for 28% of the surveyed sites, and another 21% of the sites did not have billing data that matched the surveyed building areas. Of the billing data that was gathered, 5% of the sites had so many missing records as to render the data useless for calibration purposes. Another 12% of the building models simply would not calibrate to the billing data due to unknowns about either the building or the constituents of the billing data. This left 34% of the building models which were successfully calibrated to within ±10% on a monthly basis.

In the 1996 Nonresidential New Construction Program Impact Evaluation, model calibration was attempted for all sites. In many cases, billing data or short term metering data were unavailable. The modelers were ultimately able to successfully calibrate 58% of the building models to within ±10% on a monthly basis (54% with billing data and 4% with short term metering data). Billing data could not be located for 20% of the surveyed sites. Another 22% of the building models simply would not calibrate to the billing data due to unknowns about either the building or the constituents of the billing data. For the 1996 study model calibration effects were investigated. To understand the effect of calibrating the models, the models that were successfully calibrated were projected to the population and compared. That is, only the models that were ultimately calibrated were used in the test. Overall, model calibration had the effect of changing the measured savings by 2.8%.

Because of the calibration problems encountered in the previous Nonresidential New Construction Program Impact Evaluations, PG&E is proposing to use continue the practice of using billing data for calibration only when billing data are available for the customer site and when there is a strong correspondence between the metered area and the area affected by the program. When there is poor correspondence between the two areas, PG&E proposes to substitute short-term whole-premise metering. Even though this short-term metering will not provide a complete annual cycle of building operation, it will provide highly accurate data about building operating schedules. These operating data will provide a far better basis for DOE-2 calibration than ill-matched billing data.

It should be noted that even when buildings have adequate billing data, the model calibration process remains an exercise in judgment. Matching the model outputs to the billing data gives some greater confidence that the engineering savings calculations are accurate, but it is impossible to know the degree to which the savings estimates are more accurate than before the calibration.

In the 1994 Nonresidential New Construction Program Impact Evaluation, a set of 103 calibrated DOE-2 model savings estimates were compared to their pre-calibrated savings estimates. There was a very strong correlation between the pre- and post-calibration savings estimates, and an average of 2% difference between the estimates (the calibrated model savings were slightly smaller). These results indicate that the effect of calibration was small relative to the statistical precision of the final results

Table A

Summary of Retroactive Waiver for Study 400

Impact Measurement Requirements - Table C-8 and Table 5

Parameters	**Protocol Requirements**	**Waiver Alternative**	**Rationale**
Sample Size	For less than 350 program participants, protocols require a census. Table C-8, Item 1; Table 5 - Section C	Allow smaller sample size which will achieve +/- 10% precision at 90% confidence based on annual energy savings for participants.	Smaller sample size provides +/- 10% precision at 90% confidence based on annual energy savings. Therefore a larger sample is an inappropriate use of resources.
Billing Data	Billing data are used as the primary determinant of usage; a minimum of 9 months of billing data are required. Table C-8, Items 2-3; Table 5 - Section D	Use available billing data for calibration when the metered area corresponds well to the area affected by the program. Otherwise use short-term whole premise metering for the program area.	Previous studies have shown billing data to have limited applicability. Billing data provides another option for DOE-2 calibration.

PACIFIC GAS AND ELECTRIC COMPANY RETROACTIVE WAIVER FOR PRE-98 NONRESIDENTIAL NEW CONSTRUCTION PROGRAM (STUDY ID# 400)

Date Submitted: 12/15/99

Summary of PG&E Request

This waiver requests deviations from the Protocols by Pacific Gas & Electric Co. (PG&E) for its Pre-98 Nonresidential New Construction Impact Study. PG&E seeks approval to:

3. Analyze the gross savings for the new construction industrial projects using a methodology that is consistent with the industrial retrofit methodology using measure-specific analysis instead of whole-building analysis.
4. Analyze the net savings for the new construction industrial projects using a methodology that is consistent with the industrial retrofit methodology using a self-reported net-to-gross analysis instead of a nonparticipant sample.

In the remainder of this waiver, items (1) and (2) above are referenced by their item number.

1. PROGRAM SUMMARY Commercial and Industrial (C&I) New Construction Program

Number of Participants (coupons)	246
Administrative Costs	$1,328,616
Incentive Costs	$9,187,215
Total Program Costs	$14,132,550
Net Resource Benefits	$48,939,802
Earnings	$10,349,044

PROGRAM POPULATION C&I New Construction Program by Program Type

Program Description	Number	Gross kWh	Gross kW
PRESCRIPTIVE PLUS PERF	135	38,956,755	11,715
PERFORMANCE BY DESIGN	55	23,905,198	8,645
REFRIGERATED WAREHOUSE	11	13,079,913	2,291
INDUSTRIAL NEW CONSTR	7	14,261,279	2,160
PRESCRIPTIVE EXPRESS	27	779,994	321
PRESCRIPTIVE PLUS	1	674,375	89
THERMAL ENERGY STORAGE	10	33,535	2,902
Total	246	91,691,048	28,123

Note: Savings estimates derived from program tracking database

Proposed Waiver

PG&E seeks CADMAC approval to: (see Table A for summary)

(1) Analyze the gross savings for the new construction industrial projects using measure-specific analysis.

2. Parameter

Table C-8, Item #3 The End Use Consumption and Load Impact Model, option (b).

3. *Protocol Requirement*

The Protocols specify that whole building energy simulation models be created for each program participant and whole building energy consumption be calculated.

4. Waiver Alternative

For the industrial new construction program participants we propose measure specific analysis consistent with the established industrial approach.

Rationale

There are seven projects within the new construction program participant population which are industrial in nature. They were assigned to the C&I new construction program because the process equipment (and any associated building shell) is new construction, not retrofit. Because they are industrial projects, they do not lend themselves to the normal evaluation approach for nonresidential new construction as described in the Protocols.

The whole building approach for new non-residential buildings addresses the whole-building integrated design and energy interactions. The whole building approach is practical because Title 24 provides a baseline for most of the characteristics and because building modeling software and DOE-2 can be used for all the analysis. This doesn't work for an industrial site, because the primary measure is an industrial process rather than a building element. The process equipment interactions with other building elements are uniquely determined by the nature of the process, which may be very different from normal building loads. It is difficult to establish a “normal” baseline energy performance for an industrial process because each is unique. Moreover it would be impractical to take the whole building approach since it would be necessary to establish a 'baseline' for ALL of the industrial processes at the site, not just those affected by the program.

The protocols for industrial evaluations, which are very different than those for new construction, specify the measure specific approach, in which only the specific measures affected by the program are analyzed. Our proposed approach, for those industrial processes within the new construction program, is consistent with the existing industrial protocols.

(2) Analyze the net savings for the new construction industrial projects using self-reported net-to-gross analysis.

5. Parameter

Table C-8, *COMPARISON GROUP* Item #1, Sample design and billing data requirements, which refers to Table 5, Comparison Groups. (Also Table 5, Section C, Item #2, *Estimation of Net Energy Impacts.*)

6. Protocol Requirement

The Protocols require that a comparison group, composed of similar nonparticipant new buildings be used to analyze net savings.

7. Waiver Alternative

Consistent with the Protocols for industrial evaluations, we propose to use a “self reported” net to gross analysis instead of a nonparticipant analysis.

8. Rationale

It would be impractical and inaccurate to try to find a comparable industrial non-participant site to each participant site for comparison purposes, because the unique differences between the processes would overwhelm any similarities, and so would make the comparison largely useless. Because industrial sites are unique, it is necessary to use a measure specific analysis for each individual participant to assess what would have happened in the absence of the program. This problem has been addressed already in the development of the industrial evaluation protocols, and the approach we propose follows the same methods.

As specified in Table 7 of the Protocols, we will refer to Section 4 of Appendix J, Quality Assurance Guidelines for Estimating Net To Gross Ratios Using Participant Self-Reports, for methodological issues to be addressed.

Table A

Summary of Retroactive Waiver for Study 400

Impact Measurement Requirements - Table C-8 and Table 5

Parameters	Protocol Requirements	Waiver Alternative	Rationale
Whole Building Analysis	Table C-8, Item #3 The End Use Consumption and Load Impact Model, option (b).	For the industrial new construction program participants, use measure specific analysis consistent with the established industrial approach.	Integrated whole-building analysis does not work well for industrial sites since there are generally not the same kind of interactions between measures. It is impractical to take the whole building approach since it would be necessary to establish a 'baseline' for ALL of the industrial processes at the site.
Use of nonparticipant comparison group.	Table C-8, *COMPARISON GROUP* Item #1, Sample design and billing data requirements, which refers to Table 5, Comparison Groups. (Also Table 5, Section C Item #2, *Estimation of Net Energy Impacts*.)	Use a "self reported" net to gross analysis instead of a nonparticipant analysis, for the industrial sites.	Because industrial sites are unique, it is necessary to use a measure specific analysis for each individual participant to assess what would have happened in the absence of the program. This is consistent with the industrial evaluation protocols.

1998 PG&E NRNC RECRUITMENT & DECISION-MAKER SURVEY

Site ID : ____________ Name: ____

Address ____ Participant / Nonparticipant

- Call contact (owner or site manager first) and identify yourself.
- Describe the survey project. Use this as a guide.

> "We are an independent research organization hired by Pacific Gas & Electric Company to evaluate their Commercial new Construction programs. This study is mandated by the California Public Utilities Commission. Neither I nor anyone else connected with this study will attempt to sell you anything, and your name and responses will not be used for any purpose other than this study."

- Secure cooperation.
- Qualify the respondent. Make sure that the person answering the questions had direct involvement in equipment decisions in lighting, HVAC, and mechanical systems. Specifically mention systems when you qualify.

Q1. Are you the owner or the owner's representative of the building at {address}?

- ☐ Yes
- ☐ No **(Get contact info)** **Name:**______________________________
- ☐ Don't Know **(Get contact info)** **Phone:**______________________________
- ☐ Refused **(Thank and terminate)**

Q2. Does this building get its electricity from PG&E?

- ☐ Yes
- ☐ No **(Thank and Terminate)**
- ☐ Don't Know **(Get contact info)** **Name:**______________________________
- ☐ Refused **(Thank and Terminate)** **Phone:**______________________________

Q3. Was there a major construction project (new building, expansion, or renovation) at this address that was completed during 1997 or 1998?

- ☐ Yes
- ☐ No **(Thank and Terminate)**
- ☐ Don't Know **(Get contact info)** **Name:**______________________________
- ☐ Refused **(Thank and Terminate)** **Phone:**______________________________

Q4. According to our records that construction project received an energy-efficiency rebate from PG&E. Do you remember receiving the rebate?

- ☐ Yes
- ☐ No
- ☐ Don't Know **(Get contact info)** **Name:**______________________________
- ☐ Refused **(Thank and Terminate)** **Phone:**______________________________

- If either (a) nonparticipant and answered yes to Q1, Q2, and Q3, or (b) participant and answered yes to Q1, Q2, Q3 and Q4, then attempt to schedule the on-site. Otherwise thank and terminate.

- ☐ Scheduled **Date/Time:**__________________________
- ☐ Not Authorized/talk to someone else **Name:** ______________________________
- ☐ Refused (Thank and terminate) **Phone:** ______________________________

- Secure cooperation for DM questions

- ☐ Call back **Date/Time:** __________________________
- ☐ Call someone else **Name:** ______________________________

Phone: ______________________________

Decision Maker Questions:

Q5. How would you describe the project at {address}?

- ☐ 1. A new building
- ☐ 2. First tenant improvement in an existing shell building
- ☐ 3. Renovation of an existing building
- ☐ 4. Addition to an existing building
- ☐ 5. Renovation and addition
- ☐ 98. Don't know (Get contact info) **Name:**______________________________
- ☐ 99. Refused (Get contact info) **Phone:**______________________________

Q6. Which of the following best describes the ownership of the building?

- ☐ 1. Privately owned by the principal occupant
- ☐ 2. Privately owned by a developer or property manager and rented to tenant
- ☐ 3. Owned by corporate owner and used by franchisee or subsidiary
- ☐ 4. Owned by the federal government
- ☐ 5. Owned by state or local government
- ☐ 6. Other: ________________________________
- ☐ 98. Don't know (Get contact info) **Name:**______________________________
- ☐ 99. Refused (Get contact info) **Phone:**______________________________

Q7. Which of the following best describes the circumstances under which this work was done?

- ☐ 1. Built by the owner for his/her own business
- ☐ 2. Built by the owner for a specific tenant
- ☐ 3. Built on speculation
- ☐ 4. Built for a franchisee or subsidiary by a parent company
- ☐ 5. Other_________________________
- ☐ 98. Don't know (Get contact info) **Name:**________________________________
- ☐ 99. Refused (Get contact info) **Phone:**_______________________________

Q8. Was this building built using a pre-existing design?

- ☐ Yes
- ☐ No
- ☐ Don't know (Get contact info) **Name:**________________________________
- ☐ Refused (Get contact info) **Phone:**________________________

Q9.Which of the following best describes the financial criteria used for decision making on this project? (choose one)

- ☐ 1. Lowest first cost
- ☐ 2. Lowest operating cost
- ☐ 3. Payback within a specified time period
- ☐ 4. Positive net present value
- ☐ 5. Other_________________________________
- ☐ 98. Don't know (Get contact info) **Name:**________________________________
- ☐ 99. Refused (Get contact info) **Phone:**_______________________________

Q10. Please rate your awareness of PG&E's commercial new construction rebate program before starting this project. Please use a scale of 1 to 7, where 1 is completely unaware and 7 is completely aware.

Score: __________

- ☐ Don't know (Get contact info) **Name:**________________________________
- ☐ Refused (Get contact info) **Phone:**_______________________________

Thinking about the energy efficiency of this project, please rate the significance of each of the following factors using a 7-point scale, where 1 is not at all significant and 7 is very significant.

Q11. Your input in the design process regarding decisions about energy efficiency **(to be asked of owner or owner's rep only)**

Score: __________

- ☐ Don't know **(Get contact info)** **Name:**________________________________
- ☐ Refused **(Get contact info)** **Phone:**_______________________________

Q12. The significance of energy costs on the design decisions.

Score: __________

- ☐ Don't know (Get contact info) **Name:**________________________________
- ☐ Refused **(Get contact info)** **Phone:**_______________________________

Q13. The significance of energy efficiency on the design decisions.

Score: __________

☐ Don't know **(Get contact info)** **Name:**______________________________

☐ Refused **(Get contact info)** **Phone:**______________________________

Q14. Your interaction with PG&E about the energy efficiency of this project

Score: ____________

☐ Don't know (Get contact info) **Name:**______________________________

☐ Refused (Get contact info) **Phone:**______________________________

Q15. Did PG&E influence your decisions regarding design and equipment choices for this project?

☐ Yes

☐ No

☐ Don't Know (Get contact info) **Name:**______________________________

☐ Refused (Get contact info) **Phone:**______________________________

Q16. **(If yes to Q16)** On the scale of 1 to 7 where 1 is not at all significant and 7 is very significant, how strongly would you rate the influence of PG&E on your decisions regarding design and equipment choices for this project?

Score:_____________

☐ Don't know (Get contact info) **Name:**______________________________

☐ Refused (Get contact info) **Phone:**______________________________

Q17. Could you tell me about the factors that were considered when deciding which equipment to install in this building. (open-end)

Q18. **(Participants only)** Would you have turned to PG&E for assistance regarding design and equipment choices if there had been no rebate money available?

☐ Yes

☐ No

☐ Don't Know

☐ Refused

Q19. **(Participants Only)** Would you have installed all, some, or none of the energy efficiency measures recommended by PG&E if there had been no rebate money available?

- ☐ 3. All
- ☐ 2. Some
- ☐ 1. None
- ☐ 98. Don't Know
- ☐ 99. Refused

- Thank and terminate.

INDUSTRIAL INTERVIEW QUESTIONS

Site ID: ________________________ Name: ____

Address: ____ City___________________

Contact Person:________________________________ Phone: ________________________________

From File:

PG&E Payback with Incentive: ______years.

PG&E Payback without incentive: ______years.

Rebated Measure: ____*(One questionnaire per rebated measure)*

Brief Measure Description:
____

Q1. What would you have installed in absence of the PG&E C/I New Construction Program?

1. ☐ Same As Installed
2. ☐ Standard Efficiency
3. ☐ DK

Notes:____
____
____
____

Q2. How long of a payback period did you expect from the installed measure?

1. ______ years
2. ☐ DK

Notes:____
____
____
____

<<If customer would have installed less efficient equipment in Q1, but the payback on the installed equipment is less than a year in Q2, GOTO Q3, else GOTO Q4>>

Q3. Why would you not have installed the energy efficient equipment for the measures with under a one-year payback?

1. ☐ Initial First Cost
2. ☐ Unaware of Technologies
3. ☐ Corporate Policy
4. ☐ DK
5. ☐ Other

Open:____
____
____
____

Q4. Did PG&E influence your decisions regarding design and equipment choices for this project?

1. ☐ Yes 2. ☐ No 3. ☐ DK

Notes:____
____
____
____

ON-SITE SURVEY

General Information

Site ID # | |

Surveyor Name:	Building Name:

Date:	Primary Contact:	Phone:

Building Address: City Zip

Start Time:	Finish Time:	

Circle any incidents as applicable:

1 None to report
2 Complaint about rates
3 Complaint about energy costs or lack of savings
4 Complaint about outages or power quality
5 Complaint about technology reliability
6 Complaint about PG&E customer service
7 Contact person unavailable or unaware of survey appointment
8 Customer expressed dissatisfaction with survey (list reason(s))
9 Property damage occurred during on-site survey
10 Personal injury occurred during on-site survey
11 Other (list)

Interview Questions

The following interview questions will be used to help us identify unobservable aspects of your building. These aspects include occupancy history, schedules, and heating and cooling controls. Answers to these questions will be coupled with data collected from our walk-through audit to produce a computer model which simulates the annual energy use of the building.

Building Overview

Q1. What is the overall building floor area? ____________SF

Q2. What is the floor area of the applicable new construction?

❏ same as overall building floor area

❏ ____________SF

Q3. Have there been any significant changes in building use, occupancy patterns, operating hours, or additions/removal of large electrical loads that may affect energy consumption since the applicable new construction was completed?

List changes:

Q4. How many individual tenants (businesses) occupy this building? _________________

Q5. Do the majority of tenants have their own electric meter? Y N

The remainder of this survey deals with the applicable new construction (treated space for participants, 1996 new construction that would have been eligible for the program for non-participants)

Q6. How many floors? ___________

Q7. What was the method used for Title 24 compliance?

Envelope (ENV):	Component ❑	Overall envelope ❑	Performance ❑	
Mechanical (MECH):	Prescriptive ❑	Performance ❑		
Lighting (LTG):	Complete building ❑	Area category ❑	Tailored ❑	Performance ❑

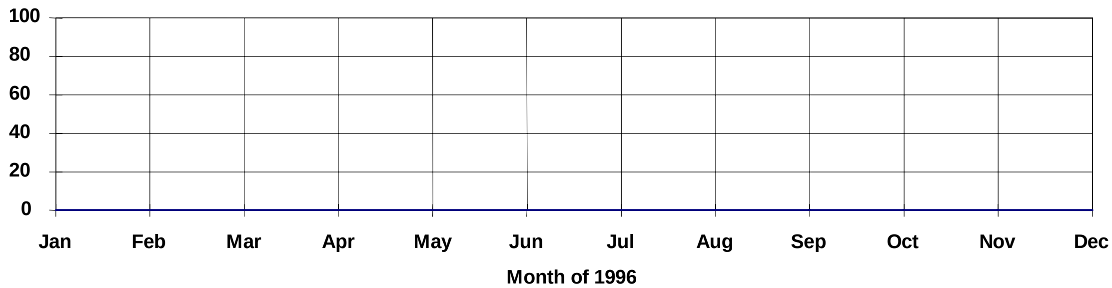
- If new construction complied using the ***performance method***, copy the compliance report or obtain the name and phone number of the firm that did the analysis.

- If the lighting system complied under the ***tailored lighting*** approach, copy or transcribe the information on the LTG forms.

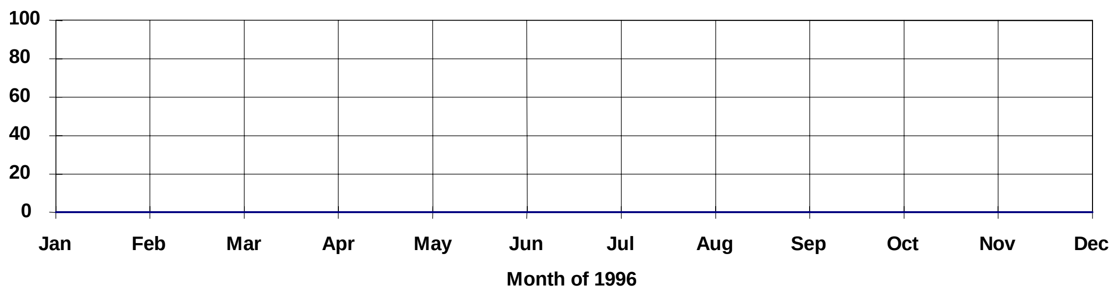
Q8. Circle the building type according to the standard CEC building types. (should be the same as that used in Title 24 whole building lighting compliance, if applicable)

1	General Commercial and Industrial Work	5	Office Building	9	School
2	Grocery Store	6	Religious Worship, Auditorium, or Convention Center	10	Theater
3	Industrial and Commercial Storage	7	Restaurant	11	Other
4	Medical Building or Clinic	8	Retail or Wholesale Store		

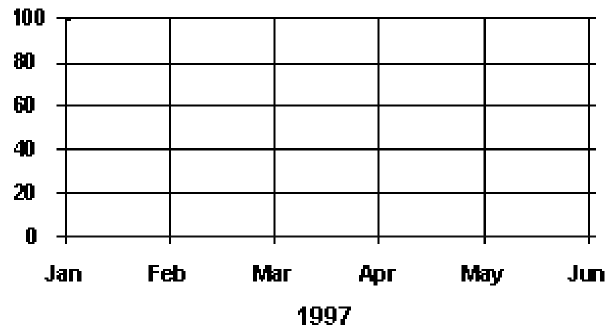
Q9. Draw a line that indicates the percentage of the new construction that was occupied (% of floor area) for 1996.



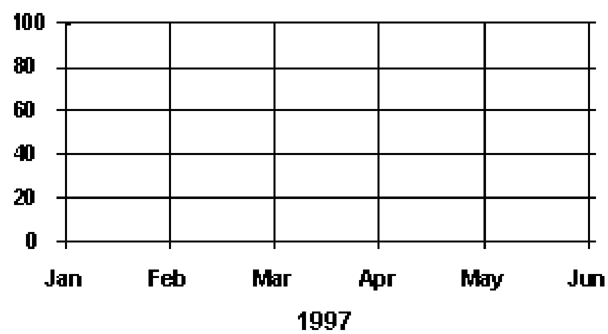
Q10. Draw a line that indicates the percentage of the new construction that was conditioned (% of floor area) during 1996.



Q11. Draw a line that indicates the percentage of the new construction that was occupied (% of floor area) for 1997.



Q12. Draw a line that indicates the percentage of the new construction that was conditioned (% of floor area) during 1997.



Q13. If there are shades or blinds on windows, which ***best*** describes their general use?

❑ Always open

❑ Always closed

❑ Operated by occupants to control comfort

❑ Open when space is occupied, closed otherwise

Q14. If different areas of the building (departments, tenants, etc.) have *substantially* different operational schedules, divide the building into up to five areas with differing schedules, and provide a name for each area:

1. ________________________
2. ________________________
3. ________________________
4. ________________________
5. ________________________

❑ **Building-Wide** **- or -**	**Area #___ and Area Name**
______________________	
(fill out only one page)	(fill out one page per area)

Schedules

The following questions will help us establish schedules for the building.

Q15. What would be the best way to group the days of the week to describe the operation of this area? One of the three operation levels must be assigned to each day of the week.

	M	Tu	W	Th	F	Sa	Su	Holiday
Full operation:	❑	❑	❑	❑	❑	❑	❑	❑
Light operation:	❑	❑	❑	❑	❑	❑	❑	❑
Closed:	❑	❑	❑	❑	❑	❑	❑	❑

Q16. Are there any months that this area has higher or lower than normal operating hours? Indicate months of increased or decreased operating hours. Normal (100%) is assumed for blank entries.

	Lighting % of Normal	HVAC % of Normal	Equip and Process % of Normal
Jan	____%	____%	____%
Feb	____%	____%	____%
Mar	____%	____%	____%
Apr	____%	____%	____%
May	____%	____%	____%
Jun	____%	____%	____%
Jul	____%	____%	____%
Aug	____%	____%	____%
Sep	____%	____%	____%
Oct	____%	____%	____%
Nov	____%	____%	____%
Dec	____%	____%	____%

Q17. Which holidays are observed (check all that apply)

❑ New Years day ❑ MLK day ❑ Presidents' day ❑ Easter ______ days

❑ Memorial day ❑ July 4th ❑ Labor day ❑ Columbus day

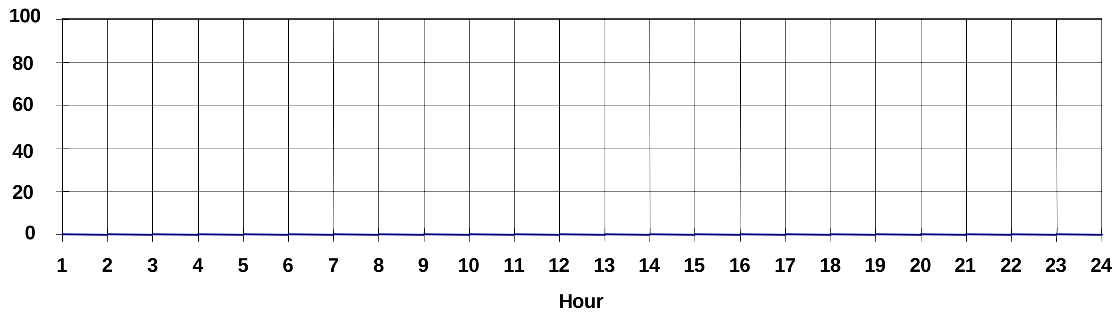
❑ Veteran's day ❑Thanksgiving ____ days ❑ Christmas _____days

Note: Holidays for 1996:

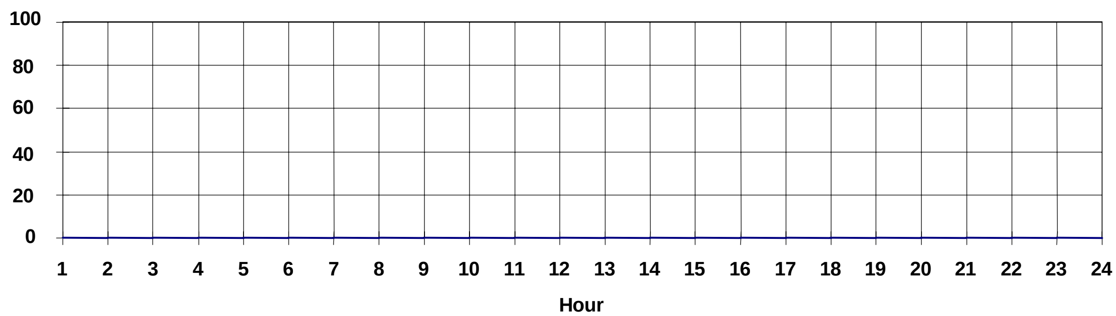
Holiday	Day/Date	Holiday	Day/Date
New Years day	Mon Jan 1	Labor day	Mon Sep 2
MLK day	Mon Jan 15	Columbus day	Mon Oct 14
Presidents' day	Mon Feb 19	Veteran's day	Mon Nov 11
Easter	Sun Apr 7	Thanksgiving	Thur Nov 28
Memorial day	Mon May 27	Christmas	Wed Dec 25
July 4th	Thur Jul 4		

❑ **Building-Wide** **- or -**	**Area #___ and Area Name** ______________________
(fill out only one page)	(fill out one page per area)

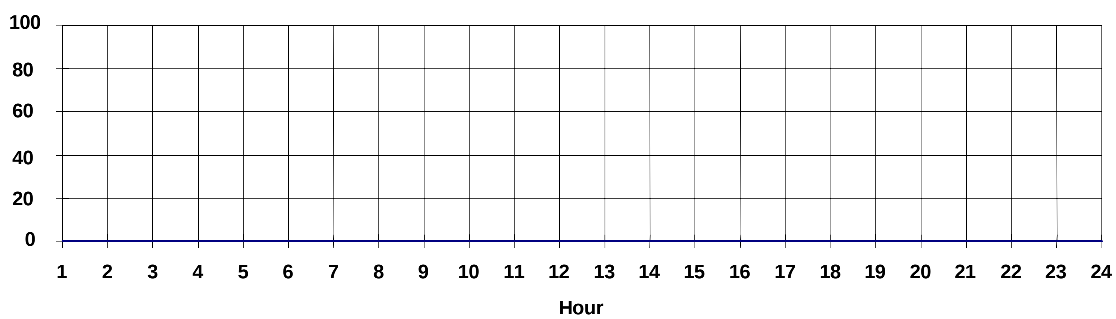
Q18. Draw a line that describes the ***occupancy*** schedule for a ***full operation day***.



Q19. Draw a line that describes the ***occupancy*** schedule for a ***light operation day***.

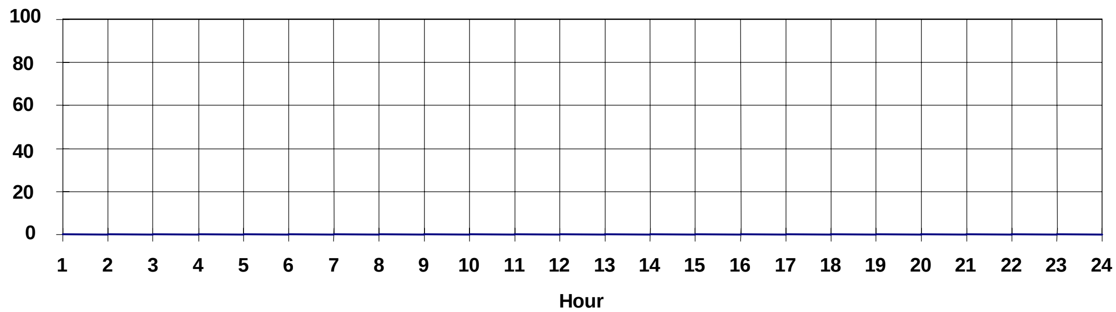


Q20. Draw a line that describes the ***occupancy*** schedule for a ***closed operation day***.

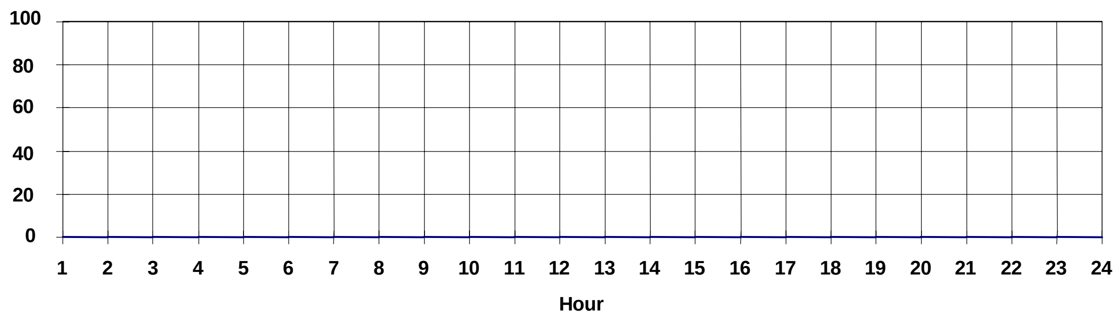


❑ **Building-Wide** **- or -**	**Area #___ and Area Name** ________________________
(fill out only one page)	(fill out one page per area)

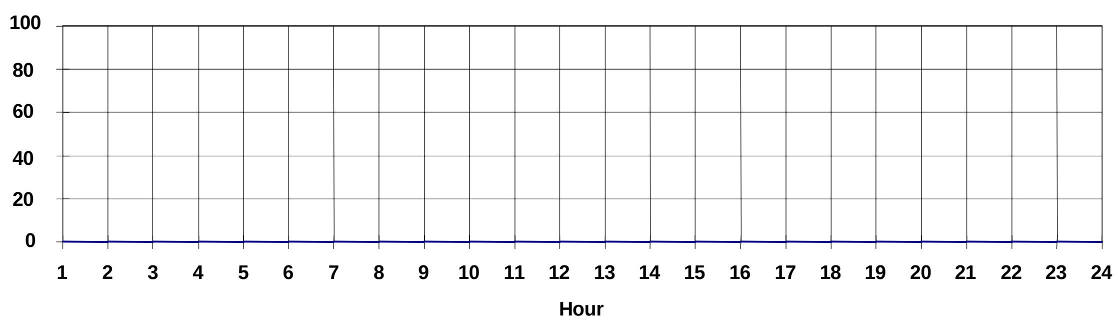
Q21. Draw a line that describes the schedule of use for ***interior lighting*** for a ***full operation day***.



Q22. Draw a line that describes the schedule of use for ***interior lighting*** for a ***light operation day***.



Q23. Draw a line that describes the schedule of use for ***interior lighting*** for a ***closed operation day***.

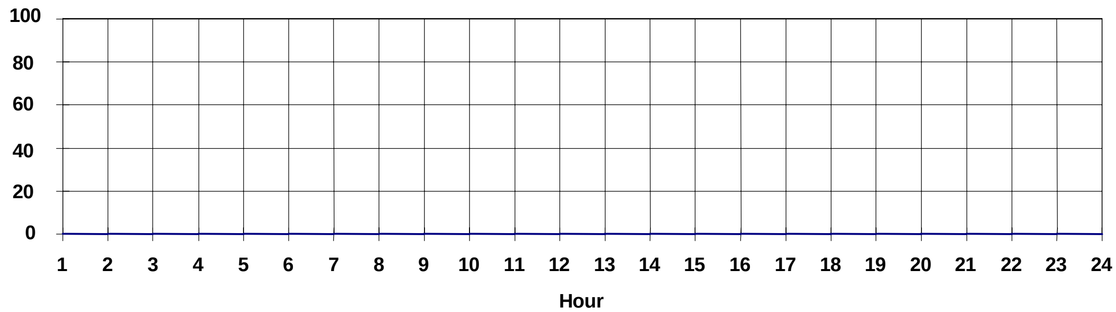


❑ **Building-Wide** **- or -** **Area #___ and Area Name** ________________________

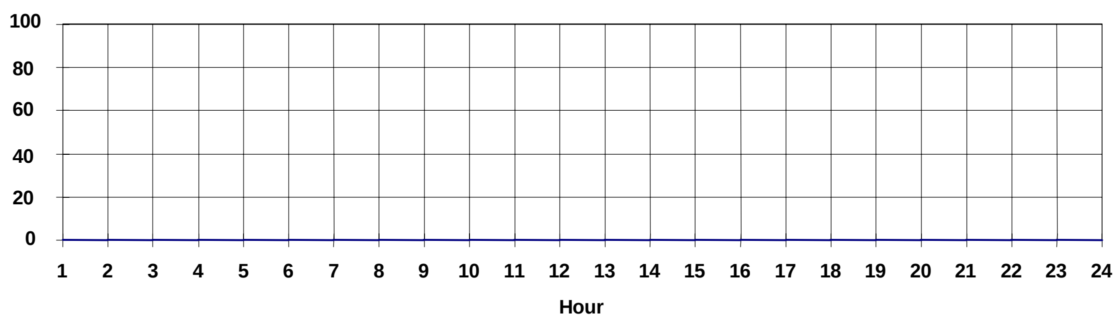
(fill out only one page) (fill out one page per area)

Miscellaneous equipment and plug loads refer to any electrical equipment located in the conditioned space which is not lighting or HVAC

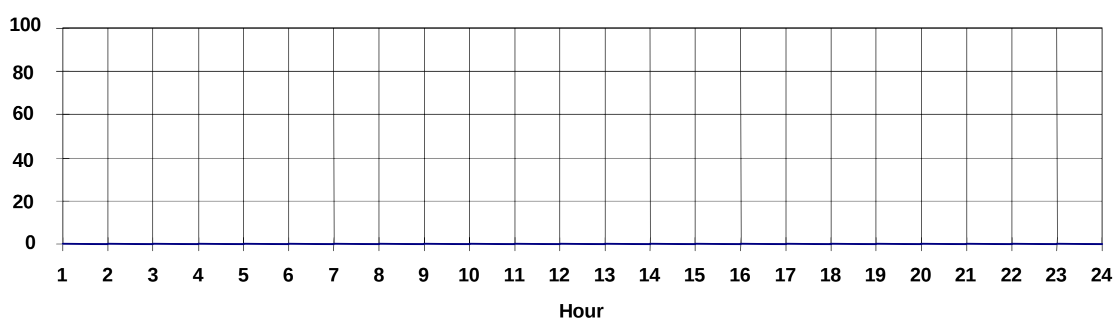
Q24. Draw a line that describes the schedule of use for ***miscellaneous equipment and plug loads*** for a ***full operation day***.



Q25. Draw a line that describes the schedule of use for ***miscellaneous equipment and plug loads*** for a ***light operation day***.



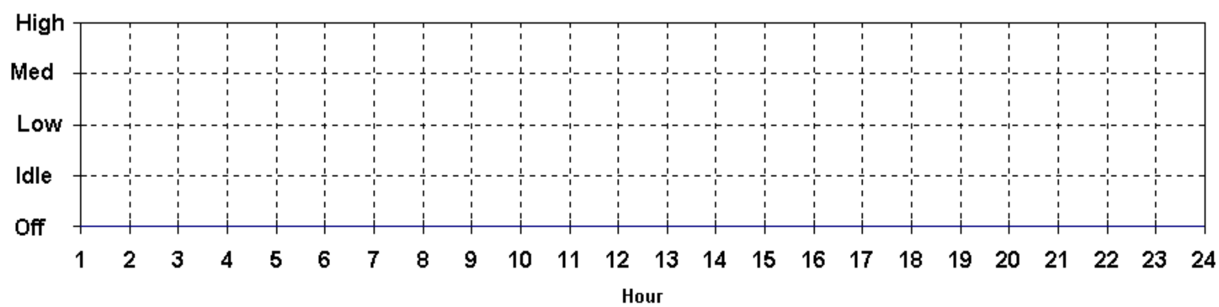
Q26. Draw a line that describes the schedule of use for ***miscellaneous equipment and plug loads*** for a ***closed operation day***.



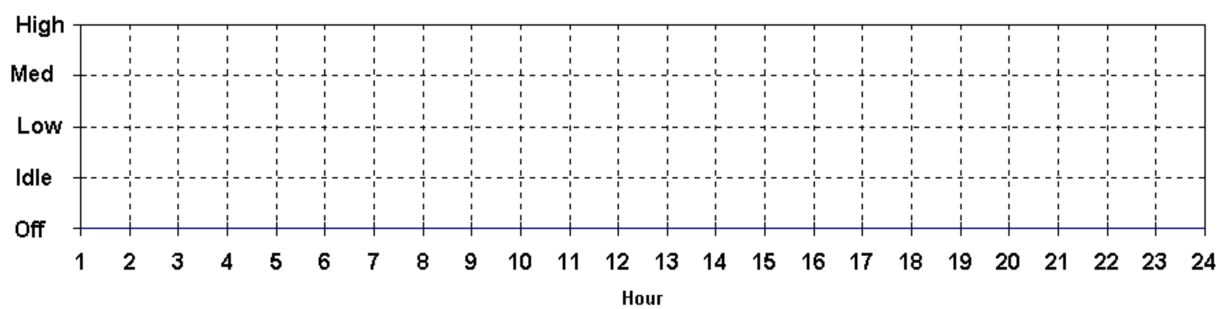
❑ **Building-Wide** **- or -**	**Area #___ and Area Name ______________________**
(fill out only one page)	(fill out one page per area)

Kitchen Operation

Q27. If the area has a commercial kitchen, draw a line that describes the schedule of use for ***kitchen equipment*** for a ***full operation day***.



Q28. If the area has a commercial kitchen, draw a line that describes the schedule of use for ***kitchen equipment*** for a ***light operation day***.



❑ **Building-Wide** **- or -**	**Area #___ and Area Name ____________________**
(fill out only one page)	(fill out one page per area)

Room Thermostat Setpoints

Q29. Enter the values for heating and cooling thermostat setpoints during normal (occupied) and setback (unoccupied) periods

Period	**Heating Setpoint**	**Cooling Setpoint**
Occupied		
Unoccupied		

Set CSP to 99 for "off," set the HSP to 45 for "off"

Q30. Does the setback schedule follow the fan on/off schedule? Y N DK

If the answer is N or DK, define the setback schedule below:

Q31. Draw a line that defines the occupied and unoccupied periods for a ***full operation day***.
DK

Occupied																								
Unoccupied																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Q32. Draw a line that defines the occupied and unoccupied periods for a ***light operation day***.
DK

Occupied																								
Unoccupied																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

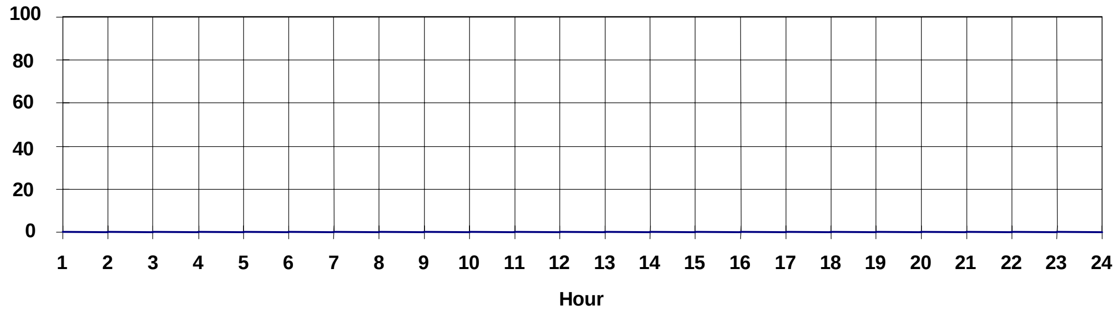
Q33. Draw a line that defines the occupied and unoccupied periods for a ***closed operation day***.
DK

Occupied																								
Unoccupied																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Exterior Lighting

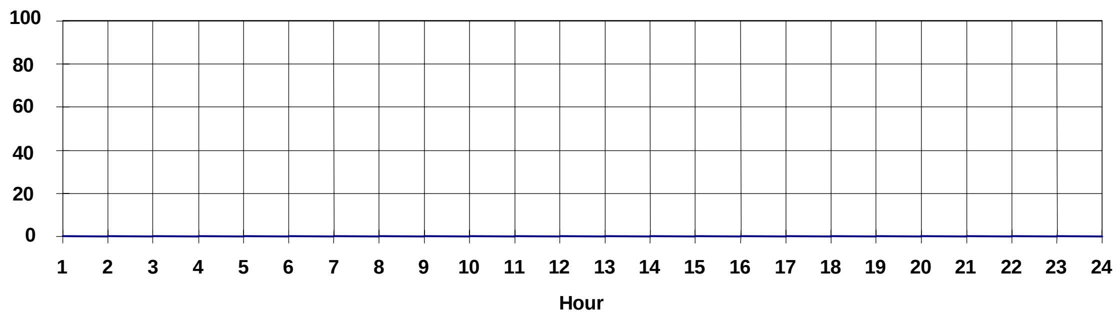
Q34. How are the exterior lights controlled? ❑ Time clock ❑ Photocell ❑ DK

Q35. If the exterior lights are controlled with a time clock, draw a line that describes the schedule

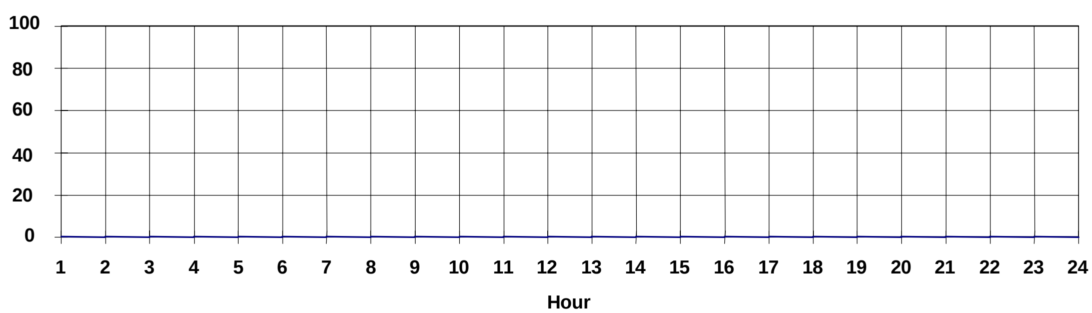


Exterior Miscellaneous Equipment

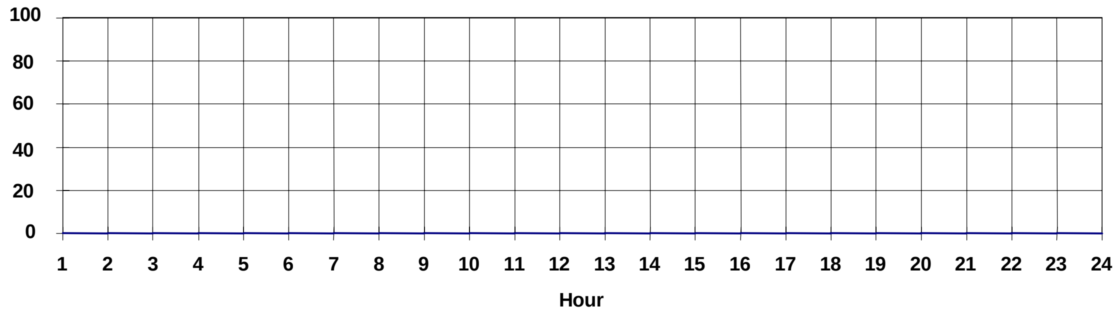
Q36. Provide a schedule for miscellaneous equipment ***not*** in the conditioned space for a ***full operation day***



Q37. Provide a schedule for miscellaneous equipment ***not*** in the conditioned space for a ***partial operation day***



Q38. Provide a schedule for miscellaneous equipment ***not*** in the conditioned space for a ***closed operation day***



Central HVAC Design and Control

The following questions will help us to understand how the HVAC systems operate in the building. (These questions are designed to be answered by someone familiar with the operation of the building mechanical and control systems.)

Q39. What is the minimum cooling supply air temperature setpoint ______°F ❏ DK

Q40. If system is VAV, what type of terminal boxes are used (check all that apply):

❏ non-powered (standard) VAV boxes ❏ fan-powered induction-type VAV boxes
❏ DK

Q41. What is the condenser water setpoint temperature ______°F ❏ DK

Q42. If the building has chillers and cooling towers, is the system equipped with a water-side economizer? Y N DK

Q43. If yes, what type of water-side economizer is used?

❏ Strainer cycle❏ Thermosyphon ❏ Plate-frame heat exchanger ❏ DK

Q44. Circle the months of the year when the water-side economizer system is typically used:

J F M A M J J A S O N D
DK

Q45. Is the heating system turned off (locked out) on a seasonal basis? ❏ Yes ❏ No

Q46. If yes, indicate the months when the heating system is typically available:

J F M A M J J A S O N D
DK

Q47. List the building control strategies used, and whether they are implemented by a building energy management system (EMS):

Control Strategy	**EMS?**	**M?**
On/off scheduling of air handlers or AC systems ❑		
Room temperature setpoint control ❑		
Supply air reset based on: ❑ outside temperature, ❑ zone temperature		
Optimum fan startup ❑		
Condenser water setpoint: ❑ fixed, ❑ reset on outdoor temperature		
Outdoor air (economizer) control: ❑ temp, ❑ enthalpy, ❑ CO_2		
Chilled water reset based on: ❑ outside temperature, ❑ zone temperature		
DDC of supply air flow rate based on terminal flow rate requirements ❑		
Lighting sweeps ❑		
Daylighting controls ❑		
Occupancy sensor controls ❑		
Peak demand limiting ❑ (explain)		

Other (list)

HVAC Fan System Operation

This section is used to establish the fan system schedule. List the hours that the fans are "on" or "off." "On" indicates occupied mode, where the fans run continuously. "Off" indicates unoccupied mode, where the fans cycle on only if needed to satisfy space temperature needs, or are shut off regardless of space temperature. For fans with optimal start/stop, indicate the building occupancy schedule - e.g. the time when the building needs to be at normal operating temperature, and indicate optimal start/stop in the control strategy section.

Q48. Draw a line that describes the fan system operation for a ***full operation day***.
DK

on																								
off																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Q49. Draw a line that describes the fan system operation for a ***light operation day***.
DK

on																								
off																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Q50. Draw a line that describes the fan system operation for a ***closed operation day***. DK

on																								
off																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

List all air handling unit, building areas, and/or packaged HVAC systems that run on this schedule below:

Refrigeration System

Q51. Does the building have a refrigeration system with remote condensers? Y N

If no, skip the remaining questions pertaining to refrigeration systems.

Q52. What refrigerants are used in each circuit of the system?

a. Low temp (Ice cream) R-_____________ DK

b. Med temp (Frozen food) R-_____________ DK

c. High temp (All others) R-_____________ DK

Q53. What is the minimum condensing temperature setpoint? ______°F, _____ psig DK

Q54. For each circuit temperature, what type of defrost is typically used?

a. Low temp (Ice cream) ❏ electric ❏ hot gas ❏ time off ❏ DK

b. Med temp (Frozen food) ❏ electric ❏ hot gas ❏ time off ❏ DK

c. High temp (All others) ❏ electric ❏ hot gas ❏ time off ❏ DK

Q55. Are the anti-sweat heaters controlled on store humdity? Y N DK

Q56. If Q56 is yes, list setpoints: RH off _____ % RH on_____ % DK

Q57. List the name and phone number of the refrigeration system service company

Name:____ Phone:________________

Q58. Please characterize the case stocking practices:

❏ cases stocked randomly as needed ❏ cases stocked on a regular schedule

Q59. If a ***regular*** schedule, describe the case stocking practices below:

Building-Wide Power Generation

Q60. Do you have an emergency back-up generator? Y N

Q61. If you have a back-up generator, do you use it for peak demand reduction? Y N

If yes, fill out the supplemental on-site power form

Q62. Do you have a cogeneration or other on-site power system? Y N

If yes, fill out the supplemental on-site power form

Thermal Energy Storage

Q63. Does the building have a thermal energy storage (TES) system? Y N

If yes, fill out the supplemental TES form.

Swimming Pools

Q64. If the building has a heated swimming pool, what water temperature is maintained? ________°F

Q65. If the building has a heated swimming pool, is a pool cover used? Y N

Q66. If a cover is used, at what time is it normally put on the pool? _____ (military time, blank if DK)

Q67. If a cover is used, at what time is it normally removed from the pool? _____ (military time)

Spas

Q68. If the building has a spa, what water temperature is maintained? ________°F

Q69. If the building has a spa, is a cover used? Y N

Q70. If a cover is used, at what time is it normally put on the spa? _____ (use military time)

Q71. If a cover is used, at what time is it normally removed from the spa? _____ (use military time)

Operations and Maintenance

Q72. Please list any equipment or system operating problems that cause thermal discomfort or excessive energy consumption?

Problem	**Equipment and/or Systems Affected**
System under or oversized	
Insufficient or excess air flow	
Faulty control sensors	
Improper control sensor installation or location	
Insufficient sensor points for control and/or monitoring	
Improper EMS or control system programming	
Control systems "locked out" (left in manual position)	
Faulty valve or damper linkage or actuator	
Loose fan belts and / or improper alignment	
Improper ductwork installation or leakage	
Leaky valves, pipes, or fittings	
Defective major components (compressors, pumps, fans, etc.)	
Refrigerant leakage	
Fouled evaporative cooler media	
Water treatment problems (corrosion or bacterial growth)	

Other (list)

Code	Equipment/system
1	Air distribution
2	Boiler
3	Chilled water
4	Chillers
5	Condenser water

Code	Equipment/system
6	Cooling towers
7	Daylight control(s)
8	Fans
9	Hot water
10	HVAC

Code	Equipment/system
11	Lighting
12	Occupancy sensor(s)
13	VSDs
14	Other

BUILT-UP HVAC SYSTEMS **(Do not enter backup or stand-by equipment)**

Chillers/ Large Split DX

	CH-	CH-	CH-
Equipment Name			
Location			
Quantity			
Manufacturer			
Model Number			
Serial Number			
Size (tons)			
Type	recip / screw / cent / absorp / gas eng	recip / screw / cent / absorp / gas eng	recip / screw / cent / absorp / gas eng
Full-load efficiency (kW/ton)	❐	❐	❐
Air-Cooled Cond. Fan hp			

Check box in upper right corner if item is a measure

Enter condenser fan hp only if not included in equipment efficiency rating

Towers/ Evaporative Condensers

	T-	T-	T-
Equipment Name	❐	❐	❐
Location			
Quantity			
Manufacturer			
Model Number			
Fan hp			
Fan Control	1-Sp / 2-Sp / Pony / VSD ❐	1-Sp / 2-Sp / Pony / VSD ❐	1-Sp / 2-Sp / Pony / VSD ❐
Spray Pump hp			

Check box in upper right corner if item is a measure

Heating System

	HS-	HS-	HS-
Equipment Name			
Location			
Quantity			
Capacity (if elec) kW			
Type	Steam / HW / Duct Htr	Steam / HW / Duct Htr	Steam / HW / Duct Htr
Fuel	Electric / Other	Electric / Other	Electric / Other

BUILT-UP HVAC SYSTEMS (CONT.) **(Do not enter backup or stand-by equipment)**

Central Air Handlers

Name	AH-	AH-	AH-
Equipment Name			
Location			
Quantity			
Type	Sngl Duct /Dual Duct/ Multi-Zone	Sngl Duct /Dual Duct/ Multi-Zone	Sngl Duct /Dual Duct/ Multi-Zone
Evaporative System Type	None / Direct / Ind / Ind-Dir ❐	None / Direct / Ind / Ind-Dir ❐	None / Direct / Ind / Ind-Dir ❐
Supply Fan Type	CV / 2-Spd / VAV	CV / 2-Spd / VAV	CV / 2-Spd / VAV
Supply Fan Control	CV / Cycles / VSD/ Discharge / Inlet ❐	CV / Cycles / VSD/ Discharge / Inlet ❐	CV / Cycles / VSD/ Discharge / Inlet ❐
Supply Fan Flow Rate (cfm)			
Supply Fan Motor HP	❐	❐	❐
motor efficiency	❐	❐	❐
Return/ Relief Fan HP	❐	❐	❐
motor efficiency	❐	❐	❐
OA Control	Fixed / Temp / Enthal / CO_2 ❐	Fixed / Temp / Enthal / CO_2 ❐	Fixed / Temp / Enthal / CO_2 ❐
OA Fraction			

Check box in upper right corner if item is a measure

Check fan hp measure box for air distribution incentive; check motor efficiency measure box for EE motor incentive

Pumps

Pump	Name	HP	Motor effic %	Control	Location	Loop	Use
P-			❐	CV / 2-spd / VSD ❐		CHW / Cond / HW	Pri / Sec
P-			❐	CV / 2-spd / VSD ❐		CHW / Cond / HW	Pri / Sec
P-			❐	CV / 2-spd / VSD ❐		CHW / Cond / HW	Pri / Sec
P-			❐	CV / 2-spd / VSD ❐		CHW / Cond / HW	Pri / Sec
P-			❐	CV / 2-spd / VSD ❐		CHW / Cond / HW	Pri / Sec
P-			❐	CV / 2-spd / VSD ❐		CHW / Cond / HW	Pri / Sec
P-			❐	CV / 2-spd / VSD ❐		CHW / Cond / HW	Pri / Sec
P-			❐	CV / 2-spd / VSD ❐		CHW / Cond / HW	Pri / Sec

Check box in upper right corner if item is a measure

Packaged HVAC Systems

	AC-	AC-	AC-
Equipment Name			
Location			
Quantity			
Type Code			
Manufacturer			
Model No. (outdoor - all)			
Model No (indoor if split)			
Cooling Capacity (ton)			
Efficiency	EER ❒ SEER	EER ❒ SEER	EER ❒ SEER
Supply CFM			
Heating Fuel	Elec / Other	Elec / Other	Elec / Other
Heating Capacity (kBtuh) (heating capacity is for compressor only)			
Heating COP (heat pumps only)			
Evap Condenser	Yes / No ❒	Yes / No ❒	Yes / No ❒
Evaporative System Type	None / Direct / Ind / Ind-Dir ❒	None / Direct / Ind / Ind-Dir ❒	None / Direct / Ind / Ind-Dir ❒
System Type	CV / VAV / VVT	CV / VAV / VVT	CV / VAV / VVT
Supply Fan Control	CV / Cycles / VSD / Discharge / Inlet ❒	CV / Cycles / VSD / Discharge / Inlet ❒	CV / Cycles / VSD / Discharge / Inlet ❒
Supply Fan HP	❒	❒	❒
Return/Relief Fan HP	❒	❒	❒
OA Control	Fixed / Temp / Enthal ❒	Fixed / Temp / Enthal ❒	Fixed / Temp / Enthal ❒
OA Fraction			

Check box in upper right corner if item is a measure

Type Code	Description	Type Code	Description
1	Single Package Rooftop AC	7	Window/Wall AC Unit
2	Single Package Rooftop Heat Pump	8	Window/Wall HP
3	Split System AC	9	Water Loop Heat Pump
4	Split System Heat Pump	10	Dual Fuel Heat Pump
5	PTAC	11	Evaporative System
6	PTHP		

Zone _____

Name ____________________ Zone Multiplier _______ HVAC zoning by exposure? Y N

Exterior Surfaces

Assembly Name	**Type Code**	Insul R-value (or)	Overall U-value	**Orientation** (circle one)	**H (ft)**	**W (ft)**
				N / NE / E / SE / S / SW / W / NW / H		
				N / NE / E / SE / S / SW / W / NW / H		
				N / NE / E / SE / S / SW / W / NW / H		
				N / NE / E / SE / S / SW / W / NW / H		
				N / NE / E / SE / S / SW / W / NW / H		

Height and width are gross dimensions, including windows

Enter "0" for R-value if uninsulated, leave blank if unknown

	Opaque Surface Type
1	Face Brick + Brick
2	Face Brick + Poured Concrete
3	Face Brick + Concrete Block
4	Poured Concrete + Finish

	Opaque Surface Type
5	Concrete Block + Finish
6	Wood Frame Wall
7	Metal Frame Wall
8	Curtain Wall

	Opaque Surface Type
9	Open
10	Concrete Deck Roof.
11	Wood Frame Roof
12	Metal Frame Roof

Windows

Assembly Name	**No. Panes**	**Glass Type**	**Frame Type**	SC	U- value	**Orientation** (circle one)	**H (ft)**	**W (ft)**	**Qty**	Int. Shade	OH Offset	OH Proj
				❐		N / NE / E / SE / S / SW / W / NW / H						
				❐		N / NE / E / SE / S / SW / W / NW / H						
				❐		N / NE / E / SE / S / SW / W / NW / H						
				❐		N / NE / E / SE / S / SW / W / NW / H						
				❐		N / NE / E / SE / S / SW / W / NW / H						
				❐		N / NE / E / SE / S / SW / W / NW / H						
				❐		N / NE / E / SE / S / SW / W / NW / H						

Check box in upper right corner if item is a measure

	Glass Type
1	Clear
2	Tinted
3	Reflective

	Frame Type
1	Standard Metal Frame
2	Thermally Broken Metal Frame
3	Wood/Vinyl Frame

	Interior Shade Type
1	Blinds
2	Light Shades or Drapes
3	Dark Shades or Drapes

Zone _____ (contd)

Zone-Level HVAC Equipment (Not Central, Not Packaged)

Name	**Type Code**	**Quantity**	Fan Hp	**Heat Source**	kW (If elec. heat)
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	
				None / Elec. / Other	

Zone-Level HVAC Equipment

Type Code	Zone-Level HVAC Equipment Description
1	Baseboard or radiant heater
2	Two-pipe fan coil
3	Four-pipe fan coil
4	Two pipe induction terminal
5	Four pipe induction terminal
6	Unit heater

Type Code	Zone-Level HVAC Equipment Description
7	Unit ventilator
8	Non-powered VAV terminal
9	Series fan-powered VAV terminal
10	Parallel fan-powered VAV terminal
11	Computer equipment cooler
12	Exhaust fan

Space _____

Name __________________ Floor
Area_________SF

Corridor/Restroom/Support Area______% Space Multiplier______

Circle appropriate occupancy code:

1	Auditorium	14	Office - Other	26	Hotel function	39	Gymnasium
2	Church /chapel	15	Computer center	27	Hotel guest room	40	Library
3	Convention, meeting	16	EEG/EKG/MRI/Radiation	28	Hotel lobby	41	Locker room
4	Courtroom	17	Hospital - Emergency	29	Barber, beauty shop	42	School shop
5	Exhibit	18	General hospital area	30	Bowling alley	43	Swimming pool
6	Main entry lobby	19	Hospital laboratory	31	Coin op laundry	44	Aircraft hanger
7	Motion picture theater	20	Patient room/ nursery	32	Comm'l dry cleaners	45	Auto repair workshop
8	Performance theater	21	Therapy (OT, PT)	33	Grocery	46	General C&I work
9	Bars, lounge, casino	22	Pharmacy	34	Mall, arcade, atrium	47	Precision C&I work
10	Dining	23	Radiology	35	Retail, whlse sales flr	48	Storage, warehouse
11	Kitchen	24	Recovery	36	Classroom	49	Other
12	Bank/financial institution	25	Surgical & OB suite	37	Day care		
13	Medical / clinical office			38	Dormitory		

Lighting LPD (all fixtures)
Measure? ❑

Name	**Fixture Code**	**Fixture Count**	Mounting	**Controls** (circle all that apply)	**% fix ctrl**	**% ctrl oper**
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		
	❐		Rec / Sus / Task	1 / 2 / 3 / 4 ❐		

Check box in upper right corner if item is a measure

Define lighting not included in LPD as task lighting - includes portable task lights, display case lighting, medical examination lighting.

Lighting Control Codes

1 = Occupancy sensor 2 = Daylight - contin. dimming 3 = Daylighting - stepped 4 = Lumen maintenance

Miscellaneous Equipment and Plug Loads

❑ Use typical value: 1 2 3 4 ❑ Define additional or unique loads (use next page)

Space _____ contd

Miscellaneous Equipment and Plug Loads

❑ Use typical value: 1 2 3 4 plus additional loads listed below:

❑ Define unique loads for this space only

Name	**Equip. Code**	**Count**	kW/ Unit or	Motor HP or	kBtuh Input	Under Hood?
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N

Equipment - Record kW for equipment without default or if default is not appropriate

	Equipment Description	Equip Code	Default kW
General	Personal Computer w/ Monitor	1	0.5
	Terminal	2	0.15
	Laser Printer	3	0.85
	Copier	4	1.4
	Fax Machine	5	0.1
	Mini-Computer + Periph	6	1.0
	Main Frame Computer + Periph	7	
	Microwave	8	1.7
	Misc. Appliance	9	
	Television	10	0.15
	Washer	11	0.5
	Dryer	12	4.
	Cash Register	13	0.15
	Box Crusher	14	10.
	Gasoline pump	15	0.7
	ATM	16	.5
	Video game	17	.5
	Exercise equipment	18	.5

	Equipment Description	Equip Code	Default kW
Grocery	Meat Grinder	19	7.
	Meat Saw	20	2.5
	Meat Slicer	21	0.25
	Wrapper	22	0.9
	Check stand	23	1.5
Hospital	Laboratory Equipment	24	
	Monitoring, Life Support	25	1.1
	EEG	26	1.1
	EKG	27	1.1
	MRI	30	26.
	X-ray machine	31	5.
	Radiation Therapy Machine	32	10.
Indust	Air Compressor	33	
	Welder	34	
	Battery Charger	35	1.5
	Machine Tools	36	
	Motor	37	
Misc.	Other	38	

Typical Miscellaneous Equipment and Plug Loads 1 2 3 4

Floor area surveyed __________________ SF

Name	**Equip. Code**	**Count**	kW/ Unit or	Motor HP or	kBtuh Input	Under Hood?
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N
						Y / N

Equipment - Record kW for equipment without default or if default is not appropriate

	Equipment Description	Equip Code	Default kW
General	Personal Computer w/ Monitor	1	0.5
	Terminal	2	0.15
	Laser Printer	3	0.85
	Copier	4	1.4
	Fax Machine	5	0.1
	Mini-Computer + Periph	6	1.0
	Main Frame Computer + Periph	7	
	Microwave	8	1.7
	Misc. Appliance	9	
	Television	10	0.15
	Washer	11	0.5
	Dryer	12	4.
	Cash Register	13	0.15
	Box Crusher	14	10.
	Gasoline pump	15	0.7
	ATM	16	.5
	Video game	17	.5
	Exercise equipment	18	.5

	Equipment Description	Equip Code	Default kW
Grocery	Meat Grinder	19	7.
	Meat Saw	20	2.5
	Meat Slicer	21	0.25
	Wrapper	22	0.9
	Check stand	23	1.5
Hospital	Laboratory Equipment	24	
	Monitoring, Life Support	25	1.1
	EEG	26	1.1
	EKG	27	1.1
	MRI	30	26.
	X-ray machine	31	5.
	Radiation Therapy Machine	32	10.
Indust	Air Compressor	33	
	Welder	34	
	Battery Charger	35	1.5
	Machine Tools	36	
	Motor	37	
Misc.	Other	38	

Refrigerated Cases

Zone: ____

Name	**Type**	**Qty**	**Length (ft)**	**Walk-in SF**	**Product**	**Comp Loc**	Door type (Reach-in)	Display Ltg (blank if none)	EE Mtr
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐
						Int / Rem	❐	Std / Ebal / T-8 ❐	Y / N ❐

Check box in upper right corner if item is a measure

Type Code	Case Description	Unit Dim.	Default kW/unit
1	Island, open, single-level narrow	ft	0.1
2	Island, open, single-level wide	ft	0.1
3	Island, open, island, single level double	ft	0.2
4	Island, closed, single-level narrow	ft	0.1
5	Island, closed, single-level wide	ft	0.1
6	Island, closed, single level double	ft	0.2
7	Open Single-deck	ft	0.3
8	Open Multi-deck	ft	0.3
9	Reach-in Multi deck	ft	0.3
10	Closed rear-entry multi-deck	ft	0.03
11	Curved glass rear entry multi deck	ft	0.06
12	Walk-in / Reach-in	ft	0.3
13	Walk-in	ft	0.015
14	Under counter Reach-in	CF	0.03
15	Blast Chiller	CF	0.03
16	Ice Maker	CF	0.15
17	Residential Reach-in Refrigerator	CF	0.03
18	Residential Reach-in Freezer	CF	0.03
19	Residential Closed Coffin Freezer	CF	0.03
20	Refrigerated Vending Machine	CF	0.03
21	Water cooler	each	0.5
22	Slurpee, frappaccino machine	each	
23	Other	kBtuh	

Product Code	Product
1	Ice Cream
2	Frozen Food
3	Fresh Meat
4	Deli
5	Dairy/Beverage
6	Produce

Door Code	Door Type
1	Single glazed
2	Double glazed
3	Triple glazed, no heater controls
4	Triple glazed, w/ heater controls
5	Triple glazed, no heaters
6	Quadruple glazed, no heater controls
7	Quadruple glazed, w/ heater controls
8	Quadruple glazed, no heaters

Refrigeration Plant

Compressors / Compressor Racks

Name	**Make**	**Model**	**Comp Code**	Circuit	SST °F	Evap tons	AHU Ht. Rec
CR-			❐	L / M / H			Y / N
CR-			❐	L / M / H			Y / N
CR-			❐	L / M / H			Y / N
CR-			❐	L / M / H			Y / N
CR-			❐	L / M / H			Y / N
CR-			❐	L / M / H			Y / N

Check box in upper right corner if item is a measure

Supply evaporator tons and rack suction temperature (SST) if known

Refrigeration Condenser

Name	**Make**	**Model**	**Type**	Comp Served	Fan Hp	Pump Hp	Fan Control
RC-			Air / Water ❐	CR-			1Sp / 2Sp / Pony / VSD ❐
RC-			Air / Water ❐	CR-			1Sp / 2Sp / Pony / VSD ❐
RC-			Air / Water ❐	CR-			1Sp / 2Sp / Pony / VSD ❐
RC-			Air / Water ❐	CR-			1Sp / 2Sp / Pony / VSD ❐

Check box in upper right corner if item is a measure

Comp Code	Compressor type
1	Stand-alone
2	Stand-alone w/ VSD
3	Parallel equal multiplex
4	Parallel unequal multiplex

Foodservice

Zone: ____

Kitchen Equipment

Appliance Name	**Qty**	**Type Code**	**Fuel**	kW or	Volts / Amps or	kBtuh Input or	**Trade Size**	**Hood**
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N
			Elec. / Other		/			Y / N

Hoods

Name	**Type**	**Size (SF)**	Flow (cfm)	Fan hp	**Makeup Air Source**
	Canopy / Island Canopy / Backshelf				Cond / Uncond
	Canopy / Island Canopy / Backshelf				Cond / Uncond
	Canopy / Island Canopy / Backshelf				Cond / Uncond
	Canopy / Island Canopy / Backshelf				Cond / Uncond
	Canopy / Island Canopy / Backshelf				Cond / Uncond
	Canopy / Island Canopy / Backshelf				Cond / Uncond

Type Code	Description	Trade size	Default kW/unit
1	Broiler (include cheesemelter)	ft	1.7
2	Char Broiler	ft	3.7
3	Griddle, single sided	ft	4.5
4	Griddle, clam shell	ft	7.5
5	Fryer, countertop	lb	0.3
6	Fryer, free-standing	lb	0.3
7	Fryer, pressure	lb	0.3
8	Fryer, donut	lb	0.3
9	Kettle, Pasta cooker	qt	0.25
10	Heat lamps	lamps	0.5
11	Range top	ft	5.
12	Oven, pizza or bake	decks	7.
13	Oven, conveyor	decks	13.
14	Oven, range	ft	2.

Type Code	Description	Trade size	Default kW/unit
15	Oven, convection, combi, or retherm	doors	3.8
16	Food warmer	ft	0.6
17	Heated display case	ft	0.5
18	Microwave oven		1.7
19	Toaster, pop-up		1.8
20	Toaster, conveyor		4.6
21	Coffee pot	burners	1.
22	Steam table	ft	0.6
23	Dishwasher, single tank	racks/hr	0.3
24	Dishwasher, conveyor	racks/hr	0.1
25	Steam jacketed kettle	qt	0.4
26	Braising pan/skillet	qt	0.1
27	Other	kW	

Hot Water

Conventional Water Heating Equipment

Name	**Location**	**Type Code**	Cap (gal)	**Fuel**	Pump hp
		❐		Elec / Other	
		❐		Elec / Other	
		❐		Elec / Other	
		❐		Elec / Other	

Check box in upper right corner if item is a measure

Solar Water Heating Equipment (collect only if electric backup)

Name	Location	System Type Code	Collector Area (SF)	Tilt (deg, horiz =0)	Storage Cap (gal)

Pools/ Spas

Name	Location	Surface Area (SF)	**Filter Motor hp**	**Heating System**
	Outside / Inside			None / PH-___
	Outside / Inside			None / PH-___
	Outside / Inside			None / PH-___
	Outside / Inside			None / PH-___

Pool/Spa Heating System (collect only if electric heater)

Name	Location	**Fuel Code**	Solar Collector Type	Collector Area (SF)	Tilt (deg, horiz =0)	Heat Recovery
PH-1		Elec / Other	Glazed / Unglazed			Y / N
PH-2		Elec / Other	Glazed / Unglazed			Y / N
PH-3		Elec / Other	Glazed / Unglazed			Y / N
PH-4		Elec / Other	Glazed / Unglazed			Y / N

WH Type Code	Water Heater Description
1	Storage
2	Instantaneous
3	Heat Pump

SWH Type Code	Solar Water Heater Description
1	Active flat plate
2	Passive flat plate
3	Integral Collector/Storage
4	Active evacuated tube
5	Active concentrating E-W tracking
6	Active concentrating N-S tracking

Miscellaneous

Interior Transformers

Name	**Location**	**Qty**	Manuf.	Model No.	**kVA**	**Temp Rise (°C)**	**Cooling Fan?**
							Y / N
							Y / N
							Y / N
							Y / N
							Y / N
							Y / N
							Y / N
							Y / N
							Y / N
							Y / N
							Y / N
							Y / N

Verify for participants receiving incentive only

Vertical Transportation

				Elevator	Escalator		
Name	**Type**	**Qty**	Motor hp	**Number of Floors**	**Width (ft)**	**Rise (ft)**	**Run (ft)**
	Elev / Esc						
	Elev / Esc						
	Elev / Esc						
	Elev / Esc						
	Elev / Esc						
	Elev / Esc						
	Elev / Esc						
	Elev / Esc						

Exterior

Exterior Lighting

Name	**Fixture Code**	**Count**

Miscellaneous Exterior Electric Loads

Name	**Equip Code**	**Quantity**	kW/unit or	Hp/unit

Equipment Description	Equipment Code	Default kW
Misc. Appliance	1	
Washer	2	0.5
Dryer	3	4.
Cash Register	4	0.15
Box Crusher	5	10.
Gasoline pump	6	0.7
Air Compressor	7	

Equipment Description	Equipment Code	Default kW
Welder	8	
Battery Charger	9	1.5
Machine Tools	10	
Motor	11	
Refrig vending machine	12	
Ice merchandizer	13	
Other	14	

Meters

Meter Number Starts with "PG&E," 6 characters, one alpha	**Surveyed Space kWh / Metered Space kWh (%)**	**Meter Location**

❑ Some or all meter information not available

❑ Short-term monitoring candidate - fill out supplemental STM form

Notes:

System / Zone Association Checklist

DOE-2 "Virtual" System ----→	1	2	3	4	5	Zonal HVAC only	Uncond
Packaged HVAC							
AC-1							
AC-2							
AC-3							
AC-4							
AC-5							
AC-6							
AC-7							
AC-8							
AC-9							
AC-10							
AC-11							
AC-12							
Central Systems							
Air Handlers							
AH-1							
AH-2							
AH-3							
AH-4							
AH-5							
AH-6							
Chillers / AC Compressors							
CH-1							
CH-2							
CH-3							
CH-4							
CH-5							
CH-6							
Towers / Evap. Condensers							
T-1							
T-2							
T-3							
T-4							
T-5							
T-6							
Heating Systems							
HS-1							
HS-2							
HS-3							

HS-4							
HS-5							
HS-6							
Pumps							
P-1							
P-2							
P-3							
P-4							
P-5							
P-6							
P-7							
P-8							
Zone 1							
Zone 2							
Zone 3							
Zone 4							
Zone 5							
Zone 6							
Zone 7							
Zone 8							
Zone 9							
Zone 10							

Check 'Zonal HVAC only' if zone is conditioned only by baseboard, radiant, or unit heaters, or unit ventilators.

Interview "Area" / Audit "Zone" Association Checklist

Areas	1	2	3	4	5
Zone 1					
Zone 2					
Zone 3					
Zone 4					
Zone 5					
Zone 6					
Zone 7					
Zone 8					
Zone 9					
Zone 10					

Space/Zone Association

	Zone									
Space	Z 1	Z 2	Z 3	Z 4	Z 5	Z 6	Z 7	Z 8	Z 9	Z 10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										

19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										

Sketch of Building Floor Plan

Be sure to include dimensions, North arrow, and zone and HVAC equipment locations

REFRIGERATED WAREHOUSE SURVEY

General Information

Site ID # [ ]

Surveyor Name:	Building Name:

Date:	Primary Contact:	Phone:

Building Address:	
City	Zip

Facility Overview

What is the total square footage of this facility? __________ sq. ft.

Which statement best describes the operation of the facility?

( ) long-term storage ( ) short-term storage
( ) distribution ( ) seasonal

Which statement best describes the operation of the facility?

( ) The entire facility operates on *basically* the same temperature and schedule.

( ) There are areas of the facility that have *substantially* different temperatures and operational schedules.

If different storage temperatures and operational schedules exist, divide the building into areas with differing schedules, and provide a name for each area:

1	________________	1b	______________________
2	________________	2b	______________________
3	________________	3b	______________________
4	________________	4b	______________________
5	________________	5b	______________________

Production and Construction Projections

Year	Production (% of 1995)	Additions to surveyed facility (% of 1995 SF)
1996		
1997		
1998		
1999		

Area 1 2 3 4 5 (Fill out pages 2-7 for each different area, and indicate on p.14)

Name ______________________ Floor Area __________ SF Temp __________ deg F

Occupancy __________ people RH __________ %

Space Type/Usage ______________________________________

SURFACES

Name	Construction Description	Orient	Tilt (0=horiz)	H (ft)	W (ft)	Adjacent to area
S-1		N S E W H				
S-2		N S E W H				
S-3		N S E W H				
S-4		N S E W H				
S-5		N S E W H				
S-6		N S E W H				
S-7		N S E W H				
S-8		N S E W H				
S-9		N S E W H				

Doors

ID	D-1	D-2	D-3	D-4	D-5
Make					
Model					
Quantity					
Size (L×W)					
Opens to (space name or ambient)					
Type					
Door material					

Door thickness (in.)					
Seal condition					
Cycle time(min)					
Peak cycles / hr					

Locate doors on sketch (see pages 14 and 15).

Doors–continued

Describe wind exposure and/or other infiltration conditions:

PRODUCTS

Product	P-1	P-2	P-3	P-4
Description				
Receiving Temp				
Receiving Condition				
Final Temp				
Container type				
Container wt.				
Cooldown time (hr)				
Cooldown %				
Cooldown temperature				

Average Daily Receiving Volume ***WD = Weekdays, WEH = Weekends and Holidays***

	P-1		P-2		P-3		P-4	
Month	WD	WEH	WD	WEH	WD	WEH	WD	WEH
Jan								
Feb								
Mar								
Apr								
May								
Jun								
Jul								

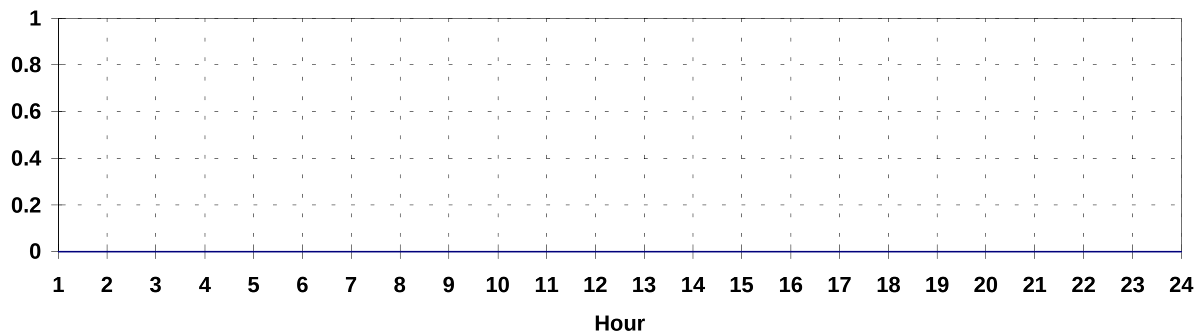
Aug								
Sep								
Oct								
Nov								
Dec								

Be sure to indicate units

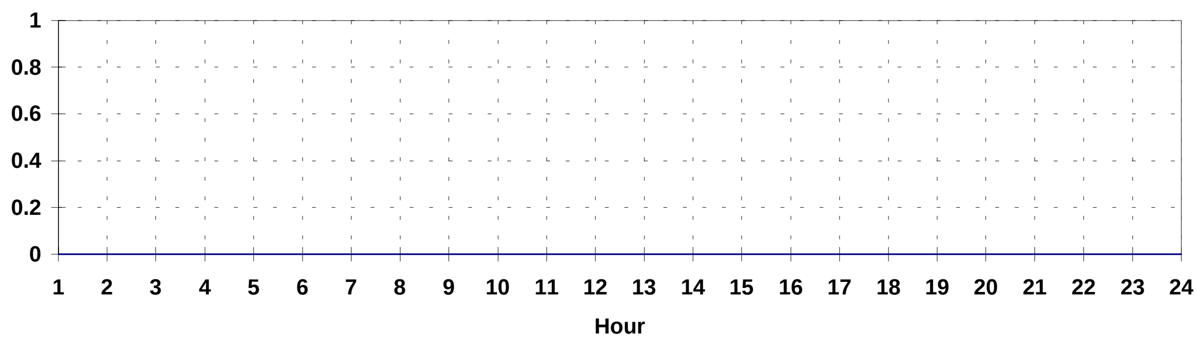
Receiving Schedules

Indicate daily receiving schedule (% of max. hourly product amount) for each of the above products.

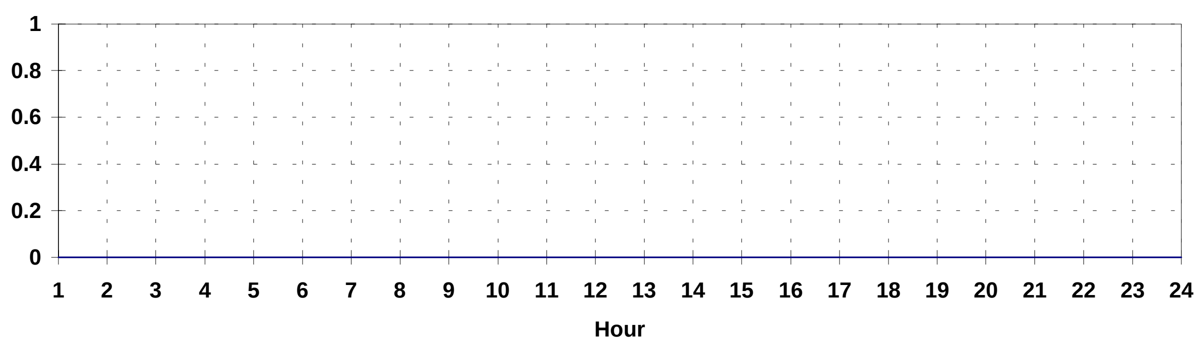
P - 1 **Month** (circle): J F M A M J J A S O N D **Daytype** (circle) WD WEH



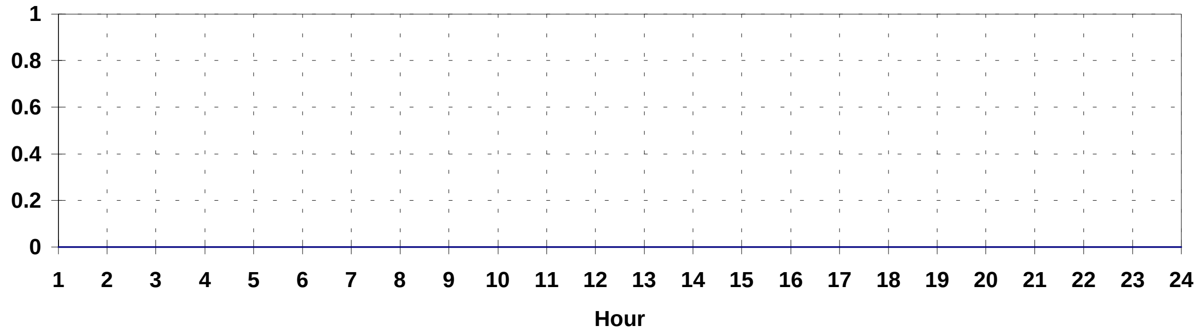
P-____ **Month** (circle): J F M A M J J A S O N D **Daytype** (circle) WD WEH



P-____ **Month** (circle): J F M A M J J A S O N D **Daytype** (circle) WD WEH



P-____ **Month** (circle): J F M A M J J A S O N D **Daytype** (circle) WD WEH


1
0.8
0.6
0.4
0.2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour

Total Product Stored

Month	P-1	P-2	P-3	P-4
Jan				
Feb				
Mar				
Apr				
May				
Jun				
Jul				
Aug				
Sep				
Oct				
Nov				
Dec				

Be sure to indicate units

Notes (record additional comments on p.13):

EVAPORATORS

ID	EV-1	EV-2	EV-3	EV-4	EV-5
Make					
Model					
Quantity					
Capacity (ton)					
Liquid feed					
Fan hp					
Fan efficiency					

Fan control type					
Defrost type					
Schedule					
Duration					
Defrost power usage					
Condensate pan heat					

Record additional comments on p.13

Lighting

Name	Fixture Code	Quantity	Schedule
L-1			
L-2			
L-3			
L-4			
L-5			
L-6			

Miscellaneous Packing and Processing Equipment

Name	Description	Count	kW/ Unit or	Motor HP or	kBtuh Input	Schedule of Operation
E-1						
E-2						
E-3						
E-4						
E-5						
E-6						
E-7						
E-8						
E-9						

Vehicles

	Description	Make	Model	Volts	Am p-hr	hp	Qty.	Schedule of Use
V-1								
V-2								
V-3								
V-4								
V-5								
V-6								

Describe vehicle usage (record additional comments on p.13):

Process Cooling Loads

ID	PCL-1	PCL-2	PCL-3	PCL-4
Type				
Make				
Model Number				
Auxiliary hp				
Product				
Entering Temp				
Leaving Temp				
Cycle length (min)				

Average Daily Process Volume ***WD = Weekdays, WEH = Weekends and Holidays***

	PCL-1		PCL-2		PCL-3		PCL-4	
Month	WD	WEH	WD	WEH	WD	WEH	WD	WEH
Jan								
Feb								
Mar								
Apr								
May								
Jun								
Jul								
Aug								
Sep								
Oct								
Nov								
Dec								

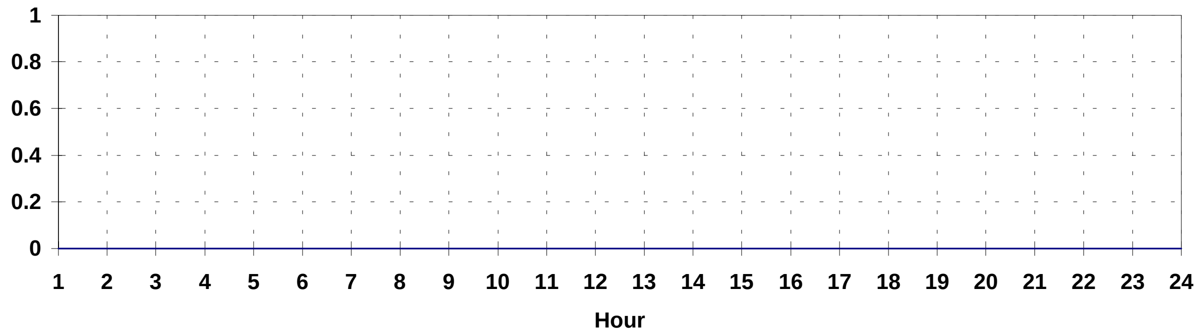
Be sure to indicate units

Any process load scheduling or sequencing information that cannot be recorded on the following page should be noted here (record additional comments on p.13):

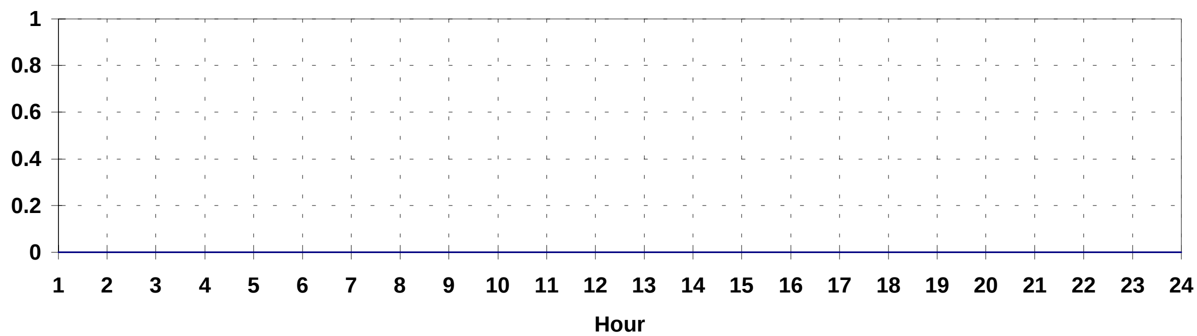
Process Cooling Schedules

Indicate average daily process schedule (% of max. hourly total amount) for each process load.

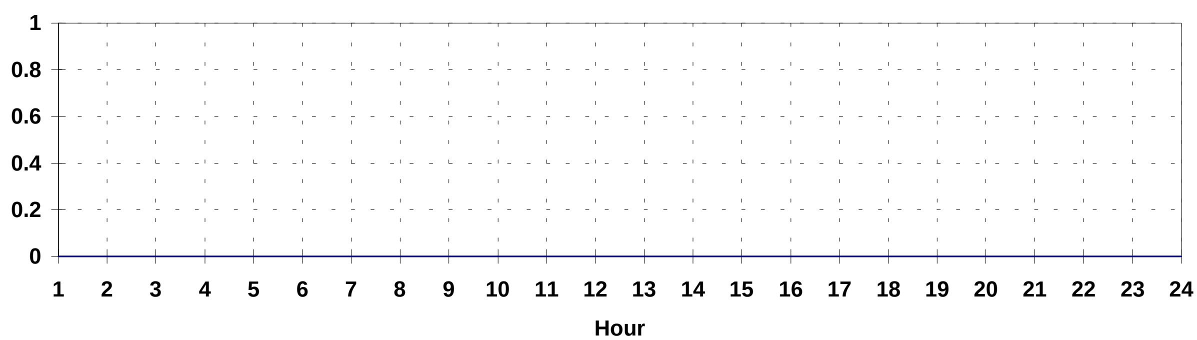
PCL - 1 : Month (circle): J F M A M J J A S O N D **Daytype** (circle) WD WEH



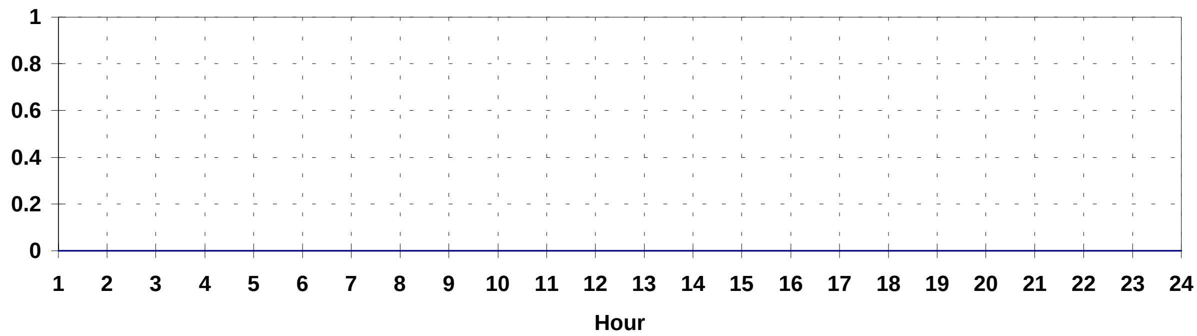
PCL-____: Month (circle): J F M A M J J A S O N D **Daytype** (circle) WD WEH



PCL-____: Month (circle): J F M A M J J A S O N D **Daytype** (circle) WD WEH



PCL-____: Month (circle): J F M A M J J A S O N D **Daytype** (circle) WD WEH



Refrigeration Plant

Compressors

ID	C-1	C-2	C-3	C-4	C-5
Make					
Model Number					
Serial Number					
Refrigerant type					
Application					
Suction setpoint					
Discharge setpoint					
Min capacity %					
Max capacity %					
Motor Make					
Model No.					
hp					
Efficiency					
RPM					
Type					

CONDENSERS

Name	RC-1	RC-2	RC-3	RC-4
Make				
Model				

Type	Air / Evap	Air / Evap	Air / Evap	Air / Evap
Fan hp				
type	ODP / TEFC	ODP / TEFC	ODP / TEFC	ODP / TEFC
RPM				
η				
control	1Sp / 2Sp / VSD	1Sp / 2Sp / VSD	1Sp / 2Sp / VSD	1Sp / 2Sp / VSD
control type				
Pump hp				
type	ODP / TEFC	ODP / TEFC	ODP / TEFC	ODP / TEFC
RPM				
η				

Condensers–continued

Describe compressor and condenser fan sequencing for each system:

REFRIGERANT VESSELS

ID	Description	Length (in.)	Diameter (in.)	Insulation
RV-1				
RV-2				
RV-3				
RV-4				
RV-5				
RV-6				
RV-7				
RV-8				

Notes (record additional comments on p.13):

HEAT EXCHANGERS FOR SUBCOOLING, DESUPERHEAT

ID	Application	HX Type	Flow Type
HX-1			
HX-2			
HX-3			
HX-4			
HX-5			
HX-6			

Notes (record additional comments on p.13):

Equipment / Load Association

	Circuit					
		1	2	3	4	5
Area	1					
	2					
	3					
	4					
	5					
	1b					
	2b					
	3b					
	4b					
	5b					
Process	PCL-1					
	PCL-2					
	PCL-3					
	PCL-4					
Compressor	C-1					
	C-2					
	C-3					
	C-4					
	C-5					
	C-1b					
	C-2b					
	C-3b					
	C-4b					
	C-5b					
Condenser	RC-1					
	RC-2					
	RC-3					
	RC-4					
Refrigerant Vessel	RV-1					
	RV-2					

	RV-3					
	RV-4					
	RV-5					
	RV-6					
	RV-7					
	RV-8					
Heat Exchanger	HX-1					
	HX-2					
	HX-3					
	HX-4					
	HX-5					
	HX-6					
Condensate Pump	CP-1					
	CP-2					
	CP-3					
	CP-4					
	CP-5					

Record total nameplate hp of condensate pump(s) under the appropriate circuit column

Exterior Lighting

Name	Fixture Code	Count	Control	Schedule
XLT-1				
XLT-2				
XLT-3				
XLT-4				
XLT-5				

Battery Chargers

Name	Make	Model	Qty.	Volts In	Amps In	Volts Out	Amps Out	Charging schedule
BC-1								
BC-2								
BC-3								
BC-4								
BC-5								
BC-6								

Miscellaneous Exterior Electric Loads

Name	Description	Qty.	kW/unit	Hp/unit	Schedule
MC-1					
MC-2					
MC-3					
MC-4					
MC-5					
MC-6					

Billing Meters

Meter Number (kWh meters only not kVAR)	Surveyed Space / Metered Spaced (%)	Meter Location
PG&E		
PG&E		

PG&E		
PG&E		
PG&E		

❑ Some or all meter information not available

Notes:

Sketch of Building Floor Plan

Be sure to include dimensions, North arrow, and zone and HVAC equipment locations

ENVELOPE SKETCH

Sketch elevations, exterior wall, interior wall, roof, and floor sections

INDUSTRIAL SITE REPORTS

Site 93

Project Overview

The project was a new air compressor for an automated bill-processing center. This system provides compressed air to the envelope making process and also supplies humidified air to the envelope processing area. Two adjacent company facilities operate on Quincy QMA two-step rotary screw compressors, the base case. An Atlas Copco with VFD control was installed in lieu of the Quincy.

Base case Analysis (From PG&E File)

One compressor is sufficient to supply all the air needed to the envelope processing center. The air demand was estimated to be an average of 205 ACFM, with peaks to 300 ACFM. The facility operates 24-hours, seven days a week. The following air demand schedule is a result of these two points.

ACFM	Frequency	Hours
110	50	438
158	200	1752
205	500	4380
253	200	1752
300	50	438
Total	1000	8760

The ex ante basecase assumed that the rotary screw compressor operating in the modulation mode would exhibit a linear relationship between actual air volume drawn into the machine inlet (ACFM) and the power required (kW). At full load the compressor in good condition would deliver its full ACFM at full load kW. During reduced air demand the compressor modulates which results in reduced ACFM and reduced kW. The typical linear performance curve extends down from the 100% ACFM @ 100% kW to a point where the compressor delivers no air and consumes 70% of full load kW.

An air demand profile was developed to determine basecase energy use. Kilowatt values were associated with each ACFM value in the air demand profile using the previous mentioned calibrated curve. The sum of the corresponding kW was multiplied by the hours to produce the energy consumed at that specific point.

Manufactured Specs @100 PSIG

	Comp 1
Make	Quincy
Model	QMA/60
Moter Eff.	92.50%
Full Load kW	55.57
Full Load CFM	300

Calculation

Estimated Data		Comp 1		Totals	
Inlet Flow ACFM	Hours	Avg. Demand kW	Avg. Flow ACFM	Total Demand	Total Energy
110	438	45.01	110	45.01	19,714
158	1752	47.65	157.5	47.65	83,483
205	4380	50.29	205	50.29	220,270
253	1752	52.93	252.5	52.93	92,733
300	438	55.57	300	55.57	24,340
	8760				*440,540 kWh*
					55.57 kW
				$	*28,193.50 $/yr*

Baseline System

%CFM	%kW
0	0.7
1	1
M	B
0.3	0.7

Proposed Analysis (From PG&E File)

A rotary screw compressor, operating in the variable speed mode, will exhibit a non-linear relationship between actual air volume drawn into the machine inlet (ACFM) and the power required (kW). At full load a compressor in good condition will deliver its full load ACFM rating @ the rated full load kW. During reduced air demand the variable speed drive reduces the speed of the motors, which results in reduced ACFM and reduced kW. The manufacturer provided the following curve.

Compressor Performance

ACFM	*kW*
55	*13*
97	*20*
110	*22.15*
132	*25.8*
157	*30.05*
205	*38.2*
245	*45.8*
252	*47.15*
273	*51.2*

291	*54.8*
300	*56.84*
328	*63.2*

Energy consumption of the proposed system was calculated using the same air demand profiles as was used for the basecase system. Kilowatt values were associated with each ACFM value in the air demand profile using manufacturer performance data. The sum of the corresponding kW is multiplied by the hours to produce energy consumption estimates. The following table summarizes the proposed case.

Manufactured Specs @100 PSIG

	Comp 1	
Make	Atlas Copco	
Model	GA50 VSD	
Moter Eff.	92.50%	
Full Load kW	66.28	*Assume 96% VSD efficiency*
Full Load CFM	328	

Calculation

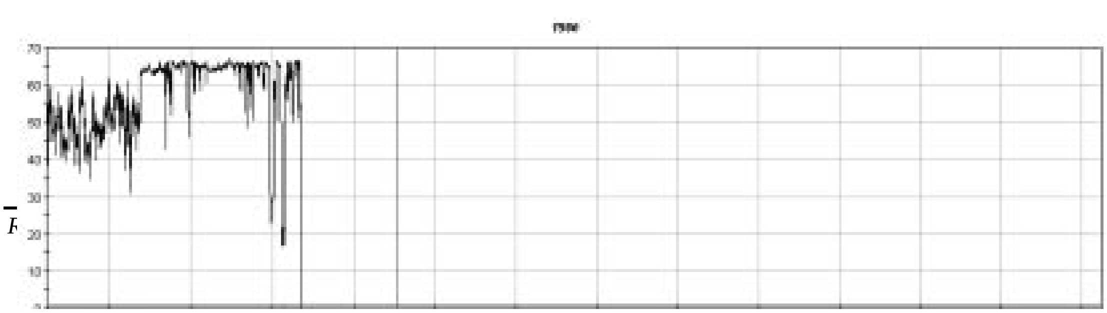
Estimated Data		**Comp 1**		**Totals**		
Inlet Flow ACFM	**Hours**	**Avg. Demand kW**	**Avg. Flow ACFM**	**Total Demand**	**Total Energy**	
110	438	22.15	110	22.15	9,702	
158	1752	30.05	157.5	30.05	52,648	
205	4380	38.2	205	38.2	167,316	
253	1752	47.15	252.5	47.15	82,607	
300	438	56.84	300	56.84	24,896	
	8760				*337,168*	*kWh*
					56.84	*kW*
				$	*21,578.58*	*$/yr*

RLW Analytics Evaluation

Changes since the basecase evaluation. There have been two envelope machines added. Each machine draws approx. 40-45 kW. Currently there are six machines that are supplied by the system, with a seventh being added in mid-September.

Metering

The compressor was metered form October 13 to November 4 for a total of 526.75 hours. The compressor power draw during this time period ranged from 16.9 to 67.2 kW, averaging 57.5 kW. The corresponding system demand ranged from 72 to 329 ACFM, averaging 285 ACFM. The compressor consumed an estimated 30,263 kWh during the metered period.



Base Case

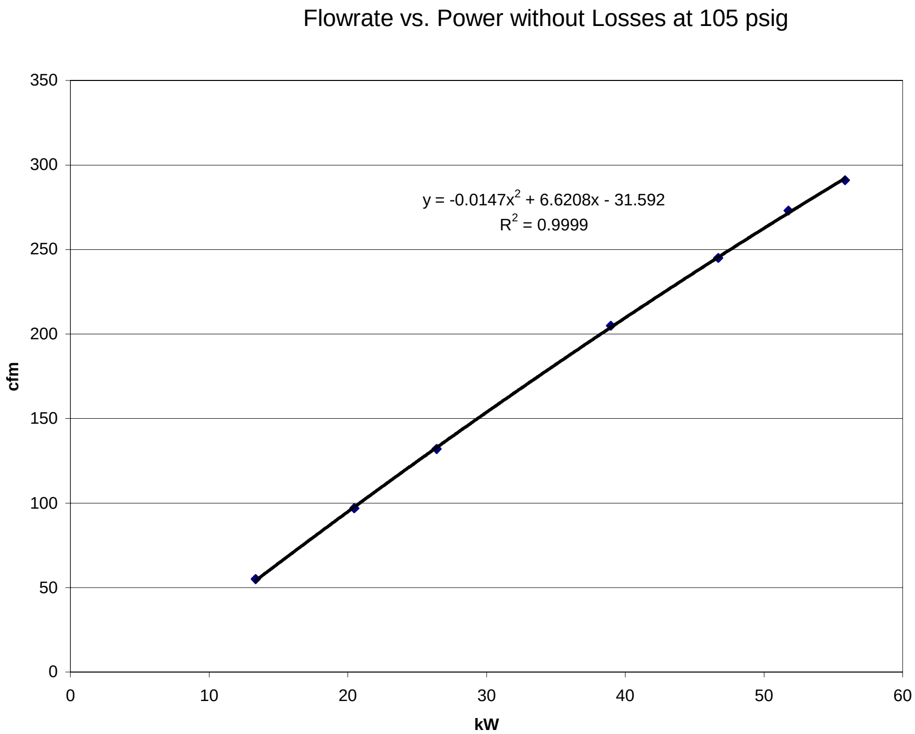
The base case used for this analysis is a Quincy QMA/60 rotary screw air compressor. This is a typical two-step compressor that operates under load, unloaded or idling mode, and off. This compressor is NOT a modulating compressor that reduces the flow rate by throttling the inlet valve, as noted in the PG&E file. For a given discharge pressure, the flow rate for this machine is set. Changing the discharge pressure will have only small change for the flow rate. According to manufacturer's specifications, under load this compressor will deliver approximately 300 ACFM at 100 psig. The discharge pressure of 105 psig found at the facility will have approximately the same flow rate, (at 125 psig the compressor has a specified flow rate of 299 ACFM), however the power draw at 105 psig will have an additional 2%, that is 102% of full rated power at 100 psig. The contention that the flow rate of this compressor can somehow be altered to meet demand is erroneous.

If the demand of the system is less than flow rate of for two-step rotary screw compressor, the system pressure will increase until it reaches a user specified unload pressure. The compressor will then go into an idling mode; the motor will still run drawing a fraction of full load power, yet no compressed air will be delivered. As the facility consumes the compressed air the system pressure decreases to an "on" pressure and the compressor goes back into loaded mode, producing compressed air. Typically, air compressor manufacturers claim power draw at idle to be 20 to 25 percent of the loaded power draw, as Quincy does with the QMA/60 , they are claiming 20%, which will be used for this analysis, however site measurements at other facilities have noted idling power draws much greater than specified, with power draws up to 50% not uncommon. The Quincy QMA/60 can be equipped with a device that will shut off the compressor after six minutes of idling time. It is doubtful that this feature would be utilized enough to produce significant energy savings at a facility with a steady demand profile such as is found at the facility under consideration.

The advantage to having a VSD installed on a rotary screw air compressor is the elimination of the wasteful idling mode. The VSD will operate continuously, delivering compressed air to match the demand of the system.

Air Demand Estimation

Atlas Copco specifications were used as a basis for air demand estimation. For discrete rotational speeds, total package power draws and compressed air flow rates are given. These values were curve fit to obtain an equation for ACFM as a function of Power draw as pictured below. No additional VFD losses were introduced, as was the case with the PG&E analysis. In discussions with Atlas Copco employee David Evans, he emphasized the compressor power draw specifications include any and all VFD losses, as the VFD is integrated with the unit.



Using the equation for compressor ACFM as a function of power draw, flow rates were calculated for each sampled power draw and summed for the metered period, this was expanded to estimate compressed air demand for an entire year. Assuming the metered period represents an average load profile over the whole year, the annual demand upon the system is estimated at 157,092,116 cubic feet per year. This would correspond to an energy consumption of 503,281 kWh per year.

The annual demand as estimated in PG&E program file, is considerably less, with the estimates multiplied out as shown in the table below.

ACFM	Hours	Total Volume
110	438	2,890,800
158	1752	16,608,960
205	4380	53,874,000
253	1752	26,595,360
300	438	7,884,000
Total	8760	107,853,120

The calculated annual volume from metered data of 157,092,116 cubic feet per year is 46% greater than the preliminary estimate of 107,853,120 cubic feet per year.

The comparison of the Atlas Copco GA-50 and the Quincy QMA/60 is hardly fair. The main reason being that, at 328 ACFM, the Atlas Copco has a greater capacity than the Quincy does, at 300 ACFM. According to our metered data, the base case Quincy QMA/60 would not have been able to supply the necessary flowrate for a majority of the metered time, in 1,237 out of 2,107 samples, the calculated flow rate is greater than 300 ACFM. Therefore there could not have been a 1:1 replacement for comparison of these two compressors. The following analysis assumes that an additional Quincy QMA/60 or equivalent is to supply the overflow demand, i.e. the demand beyond the capacity of one Quincy QMA/60.

The annual energy consumption of the calculated compressed air demand, 157,092,116 cubic feet per year, utilizing the base case Quincy QMA/60 is calculated as follows.

At the maximum delivery flow rate of 300 CFM at 105 psig the Quincy will draw an estimated 56.6 kW, an estimated 2% increase over the 100 psig manufacturer specified power draw. For the annual demand, Quincy compressor(s) would have to run continuously for 8727 hours resulting in an annual energy usage of 494,054 kWh/yr.

For samples that had corresponding flow rates less than 300 ACFM, the percentage of idling time for the compressor was calculated by summing the energy usage of the compressor producing compressed air and the energy usage for idling the compressor.

Compressor idling time was calculated for each 15-minute sample point that was below 300 ACFM with:

Idling Time = (sampled cfm/300 cfm) * 15

The idling time was summed up and expanded to provide an annual estimate. According to the data, the Quincy QMA would be unloaded mode for approximately 6.9% per cent of the time or 602 hours per year with the constant usage at IBS. At 20% of the full load power draw, 11.32 kW, this idling time would consume 6,813 kWh per year. Combined with the delivery usage of 494,054 this represents a total usage of 500,867 kWh per year.

Comparison

The 500,867 kWh per year total energy usage for the Quincy QMA/60 contrasts with the Atlas Copco GA 50-90 of 503,281 kWh/yr. This is a negative savings of 2,414 kWh/yr. This is largely due to the fact that the Quincy compressor delivers compressed air more efficiently than the Atlas Copco, 5.30 ACFM/kW compared to 5.20 ACFM/kW. Again, the demand was often greater than one Quincy QMA/60 could supply, under these circumstances the two-step compressor would not idle, therefore no wasted energy. These results should be looked at under the conditions outlined, primarily that fact that the capacity differential reduces the savings realized from the VFD, due to the fact that a smaller two step compressor will idle less than one of equal size under the same conditions and demand profiles.

A more fair comparison would be the same model compressor that has not been outfitted with a VSD. If the same model of compressor is operated as a two-step compressor, there will be an increase in efficiency due the lack of VFD losses, assumed at 4%. From manufacturers data the full power draw at 105 psig discharge pressure is 64.5 kW, assuming a 4% efficiency increase for the compressor without a VSD, the full load would be 61.9 kW (64.5 x 0.96=61.9). The following results can be derived with those assumptions.

Operating at full load, 328 ACFM, the compressor would satisfy the plant annual 105-psig compressed air demand in 7,982 hours, at 61.9 kW, this result in an energy consumption of 494,106 kWh/yr. With constant operation the compressor would then be idle for 778 hours, this computes to 8.9% idling time. Multiplying the full load hour by 61.9 kW and the idling hours by an assumed 20% of the full load power draw, the estimated idling energy usage of the compressor is 9,628 kWh/yr. Both modes represent an annual energy usage of 503,374. This would result in annual energy savings of 334 kWh/yr. Basically, the break-even point of a compressor equipped VFD against a two-step compressor with similar specifications is ~9% idling or unloaded time when assuming 4% VFD losses.

Considering the VFD on this compressor, although the energy saving are small for the time period it was monitored, that by no means rules out possible energy savings in the future. The IBS facility is expanding and more compressor power may soon be necessary. If this compressor is kept as the "top" compressor in the bank, and demand stays below 90% of full load capacity, then energy savings may yet indeed be realized.

Note

According to our metered data, savings were continuously realized from October 13 until October 21 at 1:30PM. At that point the compressor appears to operating at full power except for a few random hours until November 1, then the compressor seems to back in modulation mode until the from that point forward. Not only did the usage increase, it also became much more constant, resulting in a much smoother plot. This would indicate the utilization of more equipment or the development of a large compressed air leak. Another possible scenario is the failure of another compressor that had been supplying air to the system (this compressor is not the sole supplier for the system). When another compressor on the system "goes down' the added demand upon the Atlas Copco 50 would drive it to full load capacity, a condition where no VFD savings are realized. Whatever the activity may have been, it had a great effect on the estimated savings derived from the monitoring data.

Free Ridership

During the first site visit the facilities engineer was asked questions regarding "what they would have done in absence of the program". The facilities engineer said that the VSD would have been installed regardless of the PG&E program. The vendor of the proposed (Atlas Copco) compressed air system suggested that the company contact PG&E and inquire whether rebates were available. Company personnel asked the mechanical subcontractor to follow through with this, which they did. The incentive made purchasing the VSD more attractive, but would have been purchased regardless of the incentive. Since installing the VSD, the company has installed similar systems in other parts of the building.

Site 118

Project Overview

This project entailed the installation of premium efficiency motors instead of standard efficiency motors. The motors were used for a range of purposed associated with the offloading and processing of grain and materials from the railway.

Analysis (From PG&E file)

				Baseline			Proposed			Savings	
	QTY	HP	Hours/ year	Eff	kW	kWh	Eff	kW	kWh	kW	kWh
Main Auger	2	150	1300	93%	84	109489	95.0%	82.5	107188	3.5	4602
Grain elevator	2	100	7488	92%	57	423216	94.5%	55.3	413781	2.5	18870
Screw Auger	5	40	7488	90%	23	173424	93.0%	22.5	168182	3.5	26208
Screw Auger	2	30	7488	89%	18	131149	92.4%	17.0	126956	1.1	8387
Screw Auger	2	25	7488	90%	15	109105	92.4%	14.1	105796	0.9	6616
Screw Auger	3	20	7488	89%	12	88343	91.0%	11.5	85939	1.0	7211
Main Auger	1	60	1300	92%	34	44401	93.6%	33.5	43517	0.7	884
Screw Auger	7	15	7488	88%	9	67030	91.0%	8.6	64454	2.4	18031
Grain elevator	7	10	7488	86%	6	45487	89.5%	5.8	43690	1.7	12580
Screw Auger	3	7.5	7488	85%	5	34302	89.5%	4.4	32767	0.6	4605
Screw Auger	1	5	7488	84%	3	23265	87.5%	3.0	22344	0.1	921
Screw Auger	2	3	7488	83%	2	14161	86.5%	1.8	13562	0.2	1198
Screw Auger	2	2	7488	79%	1	9939	84.0%	1.2	9310	0.2	1258
Grain Cleaning	1	1	7488	83%	1	4730	84.0%	0.6	4655	0.0	75
Screw Auger	2	3	7488	83%	2	14155	89.5%	1.8	13107	0.3	2097
Total					270.39			263.4		18.7	113,542

Analysis was made using the formula:

kWh=((hp * .746*Loading Factor)/(Efficiency * VSD Eff)*hours per year (Eq #1)

Loading Factor was assumed to be .7 for all units.

Power consumption was calculated for both standard efficiencies and proposed efficiencies. These values were then subtracted from each other and then multiplied by the number of units to derive the total savings per unit.

RLW Analytics Evaluation

Analysis was completed by first interviewing personnel to further understand the facilities loading and scheduling profiles. A two-prong approach was taken with metering. First four Elite4 meters were used to record voltage, amperage, power factor, loading, true power, and usage hours. Second, six current loggers were used to profile usage hours. The combination of these two units allowed an extensive picture of facility.

Meters monitored the motors for four weeks.

On-site inspection revealed several different motor efficiencies than were reported. Additionally, interviews and metering indicated different run time hours. Metering further showed a different loading factor than was assumed in the initial analysis.

Savings

From the monitoring data, the load factors and operating hours of the monitored motors were determined. Unmonitored motors performing similar function as monitored were given load factors equal to the monitored counterparts. A default load factor of 0.7 was given to unmonitored motors with no monitored analogous motor. Operating schedules were obtained from plant personnel when no schedule could be derived from monitoring data.

Summary of Inspection and Monitoring Findings					
	QTY	HP	Hours/ year	Loading	Eff
Main Auger	1	150	3233	54%	91.7%
Main Auger	1	150	958	54%	91.7%
Grain elevator	1	100	3756	39%	94.5%
Grain elevator	1	100	552	39%	94.5%
Screw Auger	1	40	1016	19%	93.0%
Screw Auger	1	40	3176	19%	93.0%
Screw Auger	1	40	611	19%	93.0%
Screw Auger	1	40	1283	55%	91.0%
Screw Auger	1	40	1563	55%	91.0%
Screw Auger	1	30	360	70%	90.2%
Screw Auger	1	30	0	70%	0.0%
Screw Auger	1	25	7488	70%	89.5%
Screw Auger	1	25	360	70%	89.5%
Screw Auger	2	20	7488	70%	91.0%
Main Auger	1	60	0	70%	93.6%
Screw Auger	6	15	7488	70%	89.5%
Screw Auger	1	15	0	70%	91.0%
Grain elevator	7	10	7488	70%	89.5%
Screw Auger	3	7.5	7488	70%	89.5%
Screw Auger	1	5	7488	70%	87.5%
Screw Auger	2	3	7488	70%	87.5%
Screw Auger	2	2	7488	70%	84.0%
Grain Cleaning	1	1	0	70%	84.0%
Screw Auger	2	3	7488	70%	89.5%

This information was used to create an annual profile of 8760 hourly values for as built usage for these motors. A baseline profile was created from taking the each individual motor down to its baseline efficiency. The savings for this site was simply the difference from these two profiles. The results are as follows:

Net Period	**Energy Savings kWh)**	**Demand Savings (kW)**
Annual	**43,610**	
Summer On-Peak	3,309	-3.4
Summer Mid-Peak	4,443	6.7
Summer Off-Peak	14,291	11.4
Winter Mid-Peak	6,671	4.8
Winter Off-Peak	14,896	-2.7

The negative demand savings are a result of motor which were inspected and found to have a below baseline efficiency.

Free Ridership

Management at the facility went to PG&E looking for a rebate for motors. They would not have installed premium efficiency without a rebate. PG&E did not however influence them to change what was going to be installed more that the program acted as a funding mechanism for energy efficient motors.

Site 205

Project Overview

This project covers the installation of two dessicant dehumidification systems for a cleanroom facility in San Jose, CA. The new dessicant systems are a part of a project to convert existing office and corridor space into cleanrooms. The dessicant systems are designed to efficiently dehumidify outdoor air supplied to the facility, in order to maintain a maximum cleanroom humidity of 40%.

Base case Analysis (From PG&E File)

Existing cleanrooms use a chilled glycol system driven by an electric chiller for dehumidification. To meet the humidity control criteria for the cleanroom processes, the outdoor air must be cooled to approximately 41°F.

Proposed Analysis (From PG&E File)

The energy savings from each measure were evaluated using the DOE-2.1E building energy simulation program. The systems are expected to save 908,206 kWh per year.

Project Evaluation

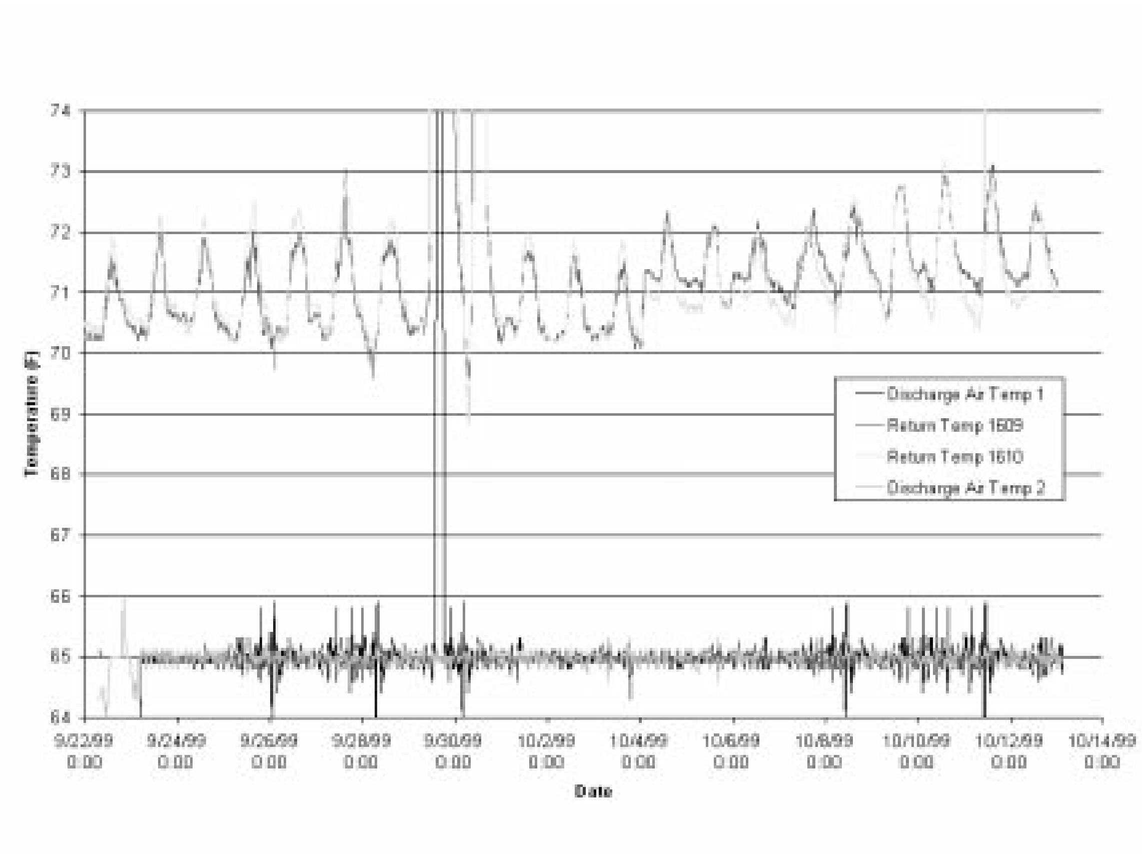
Facility characteristics were gathered during an on-site survey and plans review. These data were entered into the SurveyIT database. ModelIT software was used to develop a DOE-2 model of the facility and perform the required parametric runs. The details of the assumptions and procedures used by the ModelIT software are available upon request. Additional BDL was developed to simulate the performance of the desiccant cooling system.

Base Case

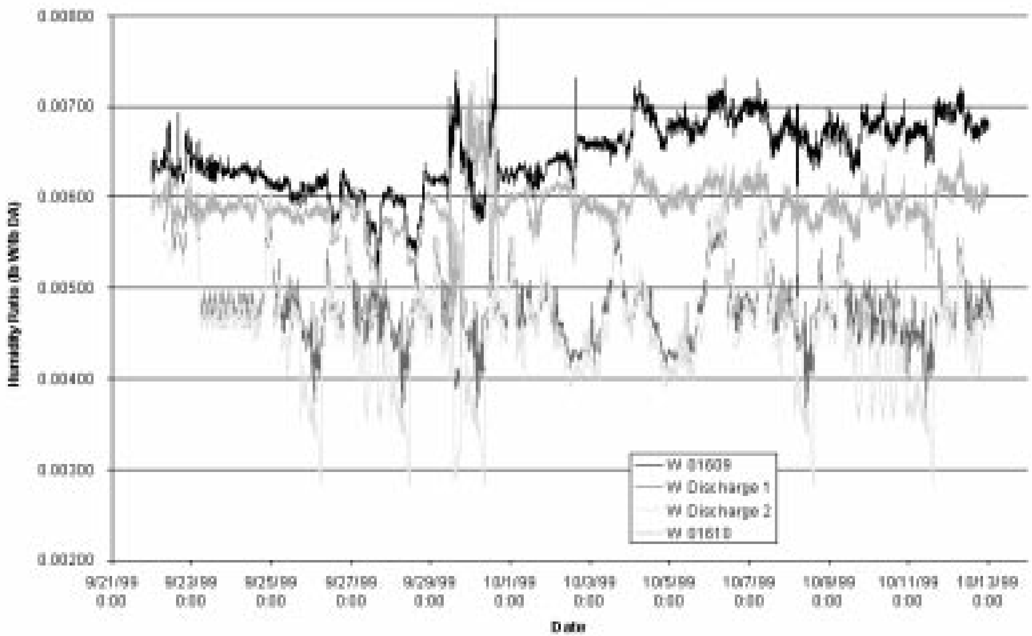
Title 24 standards were applied to all aspects of the facility covered by Title 24, such as the building shell, indoor lighting, chiller efficiency, HVAC controls, and motor efficiency. The standard was applied to all Title-24-covered attributes, regardless of whether an incentive was paid.

Metering

Short-term monitoring of HVAC equipment and process loads was used to calibrate the DOE-2 models. Data were gathered using energy management system (EMS) trend logs. A summary of the data collected is shown below:



Discharge air temperature from the desiccant/air handling system is in the range of 65°F. Zone-level cooling is done by re-circulating air handlers located in each clean room.



Supply and return air humidity ratios show some moisture pickup in the space. The return humidity ratios translate to a zone relative humidity of 40 – 45 percent.

Comparison

The energy savings calculated by the DOE-2 model created for this project are shown below:

Measure Category	Total Savings	Measures-only Savings	Program Savings
Shell	0	0	0
Lighting	31,520	0	0
HVAC	1,239,238	1,239,238	908,206
Motors	0	0	0
Refrigeration	0	0	0
Total	**1,270,758**	**1,239,238**	**908,206**
Realization rate	**1.40**	**1.36**	

Free Ridership

The customer refused to participate in the free-rider survey. The default value 0.75 was used as the net to gross ratio for this facility.

Site 210

Background

Site 210 was an Industrial New Construction participant in the PG&E 1997 C&I New Construction Program. They received an incentive for installing VSD controllers on three of the fan motors used in a glass-tempering furnace. A 200 HP primary blower supplies outside air to a 200 HP booster blower that injects high pressure air into the furnace during the quench cycle. The 60 HP low power quench fan is also used to deliver air at the same time as the two high power quench fans. Savings for this project resulted from ramping up and down the frequency of the motors between the quench cycles. The following summarizes the quench cycle used to calculate savings:

- The entire quench cycle lasts 125 seconds
- Full fan CFM is required for 20 seconds
- Fan CFM is increased over a 25 second period
- Fan CFM is decreased over a 25 second period
- Annual hours of operation (*16 hours*5 days*52.14 weeks*) 4,171 Hours / Year

Assumptions used for the engineering calculations on the equipment are as follows:

  - (2) 200 HP Fan Motors, 95% efficient, 214 BHP, 46,000 CFM
  - (1) 60 HP Fan Motor, 93.6% efficient, 57 BHP, 12,000 CFM

<u>Base case</u>

The following calculations estimate the energy use of the high pressure quench blower, booster blower, and the low pressure quench blower as the base case conditions.

Base Case Calculations

	Seconds (0)	Base Case % CFM (1)	HP Quench BHP (2)	HP Booster BHP (2)	LP Quench BHP (2)	HP Quench kW (3)	HP Booster kW (3)	LP Quench kW (3)	Total kW	Base case Annual kWh (4)
	20	100%	214	214	57	168	168	45.4	381.4	254,531
	10	97%	180	210	50	141	164.9	39.9	345.8	115,387
	10	94%	151	207	44	118.6	162.5	35.1	316.2	105,510
	10	91%	128	204	39	100.5	160.2	31.1	291.8	97,368
	10	88%	110	202	35	86.4	158.6	27.9	272.9	91,061
	10	85%	98	201	33	77	157.8	26.3	261.1	87,124
	55	80%	90	200	31	70.7	157.1	24.7	252.5	463,398
Total Cycle Secs.	125									1,214,378
Hours Per year	4171					**Average 15-Minute Demand (5)**			291.15	

Notes:

(0) Time per cycle at each speed

(1) The fan flow profile is linear between the maximum and minimum flows. The minimum flow is takenf form the fan curves at the min. flow position. Minimum flow for the HP quench is system is 37,000 CFM per the curves supplied by manufactureer. Max flow for the HP, booster, and LP are 46,000, 46,000, and 12,000 respectively.

(2) Base case fans curves supplied by manufacturer for the minimum flow case. The intermediate flows are assumed to be decreased linearly through the acceleration and the deceleration periods of the fan cycle. The resulting BHP is calculated as varying with the square of the speed between the min and max points... *BHP = BHMmin + ((CFM - CFMmin)/(CFMmax - CFMmin))^2 * (BHPmax - BHPmin)*

(3) The motor *kW = BHP * 0.746 (kW/HP) / Motor Eff.*

(4) The annual energy use at each point in the fan profile.... *kWh = kW * time per cycle (sec) / total cycle duration (sec) * annual hour / year*

(5) The average 15-minute demand while the furnace is in operation is calculated as kW = kWh / annual hours / yr.

RLW Analysis

Since participating in the program the operation at site 210 has changed significantly. Shortly after the installation of the VSDs, site 210 added another furnace to the tempering equipment. By adding another furnace to the line there is no longer a need to ramp down the VSD's because they have doubled the amount of product coming out of the furnace. Additionally, they have reduced the number of hours per day that 1/8-inch glass is tempered. Note that the fans rebated are only used to temper 1/8-inch glass, thicker glass does not require cooling down as does 1/8 inch glass.

Glass tempering of 1/8-inch glass now happens approximately six hours per day. During this time the VSDs are all running near full frequency. To verify this, the owner of the company tempered several pieces of 1/8 inch glass during the site visit to confirm VSD frequencies during the process and to explain the new operation. The following operation was visually and verbally verified.

- Full cycle now takes 63 seconds because of added furnace
- (2) 200 HP booster and quench fans ran at 49.7 Hz consistently during the 63 second quench cycle.
- (1) 60 HP LP booster ran at 59 Hz during the 63 second quench cycle.
- Annual hours of operation are (6 hours/day * 5 days * 52.14) 1,564.2 hours per year.
- Motor efficiencies, 200 HP @ 95%, 60HP @ 93.6%
- Not able to verify CFM

There are no savings associated with the measures installed at this site because the operation of the tempering systems has changed. The VSD controllers are now a constant volume application and are possibly causing negative net energy savings due to energy consumed by the controllers. A decision was made not to meter this site based upon information attained while on-site and information given by the owner of the building, that information is as follows:

- The VSD controls have been reprogrammed to run at a fixed speed during tempering of 1/8-inch glass. (Visually verified)
- Different size glass is tempered, only 1/8 inch glass requires the rebated fans during the quench cycle.

The owner of the building felt like there may be some potential savings if the VSDs were reprogrammed for the new operation. They would be significantly reduced because there is only a 30-second period of time that the fan speed could be reduced. The owner felt this would probably not be in his best interest because he felt it would depreciate his motors and the frequent increase and decrease in RPMs would be a sonic annoyance to his employees.

Decision Maker Information

The owner of site 210 went to PG&E with the intentions of getting a rebate for installing this VSD. He was aware of PG&E rebates and thought it could help fund installing the VSD in lieu of the constant volume system. He would not have installed the VSD without the rebate, but at the same time was not influenced by PG&E. He did not know how long of a payback the installed measure would have.

Site 223

Project Overview

The project entailed the installation of a VSD on a 2000 hp motor. This system provided crude oil transportation to the refineries in Los Angeles from the oil fields in Kern County. The VSD was installed on the motor to allow reduction in the speed of the motor to meet the head requirements caused by changing barreling needs at the refinery.

Base Case (From PG&E file)

A 2000 hp motor would have been installed to provide transportation. The basecase assumed pumping requirements of 130,000 barrels per day (3792GPM), with the facility pumping 24 hours a day 7 days a week.

Hp	Motor Eff	VSD Eff	kW	hrs/year	kWh
2050	95.7%	NA	1598	8760	13,998,608

Analysis was made by first determining hp requirements from the pump curve to maintain the specified flow. That hp was then applied to the equation:

kWh=((hp * .746)/Motor Efficiency * VSD Eff)*hours per year (Eq #1)

Proposed Analysis (From PG&E file)

The proposed case was calculated in the same manner. However, due to the modulation of the speed to meet minimum head requirements a lower hp was required.

HP	Motor Eff	VSD Eff	kW	hrs/year	kWh
1446.7	96%	96.63%	1163	8760	10,191,502

RLW Analytics Evaluation

Upon interviewing station personnel it was revealed that the flow requirements of the refinery, originally estimated at 130,000 barrels per day, is well below what was anticipated and used in the original base case. This was confirmed in analysis of the metered data. Thus it was necessary to re-calculate the base case using actually occurring flows.

The motor was metered using an Elite4 meter. This meter records voltage, current, power factor and true power at fifteen-minute intervals. The data revealed that the average power consumption per hour was 885 kW.

Using the above formula and inserting the average kW the average VFD hp was derived.

	hrs/yr	kW	HP	GPM	BPD	kWh
Basecase	8760	1216	1559	3461	118,671	10,648,637
VFD	8760	885	1100	3461	118,671	7,752,600
						2,896,037

The calculated horsepower was then inputted into the Affinity laws:

$(F_1/F_2)^3 * hp_2 = hp_1$ (Eq #2)

$F_1=3792$

$HP_1=1446.7$

$HP_2=1100$

These values were taken from the maximum flow as defined previously and were used to solve for the new flow rate. This flow rate was then converted into barrels per day, using the relationship that one barrel is equal to 42 gallons. This flow rate was then used to calculate the basecase hp by again using the Affinity laws (Eq #2) to solve for hp by employing the motors statistics:

$HP_1=2050$

$F_1=3792$

$F_2=3461$

This hp rating was then applied to Equation 1 to determine kW usage. Reductions in savings were found to be due to reduced usage.

	Ex Ante	Recalculated
Basecase	13,998,608	10,648,637
VFD	10,191,502	7,752,600
Total	**3,807,106**	**2,896,037**

Demand Savings

According to plant personnel activity at the facility was not seasonal and the monitored period was representative of the entire year. Thus, the load profile for the monitored period was annualized by simple extrapolation to create an as-built yearly profile of 8760 hourly values. The recalculated basecase was used for generation of a baseline profile. The demand savings were simply the difference between the as built and the baseline profiles at the utility coincident peak hours. The result are summarized as follows:

Net Period	Energy Savings (MWh)	Demand Savings (MW)
Annual	**2,896,037**	
Summer On-Peak	255,883	144.9
Summer Mid-Peak	298,530	647.2
Summer Off-Peak	905,508	178.4
Winter Mid-Peak	537,222	299.7
Winter Off-Peak	898,896	299.2

Free Ridership

A design engineer for Site 223 was interviewed as the decision-maker for this project. He was first introduced to the project in 1990 when the project was in its conceptual stage. In 1994 an environmental impact report (EIR) was prepared for the company. One of the clauses of the EIR was that this company should make all efforts to install Variable Frequency Drives on the pipeline pumping motors. The first conceptual design of the pumping station was a parallel system that did not utilize VSDs due to cost effectiveness. A parallel pumping system would have meant that approximately six VSDs would have been needed to be installed on Grapevine station (station #3) and pumping station #2.

Later a second conceptual design was completed. This design was a series pumping configurations at Grapevine station and a parallel pumping configuration at station #2. This new design would only require one large VFD at Grapevine station. At this time company employees called PG&E to see if their rebate program would support this design. The rebate PG&E offered made the project more cost effective and attractive to Pacific Pipeline. When I asked the design engineer if the VSD would have been installed without the rebate he said that he thinks he would have recommended it with or without the incentive. He also stated that without the VSD they may not have been in compliance with the EIR. Finally, he said that they had ordered the VSD before PG&E approved the project because of the fast tracked nature of the project.

Site 229

Project Overview

This project covers energy efficiency improvements to a new manufacturing facility constructed in Emeryville, CA. The project covers building 4; a 280,000 SF, six story laboratory and administration building, and building 7a; an adjacent central plant building. Incented measures include:

- Variable flow laboratory hoods
- Supply air reset control
- Close-approach cooling tower
- High-efficiency chillers
- High efficiency steam boiler
- Variable speed drives for chilled water and hot water pumping loops
- Energy-efficient motors

Base case Analysis (From PG&E File)

Title 24 standards were used to define the baseline for all applicable measures. For motors, PG&E prescriptive incentive program minimum efficiencies were used. Where Title 24 did not apply, the conditions prevailing at the existing facility were used as the baseline. A summary of the baseline specifications is shown below:

Measure	**Description**	**Baseline**
1	VAV Controls for Lab	Constant-volume hoods, as operated in the existing facility
2	HVAC reset controls for supply air temps	Constant supply air temperature @ 55°F
3	Low approach cooling towers	17°F approach
4	High efficiency chillers	Standard efficiency chiller per Title 24
5	High efficiency boilers	Standard efficiency boilers per Title 24
6	ASDs on CHW tertiary pumps	Constant speed pumps
7	ASDs on CHW secondary pumps	Constant speed pumps
8	ASDs on HW pumps	Constant speed pumps

	Hi efficiency motors (building 4)	Standard efficiency motors

Proposed Analysis (From PG&E File)

The energy savings from each measure were evaluated using the DOE-2.1E building energy simulation program. A summary of the measure savings estimates are shown below:

Measure	**Description**	**Projected Savings**
1	VAV Controls for Lab	3,673,436 kWh 20 kW
2	HVAC reset controls for supply air temps	65,606 kWh 0 kW
3	Low approach cooling towers	Rebate not paid for this ECM
4	High efficiency chillers	Rebate not paid for this ECM
5	High efficiency boilers	Rebate not paid for this ECM
6	ASDs on CHW tertiary pumps	111,061 kWh 0 kW
7	ASDs on CHW secondary pumps	155,248 kWh 0 kW
8	ASDs on HW pumps	33,285 kWh 0 kW
	Hi efficiency motors (building 4)	504,042 kWh 66 kW

Project Evaluation

Facility characteristics were gathered during an on-site survey and plans review. These data were entered into the SurveyIT database. ModelIT software was used to develop a DOE-2 model of the facility and perform the required parametric runs. The details of the assumptions and procedures used by the ModelIT software are available upon request.

Base Case

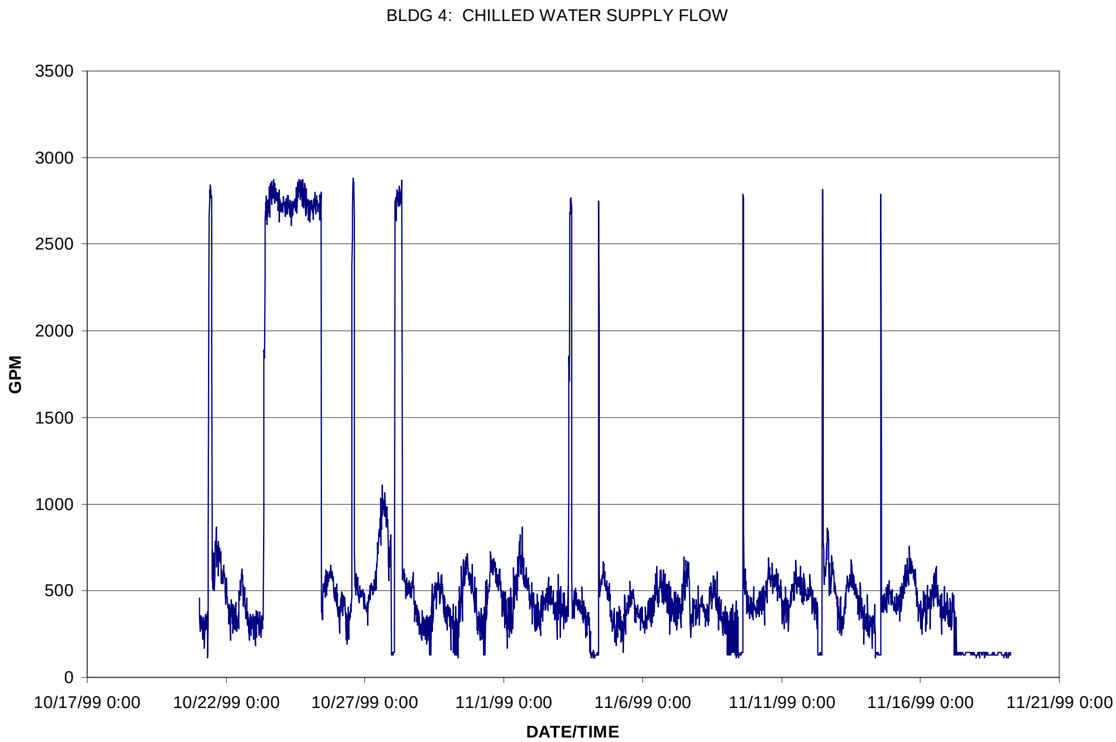
Title 24 standards were applied to all aspects of the facility covered by Title 24, such as the building shell, indoor lighting, chiller efficiency, HVAC controls, and motor efficiency. The standard was applied to all Title-24-covered attributes, regardless of whether an incentive was paid. Baseline characteristics defined by the program were used for building attributes not covered by Title 24.

Metering

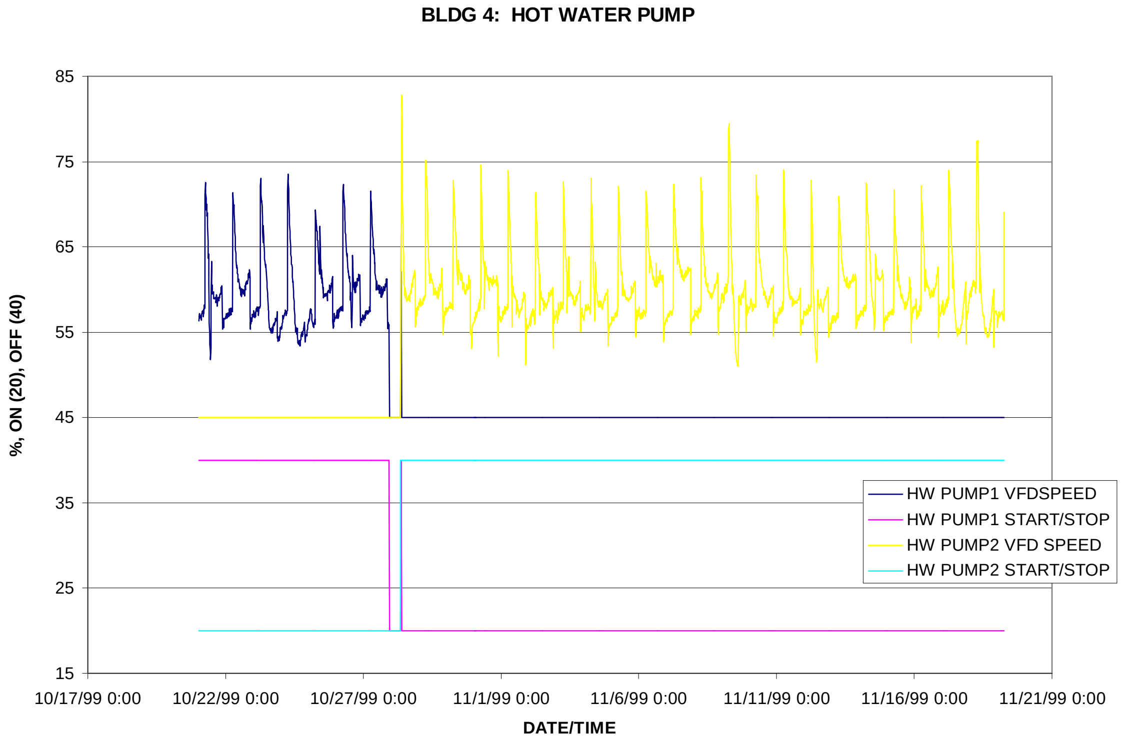
Short-term monitoring of HVAC equipment and process loads was used to calibrate the DOE-2 models. Data were gathered using energy management system (EMS) trend logs. A summary of the data collected is shown below:

- CHILLED WATER SUPPLY FLOW
- CHILLED WATER SUPPLY TEMP
- CHILLED WATER RETURN TEMP
- CHILLED WATER PUMP1 VFD SPEED OUTPUT
- CHILLED WATER PUMP1 START/STOP
- CHILLED WATER PUMP2 VFD SPEED OUTPUT
- CHILLED WATER PUMP2 START/STOP
- HOT WATER PUMP1 VFD SPEED OUTPUT
- HOT WATER PUMP1 START/STOP
- HOT WATER PUMP2 VFD SPEED OUTPUT
- HOT WATER PUMP2 START/STOP
- HOT WATER SUPPLY TEMP
- HOT WATER RETURN TEMP
- AIR HANDLER 1 VFD SPEED OUTPUT
- AIR HANDLER 4 VFD SPEED OUTPUT
- AIR HANDLER 1 SUPPLY AIR TEMP
- AIR HANDLER 2 SUPPLY AIR TEMP
- AIR HANDLER 3 SUPPLY AIR TEMP
- AIR HANDLER 4 SUPPLY AIR TEMP
- AIR HANDLER 5 SUPPLY AIR TEMP
- AIR HANDLER 6 SUPPLY AIR TEMP
- AIR HANDLER 1 PRE HEAT TEMP
- AIR HANDLER 2 PRE HEAT TEMP
- AIR HANDLER 3 PRE HEAT TEMP
- AIR HANDLER 4 PRE HEAT TEMP
- AIR HANDLER 5 PRE HEAT TEMP
- AIR HANDLER 6 PRE HEAT TEMP

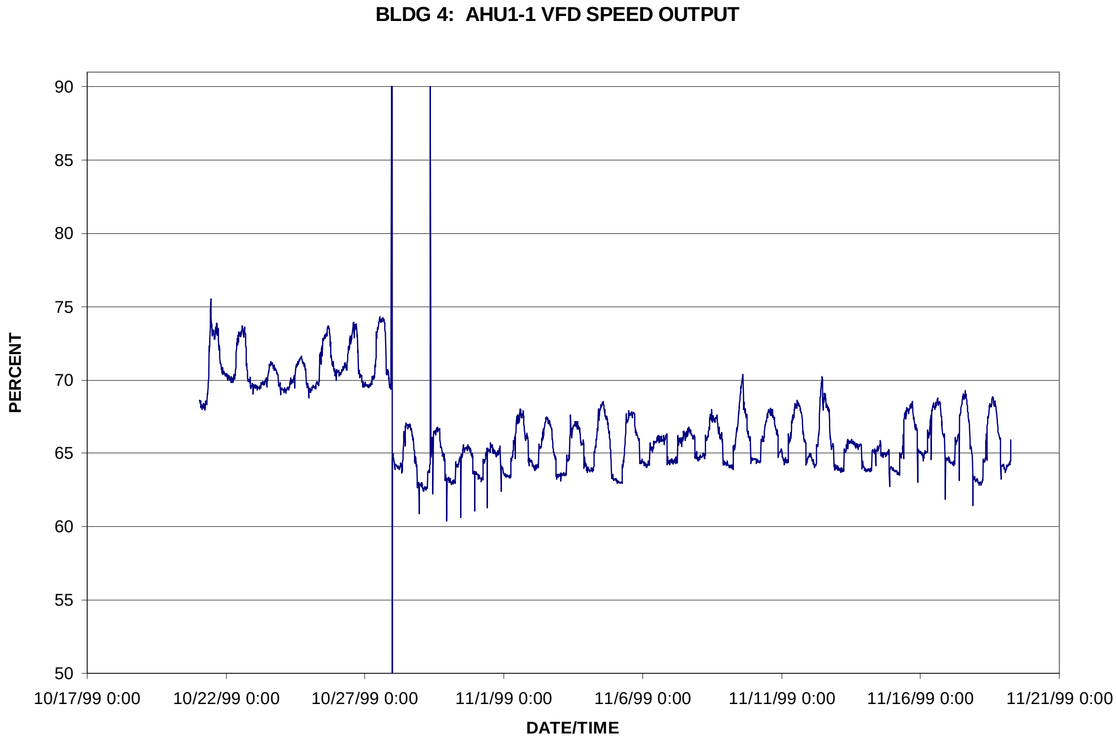
Representative results of the short-term monitoring are presented in the following graphs:



This plot demonstrates significant variation in the chilled water flow rate to Building 4, indicating effective application of a variable speed drive.

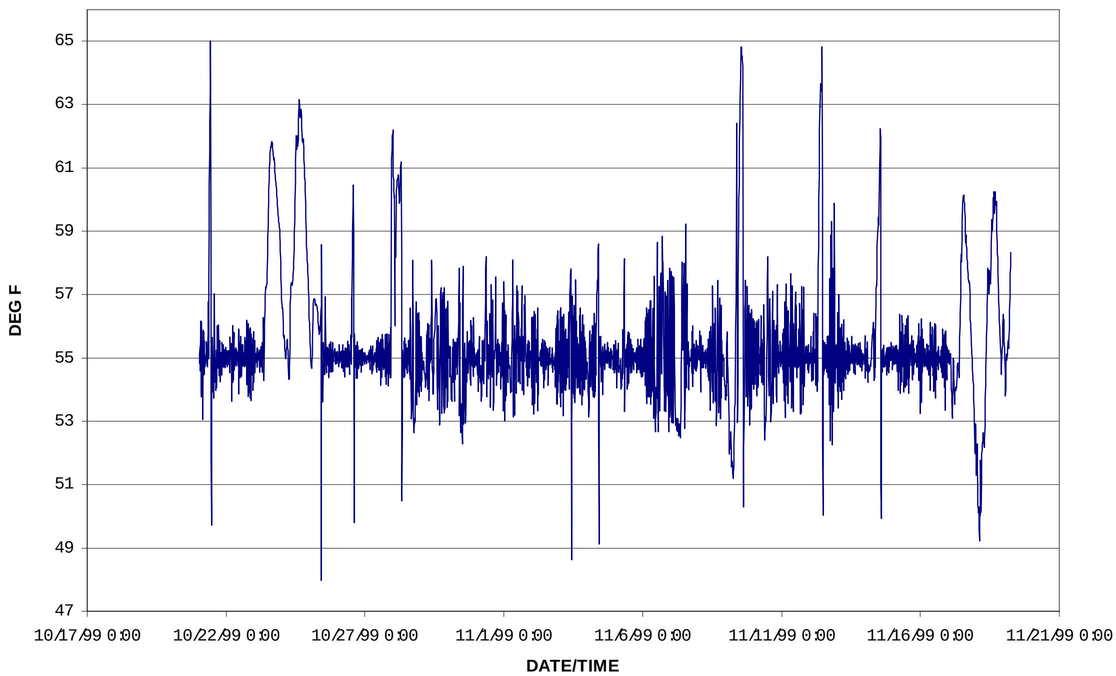


This plot demonstrates significant variation in the hot water flow rate to Building 4, indicating effective application of a variable speed drive.

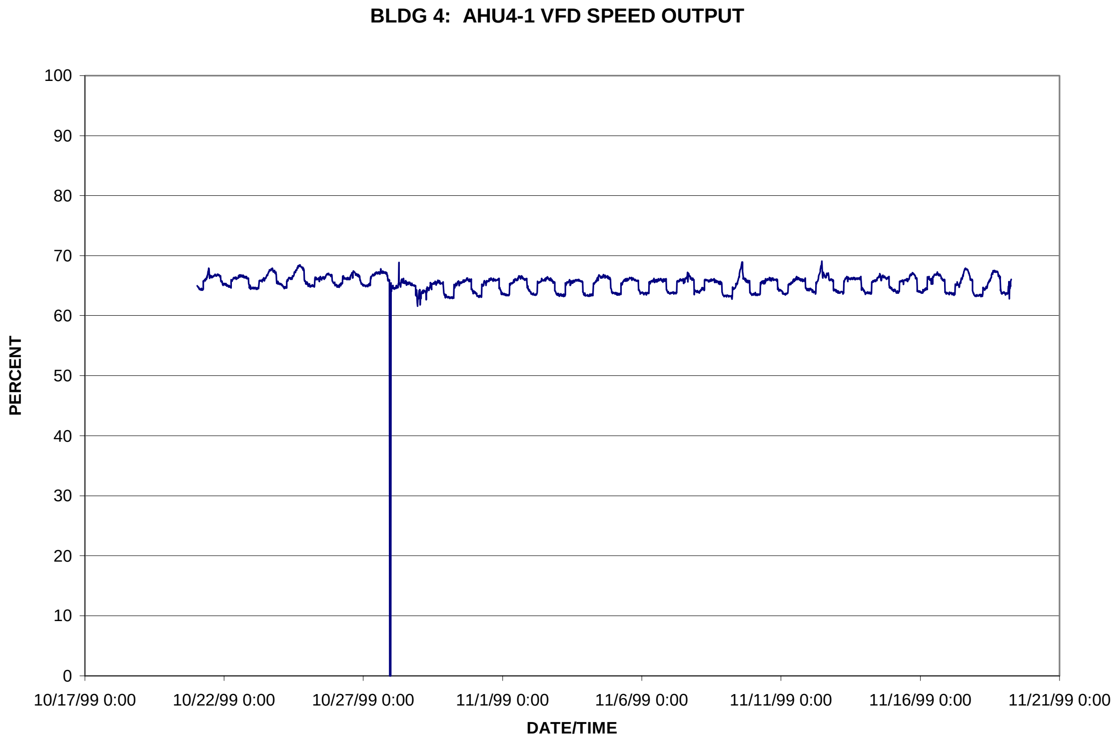


This plot demonstrates significant variation in the air flow rate from AHU-1, indicating effective application of a variable speed drive. A similar plot was obtained for other air handlers serving office and administrative spaces.

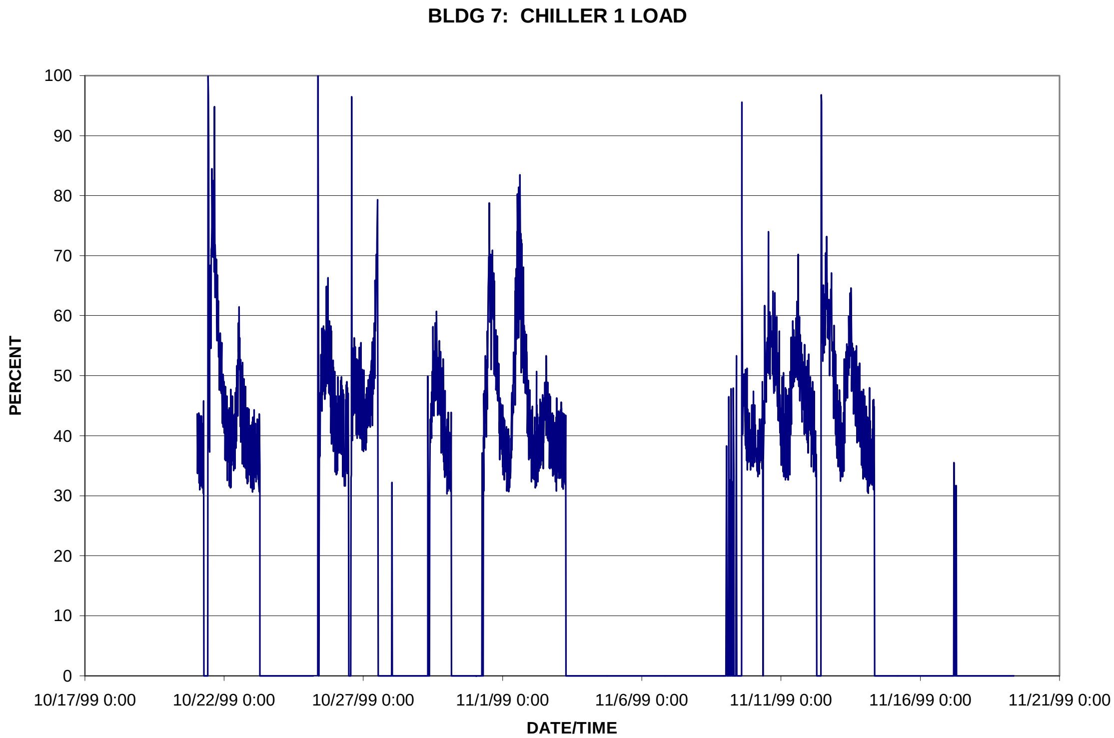
BLDG 4: AHU1 SUPPLY AIR TEMP.



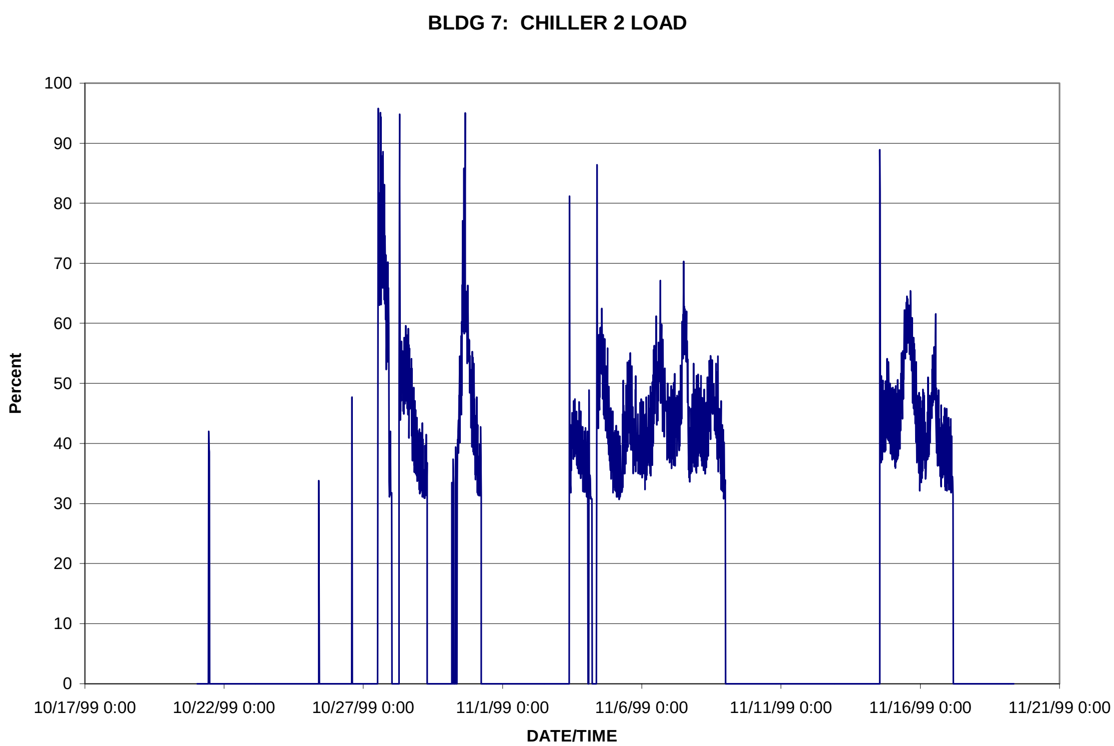
This plot indicates variability in the supply air discharge temperature from AHU-1, indicating the supply air reset control is functioning. A similar plot was obtained for other air handlers serving office and administrative spaces.



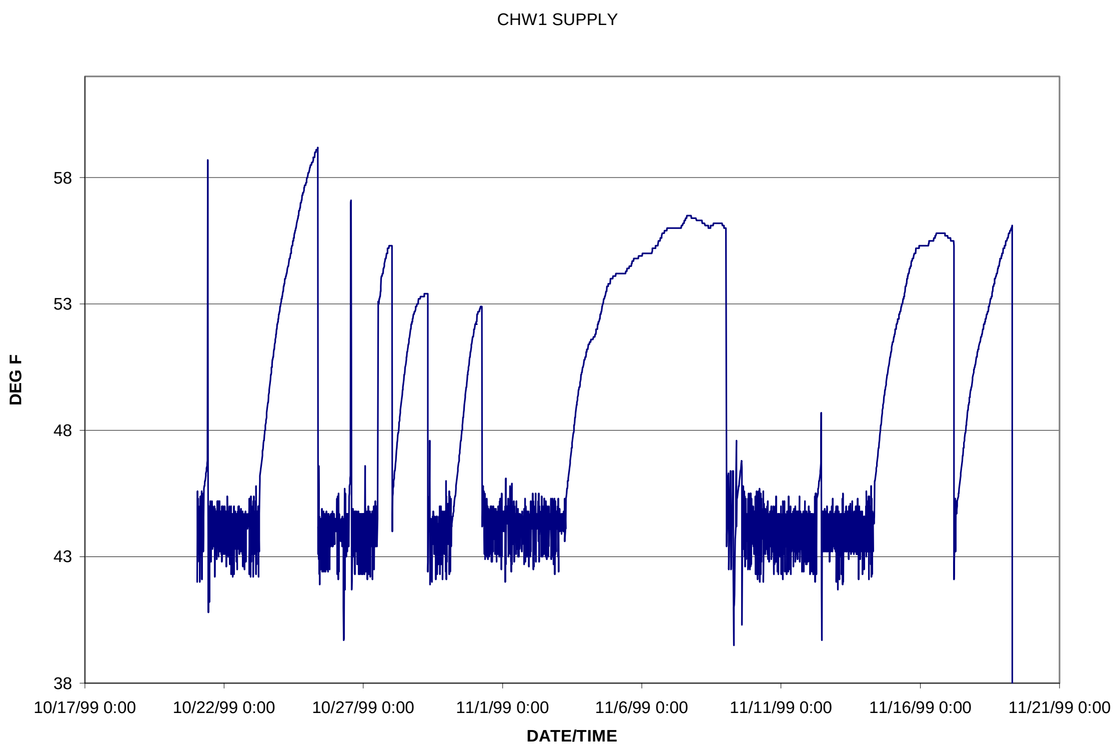
This plot demonstrates significant variation in the air flow rate from AHU-4, indicating effective application of a variable speed drive. Although the relative variation is small, the average flow rate is about 60 percent of design, indicating significant savings in fan power and outdoor air conditioning energy. A similar plot was obtained for other air handlers serving primarily laboratory spaces.

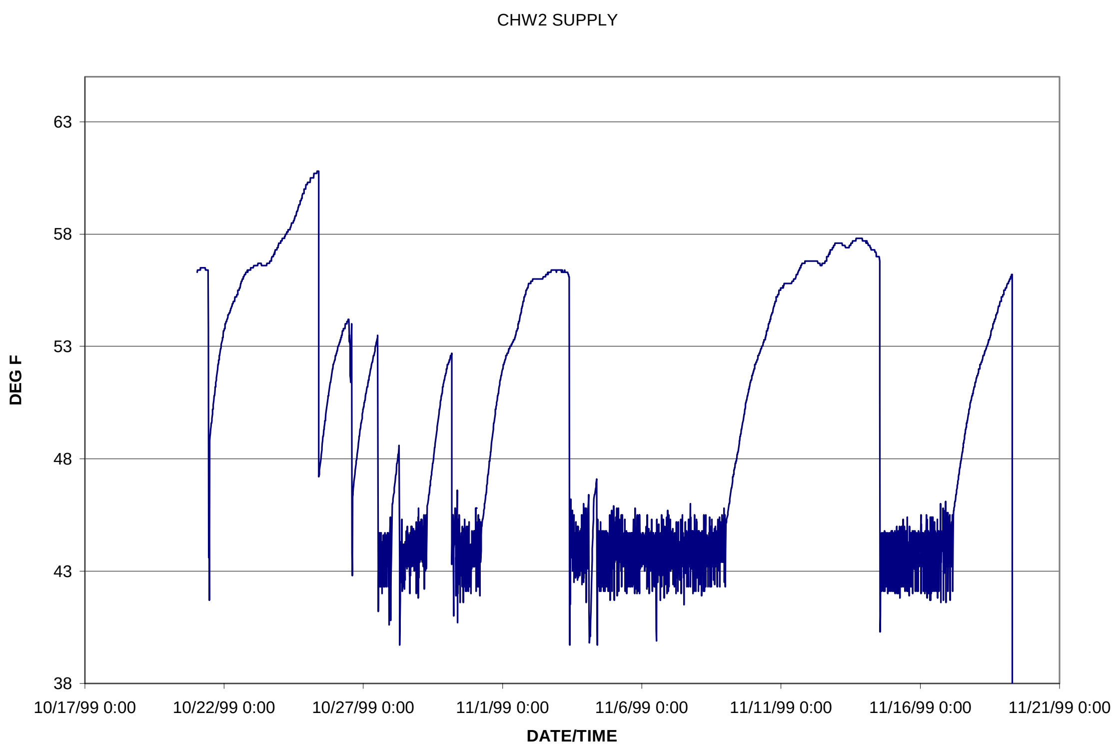


This plot shows the hourly variation in chiller loading for chiller 1. Average loading is around 40 to 50 percent, with periodic loading approaching 80 percent. The small, instantaneous spikes are due to chiller startup transients.

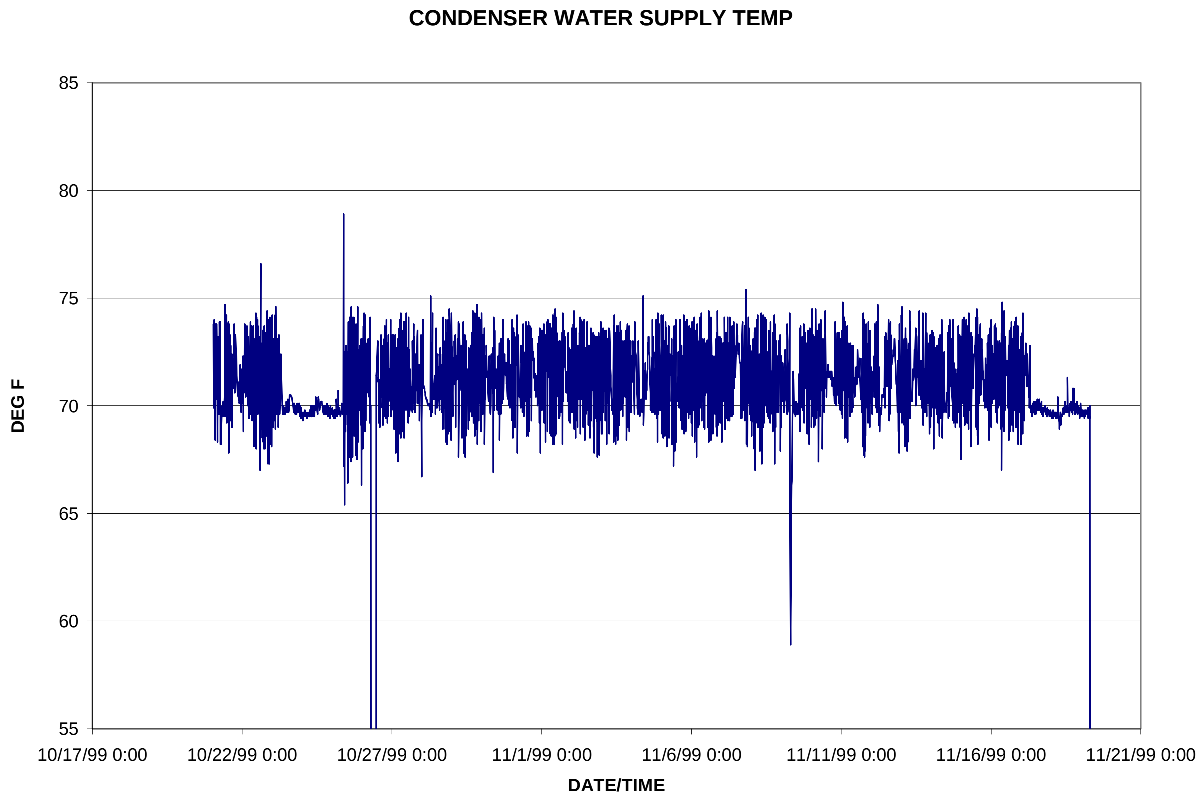


This plot shows the hourly variation in chiller loading for chiller 2. Average loading is also around 40 to 50 percent, with periodic loading approaching 80 percent. The chillers appear to be operating in a "duplex mode," where the chillers operation is alternated.





The preceding two plots indicate a chilled water setpoint of about 44°F. Note the temperature excursions caused by duplex operation.



This plot indicates a condenser water setpoint temperature of about 70°F.

Comparison

The energy savings calculated by the DOE-2 model created for this project are shown below:

Measure Category	Total Savings	Measures-only Savings	Program Savings
Shell	-364,500	0	0
Lighting	583,839	0	0
HVAC	5,488,342	5,419,125	4,038,636
Motors	27,874	27,874	504,042
Refrigeration	0	0	0
Total	**5,735,555**	**5,446,999**	**4,542,678**
Realization rate	**1.26**	**1.20**	

Although the shell (primarily glazing) specifications did not meet Title 24, non-incented lighting measures more than made up the difference. The surveyor could not gain access to air handler motors during on-site survey, thus the motor savings may be under-reported. HVAC savings, primarily from VAV hoods, are very close to program expectations. Short-term monitoring of air-handler flow rates show significant turn-down of AHUs during all hours.

Free Ridership

Measure	Description	Survey Question #1 Comments
1	VAV Controls for Lab	Management would have installed some VAV controls but not to the extent done with rebate.
2	HVAC reset controls for supply air temps	Would **not** have done w/o rebate
3	Low approach cooling towers	Would **not** have done w/o rebate
4	High efficiency chillers	Management would have installed a high efficiency chiller but not as high performance as the one chosen with PG&E analysis.
5	High efficiency boilers	Would have done w/o rebate
6	ASDs on CHW tertiary pumps	Would **not** have done w/o rebate
7	ASDs on CHW secondary pumps	Would **not** have done w/o rebate
8	ASDs on HW pumps	Would **not** have done w/o rebate
9	Hi efficiency motors (building 4)	

Note: The facility engineer interviewed for this survey was instrumental in getting support from upper management for this project. He said that PG&E was involved from the beginning so it is difficult to define would have been done in their absence. He said that the engineering analysis services provided by PG&E were very important to the success of this project. In response to the question regarding corporate payback criteria, he said that the company likes quick paybacks but he did not define what "quick" meant. Further discussion indicated that a 2-4 year range was acceptable for most projects. He said that no specific payback was expected for the measures in this project, but that upper management had to be convinced that the long term savings was worth the investment on this project.

Site 257

Project Overview

This project covers energy efficiency improvements to a new manufacturing facility constructed in Vacaville, CA. The project covers 6 buildings totaling approximately 240,000 SF of new construction. Incented measures include:

- Energy-efficient lighting
- Supply air reset control
- Tower-direct process cooling loop
- High-efficiency process chiller with thermal energy storage
- Close-approach cooling tower
- Variable speed drives for chilled water, hot water, and process water pumping
- Variable speed drives for VAV air handler fan flowrate control
- Energy-efficient motors
- Refrigeration system improvements

Base case Analysis (From PG&E File)

Title 20 and Title 24 standards were used to define the baseline for all applicable measures. For motors, PG&E prescriptive incentive program minimum efficiencies were used. Where Title 24 did not apply, the characteristics of the company's South San Francisco facility, design engineer standards, or company internal design standards were used as the baseline. A summary of the baseline specifications is shown below:

Measure	Description	Baseline
1	Lighting Efficiency	Title 24 LPD
2	High performance glazing	Title 24 U-value and shading coefficient
3	Discharge air reset	No reset per design standards
4	Adjustable speed drives for VAV air handlers	Inlet vane control per Title 24
5	High efficiency boilers	Standard efficiency boiler
6	Boiler economizers	No boiler economizer
7	Tower water for process cooling	Standard-efficiency chiller per

		Title 24 and tower
8	Process chiller w/ surge tank	No surge tank
9	Process chiller efficiency	Standard efficiency chiller per Title 24
10	HVAC chiller efficiency	Standard efficiency chiller per Title 24
11	Cooling tower approach 8°F	Cooling tower approach of 14°F per design standards
12	Cooling tower approach 4°F	Cooling tower approach of 14°F per design standards
13	ASD for HW pumps	Constant volume pumps per design standards
14	ASD for Primary RW pump	Constant volume pumps per design standards
15	ASD for RW Cond pumps	Constant volume pumps per design standards
16	ASD for secondary RW pumps	Constant volume pumps per design standards
17	ASD for tertiary RW pumps	Constant volume pumps per design standards
18	Environmental room floating head pressure	Fixed head pressure per design standards
19	Motor efficiency	Program minimum efficiency
20	RW Evap flow reset	No reset per design standards
21	Tower controls	Fixed temperature tower controls per design standards
22	Vacuum pump efficiency	Standard-efficiency pump per design standards

Proposed Analysis (From PG&E File)

The energy savings from each measure were evaluated using the Trane Trace simulation program. The models were calibrated using measured data from the facility gathered during facility commissioning.

Activity at this facility is expected to ramp up over at two-year period as the facility enters full production. A company design engineer estimated the peak process loads used in the building simulation model. Company operations personnel estimated process load profiles and building occupancy schedules.

A summary of the measure savings estimates are shown below:

Measure	**Description**	**Projected Savings**
1	Lighting Efficiency	127,707 kWh 62 kW
2	High performance glazing	179,785 kWh 56 kW
3	Discharge air reset	754,348 kWh 25 kW
4	Adjustable speed drives for VAV air handlers	226,479 kWh 31 kW
5	High efficiency boilers	1,314 kWh 0 kW
6	Boiler economizers	0 kWh 0 kW
7	Tower water for process cooling	293,755 kWh 455 kW
8	Process chiller w/ surge tank	-152,954 kWh 559 kW
9	Process chiller efficiency	164,479 kWh 26 kW
10	HVAC chiller efficiency	594,327 kWh 137 kW
11	Cooling tower approach 8°F	148,653 kWh 21 kW
12	Cooling tower approach 4°F	152,937 kWh 49 kW
13	ASD for HW pumps	81,935 kWh 0 kW
14	ASD for Primary RW pump	120,776 kWh 0 kW
15	ASD for RW Cond pumps	231,241 kWh

		0 kW
16	ASD for secondary RW pumps	139,884 kWh 0 kW
17	ASD for tertiary RW pumps	106,482 kWh 0 kW
18	Environmental room floating head pressure	56,686 kWh 0 kW
19	Motor efficiency	646,592 kWh 131 kW
20	RW Evap flow reset	33,695 kWh 0 kW
21	Tower controls	99,872 kWh -17 kW
22	Vacuum pump efficiency	10,136 kWh 2 kW

Project Evaluation

Facility characteristics were gathered during an on-site survey and plans review. These data were entered into the SurveyIT database. Due to the complexity of the facility, the site was broken down into four separate models. ModelIT software was used to develop a DOE-2 model of the facility and perform the required parametric runs. The details of the assumptions and procedures used by the ModelIT software are available upon request. The results from each of the four models were combined to predict the savings for the entire facility.

Base Case

Title 24 standards were applied to all aspects of the facility covered by Title 24, such as the building shell, indoor lighting, chiller efficiency, HVAC controls, and motor efficiency.

Note: Due to manufacturing process and heath and safety requirements, the air handlers supplying the manufacturing areas include additional filtration beyond that required for normal HVAC systems; thus the Title 24 specific fan power (W/CFM) restrictions were not applied to these air handlers.

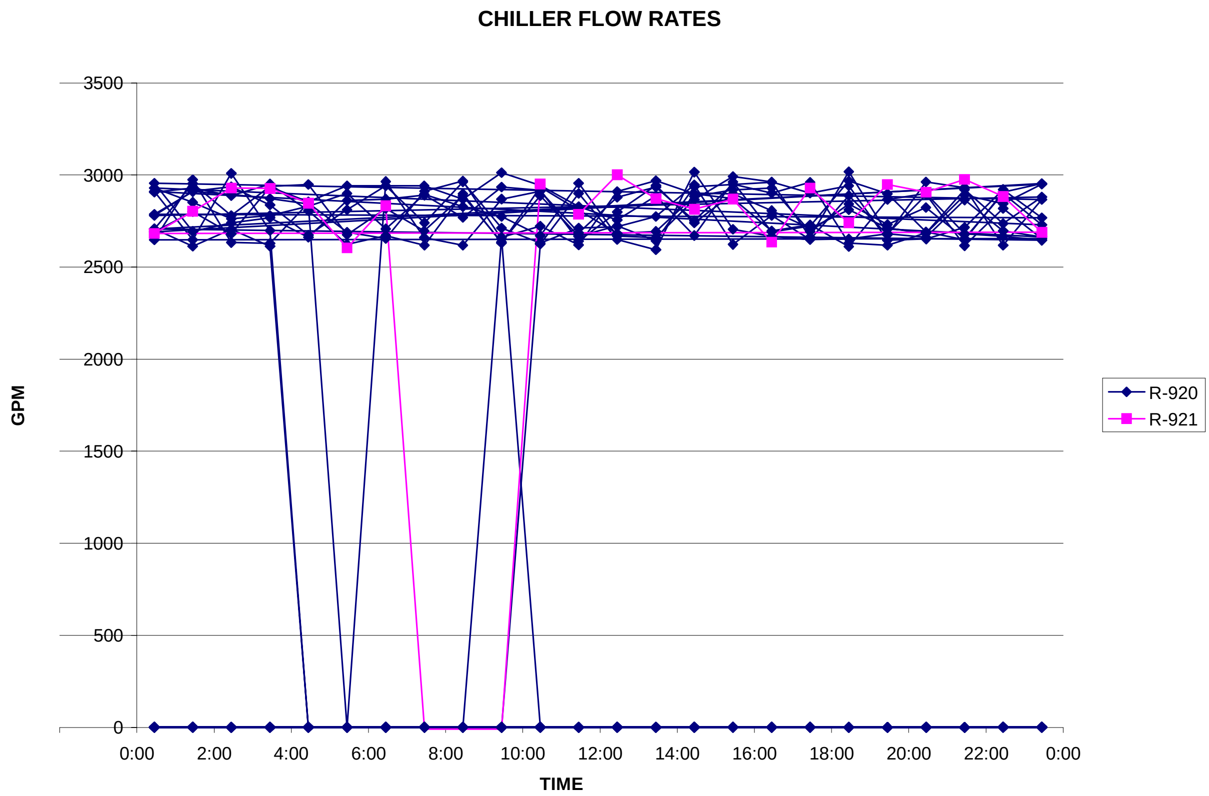
The standard was applied to all Title-24-covered attributes, regardless of whether an incentive was paid. Baseline characteristics defined by the program were used for building attributes not covered by Title 24.

Metering

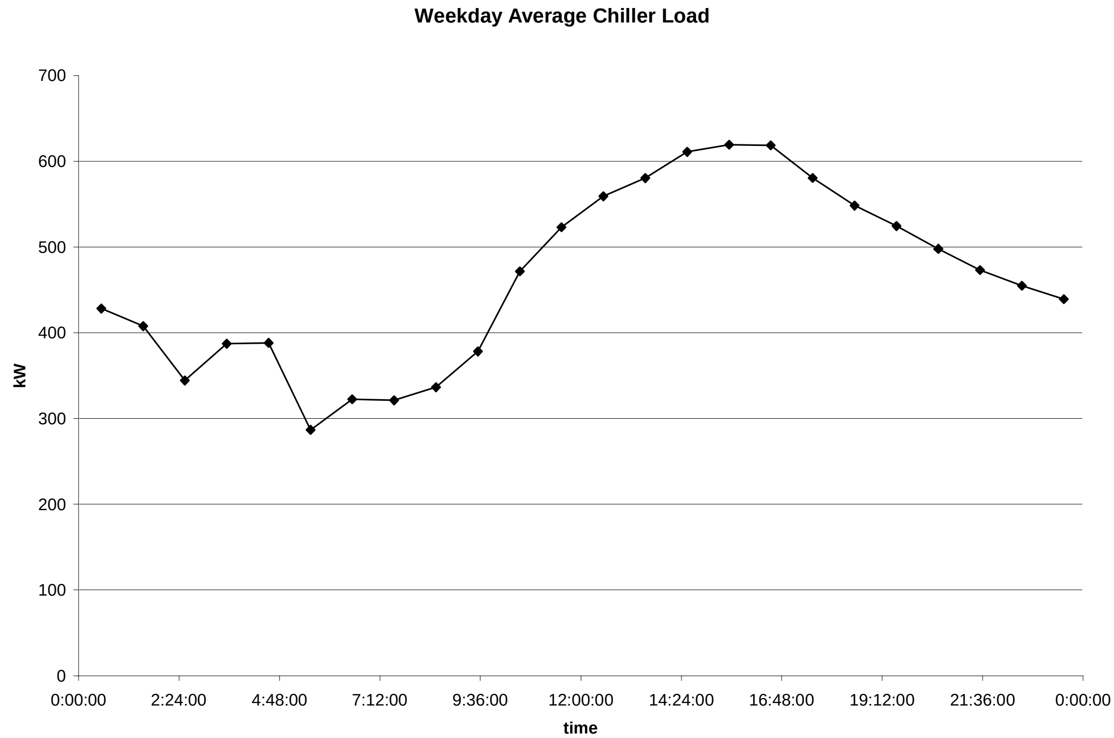
Short-term monitoring of HVAC equipment and process loads was used to calibrate the DOE-2 models. Data were gathered using a combination of portable, battery-powered data loggers and energy management system (EMS) trend logs. A summary of the data collected is shown below:

- Process Chiller Load
- Tertiary Return Temp
- Tertiary Supply Temp
- Boiler 900 Supply Temp
- Boiler Supply Temp
- Pump 930 % Speed
- Chiller 920 Condenser Flow
- Chiller 920 Condenser Inlet Temp
- Chiller 920 Condenser Outlet Temp
- Chiller 920 CHW Flow
- Chiller 920 Return Temp
- Chiller 920 Supply Temp
- Chiller 920 Power
- Chiller 921 Condenser Flow
- Chiller 921 Condenser Inlet Temp
- Condenser pump amps
- Cooling tower fan 1 amps
- Boiler economizer temperatures
- Chiller 921 Condenser Outlet Temp
- Chiller 921 CHW Flow
- Chiller 921 Return Temp
- Chiller 921 Supply Temp
- Chiller 921 Power
- Chiller 922 Condenser Flow
- Chiller 922 Condenser Inlet Temp
- Chiller 922 Condenser Outlet Temp
- Chiller 922 CHW Flow
- Chiller 922 Return Temp
- Chiller 922 Supply Temp
- Chiller 922 Power
- AHU 5020 Supply Air Temp
- O.A. Temp
- Tower Wet Bulb Approach Temp
- Web Bulb Temp
- Cooling tower fan 2 amps

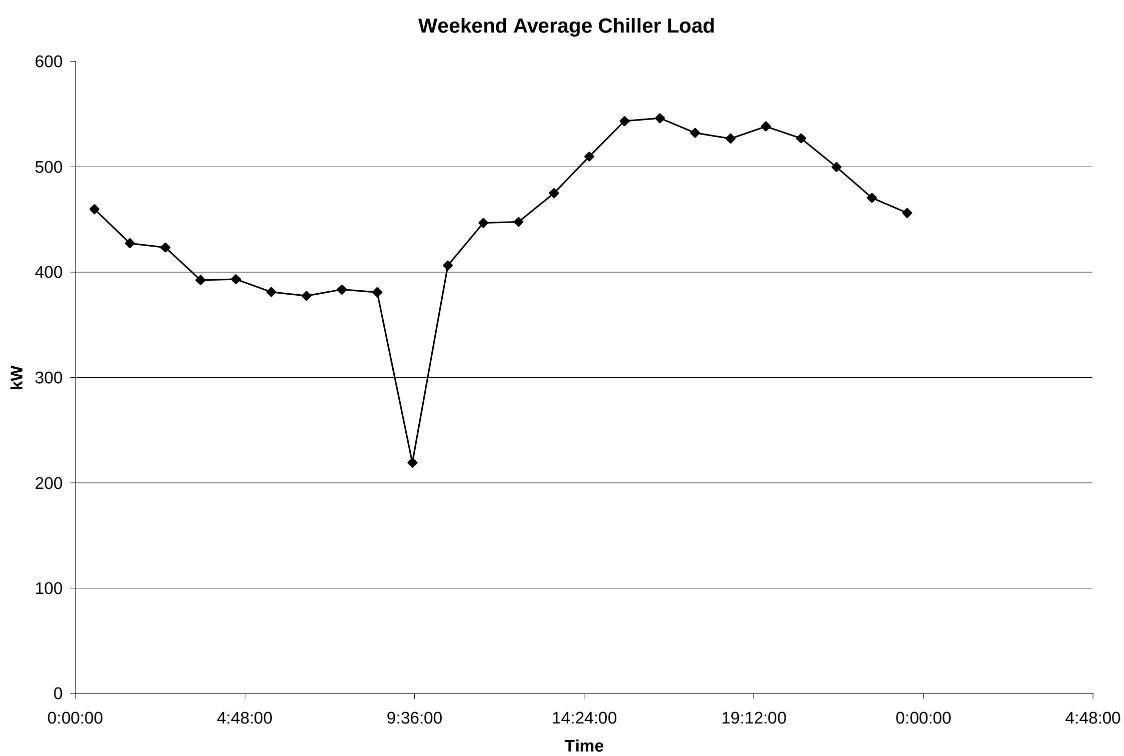
Results of the short-term monitoring are presented in the following graphs:



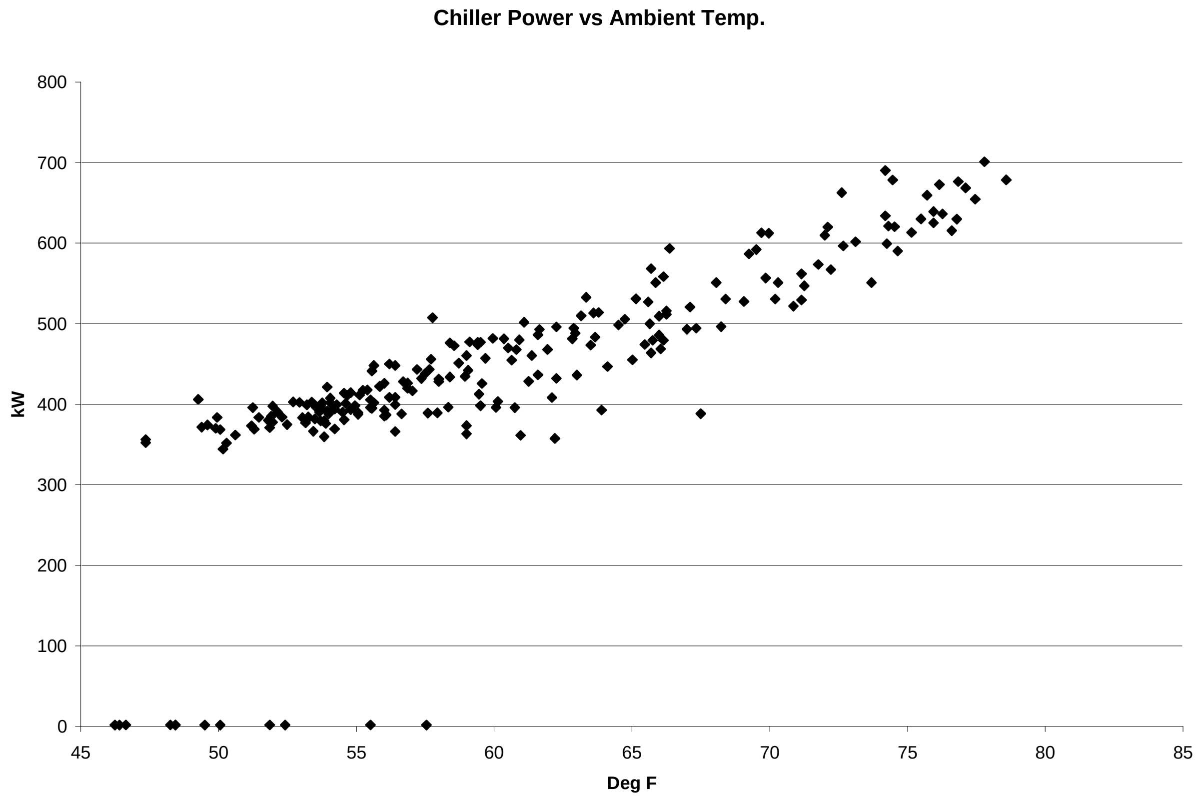
This figure shows the hourly variation in the chilled water flow rate. Although this loop has a variable speed drive, the hourly variation in the flow rate is minimal.



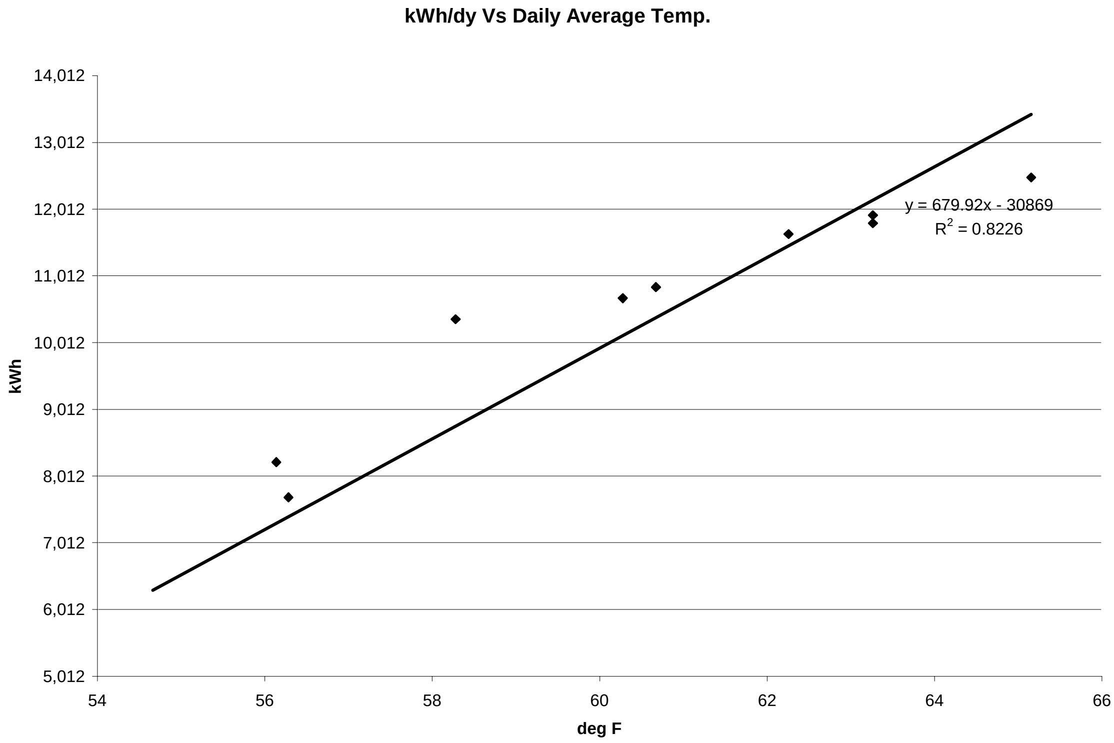
This figure shows the average weekday load shape for the chiller plant during the monitoring period.



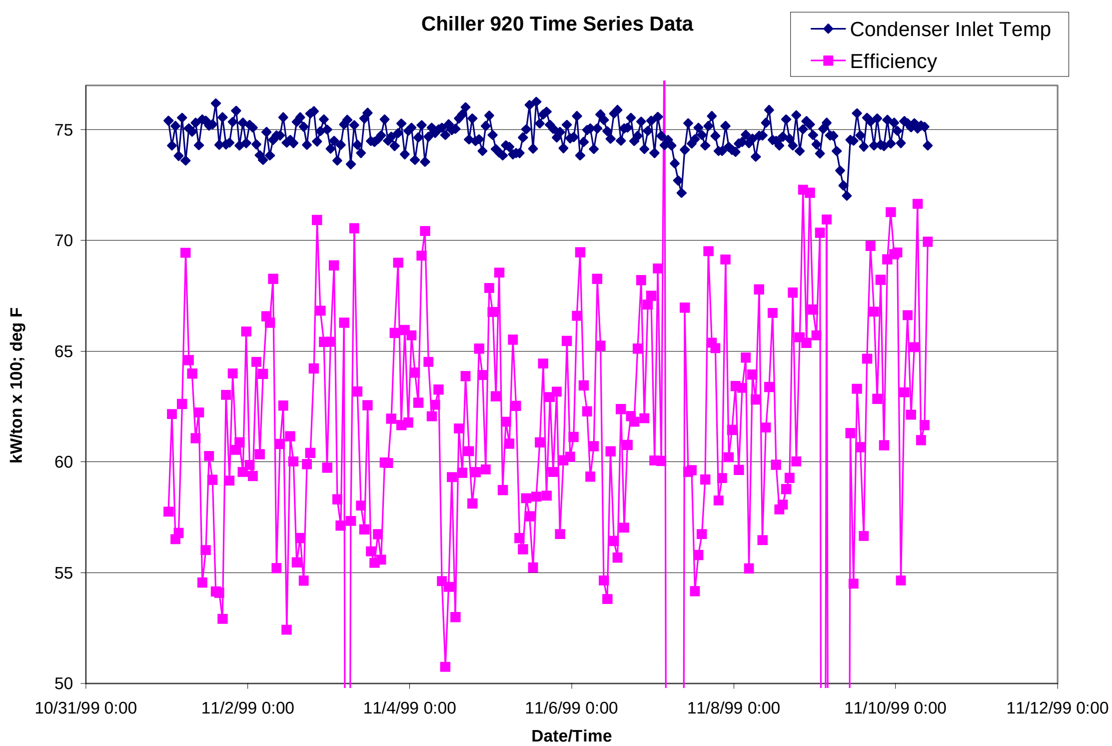
This figure shows the average weekend load shape for the chiller plant during the monitoring period. Note, the dip is due to a chiller plant outage during one of the weekend days.



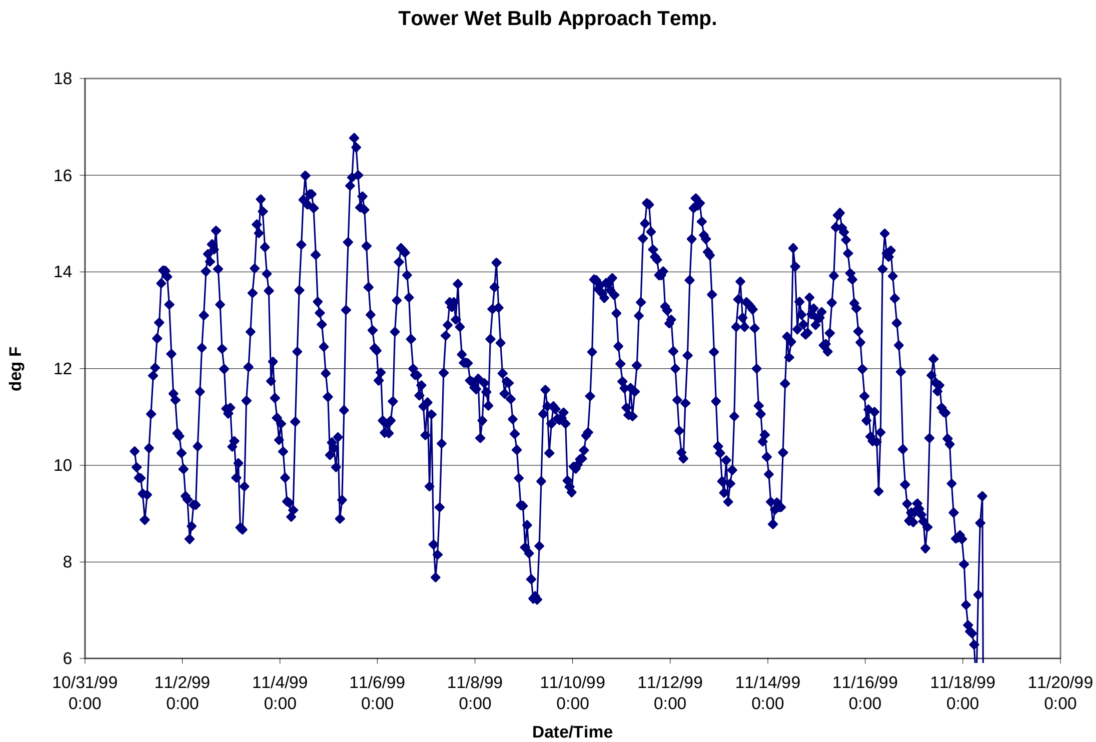
This plot shows the sensitivity of the instantaneous chiller plant load to outdoor temperature.



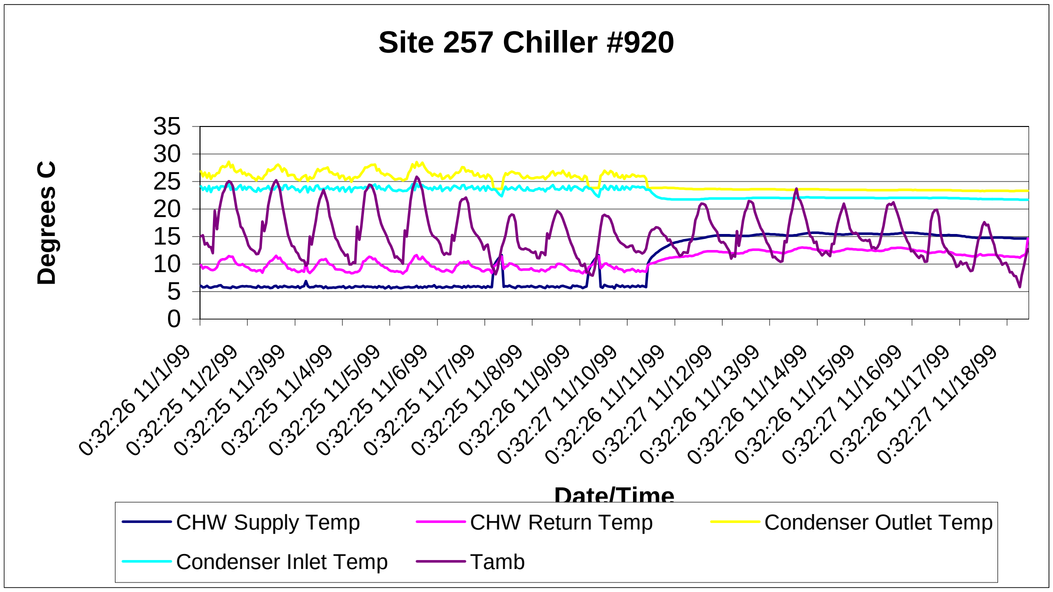
This plot shows the correlation of average daily chiller plant kWh to average daily dry bulb temperature.



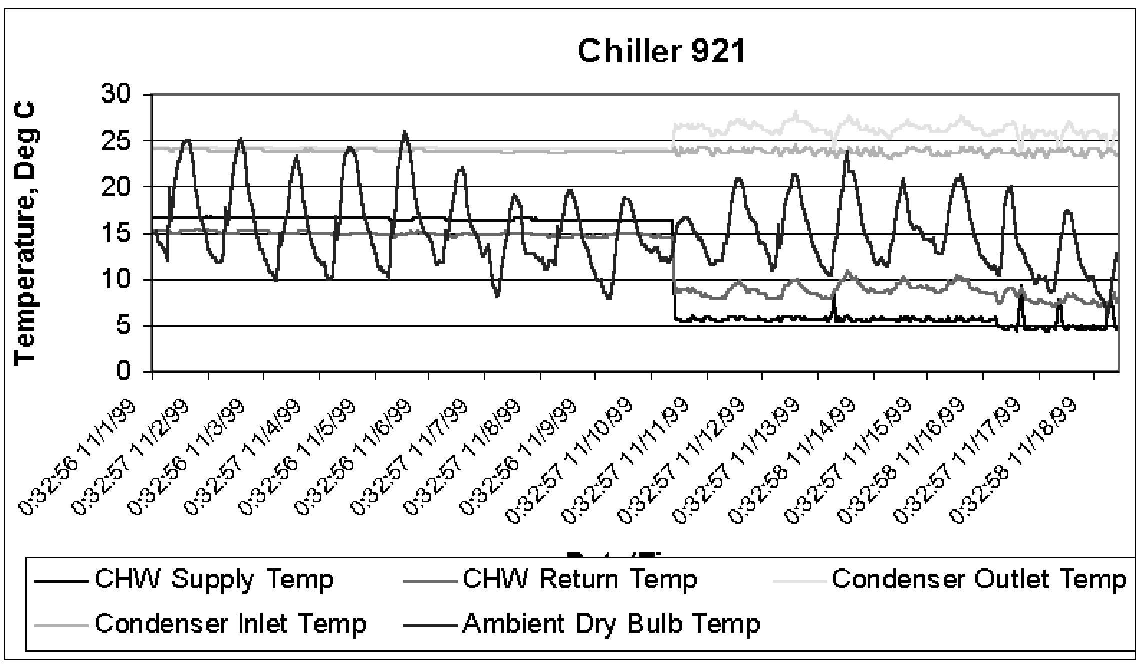
This figure shows time series measurements of instantaneous efficiency (kW/ton) for chiller 920, along with the entering condenser temperatures. During the monitoring period, the cooling tower was capable of closely maintaining the 75°F setpoint temperature.



The wet bulb approach temperature is plotted above. Under low wet bulb temperature conditions, the tower wet bulb approach is limited by the condenser water setpoint. However, at higher wet bulb temperatures, approach temperatures on the order of 6°F are observed.



This plot shows daily operating temperatures for chiller 920 during the monitoring period. This chiller was in use through November 11, when it was taken off-line and the load shifted to chiller 921.



This plot shows daily operating temperatures for chiller 921 during the monitoring period. This chiller was off-line until November11. These plots show that the chillers were operated in a "duplex" mode during the monitoring period.

Comparison

The energy savings calculated by the DOE-2 models created for this project are shown below:

Measure Category	**Total Savings**	**Measures-only Savings**	**Program Savings**
Shell	85,216	27,658	179,785
Lighting	544,580	425,358	127,707
HVAC	8,192,548	1,684,314	3,007,359
Motors	418,902	418,902	646,592
Refrigeration	38,622	38,622	56,686
Total	**9,279,868**	**2,594,854**	**4,018,129**
Realization rate	**2.31**	**0.65**	

The measures-only realization rate fell short of program expectations due to reduced loading on the chiller plant and process cooling plant. The total realization rate for all efficiency actions, including incented and non-incented measures, was quite good.

Free Ridership

Measure	**Description**	**Interviewee Comments**
1	Lighting Eff	Management would not have installed high efficiency lighting w/o rebate. Would only have met Title 24.
2	High performance glazing	Management was not influenced by PG&E for this measure. High performance glazing was already specified by the architect for reasons other than energy.
3	Discharge air reset	Would **not** have done w/o rebate.
4	ASD's for VAV AHUs	Management probably would have installed ASDs w/o the rebate.
5	High efficiency boilers	Would **not** have done w/o rebate.
6	Boiler economizers	Would **not** have done w/o rebate.
7	Tower water for process cooling	Would **not** have done w/o rebate.
8	Process chiller w/ surge tank	Would **not** have done w/o rebate.

9	Process chiller efficiency	Would **not** have done w/o rebate.
10	HVAC chiller efficiency	Would **not** have done w/o rebate.
11	Cooling tower approach 8°F	Would **not** have done w/o rebate.
12	Cooling tower approach 4°F	Would **not** have done w/o rebate.
13	ASD for HW pumps	Management probably would have installed ASDs w/o the rebate.
14	ASD for Primary RW pump	Management probably would have installed ASDs w/o the rebate.
15	ASD for RW Cond pumps	Management probably would have installed ASDs w/o the rebate.
16	ASD for secondary RW pumps	Management probably would have installed ASDs w/o the rebate.
17	ASD for tertiary RW pumps	Management probably would have installed ASDs w/o the rebate.
18	Environmental room floating head press.	
19	Motor efficiency	
20	RW Evap flow reset	
21	Tower controls	
22	Vacuum pump efficiency	

Note: The facility engineer interviewed for this survey was instrumental in getting support from upper management for this project. He said that PG&E was involved from the beginning so it is difficult to define would have been done in their absence. He said that the engineering analysis services provided by PG&E were very important to the success of this project. In response to the question about payback criteria, he said that this company has no set criteria for payback. He said that no specific payback was expected for the measures in this project, but that upper management had to be convinced that the long term savings was worth the investment for each measure.