Prescriptive vs. Performance Projects Comparison

A Follow-on to the
Nonresidential New Construction Baseline Study
Project 2

Final Report

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PREPARED BY:
RLW ANALYTICS, INC.
1055 BROADWAY, SUITE G
SONOMA, CA 95476

PREPARED FOR:
MARIAN BROWN
SOUTHERN CALIFORNIA EDISON
2131 WALNUT GROVE AVENUE
ROSEMEAD, CA 91770

California State-Level Market Assessment and Evaluation Study
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1. Executive Summary

This study is a continuation of the California Nonresidential New Construction Baseline Study[1]. The follow-on baseline study provides a deeper look at the energy efficiency of newly constructed commercial buildings in California.

The study consists of three projects:

1. End Use Savings and Analysis of New LPD Baseline
   - Provide a better understanding of end use savings and the effect of the new lighting power density requirements in the 1998 version of Title 24.
   - Questions addressed: When the 1998 Title 24 revisions strengthened the energy efficiency standards for new construction, how much did the stringency of Title 24 change? Would the baseline buildings, built under the older Title 24, be able to meet or exceed the 1998 standards? By how much of a margin?
2. Utility Program Paths
   - Compare the two major paths in utility energy efficiency programs: the whole-building (performance) approach and the systems (prescriptive) approach.
   - Questions addressed: Given that the Savings By Design program seeks to encourage whole building energy efficiency, while providing a prescriptive, systems option, how many of the participants in the previous programs used the performance method and how many the prescriptive? Which method produces greater energy savings?
3. Lighting Assessment
   - Validate the accuracy of the lighting measurements taken on-site and provide an in-depth look at lighting quality.
   - Questions addressed: Since the lighting power density numbers in the baseline population (both participants and non-participants) appear to be relatively low, how accurate are those numbers? What is the magnitude of the measurement error? What are the sources of measurement error? Given the low LPDs, are there any significant problems with lighting quality or occupant satisfaction with the lighting systems observed?

In this project we have summarized both the participant population and the participant sample data from the 1994 and 1996 NRNC Evaluations by program approach: prescriptive or performance. Non-participants were not included in this

[1] RLW Analytics, Inc., July 1999, *California Nonresidential New Construction Baseline Study.* Sonoma, CA. Available at: www.rlw.com under 'publications'.

analysis since there was no program participation approach for these projects, by definition.

The primary objective of this study was to obtain a better understanding of the differences between the performance and prescriptive approaches. Note that these approaches are termed "whole building" for performance and "systems" for prescriptive for Savings By Design. It is generally assumed that performance projects, which utilize an integrated design concept that looks at the building as a whole rather than individual components as in the systems approach, will result in greater energy savings. We aimed to prove this assumption and determine whether whole building design produced significantly greater energy savings than the systems approach.

Key Findings

The tracking information provided by the utilities showed an average of 318 mWh savings per performance project and 4.1 kWh savings per square foot. The average savings per prescriptive project was 184 mWh and 3.3 kWh savings per square foot. The population data indicates that one should expect performance projects to result in greater energy savings.

	Total Number of Projects	Average kWh Savings per Project	Average kWh Savings per SqFt
Performance	125	318,346	4.1
Prescriptive	1,122	184,233	3.3

Table 1: Summary of Program Tracking Data by Program Approach

Upon analyzing the weighted Baseline sample data, it was found that performance projects have a lower energy ratio than prescriptive projects, at 0.82 and 0.85 respectively. An energy ratio is the consumption of a building or set of buildings relative to what their consumption would have been under Title 24. An energy ratio of one indicates that the buildings are performing exactly in accordance with the Title 24 baseline. An energy ratio below one indicates that the buildings are using less energy. Performance projects are consuming on average 18% less energy than Title 24, and prescriptive projects are consuming 15% less than Title 24 on average.

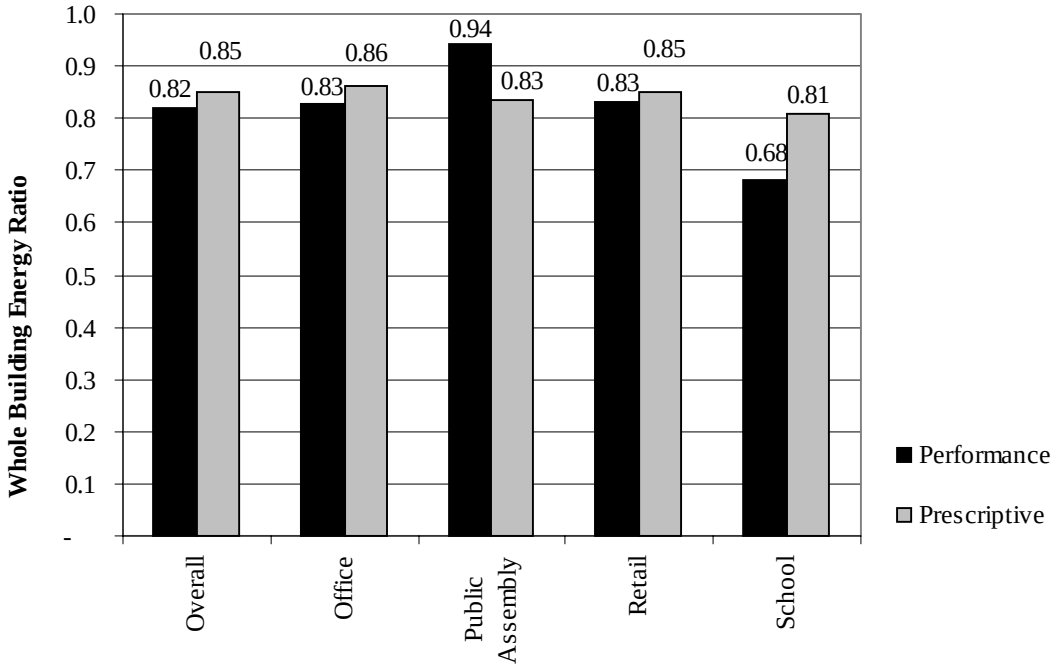

Figure 1: Average Whole Building Energy Ratio by Building Type and Program Approach

However, with the error associated with each estimate, these results are not statistically significant. There is a relatively large error associated with the performance estimates due in part to the small sample size for this subgroup.

The weighted sample data also indicate that fan savings make up a larger percentage of whole building savings for performance projects than prescriptive projects, with fan savings totaling 23% and 6% respectively, as shown in Figure 2. Lighting savings makes up more of the prescriptive savings than of the performance savings, 79% and 65% respectively. Cooling makes up approximately the same percentage of savings for both approaches.

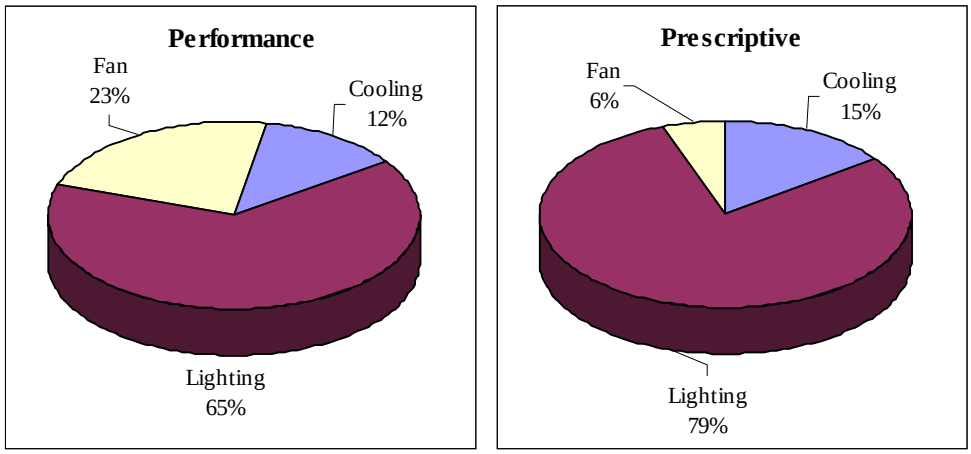

Figure 2: Percentage of Overall Savings by Program Approach

Slightly more than 17% of performance projects were found to have variable speed drives, while only 10% of prescriptive projects utilized this technology. This is one possible explanation for the lower fan energy ratio for performance projects.

Almost 25% of the lighting connected load for performance projects is controlled by occupancy sensors, while only 16% of lighting connected load for prescriptive projects are controlled by occupancy sensors.

Nearly 75% of fluorescent lighting connected load for prescriptive projects is connected to T-8/Electronic Ballast fixtures, while only 58% of performance fluorescent lighting kW is utilizing this fixture type. Over 26% of the performance fluorescent lighting kW is connected to T-12 Energy Saving Magnetic Ballasts, while only 12% of prescriptive projects utilize this ballast type.

A much larger percentage of square footage in performance projects utilizes HVAC controls than prescriptive projects. The most common HVAC control is 'condenser water setpoint fixed' with over 38% of performance project square footage connected to this control.

2. Introduction

This is the final report for Project 2 of the follow-on baseline study of the Non-Residential New Construction (NRNC) market in California. The study was conducted by RLW Analytics on behalf of the California Public Utilities Commission (CPUC) under the management of Southern California Edison Company. This study was intended to give future program administrators and implementers some of the information needed to compare whole building (performance) projects with systems (prescriptive) projects.

This study is a continuation of the California Nonresidential New Construction Baseline Study. The follow-on baseline study provides a deeper look at the energy efficiency of new commercial buildings built recently in California.

The study consists of three projects:

1. End Use Savings and Analysis of New LPD Baseline
   - Provide a better understanding of end use savings and the effect of the new lighting power density requirements in the 1998 version of Title 24.
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   - Questions addressed: Given that the Savings By Design program seeks to encourage whole building energy efficiency, while providing a prescriptive, systems option, how many of the participants in the previous programs used the performance method and how many the prescriptive? Which method produces greater energy savings?
3. Lighting Assessment
   - Validate the accuracy of the lighting measurements and provide an in-depth look at lighting quality.
   - Questions addressed: Since the lighting power density numbers in the baseline population (both participants and non-participants) appear to be relatively low, how accurate are those numbers? What is the magnitude of the measurement error? What are the sources of measurement error? Given the low LPDs, are there any significant problems with lighting quality or occupant satisfaction with the lighting systems observed?

This report describes the results from Project 2. In this project we have compared the energy savings and project characteristics of performance and prescriptive projects. This project was carried out in order to test the hypothesis of the Savings By Design program that integrated whole building design produces significantly greater energy savings than the prescriptive approach (now called the systems approach).

Performance projects are those projects whose incentives are typically based upon a series of interactive measures, with the savings being estimated using computer energy simulations. *Prescriptive* projects are incented on a measure-by measure basis using a prescribed list of approved measure for each end measure group. There is one other type of classification that appears in this report. *'Other'* projects are specific to PG&E PY94 only. These projects were never originally classified as either performance or prescriptive in the original databases and program files, thus they were treated separately in this report.

The NRNC Baseline study database includes a mix of projects that used performance and prescriptive approaches. The relative energy efficiency of these two project approaches will be compared at both the whole building and the end use levels.

The first objective of this study is to compare performance projects with prescriptive projects in the Baseline Study program participant population to identify any differences in the program populations in terms of project characteristics and energy savings.

A second objective of this study is to compare the relative energy efficiency of these two project approaches at both the whole building and the end use levels using the Baseline Study program participant sample data.

Project Tasks

The tasks for this project consisted of the following steps:

1. Program Population Analysis - Review of Utility Tracking Data and Classification of Sites by Program Approach
2. Program Sample Analysis - Summarize Baseline Sample Data by Program Approach

Chapter 3 contains the results from task 1. Since the Baseline Study participant sites were not stratified by program approach, we investigated the original program population tracking databases in order to identify any differences between the population and the weighted sample.

The first task consisted of the review of the program population tracking data to determine which sites participated in the new construction programs using the prescriptive approach versus the performance approach.

Once all of the project populations were classified by program approach, the PG&E and SCE program population tracking databases for program years 1994 and 1996 were analyzed to summarize the following, by program approach for both PG&E and SCE, and overall:

- Overall energy savings – Prescriptive vs. Performance by Utility and overall,
- Savings Intensities – Savings per project and square foot by Prescriptive vs. Performance,
- Number of projects- Prescriptive vs. Performance by Utility and overall,
- Square Footage of projects- Prescriptive vs. Performance by Utility and overall, and
- Savings by Measure Type – Prescriptive and '*Other*' for PG&E only[2].

The second and final task was to summarize the weighted Baseline sample data by program approach. Chapter 4 summarizes the energy savings and some additional system characteristics of the Baseline sample data for the PG&E and SCE 1994 and 1996 participant sites by program approach.

The results of the energy savings analyses are in the form of an energy ratio at the whole building and end-use levels for the sampled sites. The end use consumption was calculated for the Baseline study in order to calculate the indirect effects of the measures on the individual end uses. In this study we use the end use savings to identify any differences between program approaches within the general categories of energy use.

The energy savings were cross-tabulated by program approach and some additional data that was only verified or collected for the sampled participants, such as

- Building Type, or
- Building Ownership,

The second component of Chapter 4 summarizes some building characteristics of the sampled sites. The following is a list of the summaries presented:

- Lighting-Fixture type, ballast type, and control type by program approach,
- HVAC-Distribution system type, cooling system type, fan type, and HVAC control type by program approach.

[2] Only PG&E measure data was found in the original tracking databases. SCE data could not be obtained at the time this report was completed.

3. Program Population Tracking Data Analysis

This chapter of the report summarizes the participant population tracking data for the 1994 and 1996 program years for both SCE and PG&E. The tracking data was obtained when RLW and AEC conducted the 1994 and 1996 NRNC evaluations for both PG&E and SCE. The original sample designs for the evaluation studies were not stratified by program approach, therefore it is important to understand the proportion of each project type within the original population in order to identify any fundamental differences between the population and the weighted sample.

The data presented in this section of the report summarizes each of the following data types by program approach:

- Energy Savings (Savings per project and savings per square foot),
- Number of Projects,
- By Square Footage,
- Measure Savings, and
- Differences Among Utilities where appropriate.

KWh Savings

Figure 3 shows the percentage of estimated kWh savings by program approach. The percentage of prescriptive savings is smaller relative to the percentage of projects for SCE, indicating that the performance projects were associated with larger kWh savings. Overall the prescriptive savings totaled almost 80% of the total savings. The PG&E and SCE programs were largely dominated by projects that were completed under the prescriptive approach. The SCE program included a larger percentage of performance savings than did the PG&E program, totaling 29% and 5% respectively of the total estimated savings. '*Other*' projects are specific to PG&E PY94 only. These projects were never originally classified as either performance or prescriptive in the original databases and program files, thus they were treated separately in this report. These projects account for approximately 10% of PG&E's total kWh savings and 5% of the overall total kWh savings.

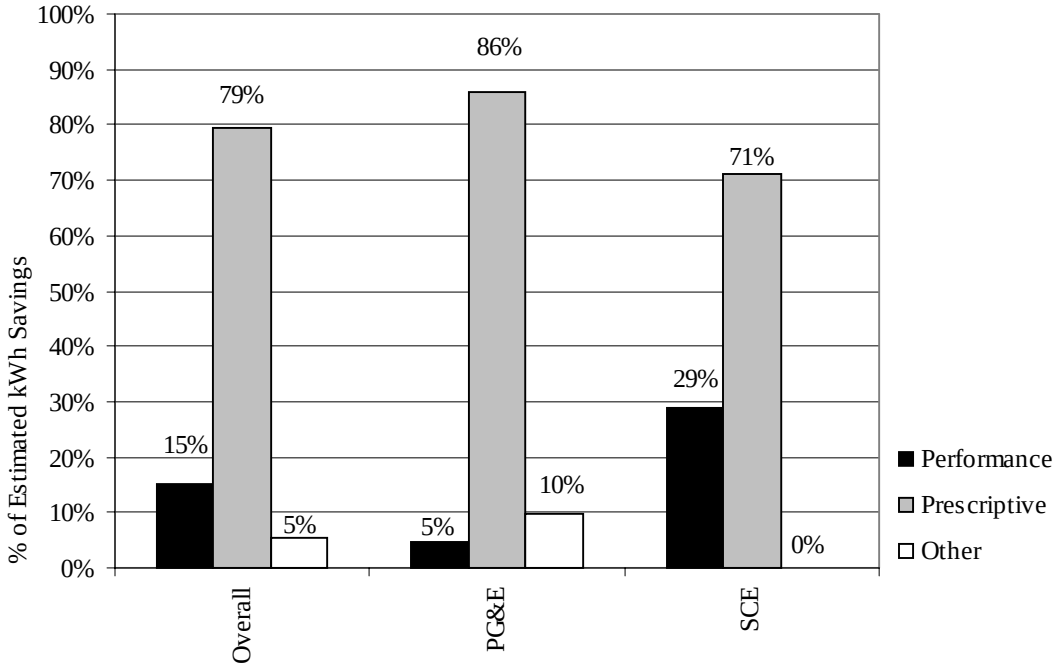

Figure 3: Percentage of kWh Savings by Utility and Program Approach (Participants)

Table 2 shows the total kWh savings and the percentage of savings by project type for each utility. PG&E had over 25% more estimated savings than SCE.

	Overall		PG&E		SCE	
	kWh Savings	% of kWh	kWh Savings	% of kWh	kWh Savings	% of kWh
Performance	39,793,229	15%	6,592,552	5%	33,200,677	29%
Prescriptive	206,709,765	79%	124,366,259	86%	82,343,506	71%
Other	14,006,834	5%	14,006,834	10%	-	0%
Total	260,509,827	100%	144,965,644	100%	115,544,183	100%

Table 2: Total Estimated kWh Savings and Percentage of Estimated kWh Savings by Program Approach and Utility (Participants)

Savings Intensities

The amount of kWh savings per project and the average amount of kWh savings per square foot are summarized in this section. The savings intensities provide a better understanding of the relative savings of the buildings using each program approach.

kWh Savings per Project

Table 3 presents the average kWh savings per participant project by program approach. Performance projects had over 134 mWh higher savings (over 40%) on average than prescriptive projects. The average overall savings per project was 202 mWh.

	Average kWh Savings/ Project
Performance	318,346
Prescriptive	184,233
Other	318,337
Total	201,789

Table 3: Average kWh Savings per Participant Project by Program Approach

Table 4 presents the percentage of projects within kWh savings ranges. Almost all of the projects are within the 0 to 999,999 kWh range.

kWh Savings Range	Performance	Prescriptive
0-999,999	96.0%	96.9%
1,000,000-1,999,999	1.6%	2.1%
2,000,000-2,999,999	0.0%	0.5%
3,000,000-3,999,999	2.4%	0.2%
4,000,000-4,999,999	0.0%	0.1%
5,000,000-5,999,999	0.0%	0.1%
6,000,000-6,999,999	0.0%	0.0%
7,000,000-7,999,999	0.0%	0.0%
8,000,000-8,999,999	0.0%	0.0%
9,000,000-10,000,000	0.0%	0.1%

Table 4: Percentage of Participant Projects within kWh Savings Ranges by Program Approach

Figure 4 breaks down the participant projects within the 0 and 999,999 kWh savings range by program approach. The projects are grouped into savings ranges of 100,000 kWh. A much larger percentage of prescriptive projects had savings between 0 and 200,000 kWh than perfromance projects, at 76% and 62% respectively. Performance projects are more equally distributed than prescriptive projects, with a higher percentage of projects within all ranges other than the smallest savings range on this chart. Figure 4 and Figure 5 use the convention of using the midpoint of the relevant range as the label shown on the x-axis.

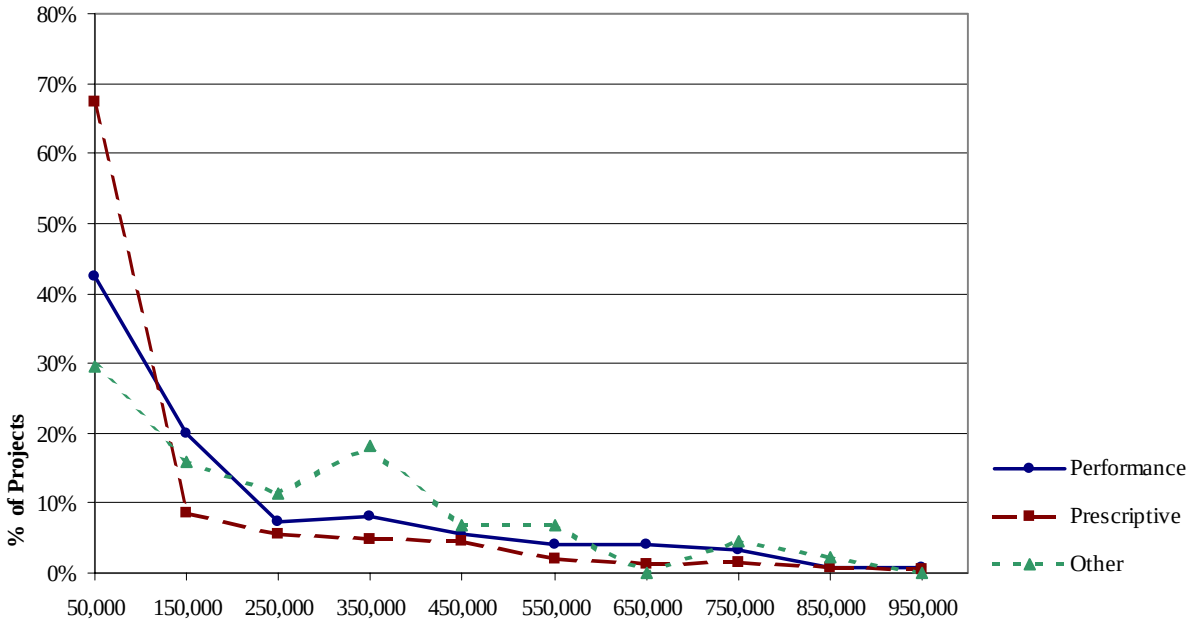

Figure 4: Percentage of Participant Projects within kWh Savings Ranges by Program Approach

Table 5 shows the x-axis values used in Figure 4. The first column contains the values actually displayed on the x-axis, and the second column contains the kWh savings ranges that are used to define each midpoint.

Midpoint	Range of Values (kWh Savings)
50,000	0-99,999
150,000	100,000-199,999
250,000	200,000-299,999
350,000	300,000-399,999
450,000	400,000-499,999
550,000	500,000-599,999
650,000	600,000-699,999
750,000	700,000-799,999
850,000	800,000-899,999
950,000	900,000-1,000,000

Table 5: Intervals for the X-axis Values for Figure 4

kWh Savings per SqFt

Table 6 presents the average kWh savings per square foot by program approach. The table shows that on average performance projects have 20% more savings than prescriptive projects.

	Average kWh Savings/SqFt
Performance	4.1
Prescriptive	3.3
Other	3.1
Total	3.4

Table 6: Average kWh Savings per Square Foot for Participants by Program Approach

Figure 5 presents the percentage of projects within kWh savings per square footage ranges by program approach. There is a much higher percentage of prescriptive projects with a low (between 0.1 and 2) kWh savings per square foot than performance projects. There is a higher percentage of performance projects with kWh savings per project in the higher ranges between 3 and 10 kWh per square foot.

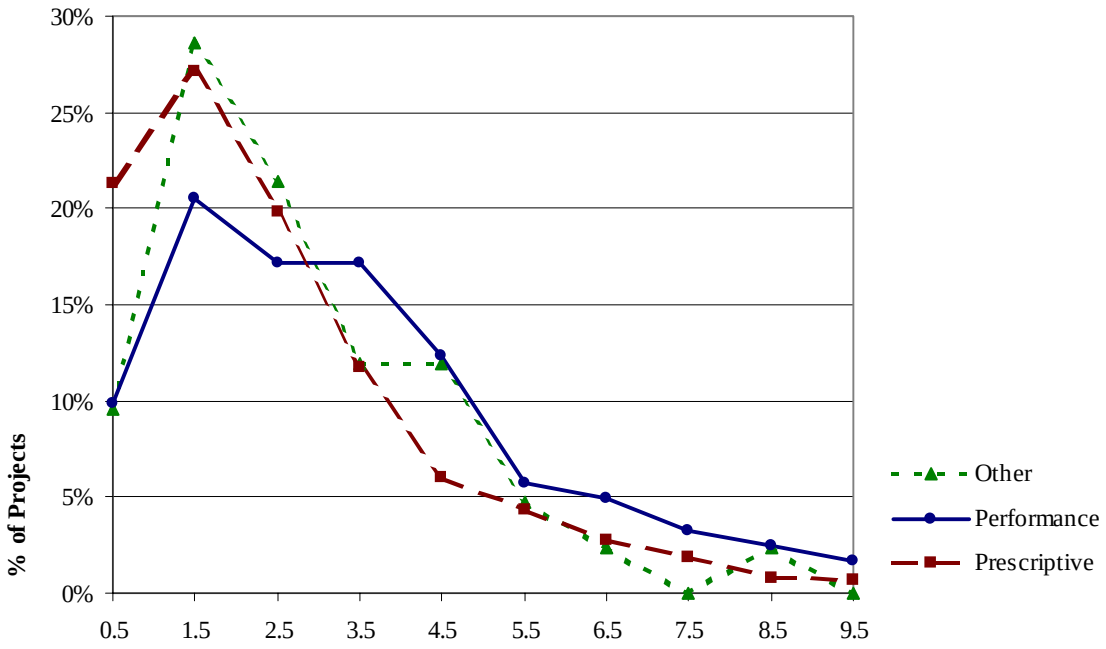

Figure 5: Percentage of Projects within kWh Savings per Square Footage Ranges for Participants by Program Approach

Table 7 shows the x-axis values used in Figure 5. The first column contains the values actually displayed on the x-axis, and the second column contains the kWh savings ranges that are used to define each midpoint.

Midpoint	Range of Values (kWh / SqFt)
0.5	0-1
1.5	1-2
2.5	2-3
3.5	3-4
4.5	4-5
5.5	5-6
6.5	6-7
7.5	7-8
8.5	8-9
9.5	9-10

Table 7: Intervals for the X-axis Values for Figure 5

Number of Projects

Figure 6 shows the percentage of projects by program approach. As seen with the kWh savings for both PG&E and SCE, the majority of projects are prescriptive, with over 80% of projects for both utilities being prescriptive.

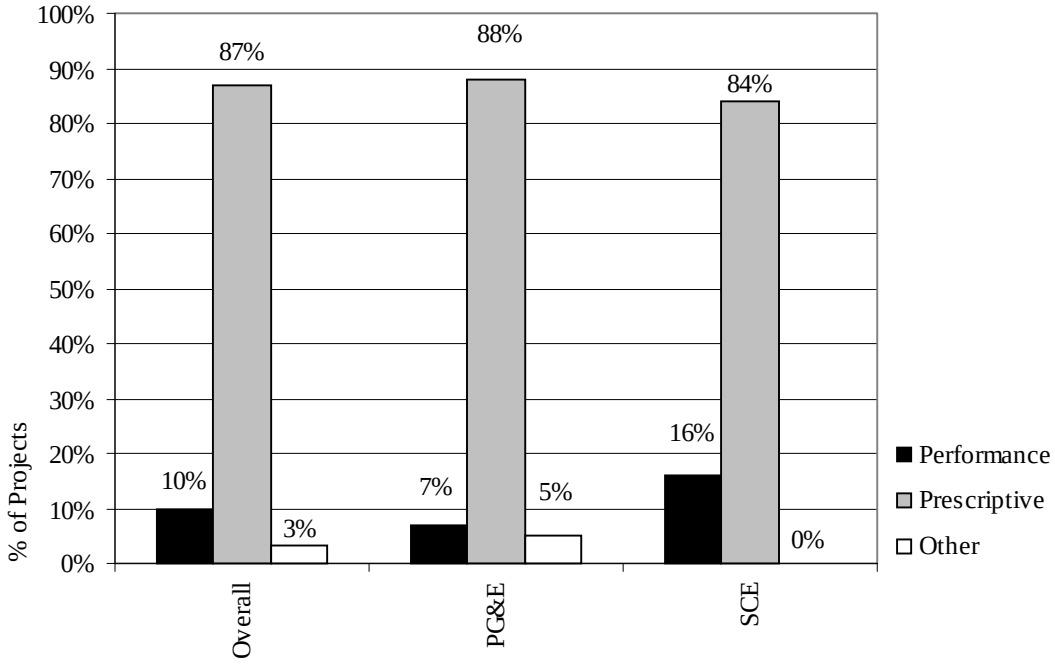

Figure 6: Percentage of Participant Projects by Utility and Program Approach

Table 8 shows the actual number of projects and the percentage of projects by project type for each utility. PG&E had a larger number of participants, with a total of 888 projects and SCE with a total of 403 projects. PG&E had a smaller percentage of performance projects than SCE. Recall that '*Other'* projects are specific to PG&E PY94 only. These projects were never originally classified as

either performance or prescriptive in the original databases and program files, thus they were treated separately in this report.

	Overall		PG&E		SCE	
	# Projects	% of Projects	# of Projects	% of Projects	# of Projects	% of Projects
Performance	125	10%	61	7%	64	16%
Prescriptive	1,122	87%	783	88%	339	84%
Other	44	3%	44	5%	-	0%
Total	1,291	100%	888	100%	403	100%

Table 8: Number and Percentage of Participant Projects by Utility and Program Approach

Square Footage

Figure 7 shows the percentage of square footage by program approach.

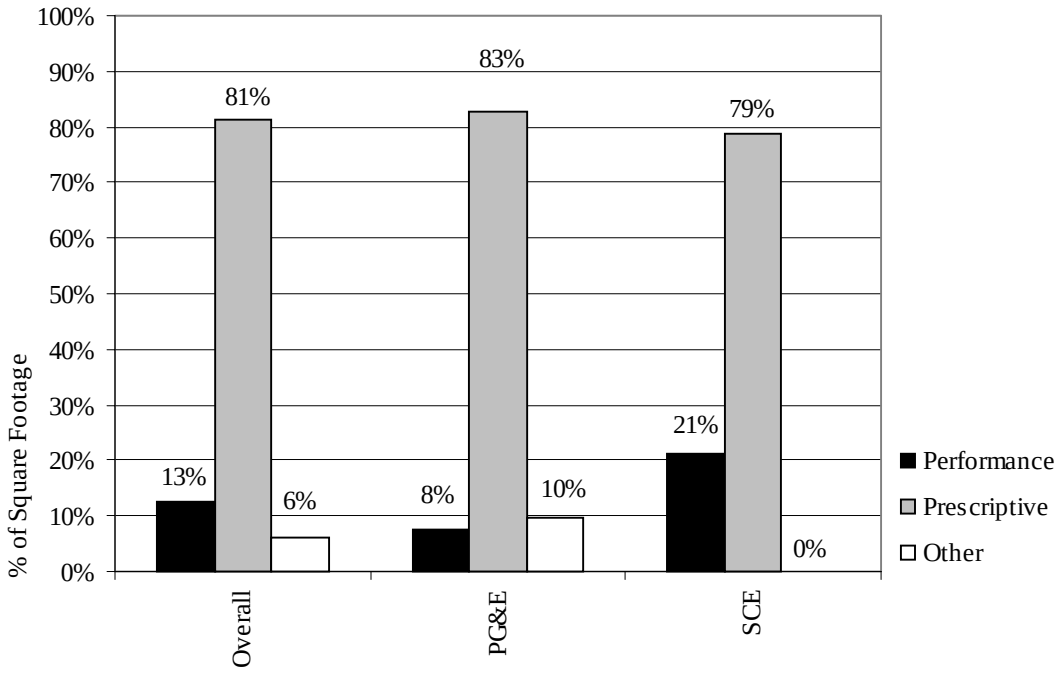

Figure 7: Percentage of Participant Square Footage by Utility and Program Approach

Table 9 shows the total square footage and the percentage of square footage by project type for each utility. The square footage for the PG&E participants is more than twice that of the SCE participants. This is due to the fact that the PG&E program had a much larger number of participants than SCE. A strong correlation between the number of projects and square footage by program approach is noticeable in Figure 6 and Figure 7. This suggests that overall there is not a large difference in the size of the projects in the two programs, however as one might expect, performance projects are slightly larger since they constitute a larger percentage of the square footage than the number of projects.

	Overall		PG&E		SCE	
	Square Footage	**% of Sqft**	**Square Footage**	**% of Sqft**	**Square Footage**	**% of Sqft**
Performance	9,684,988	13%	3,558,407	8%	6,126,581	21%
Prescriptive	61,910,678	81%	39,193,818	83%	22,716,860	79%
Other	4,579,784	6%	4,579,784	10%	-	0%
Total	76,175,450	100%	47,332,009	100%	28,843,441	100%

Table 9: Total Square Footage and Percentage of Total Square Footage for Participants by Program Approach and Utility

Measures

The analysis is based on data obtained from existing tracking databases supplied by the utilities for previous NRNC studies. Measure specific information for prescriptive projects was obtained from the PG&E tracking databases. The SCE databases did not contain this level of detail. Since the original SCE 1994 and 1996 NRNC Evaluations did not require this level of detail, it was not necessary for the information to be provided. Moreover, the necessary information could not be obtained from SCE in time for inclusion in the report.

Only prescriptive and *'Other'* program approaches are included in this section since performance projects are incented at the whole building level, thus the program tracking database has no measure specific information.

The five measure types and a brief description of what is included in each measure category is provided in the list below:

- Glazing-Windows and Skylights
- HVAC-High Efficiency Packaged Units, Heat Pumps, and Chillers
- Lighting-High Efficiency Lamps and Ballasts, Lighting Controls
- Motors-Variable Speed Drives, Premium Efficiency Motors
- Refrigeration-Condensers, Compressors, Defrost Elements

Figure 8 shows the percentage of estimated kWh savings by measure type for prescriptive and *'Other'* program approaches. The majority of savings for PG&E prescriptive participants were in lighting, totaling over 40% of the kWh savings. The second largest percentage of estimated savings was in refrigeration, totaling almost 33% of the savings. Glazing was the least commonly incented measure, constituting only 0.9% of the measure savings. This could be characterized by the longer payback period associated with glazing measures as compared to other measures in the program.

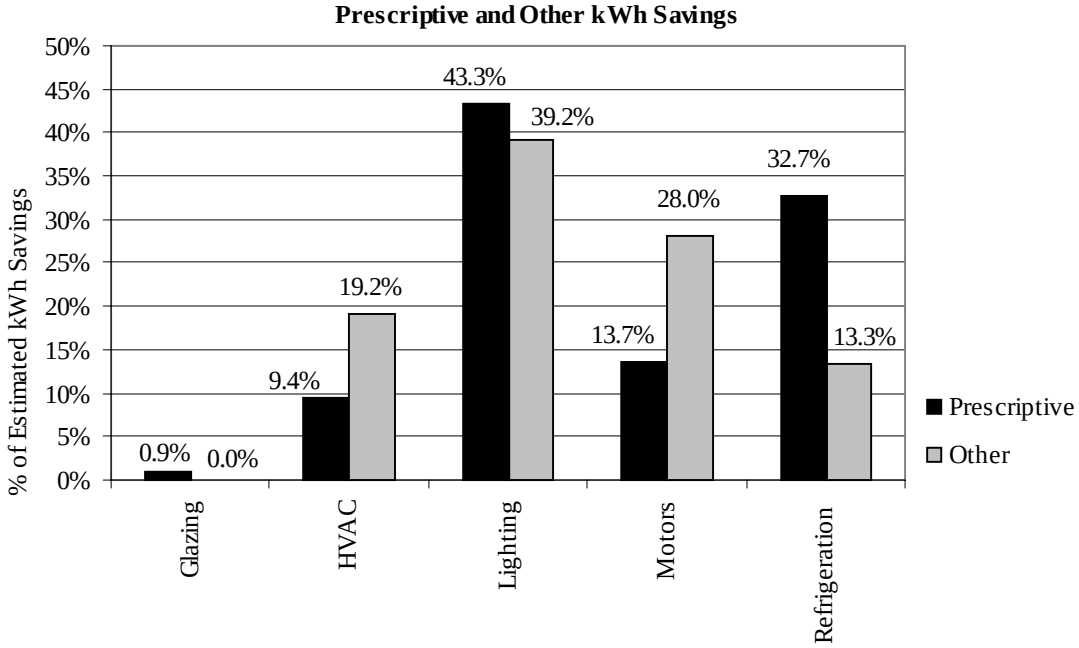

Figure 8: Percentage of Estimated kWh Savings for Prescriptive Projects by Measure Type for PG&E Participants

Table 10 shows the total estimated kWh savings and the percentage of the total savings by measure type for the prescriptive and *'Other'* program approaches. The largest percentage of energy savings is in lighting for both prescriptive and *'Other'* participants.

Measure Type	PG&E			
	Prescriptive		Other	
	kWh Savings	% of Savings	kWh Savings	% of Savings
Glazing	1,174,015	0.9%	-	0.0%
HVAC	11,687,226	9.4%	2,692,252	19.2%
Lighting	53,801,977	43.3%	5,496,197	39.2%
Motors	16,986,325	13.7%	3,924,063	28.0%
Refrigeration	40,621,098	32.7%	1,857,979	13.3%
Overall	124,270,640	100.0%	14,006,834	100.0%

Table 10: Total Estimated kWh Savings and Percentage of Estimated kWh Savings by Program Approach and Measure Type for PG&E Participants

4. Sample Site Analyses

This section of the report presents a summary of the Baseline data used in this study and summarizes some additional characteristics of the Baseline sample data for the PG&E and SCE 1994 and 1996 participant sites by program approach. These analyses summarize the energy savings at the whole building and end-use levels.

The end use consumption was calculated for the Baseline study in order to calculate the indirect effects of the measures on the individual end uses. The sum of the consumption of the end uses equals the whole building energy consumption. In this section we use the end use savings to identify any differences between program approaches within the general categories of energy use.

The sampled sites were cross-tabulated by some additional data that was only verified or collected for the sampled participants, such as:

- Building Type,
- Building Ownership, and
- System Type.

Once again, all of the results in this section have been weighted to the participant population.

Sample Size and Population

The population and sample sizes were described in full detail in the original Baseline study[3]. The sample sites used in this Baseline follow-on project are those participant sites that were used in the original baseline study for the participant vs. non-participant comparison. The participant sample sites are restricted to the 1994 and 1996 PG&E and SCE participants within the four Baseline study building types: offices, schools, public assembly, and retail.

The shaded cells in Table 11 show the subsample used in this follow on study. The total number of participant sites used in all of the analyses in this report is 242 sites. There was a total of 130 sites from 1994 and 112 from 1996.

[3] RLW Analytics, Inc., July 1999, *California Nonresidential New Construction Baseline Study.* Sonoma, CA. Available at: www.rlw.com under 'publications'.

	1994		1995		1996		1998	
Type of Analysis:	**Participant**	**Non-Participant**	**Participant**	**Non-Participant**	**Participant**	**Non-Participant**	**Non-Participant**	**Total Number in Sample**
Building Type	130	124	17	10	112	126	148	667
Ownership Type	130	124	0	0	112	126	148	640
Participant vs. Non-Participant	130	124	17	10	112	126	0	519
Time Trends	0	124	0	0	0	126	148	398

Table 11: Sample Sizes

Table 12 presents the population characteristics of the 1994 and 1996 participant data used for this project of the follow on baseline study. In preparing the data for our follow-up analysis, new case weights were created to properly project the sample sites up to our target population[4]. These case weights adjust for differences between our sample and the population in terms of program participation, building type and square footage. For example, the case weights adjust for the fact that schools represent 26% of the sample projects but only 18% of the projects in the population.

	Office	Public Assembly	Retail	School	Total
Percentage of Total Population	37%	32%	14%	18%	100%
Percentage of Total Floor Area	47%	15%	26%	12%	100%
Percentage of Total Energy	42%	11%	41%	7%	100%
Sample Size	90	35	53	64	242
Percentage of Sample	37%	14%	22%	26%	100%

Table 12: Population Characteristics by Building Type

Savings

This savings section describes the proportion of the whole building savings broken down by end use by program approach and overall. The proportion of whole building energy savings by end use have been calculated as the ratio a/b where:

(a) is the baseline end-use energy use minus the as built end-use energy use, and

(b) is the baseline whole-building energy use minus the as built whole-building energy use.

[4] Our target population was modified from the original target population due to a project that was completed subsequent to the Baseline study in which all of the dodge data were cleaned for duplicates. The case weights were modified as a result of the cleaned and reduced Dodge data.

The end use savings in this section are general categories of energy savings in lighting, cooling, and fan categories. The sum of the end use savings totals the whole building energy savings.

Figure 9 shows the percentage of whole building savings broken down by end use. The lighting end use constitutes the majority of savings for all of the program approaches. Performance projects have a larger percentage of fan savings than prescriptive or *'Other'* projects.

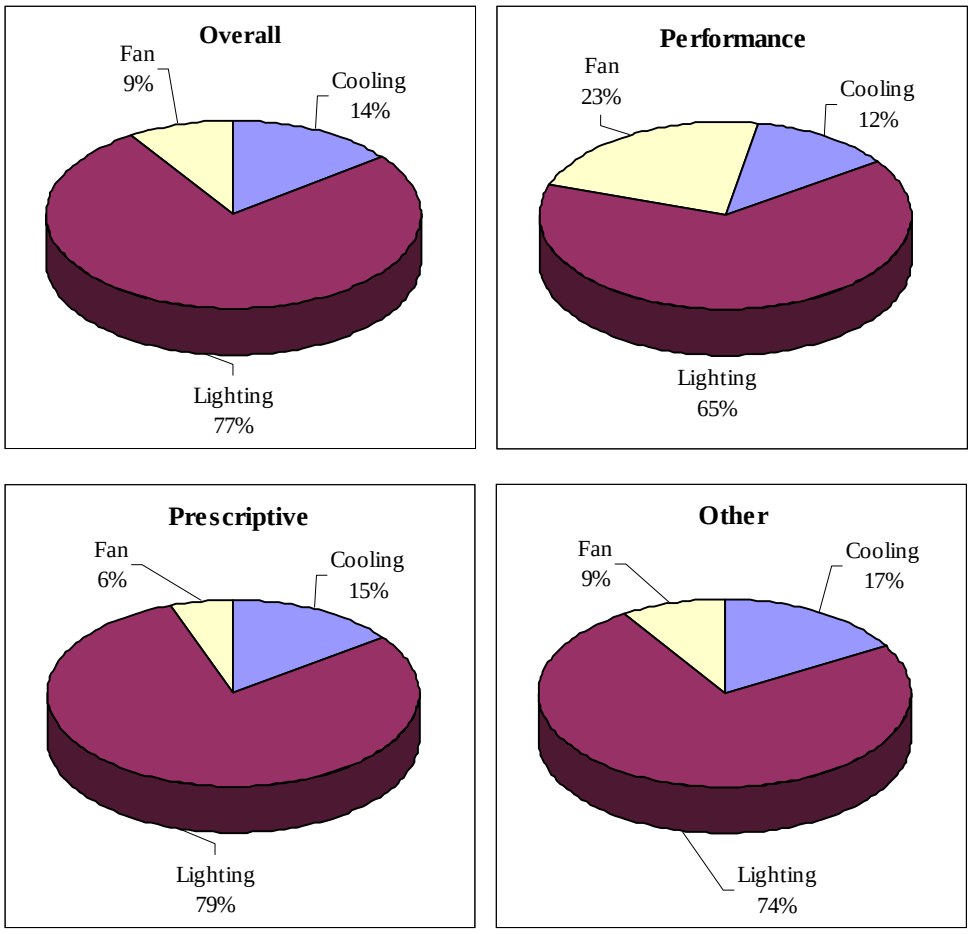

Figure 9: Percentage of Overall Savings by End Use and by Program Approach

Figure 10 shows the percentage of kWh savings overall and by utility and program approach for the weighted Baseline sample. In comparing Figure 10 with Figure 3, which contains the percentage of kWh savings by program approach for the tracking data population, it can be seen that the overall percentage of savings by program approach is relatively similar. The prescriptive projects constitute 74% of the savings in the weighted sample and 79% in the population. Therefore, we can conclude that the weighted sample data fairly accurately represents the population.

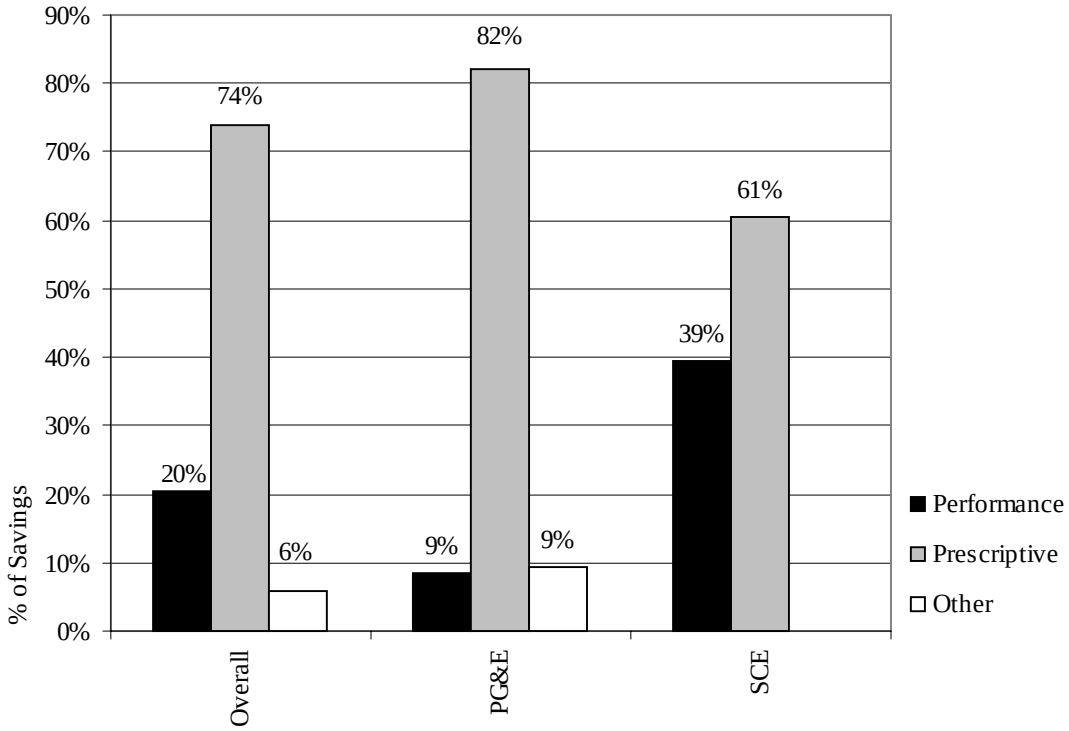

Figure 10: Percentage of kWh Savings by Utility and Program Approach

Energy Ratios

An energy ratio is calculated as the total as-built energy of the entire segment of buildings relative to what their consumption would have been if the buildings had been built just to Title 24 requirements. An energy ratio of one indicates that the buildings are performing just at our Title 24 baseline. An energy ratio below one indicates that the buildings are using less energy. For example, in the table below, performance projects have an energy ratio of 0.82; i.e. they use 18% less energy than code.

Note that due to the small sample sizes for performance and *'Other'* program approaches, the error bounds on the energy ratios are relatively large. All of the energy ratios in this section are presented with error bounds in order for the reader to comprehend the significance of the estimates.

Table 13 shows the average energy ratio by program approach. The average whole building energy ratio for performance projects is lower than that of prescriptive projects, indicating that performance projects saved 3% more than prescriptive projects. However, the error bounds associated with the estimated energy ratios indicate that this is not a statistically significant finding. In the fan end use, performance projects have a statistically lower fan energy ratio than prescriptive projects.

Program Type	Whole Building			Cooling			Lighting			Fans		
	Energy Ratio	Error Bound	Sample Size	Energy Ratio	Error Bound	Sample Size	Energy Ratio	Error Bound	Sample Size	Energy Ratio	Error Bound	Sample Size
Performance	0.82	0.03	34	0.84	0.04	33	0.66	0.05	34	0.70	0.08	33
Prescriptive	0.85	0.02	197	0.81	0.06	190	0.65	0.03	197	0.93	0.02	194
Other	0.84	0.08	11	0.77	0.14	11	0.68	0.11	11	0.84	0.15	11

Table 13: Average Energy Ratio by Program Approach and End Use

Table 14 shows the average energy ratio by ownership type and program approach. The three ownership types explored in this analysis are public, owner occupied, and speculative development. Public buildings are typically buildings owned and operated by federal, state, or local governments. These buildings tend to be office buildings, public assembly space, and specialized uses such as police and fire stations. Owner occupied buildings are funded and constructed by private organizations for private use. Speculative development describes construction practice that speculates needs in the building market. Developers construct new buildings with the prospect of selling or leasing the building for profit.

The information on ownership type was obtained through the decision-maker survey that was administered during the evaluations in order to conduct the net-to-gross analyses. The owner occupied sector accounts for almost half of the projects in the weighted Baseline sample, while the second largest sector is public followed by speculative development.

The analyses by ownership type are to determine if there are any fundamental differences in the construction of buildings within each sector. Table 14 shows that public owners have a lower whole building energy ratio than speculative developments and owner occupied buildings. However, this result is not statistically significant. It is not surprising that speculative development is the least efficient since in most cases the developer does not intend to occupy the building. The reality is that the tenants leasing or purchasing the building from the developer do not have a say in the efficiency of the building systems or design but are ultimately the ones responsible for the energy costs.

Ownership	Program Type	Whole Building		
		Energy Ratio	Error Bound	Sample Size
Owner Occupied	Overall	0.84	0.02	121
	Performance	0.83	0.04	20
	Prescriptive	0.84	0.03	99
	Other	0.98	0.03	2
Speculative Development	Overall	0.90	0.04	36
	Performance	0.81	0.03	6
	Prescriptive	0.92	0.03	28
	Other	0.87	0.06	2
Public Owner	Overall	0.81	0.03	85
	Performance	0.73	0.09	8
	Prescriptive	0.83	0.03	70
	Other	0.74	0.06	7

Table 14: Average Energy Ratio by Ownership and Program Approach

Table 15 shows the average energy ratio by building type and program approach. Schools have a significantly lower whole building energy ratio than the other building types.

Building Type	Program Type	Whole Building		
		Energy Ratio	Error Bound	Sample Size
Office	Overall	0.85	0.03	90
	Performance	0.83	0.06	12
	Prescriptive	0.86	0.03	76
	Other	0.76	0.07	2
Public Assembly	Overall	0.86	0.05	35
	Performance	0.94	0.09	4
	Prescriptive	0.83	0.06	29
	Other	0.93	0.01	2
Retail	Overall	0.85	0.03	53
	Performance	0.83	0.03	8
	Prescriptive	0.85	0.04	43
	Other	0.92	0.09	2
School	Overall	0.76	0.03	64
	Performance	0.68	0.06	10
	Prescriptive	0.81	0.03	49
	Other	0.65	0.11	5

Table 15: Average Energy Ratio by Building Type and Program Approach

Figure 11 shows the shows the average energy ratio by building type and program approach. All of the building types, with the exception of public assembly, have a slightly lower energy ratio for performance sites relative to prescriptive sites.

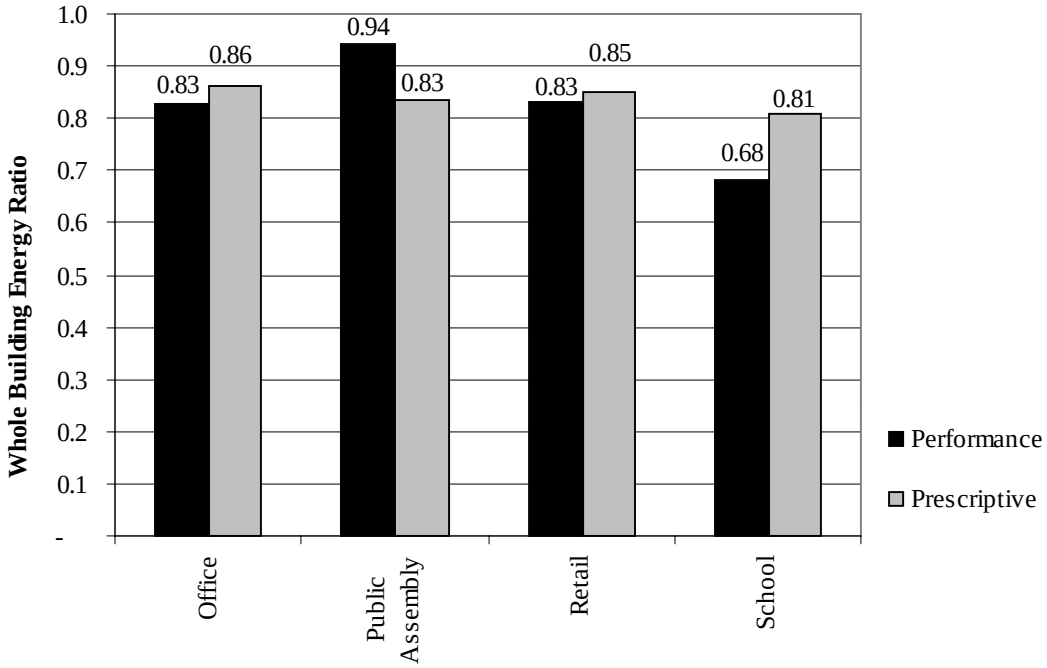

Figure 11: Average Energy Ratio by Building Type and Program Approach

Building Characteristics

This section of the report summarizes some of the building characteristics found on site by program approach. It is intended to give the reader an idea of how the lighting and HVAC systems differ by program approach.

Lighting

The percentage of lighting kW by fixture type and control type, and the percentage of fluorescent lighting kW by ballast type were summarized and are presented in this section.

Table 16 shows the percentage of lighting kW connected to each fixture type by program approach. For all three project types, fluorescent fixtures are the most common. One significant difference between the prescriptive and performance projects is that over 16% of the lighting kW for prescriptive projects is connected to metal halide fixtures, while only 7% of performance projects are connected to metal halides. The second most common for performance and *'Other'* projects are incandescent fixtures.

Fixture Type	Overall (n=242)		Performance (n=34)		Prescriptive (n=197)		Other (n=11)	
	% of Lt kW	Error Bound	% of Lt kW	Error Bound	% of Lt kW	Error Bound	% of Lt kW	Error Bound
Fluorescent	69.5%	4.7%	79.2%	7.0%	67.0%	5.7%	76.8%	11.1%
Metal Halide	13.9%	4.8%	6.6%	2.7%	16.3%	6.1%	1.3%	1.0%
Incandescent	9.9%	2.3%	7.3%	3.4%	10.1%	2.7%	14.2%	10.4%
Compact Fluorescent	4.7%	0.8%	4.4%	2.0%	4.5%	0.9%	6.9%	3.7%
Sodium	0.9%	0.7%	0.0%	0.0%	1.1%	0.9%	0.4%	0.6%
Biaxial	0.5%	0.3%	2.1%	1.6%	0.3%	0.1%	0.0%	0.0%
Halogen	0.3%	0.1%	0.1%	0.0%	0.3%	0.1%	0.2%	0.2%
Mercury Vapor	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%

Table 16: Percentage of Lighting Connected Load by Fixture Type and Program Approach

Table 17 shows the percentage of fluorescent lighting kW connected to each ballast type by program approach. The most common ballast type for all programs are T-8 electronic. Almost 75% of the prescriptive ballasts are of this type. The performance projects have a large percentage of T-12 Energy Saving Magnetic Ballasts, totaling 26% of the fluorescent lighting kW. Note the large error bounds on the estimates for the performance sites which are caused by both the small sample size and the large variation in ballast types.

Lamp Ballast Type		Overall (n=242)		Performance (n=34)		Prescriptive (n=197)		Other (n=11)	
		% of Fl Lt kW	Error Bound	% of Fl Lt kW	Error Bound	% of Fl Lt kW	Error Bound	% of Fl Lt kW	Error Bound
T-8	Electronic	69.6%	7.3%	57.7%	19.2%	74.4%	7.4%	47.7%	26.0%
	En Saving Magnetic	3.0%	1.5%	2.4%	1.5%	3.4%	1.9%	0.0%	0.0%
	Std Magnetic	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
T-12	Electronic Ballast	10.0%	3.8%	13.0%	8.3%	7.1%	3.3%	32.4%	28.3%
	En Saving Magnetic	14.1%	5.1%	26.4%	17.8%	11.7%	4.7%	9.6%	9.3%
	Std Magnetic	3.3%	2.2%	0.5%	0.4%	3.2%	2.7%	10.3%	11.0%

Table 17: Percentage of Fluorescent Lighting Connected Load by Ballast Type and Program Approach

Table 18 shows the percentage of lighting kW with each lighting control type by program approach. For all programs, occupancy sensors are the most common lighting control type. *'Other'* sites have a larger percentage of lighting kW controlled by occupancy sensors than any other program approach. Performance sites have the second largest percentage, and prescriptive has the lowest percentage. Prescriptive sites are much more likely to have a stepped dimming daylight system than are performance projects. During the on site visits it was observed that this system is often used in conjunction with metal halide fixtures.

Lighting Control Type	Overall (n=242)		Performance (n=34)		Prescriptive (n=197)		Other (n=11)	
	% of Lt kW	Error Bound	% of Lt kW	Error Bound	% of Lt kW	Error Bound	% of Lt kW	Error Bound
Occupancy Sensor	19.1%	5.3%	24.9%	11.9%	16.5%	5.3%	35.4%	33.3%
Stepped Dimming Daylight	3.1%	2.9%	0.4%	0.1%	3.9%	3.7%	0.0%	0.0%
Continuous Dimming Daylight	0.5%	0.3%	0.2%	0.1%	0.6%	0.4%	0.0%	0.0%
Lumen Maintenance	0.4%	0.5%	0.0%	0.0%	0.5%	0.6%	0.0%	0.0%
Occupancy Sensor and Daylight Control	0.4%	0.5%	0.0%	0.0%	0.5%	0.6%	0.0%	0.0%

Table 18: Percentage of Lighting Connected Load with Lighting Control Type and Program Approach

HVAC

In this section, the percentage of square footage is summarized by distribution type, cooling system type, and HVAC control type. The percentage of projects with variable speed drives is also presented.

Table 19 shows the percentage of square footage by distribution system type and program approach. In general, the performance and prescriptive programs have similar percentages for each distribution system type.

Distribution System Type	Overall (n=242)		Performance (n=34)		Prescriptive (n=197)		Other (n=11)	
	% of SqFt	Error Bound	% of SqFt	Error Bound	% of SqFt	Error Bound	% of SqFt	Error Bound
Packaged System	60.8%	10.2%	62.6%	22.4%	61.7%	12.2%	44.5%	29.3%
Single Duct Built-up System	27.6%	10.6%	23.9%	14.1%	27.0%	13.2%	46.1%	30.1%
Multizone Built-up System	4.0%	3.7%	1.6%	1.3%	4.8%	4.7%	0.0%	0.0%
Dual Duct Built-up System	1.3%	0.8%	0.5%	0.5%	1.6%	1.0%	0.0%	0.0%
Zonal	3.6%	1.7%	1.9%	3.1%	3.5%	1.8%	9.4%	12.1%
Unconditioned	2.6%	2.0%	9.6%	9.6%	1.3%	0.7%	0.0%	0.0%

Table 19: Percentage of Square Footage by Distribution System Type and Program Approach

Table 20 shows the percentage of square footage served by cooling system types by program approach. The majority of prescriptive and performance projects have rooftop AC units, with the second most common type being built-up systems. There are no significant differences in the cooling systems between performance and prescriptive projects.

Cooling System Type	Overall (n=242)		Performance (n=34)		Prescriptive (n=197)		Other (n=11)	
	% of SqFt	Error Bound	% of SqFt	Error Bound	% of SqFt	Error Bound	% of SqFt	Error Bound
Rooftop AC	44.7%	8.7%	45.4%	19.2%	45.5%	10.2%	33.1%	29.3%
Built-up System	34.2%	10.2%	25.9%	13.7%	34.4%	12.6%	55.5%	29.3%
Split System AC	9.0%	5.3%	2.3%	2.2%	10.9%	6.7%	2.8%	2.1%
Rooftop Heat Pump	2.7%	1.4%	8.9%	7.6%	1.1%	0.6%	8.4%	7.6%
Split System Heat Pump	2.1%	2.1%	0.0%	0.0%	2.6%	2.6%	0.3%	0.3%
Water Loop Heat Pump	1.4%	1.4%	4.2%	6.0%	1.0%	1.3%	0.0%	0.0%
Evaporative Cooler	0.8%	0.4%	2.0%	1.6%	0.6%	0.4%	0.0%	0.0%
Window/Wall AC	0.03%	0.04%	0.0%	0.0%	0.04%	0.05%	0.0%	0.0%
Window/Wall Heat Pump	0.01%	0.00%	0.0%	0.0%	0.01%	0.00%	0.0%	0.0%
Uncooled	4.9%	2.3%	11.5%	9.4%	4.0%	1.6%	0.0%	0.0%

Table 20: Percentage of Square Footage by Cooling System Type and Program Approach

Table 21 shows the percentage of sites with variable speed drives by program approach. Performance projects were found to have a higher percentage of variable speed drives, at 17%, while only 10% of prescriptive projects have variable speed drives. This is one possible explanation for the higher fan savings for performance projects. However, these results are not statistically significant due to the small sample sizes.

Program Type	Variable Speed Drive		Sample Size
	Percentage	Error Bound	
Performance	17%	10%	34
Prescriptive	10%	3%	197
Other	15%	15%	11

Table 21: Percentage of Sites with Variable Speed Drives by Program Approach

Table 22 shows the percentage of total square footage under each HVAC control type by program approach. The percentages in the columns will not add to 100% since some of the spaces use standard packaged equipment with self-contained controls, operated from a simple room thermostat. In addition to the self-contained controls, unconditioned spaces and unobservable control actions are included in the total square footage, but are not broken out separately as a percentage of the square footage.

A larger percentage of square footage for performance projects utilizes HVAC controls. The most common HVAC control type found in performance projects was 'Condenser Water Setpoint Fixed', which is the most simple of the HVAC control types in the table. The second most common type of HVAC control used in performance sites was 'Supply Air Temp Based on Zone Temp'. Almost one-third of the square footage of performance sites utilize this control which is a more complex strategy with zone sensors to monitor the air temperature. However, note the large errors associated with each estimate.

The most common HVAC control type in prescriptive projects was 'Supply Air Temp Reset Based on Outside Temp'. Only 13.7% of the prescriptive square footage utilizes this type of control which is more complex than 'Condenser Water Setpoint Fixed', but less complex than 'Supply Air Temp Based on Zone Temp'. This control type utilizes a sensor to monitor the outside air temperature, which requires less equipment, sensors, and integration than a zonal system.

HVAC Control	Overall (n=242)		Performance (n=34)		Prescriptive (n=197)		Other (n=11)	
	% of SqFt	Error Bound	% of SqFt	Error Bound	% of SqFt	Error Bound	% of SqFt	Error Bound
Condenser Water Setpoint Fixed	17.6%	11.8%	38.5%	32.2%	0.0%	0.0%	19.6%	14.4%
Condenser Water Setpoint Reset on Outdoor Temp	1.7%	1.1%	0.0%	0.0%	2.1%	1.7%	1.7%	1.4%
DDC of Supply Air Flow Rate Based on Terminal Flow	2.9%	1.5%	0.0%	0.0%	5.6%	4.5%	2.6%	1.8%
Optimum Fan Startup	21.1%	11.4%	0.0%	0.0%	0.6%	0.3%	26.8%	13.6%
Outdoor Air Control with CO2 Sensor	3.5%	3.7%	0.0%	0.0%	2.5%	2.5%	4.0%	4.7%
Supply Air Temp Reset Based on Outside Temp	22.0%	11.1%	9.7%	13.7%	13.7%	16.5%	24.6%	13.4%
Supply Air Temp Reset Based on Zone Temp	16.1%	6.7%	31.0%	33.1%	2.1%	1.7%	17.9%	8.0%

Table 22: Percentage of Square Footage by HVAC Control Type and Program Approach