# An Evaluation of the 2004-2005 Savings By Design Program

**CALMAC Study ID SCE0221.01**

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**Volume 1 of 2**

# Final Report

## Prepared for the California Public Utilities Commission

and the following California Investor Owned Utilities:

**Pacific Gas and Electric**

**San Diego Gas and Electric**

**Southern California Edison**

**Southern California Gas Company**

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**Prepared by:**

RLW ANALYTICS

466 Geary Suite 400
San Francisco CA
94102
415.684.1070

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# Executive Summary

This document is the final report for the Savings By Design (SBD) study for the statewide Non-Residential New Construction (NRNC) program area for 2004-2005. This report contains summary results for program participants of Savings By Design (SBD). Savings By Design is the statewide NRNC energy efficiency program administered and implemented by Pacific Gas and Electric Company, San Diego Gas and Electric Company, Southern California Edison Company, and Southern California Gas Company, also known as the California investor-owned utilities (IOUs). Previously this evaluation was also called the Building Efficiency Assessment study.

The key objectives of the study are to:

- Develop gross and net impact estimates for the gross whole building energy and demand savings resulting from the Savings By Design program,
- Develop gross and net energy and demand impact estimates of both incented and non-incented measure categories,
- Develop estimates of free-ridership,
- Develop net energy and demand impacts, and
- Provide process findings of the SBD program from the perspective of the program participants.

The SBD program has included industrial projects participating at varying levels at each utility. As of Program Year 2002, all four utilities allowed industrial projects to participate in their program and to receive incentive payments. The industrial results have been reported separately due to the unique considerations of these process specific measures.

The sample was not stratified by project type (i.e. commercial, industrial); instead an overall evaluation sample was selected using energy savings as the stratification variable. The sampling plan was designed to over-sample the large customers, increasing the variance captured by the sample and improving the overall precision.

The 2004-2005 SBD Evaluation Study is an evaluation of Savings By Design projects that were paid incentives in calendar year 2004-2005. Though this study is restricted to projects paid in 2004-2005, the evaluated projects may have initially signed onto the program several years ago, or as late as 2005. The basis of the gross energy and demand savings methodology were DOE-2 engineering models and engineering calculations that are informed by detailed onsite surveys, end-use metered data and monthly billing data. The output of the engineering models is statistically projected to the program population to show program impacts at the 90% confidence level. The study is further informed by in-depth telephone surveys with the building owners and/or designers regarding the energy design choices made for these buildings. The results of the decision-maker data not only produce process findings, they are also used to adjust the engineering models for estimating the program's net energy impacts.

The following sections describe the high-level findings identified by the evaluators in the course of the 2004-2005 SBD Study. When compared to prior SBD evaluations for years 2002 and 2003, the overall savings numbers in this report are higher because this evaluation covers two years, while the prior evaluations were for a single year.

This revised version of this report contains significant changes in the savings figures reported in the previous published version. The prior version had erroneous relative precisions on many of the savings estimates. Additionally, there was one large site that was reassessed after the report was published.

The reassessed site was a large industrial project with a single measure, where the incented equipment failed and was replaced. In the prior report, no gross or net savings were attributed to the measure since, at first glance, the replacement appeared beyond the reach of program influence. Upon further investigation, the utility representative proved to be as influential for the replacement measure as he was for the initial measure. Therefore the site was reevaluated to generate gross and net savings for the measure. The current version of this report includes the revised results for this sample point as well as the revised Program savings results. The site in question had large savings numbers, so the effect on the overall Program savings numbers and the utility in question is noticeable.

## Gross Impact Findings

This section presents gross impact findings for the statewide Savings By Design program, including both commercial and industrial projects. Impact findings have been calculated at the utility level, and then aggregated to the statewide level. A limitation of the study is that the sample was designed to optimize the precision at the *statewide* level in order to achieve a relative precision of 8% at the 90% level of confidence for *statewide* kBtu savings estimates. However, CPUC mandated reporting requires savings estimates at the utility level. When samples that are optimized for statewide precision are used to predict utility specific savings, the number of sites per utility is smaller than optimal in some cases, resulting in higher uncertainty around the utility level savings estimates.

The evaluation results show that the utilities' tracking estimates are slightly exceeded by the gross energy savings estimates developed from our evaluation methodology, resulting in about a 103% realization rate for electrical energy savings, kWh, as shown in Table 1. These findings are based on a sample of sites that comprise roughly 42% of the program estimated electrical energy savings, almost 40% of the program estimated electrical demand savings, and approximately 48% of the program estimated natural gas savings. Gas savings were driven largely by HVAC measures, which account for almost six million therms (over 67%) of savings and have a relative precision of 114%.[1]

| | Ex-Ante Gross Savings | Sampled Savings | % Savings Sampled | Ex-Post Gross Savings | Gross Realization Rate |
|---|---|---|---|---|---|
| Energy(MWh) | 344,748 | 144,339 | 41.9% | 355,453 | 103.1% |
| Demand(MW) | 68.7 | 27.3 | 39.7% | 55.3 | 80.4% |
| Gas (therms) | 8,662,541 | 4,194,603 | 48.4% | 10,901,876 | 125.9% |

**Table 1: Gross Energy and Demand Impacts – Combined Total**

Energy, demand, and gas findings presented in Table 2 show the impacts attributed to commercial projects and industrial projects separately. The table shows the estimated gross realization rate for industrial projects is approximately 76%, 111%, and 76% respectively for energy, demand, and gas savings respectively.

[1] An explanation of statistical terms, such as relative precision and error bounds, can be found in the appendix.

| | | Ex-Ante Gross Savings | Ex-Post Gross Savings | Gross Realization Rate |
|---|---|---|---|---|
| Commercial | Energy(MWh) | 231,036 | 268,758 | 116.3% |
| | Demand(MW) | 58.5 | 43.9 | 75.1% |
| | Gas (therms) | 2,878,393 | 6,489,318 | 225.4% |
| Industrial | Energy(MWh) | 113,712 | 86,696 | 76.2% |
| | Demand(MW) | 10.3 | 11.4 | 110.8% |
| | Gas (therms) | 5,784,148 | 4,412,558 | 76.3% |

**Table 2: Gross Energy and Demand Impacts – Commercial and Industrial**

## Net Impact Findings

In this study, RLW prepared a decision-maker survey that asked measure-specific questions of program participants. We used self-reported decision-maker survey responses to calculate the estimates of free-ridership by measure category and end-use. The survey questions elicited information describing why the efficiency choices were made and the various influences on these decisions. The purpose of the measure/end-use questions was to reconstruct what might have happened absent program influences. Using a scoring methodology developed early in the study, the surveys were scored and then given to the surveyor responsible for the project DOE-2 modeling. Using a "net savings report" furnished by the analysts, the surveyor adjusted the DOE-2 model to reflect program influences. The models were then re-simulated and compared to the as-built and baseline parametric models to develop end-use and measure level estimates of participant free-ridership. A comprehensive explanation of the net savings methodology can be found in the appendix.

The net impact findings for the 2004-2005 program cycle are presented in Table 3 below including both commercial and industrial projects. The results indicate a net-to-gross ratio of roughly 75% for commercial energy savings and 79% for commercial demand savings. The industrial net-to-gross ratio is approximately 65% and 66% for energy and demand savings, respectively. While lower than the commercial net-to-gross, these industrial results are an improvement over 2003 results (59% energy N-T-G and 55% demand N-T-G) and significantly improved over the 2002 results (35% energy N-T-G and 33.3% demand N-T-G).

| | | Ex-Post Net Savings | Ex-Post Gross Savings | Net-to-Gross Ratio |
|---|---|---|---|---|
| Commercial | Energy(MWh) | 203,409 | 268,758 | 75.7% |
| | Demand(MW) | 34.7 | 43.9 | 79.0% |
| | Gas(therms) | 6,801,954 | 6,489,318 | 104.8% |
| Industrial | Energy(MWh) | 56,121 | 86,696 | 64.7% |
| | Demand(MW) | 7.6 | 11.4 | 66.4% |
| | Gas(therms) | 2,731,491 | 4,412,558 | 61.9% |

**Table 3: Savings and Demand Reduction – Commercial & Industrial**

The participant net-to-gross is an estimate of program-induced savings, less what the participants would have done absent the program (i.e., free-ridership), as a percentage of participant gross savings. The participant net-to-gross ratio is most closely comparable to net-to-gross ratios calculated for past NRNC program evaluations conducted in California. Table 4, Table 5, and Table 6 present ex-ante gross savings, ex-post gross savings, ex-post net savings, and the net to gross ratios for each end use. Referring to Table 4, the commercial participant net-to-gross ratio is around 76%, which represents the percentage of the energy savings that are a direct result of the SBD program, while the remainder (~24%) is considered program free-ridership. Industrial participant net-to-gross ratio is nearly 65%.

| | Commercial Energy Impacts (MWh) | Industrial Energy Impacts (MWh) | Calculation |
|---|---|---|---|
| Ex-Ante Gross Savings | 231,036 | 113,712 | A |
| Ex-Post Gross Savings | 268,758 | 86,696 | B |
| Gross Realization Rate | 116.3% | 76.2% | (B/A) |
| Ex-Post Net Savings | 203,409 | 56,121 | C |
| Net-to-Gross Ratio | 75.7% | 64.7% | (C/B) |

**Table 4: Program Net Electrical Energy Savings**

| | Commercial Energy Impacts (MW) | Industrial Energy Impacts (MW) | Calculation |
|---|---|---|---|
| Ex-Ante Gross Savings | 58.5 | 10.3 | A |
| Ex-Post Gross Savings | 43.9 | 11.4 | B |
| Gross Realization Rate | 75.1% | 110.8% | (B/A) |
| Ex-Post Net Savings | 34.7 | 7.6 | C |
| Net-to-Gross Ratio | 79.0% | 66.4% | (C/B) |

**Table 5: Program Net Electrical Demand Reduction**

| | Commercial Energy Impacts (Therms) | Industrial Energy Impacts (Therms) | Calculation |
|---|---|---|---|
| Ex-Ante Gross Savings | 2,878,393 | 5,784,148 | A |
| Ex-Post Gross Savings | 6,489,318 | 4,412,558 | B |
| Gross Realization Rate | 225.4% | 76.3% | (B/A) |
| Ex-Post Net Savings | 6,801,954 | 2,731,491 | C |
| Net-to-Gross Ratio | 104.8% | 61.9% | (C/B) |

**Table 6: Program Net Natural Gas Savings**

Table 7 reports the electrical energy net-to-gross ratios from the past three NRNC evaluation studies. The commercial net-to-gross ratio of 76% for the 2004-2005 SBD compares favorably with past results. The industrial program continues to improve its net-to-gross ratio, but at levels lower than the commercial program.

| Sector | Program Year | Net-to-gross Ratio |
|---|---|---|
| Commercial | 1999-2001 | 82% |
| Commercial | 2002 | 75% |
| Commercial | 2003 | 76% |
| Commercial | 2004-2005 | 76% |
| Industrial | 2002 | 35% |
| Industrial | 2003 | 59% |
| Industrial | 2004-2005 | 65% |

**Table 7: Historic Electrical Energy Net to Gross Ratios for NRNC Studies**

## CPUC Reporting Tables

The following 5 tables are what have been reported to the CPUC for net program lifecycle savings of the Savings By Design program. The first table lists the “statewide” savings, which is the aggregate of all four utilities; the subsequent four tables are the utility specific net program lifecycle savings.

**Program IDs*:** 1161-04 1183-04 1506-04 1127-04 1323-04 1346-04 1249-04
**Program Name:** Savings By Design

| Year | Calendar Year | Ex-ante Gross Program-Projected Program MWh Savings (1) | Ex-Post Net Evaluation Confirmed Program MWh Savings (2) | Ex-Ante Gross Program-Projected Peak Program MW Savings (1**) | Ex-Post Evaluation Projected Peak MW Savings (2**) | Ex-Ante Gross Program-Projected Program Therm Savings (1) | Ex-Post Net Evaluation Confirmed Program Therm Savings (2) |
|---|---|---|---|---|---|---|---|
| 1 | 2004 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 2 | 2005 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 3 | 2006 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 4 | 2007 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 5 | 2008 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 6 | 2009 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 7 | 2010 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 8 | 2011 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 9 | 2012 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 10 | 2013 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 11 | 2014 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 12 | 2015 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 13 | 2016 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 14 | 2017 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| 15 | 2018 | 326,693 | 259,530 | 64.91 | 42.27 | 7,644,619 | 9,533,445 |
| 16 | 2019 | 204,517 | 178,367 | 39.73 | 28.34 | 5,040,455 | 3,024,948 |
| 17 | 2020 | 37,386 | 53,381 | 7.12 | 7.37 | 672,450 | 2,731,491 |
| 18 | 2021 | 37,386 | 53,381 | 7.12 | 7.37 | 672,450 | 2,731,491 |
| 19 | 2022 | 37,386 | 53,381 | 7.12 | 7.37 | 672,450 | 2,731,491 |
| 20 | 2023 | 37,386 | 53,381 | 7.12 | 7.37 | 672,450 | 2,731,491 |
| **TOTAL** | **2004-2023** | 5,469,833 | 4,231,455 | | | 135,977,998 | 154,221,099 |

## Table 8: Overall 2004-2005 Net Program Lifecycle Savings

**Program ID*:** 1506-04(proc) 1127-04
**Program Name:** Savings By Design

| Year | Calendar Year | Ex-ante Gross Program Projected Program MWh Savings (1) | Ex-Post Net Evaluation Confirmed Program MWh Savings (2) | Ex-Ante Gross Program-Projected Peak Program MW Savings (1**) | Ex-Post Evaluation Projected Peak MW Savings (2**) | Ex-Ante Gross Program Projected Program Therm Savings (1) | Ex-Post Net Evaluation Confirmed Program Therm Savings (2) |
|---|---|---|---|---|---|---|---|
| 1 | 2004 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 2 | 2005 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 3 | 2006 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 4 | 2007 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 5 | 2008 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 6 | 2009 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 7 | 2010 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 8 | 2011 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 9 | 2012 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 10 | 2013 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 11 | 2014 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 12 | 2015 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 13 | 2016 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 14 | 2017 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 15 | 2018 | 90,801 | 74,989 | 19.28 | 13.84 | 5,119,323 | 3,038,243 |
| 16 | 2019 | 84,811 | 75,171 | 18.00 | 13.22 | 4,781,623 | 3,040,725 |
| 17 | 2020 | 10,912 | 23,753 | 2.32 | 4.87 | 615,207 | 2,731,491 |
| 18 | 2021 | 10,912 | 23,753 | 2.32 | 4.87 | 615,207 | 2,731,491 |
| 19 | 2022 | 10,912 | 23,753 | 2.32 | 4.87 | 615,207 | 2,731,491 |
| 20 | 2023 | 10,912 | 23,753 | 2.32 | 4.87 | 615,207 | 2,731,491 |
| **TOTAL** | **2004-2023** | 1,732,334 | 1,271,269 | | | 97,667,996 | 56,808,843 |

## Table 9: PG&E 2004-2005 Net Program Lifecycle Savings.

| Program ID*: | 1183-04(procurement) and 1161-04 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Program Name: | Savings By Design | | | | | | | |
| | Year | Calendar Year | Ex-ante Gross Program-Projected Program MWh Savings (1) | Ex-Post Net Evaluation Confirmed Program MWh Savings (2) | Ex-Ante Gross Program-Projected Peak Program MW Savings (1**) | Ex-Post Net Evaluation Projected Peak MW Savings (2**) | Ex-Ante Gross Program-Projected Program Therm Savings (1) | Ex-Post Net Evaluation Confirmed Program Therm Savings (2) |
| | 1 | 2004 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 2 | 2005 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 3 | 2006 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 4 | 2007 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 5 | 2008 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 6 | 2009 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 7 | 2010 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 8 | 2011 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 9 | 2012 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 10 | 2013 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 11 | 2014 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 12 | 2015 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 13 | 2016 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 14 | 2017 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 15 | 2018 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| | 16 | 2019 | 119,705 | 103,196 | 22 | 15.12 | 258,832 | (15,778) |
| | 17 | 2020 | 26,474 | 29,628 | 5 | 2.50 | 57,243 | - |
| | 18 | 2021 | 26,474 | 29,628 | 5 | 2.50 | 57,243 | - |
| | 19 | 2022 | 26,474 | 29,628 | 5 | 2.50 | 57,243 | - |
| | 20 | 2023 | 26,474 | 29,628 | 5 | 2.50 | 57,243 | - |
| | TOTAL | 2004-2023 | 2,503,278 | 2,096,540 | | | 5,412,706 | 61,925,861 |

**Table 10: SCE Net Program Lifecycle Savings**

| Program ID*: | 1323-04 (proc) 1346-04 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Program Name: | Savings By Design | | | | | | | |
| | Year | Calendar Year | Ex-ante Gross Program-Projected Program MWh Savings (1) | Ex-Post Net Evaluation Confirmed Program MWh Savings (2) | Ex-Ante Gross Program-Projected Peak Program MW Savings (1**) | Ex-Post Net Evaluation Projected Peak MW Savings (2**) | Ex-Ante Gross Program-Projected Program Therm Savings (1) | Ex-Post Net Evaluation Confirmed Program Therm Savings (2) |
| | 1 | 2004 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 2 | 2005 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 3 | 2006 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 4 | 2007 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 5 | 2008 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 6 | 2009 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 7 | 2010 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 8 | 2011 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 9 | 2012 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 10 | 2013 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 11 | 2014 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 12 | 2015 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 13 | 2016 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 14 | 2017 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 15 | 2018 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 16 | 2019 | | | | | | |
| | 17 | 2020 | | | | | | |
| | 18 | 2021 | | | | | | |
| | 19 | 2022 | | | | | | |
| | 20 | 2023 | | | | | | |
| | TOTAL | 2004-2023 | 959,385 | 633,597 | | | 31,826,940 | 35,430,705 |

**Table 11: SDG&E Net Program Lifecycle Savings**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Program ID*:** | 1249-04 | | | | | | | | |
| **Program Name:** | Savings By Design | | | | | | | | |
| | Year | Calendar Year | Ex-ante Gross Program-Projected Program MWh Savings (1) | Ex-Post Net Evaluation Confirmed Program MWh Savings (2) | Ex-Ante Gross Program-Projected Peak Program MW Savings (1**) | Ex-Post Net Evaluation Projected Peak MW Savings (2**) | Ex-Ante Gross Program-Projected Program Therm Savings (1) | Ex-Post Net Evaluation Confirmed Program Therm Savings (2) |
| | 1 | 2004 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 2 | 2005 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 3 | 2006 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 4 | 2007 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 5 | 2008 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 6 | 2009 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 7 | 2010 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 8 | 2011 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 9 | 2012 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 10 | 2013 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 11 | 2014 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 12 | 2015 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 13 | 2016 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 14 | 2017 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 15 | 2018 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 16 | 2019 | | | | | | |
| | 17 | 2020 | | | | | | |
| | 18 | 2021 | | | | | | |
| | 19 | 2022 | | | | | | |
| | 20 | 2023 | | | | | | |
| | **TOTAL** | **2004-2023** | 274,836 | 230,048 | | | 1,070,355 | 55,690 |

**Table 12: SoCalGas Net Program Lifecycle Savings**

## Total Resource Cost Results

Total resource cost (TRC) is a cost-effectiveness metric for utility energy efficiency programs. If a program has a TRC value greater than one, it is considered cost effective. Table 13 shows each utility's projected TRC based upon project goals that were calculated before 2004. The ex ante TRC is based upon actual project activities recorded during 2004-2005. The ex post TRCs are the calculated based upon the evaluated savings and our net-to-gross analysis values. Due to project scope, ex post TRCs used utility budgets as reported, incremental measure cost, and utility estimates of effective useful measure life without question.

Due to the long project cycles of new construction projects, this is not an exact comparison of activities. The utility estimates were solely based on 2004-2005 program efforts, while the ex post TRC considers only projects paid in 2004-2005, many of which were result of projects committed in prior program years. Similarly, many projects committed in 2004-2005 have not been completed or paid, and the savings associated with these projects are not counted in the evaluation estimates.

| Utility | Utility Projected TRC Ratio | Utility Ex-Ante TRC Ratio | Ex-Post TRC Ratio |
|---|---|---|---|
| PGE | * 2.10 | * 2.60 | 2.12 |
| SCE | * 2.56 | * 2.45 | 3.29 |
| SDGE | * 1.91 | * 3.37 | 2.34 |
| SoCalGas | 2.59 | 2.89 | 2.64 |
| Overall | 2.27 | 2.60 | 2.64 |

**Table 13: Total Resource Cost (TRC) by Utility[2]**

## Process Findings

RLW designed and completed decision-maker (DM) surveys to help determine the net savings attributable to the program.[3] The questions were formulated to learn more about program awareness and attitudes, specific building characteristics, and design and construction practices. The process questions addressed several general categories of interest:

- **General Building Information** – General building information such as ownership type and type of project.
- **Program Attitudes and Awareness** – The importance of energy efficiency to the company and other factors which influenced them to participate.
- **Dollar Incentives, Design Assistance and Design Analysis** – Value of services offered by the Savings by Design Program.[4]

### *General Building Information*

This portion of the survey addressed the types of projects, types of building, ownership intent, etc. Many of these results are as expected, such as the finding that over 70% of the surveyed projects were new construction, while the others were major renovations, also allowed in the SBD program. Similarly, almost 70% of the buildings were privately owned and the remainder was publicly owned. Table 14 shows building ownership by occupancy intent. All publicly owned buildings were intended to be occupied by the owner while only 81.7% of privately owned buildings were intended to be owner occupied.

[2] *Combined TRC of utility's SBD public goods and procurement funded projects

[3] The same sites used in the gross savings estimation were included in the net savings decision maker interviews.

[4] Design analysis includes energy modeling and engineering calculations. Design assistance includes the identification of energy efficiency opportunities, resources and design development support to aid building owners and design teams with energy-efficient facility design.

| Ownership of Building | Occupancy Intent | | | Total |
|---|---|---|---|---|
| | Owner Occupied | Lease Space | Developer Occupied | |
| Private | 81.7% | 17.8% | 0.5% | 100.0% |
| Public | 100.0% | 0.0% | 0.0% | 100.0% |

**Table 14: Building Ownership by Occupancy Intent (q8 & q9)**

## *SBD Attitudes and Awareness*

The program participants were generally satisfied with the program. This is indicated by the frequent "no changes needed" responses when asked what the program should improve. This is shown in Table 15. Some of the requests for change came in the following areas: making the program easier and faster to use, involving the utilities earlier in the projects, increasing marketing efforts, and increasing interaction with the design team. Respondents were allowed to give multiple recommendations; therefore the sum of the percentages is greater than 100%.

| Recommendations | % of Respondents |
|---|---|
| No Changes Needed | 50.8% |
| Other | 21.5% |
| More marketing to increase awareness of program | 9.8% |
| Increase Incentives | 9.5% |
| Utilities should try to get involved earlier in projects | 9.0% |
| Don't Know | 7.2% |
| More interaction with design team | 7.0% |
| Review and response from utility needs to be more timely | 5.1% |
| Utility Reps need to present benefits more clearly | 1.7% |
| Less paperwork and red tape | 1.3% |
| Increase post project feedback, better "closure" | 0.6% |
| Refused | - |
| Sample Size | 191 |

**Table 15: Recommended Changes to Savings by Design (q20)**

The majority of the participants became aware of the program through a utility representative or previous utility program participation. At the same time, the owner was the biggest advocate for participating in the program, representing 62.3% of the primary supporters.

## *Importance of Incentives, Design Assistance and Design Analysis*

In each of the categories of incentives, and design assistance or design analysis, the majority of the respondents indicated that these items were very or somewhat valuable. Figure 1 shows the results. Additionally, over three-quarters of the respondents indicated that they had changed their construction practices to include more energy efficient designs as a result of participation in the program. These factors combine to show that participants rely greatly on the program's offerings and the effects of these services go beyond the SBD project.

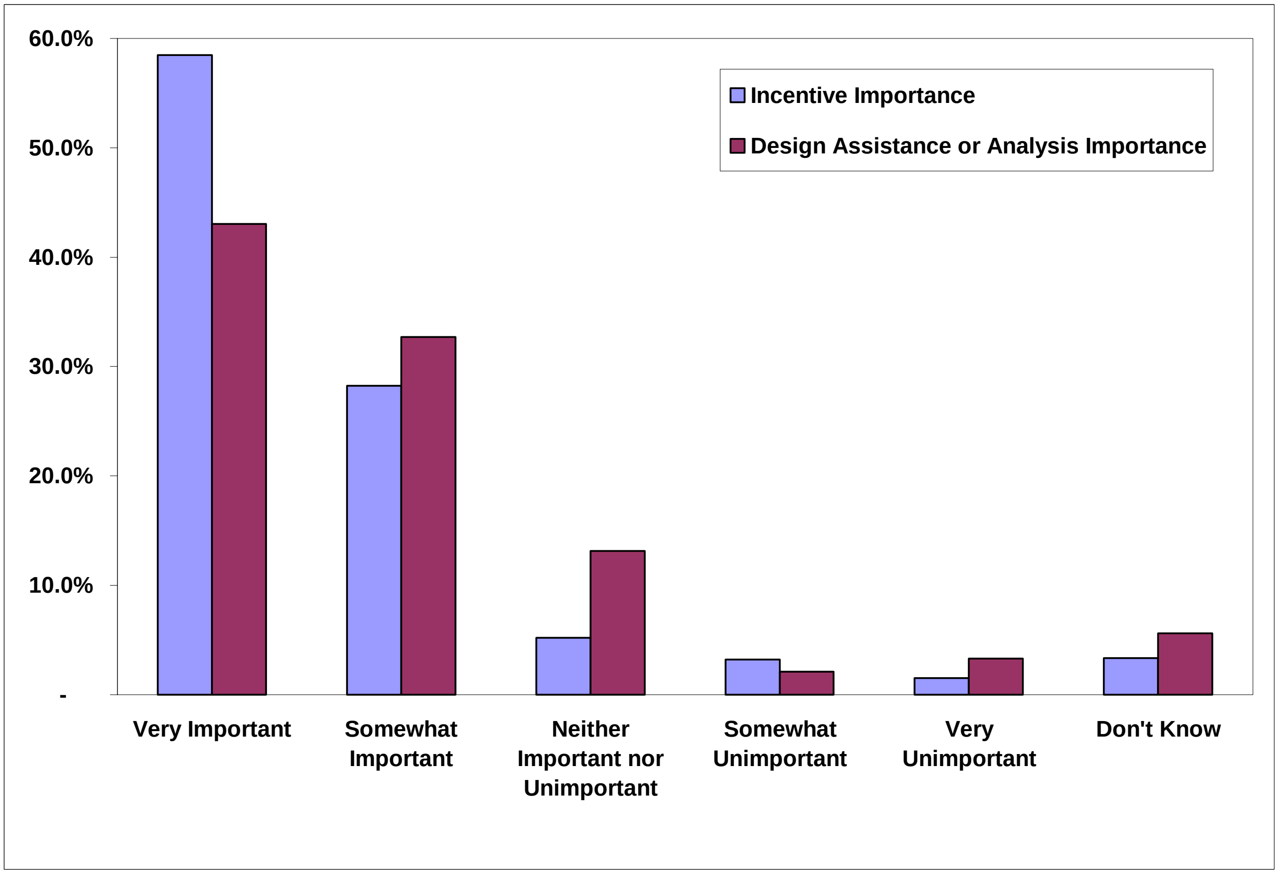


**Figure 1: Importance of Incentive and Design Assistance/Analysis**

# Introduction

RLW Analytics, Inc. (RLW) conducted an evaluation of the 2004-2005 Savings By Design (SBD) Program, California's statewide non-residential new construction (NRNC) energy efficiency program administered by PG&E (CPUC #1127-04), SCE (CPUC #1261-04 and 1183-04), SoCalGas (CPUC #1249-04), and SDG&E (CPUC # 1346-04 and 1323-04). Prior evaluations of this program were called the Building Efficiency Assessment (BEA) study. A separate report was written that was paid for out of PG&E Procurement funding for SBD (CPUC #1506-04).

This document is the final report for the Savings By Design (SBD) study for the statewide Non-Residential New Construction (NRNC) program area, covering calendar years 2004 and 2005. This report contains summary results for program participants over multiple years that received their incentive payments in 2004 and 2005. The key objectives of the study are to:

- Develop on-going gross whole-building energy and demand impact estimates for the SBD program,
- Develop on-going impact estimates of both incented and non-incented measure categories,
- Develop on-going estimates of both free-ridership at the measure and end-use level,
- Develop net energy and demand impacts, and
- Provide on-going process findings of the SBD program from the perspective of the program participants.

## Evaluation Overview

RLW Analytics (RLW) is the prime contractor on this project and carried out all statistical analysis for this report. Architectural Energy Corporation (AEC) of Boulder Colorado participated in the on-site data collection, and is the lead on the engineering simulation work. Eskinder Berhanu & Associates (EBA), located in Southern California, assisted RLW and AEC in the data collection and engineering modeling.

The RLW Team has developed a sound and reliable process for estimating the energy impact of the Statewide Non-residential New Construction (NRNC) program. Our methodology builds on our prior experience evaluating the 1994, 1996, 1998, and 1999 NRNC programs for PG&E and SCE, our work on the CBEE California Statewide Non-residential New Construction Baseline study, as well as our work on the 1999-2001, 2002 and 2003 BEA studies (Savings By Design evaluations have been titled "Building Efficiency Assessment Studies" (BEA) in the past). Moreover, the same approach was applied to the last five years of program activities, including 1999 through 2003. Findings from these studies are presented in the previous four Building Efficiency Assessment Study reports. This is the fourth in a series of Savings By Design evaluation reports. The participant population for this study consisted of 1096 sites paid in the statewide SBD program during 2004-2005.

The Savings By Design evaluation defines participants by the year in which they were paid their incentive. Alternatively, the utilities define program participation year based upon the year the participant signed a contract to receive program incentives. Therefore the 2004-2005 SBD study is not a true study of PY 2004-2005 program activities. However, because this is an on-going evaluation of SBD, a complete picture of SBD and corresponding non-participant projects is evolving over time.

The selection of the participant sites was guided by a model-based statistical sampling plan as in each of the last studies dating back to the 1994 NRNC evaluation. We used a participant sample that was efficiently stratified by utility and the tracking estimate of annual energy savings, with proportional representation of building types and climate zones in the combined participant population. The final participant sample size was 180 sites.

This study and the two previous studies are different from prior NRNC program and SBD evaluations in that they include industrial projects. Although the industrial projects do not conform to the standardized evaluation methods developed by the evaluation team for commercial projects, all sampled industrial projects did undergo rigorous evaluation and review. This study, unlike prior years, did not examine non-participants.

The gross savings evaluation is based on DOE-2 engineering models and engineering calculations that are informed by detailed on-site surveys statistically projected to the program population. Title 24 is the baseline used by the Model-IT software for generating gross savings estimates for the whole building and at the measure level. To refine the engineering models, short term monitoring was conducted at a sample of sites and the models were calibrated to the empirical field measurements.

The net savings component of the evaluation considers free-ridership (i.e., savings that would have occurred even if the customer had not participated in the program), at the measure and end-use level. Free-ridership values are calculated by revising the DOE-2 site specific engineering models to reflect the efficiency choices of the owner absent the program, or any previous interactions with the program. DOE-2 model adjustments are determined through in-depth interviews with the project decision-makers. This approach results in net savings at the end-use level for program participants

The SBD study also includes an analysis of process findings as reported by the participant decision-makers. In-depth telephone surveys are conducted with participant building owners and designers in order to assess the effectiveness of the program, reasons for participation, satisfaction with the program, and other areas of program influence. This aspect of the evaluation also includes questions for participants regarding design and construction decisions made in the process of the project. The responses from these surveys are tabulated and expanded back to the population of participants. Results are used to assess the attitudes, decision-making processes and beliefs of NRNC market actors for use in improving program delivery of the Savings By Design program.

## Savings By Design Program Description

The Savings By Design program offered by California's Investor Owned Utilities includes design assistance and financial incentives to improve the energy efficiency of commercial new construction and industrial projects. The incentive program has two participation paths, the Systems approach and the Whole Building approach. Within the Systems approach, there are commercial and industrial projects. The incentive structure targets both the building owner and the building design team.

### *Systems Approach*

#### *Commercial Projects*

The Systems Approach used "CaNCCalc" which is a specially designed savings estimation tool to provide savings values for efficient systems that are broadly available, though not currently standard practice. Since mid-2001, SBD has used an evolved version of CaNCCalc that uses a DOE-2 simulation engine with an eQUEST front-end that provides detailed results for custom inputs.

Building Systems covered under this approach include the following:

*Shell Measures*

Buildings with shell components that have better than minimally compliant code performance in their building designs are eligible for incentives.

- Low solar heat gain coefficient (SHGC) glazing
- Increased opaque surface insulation
- Cool roofs

*Daylighting Systems*

Buildings incorporating control systems to take advantage of sidelighting from windows and toplighting from skylights are both eligible for incentives. The energy savings estimates are based on the lighting power (kW) controlled, the Performance Index (PI) of the glazing (visible light transmittance/solar heat gain coefficient), and the total area of high performance glazing.

*Other Lighting Controls*

All control schemes, other than daylighting system that reduce building lighting energy use are also eligible for incentives. However, the savings associated with this measure category are dominated by lighting occupancy sensor control systems.

*Low Lighting Power Density Lighting Systems*

To qualify for owner incentives, projects need to achieve at least a 10% reduction in the building's lighting power density (LPD). The system must still provide adequate light levels as recommended by the Illuminating Engineering Society. At least two of the following lighting measures must be included in an efficient lighting system design to qualify for incentives:

- High-efficiency lamps
- Efficient ballasts
- Improved lighting design

*HVAC Systems*

The HVAC systems component includes high-efficiency equipment and controls that regulate the system. The HVAC Systems component addresses the following measures:

- High-efficiency packaged units
- High-efficiency heat pumps
- High-efficiency water-cooled chillers
- High-efficiency boilers
- Variable-speed motor drives on system fans and pumps
- Demand-controlled ventilation

- Premium-efficiency motors

*Service Hot Water Systems*

- High efficiency instantaneous and storage water heaters

*Refrigeration Systems*

The following efficient supermarket refrigeration system improvements are eligible for incentives in SBD:

- Floating head pressure
- Variable-speed drive condensers fans
- Variable suction pressure
- High efficiency evaporator fans
- Mechanical subcooling
- Timers on case lighting

*Industrial Process or Other Systems*

The Other Systems or Processes portion of Savings By Design offers financial incentives to facility owners for energy efficient measures utilized in a wide range of unique industrial applications. These projects mostly utilize the Systems Approach, except for refrigerated warehouses as discussed below, and rely on calculations outside of CaNCCalc provided by utility engineers or independent consultants. In most cases, the industrial measures are completely isolated from any commercial building.

The incented industrial measures include the following:

- Carbon monoxide sensors for parking garage fans
- Compressed air measures –
  - VSD compressors, efficient air dryers, system pressure reduction, loss control
- Premium efficiency motors and VSDs on pumping, fan, and blower applications
- Lighting measures in dairy barns
- Heat exchangers
- Groundwater cooled condensers
- Efficient injection molding machines
- Low pressure UV wastewater treatment
- Efficient specialized process equipment and design
- High volume low speed fans

*Refrigerated Warehouses*

The refrigerated warehouse component of the industrial process measures utilized a customized approach using DOE-2.2R simulation models. The measures found in the sampled projects included the following:

- Efficient condensers
- Floating head pressure, variable condenser set point, VFD on condenser fan
- VFDs on motors and pumps
- Efficient motors- compressors, supply fans, conveyor motors
- Low lighting power density (LPD)
- Occupancy sensor lighting controls- freezers, warehouses
- Waste water heat exchanger
- Increased insulation
- Evaporator fan run time strategy
- Floating suction pressure
- Hot gas defrost
- Mechanical sub cooling

Note that the refrigerated warehouse savings are reported within the “industrial’ measure category

### *Whole Building Approach*

The Whole Building Approach offers a comprehensive package of services designed to analyze energy-efficient, cost-effective design alternatives. The Whole Building Approach is not limited to particular measures, but provides incentives based on reduced energy consumption relative to Title-24. This program component provides Design Assistance and Design Analysis to help provide an optimized “whole-building” design.

### *Design Assistance*

Design assistance is available to building owners and to their design teams, regardless of the design approach, and is matched to the needs of the project. Under the Systems Approach, design assistance may include recommendations for efficient equipment, consultation on enhanced design strategies, or provision of sample specifications. Under the Whole Building Approach, design assistance may involve support to the design team in developing a building energy simulation model, preparing a report for the owner on recommended design modifications, and facilitating the integration of any modifications into the final building design. In this report, we refer to these activities as Design Analysis.

One of the purposes of design assistance is to provide resources for the development of new skills and capabilities that design team members can apply to their future projects. Design assistance may include training services for design team members on new techniques or analysis tools.

### *Owner Incentives*

Financial incentives are available to building owners when the efficiency of the new building exceeds the minimum SBD thresholds, generally 10% better than Title-24 standards. These incentives encourage owners to make energy efficiency a priority in their new buildings and help to defray the additional costs associated with increased efficiency. Owner incentives are determined in different ways, depending on whether the Whole Building or the Systems Approach is used.

Under the Whole Building Approach, the overall efficiency of the building is evaluated using a computer simulation program. If the building is at least 10% better than baseline, incentives are available. The incentives range from $0.06 to $0.18/annualized kWh savings and $0.34 to $0.80/ annualized therm savings, depending on the amount of savings relative to Title-24. The maximum incentive is $150,000 per freestanding building or individual meter and may not exceed 50% of the incremental cost.

Under the Systems Approach, energy savings and incentives are calculated system-by-system, based on the quantities and efficiencies of qualifying components. Owner incentives are calculated at a rate of $0.10/annualized kWh and $0.60/ annualized therm savings depending on the end-use system type, with a maximum incentive of $75,000 per freestanding building or individual meter and may not exceed 50% of the incremental cost.

### *Design Team Incentives*

To support the extra effort required for integrated energy design and to reward exceptional design accomplishments, SBD offers financial incentives to design teams. To qualify for design team incentives, the team must use the Whole Building Approach and a computer simulation model to optimize their design. The model calculates the energy savings of the building relative to Title-24 standards. If the building design saves at least 15% relative to Title-24, the design team qualifies for incentives.

Incentives range from $0.03 - $0.06/annualized kWh savings and $0.15 - $0.27/annualized therm savings as the design becomes more efficient, with a maximum of $50,000 per project. Design team incentives are paid directly to the design team and are in addition to the incentives the building owner receives.

# Program Activity and Sample Summary

This section provides an overview of the statewide Savings By Design (SBD) program for projects paid in 2004-2005. Only projects that were paid incentives within the evaluation years 2004-2005 were considered although the evaluated projects initially signed onto the program as early as 2000, or as late as 2005. The following tables demonstrate the variation of results due to sponsoring utility, project size and participation path. Analysis of these differences provides insight into the underlying patterns and trends within the program delivery history, and provides a foundation for future program modifications.

## Ex-Ante Gross Savings

Table 16 shows the number of projects, the total associated ex-ante gross energy savings and the average energy savings by utility for the Savings By Design program. PG&E and SDG&E projects are larger on average than the average SCE and SoCalGas projects. Together, PGE and SCE dominate the program, accounting for over 77% of the projects and 76% the energy savings.

| Utility | Number of Projects | Total MBtu | Average MBtu | kBtu / SQFT |
|---|---|---|---|---|
| **PG&E** | 419 | 1,728,302 | 4,125 | 45 |
| **SCE** | 428 | 1,606,028 | 3,752 | 54 |
| **SoCal Gas** | 70 | 194,738 | 2,782 | 53 |
| **SDG&E** | 179 | 874,296 | 4,884 | 83 |
| **Statewide** | **1,096** | **4,403,365** | **4,018** | **54** |

**Table 16: Savings By Design Ex-Ante Gross Savings**

Table 17 presents the energy savings[5] and participation rates for the Savings By Design program, and previous NRNC programs, by year and by utility. In the two year period 2004-2005, the SBD program completed roughly 1,096[6] projects, a little more than twice the number achieved in 2003 indicating that the program was operating in a relatively stable mode.

[5] Energy Savings are reported in both MWh and MBtu for 2004-05. MBtu savings includes both electricity and gas savings. Gas savings were not reported in previous years.

[6] Out of 1,096 projects in the population, two were split into two separate projects for evaluation purposes since two different approaches (Systems Approach and Whole Building) were found in the data for the same site. One site was dropped later in the analysis due to insufficient on-site survey information. The tracking database was not always internally consistent – savings reported in the site and the measures tables did not add up exactly all the time. Corrections made to the database due to these discrepancies resulted in negligible differences in energy savings.

| Utility | 2005 | | | 2004 | | | 2003 | | 2002 | | Q4 1999-2001 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # Projects | Total MWh | Total Therms | # Projects | Total MWh | Total Therms | # Projects | Total MWh | # Projects | Total MWh | # Projects | Total MWh |
| PG&E | 231 | 61,305 | 459,980 | 188 | 47,551 | 5,677,265 | 165 | 47,158 | 133 | 16,877 | 127 | 19,418 |
| SCE | 212 | 71,680 | 154,261 | 216 | 81,930 | 177,882 | 198 | 65,855 | 198 | 77,467 | 169 | 53,835 |
| SoCalGas | 42 | 7,424 | 36,396 | 28 | 10,898 | 34,961 | NA | NA | NA | NA | NA | NA |
| SDG&E | 80 | 18,376 | 251,492 | 99 | 46,208 | 1,878,701 | 104 | 16,414 | 95 | 27,187 | 190 | 17,034 |
| **Statewide** | **565** | **158,785** | **902,129** | **531** | **186,588** | **7,768,809** | **467** | **129,428** | **426** | **121,531** | **486** | **90,287** |

**Table 17: Savings By Design Participation Rates and Energy Savings**

## Program Participation Approach

The Savings By Design program has an integrated design philosophy that intends to move the NRNC market toward a more holistic approach to building design and construction. The *Whole Building Approach,* as it is termed in the SBD program, takes advantage of the integrated design philosophy. In some instances in this report we make comparisons between Whole Building and Systems projects.

Table 18 shows the number of projects paid in 2004-2005, the associated energy savings (MBtu) and savings per square foot (kBtu) by participation approach. During 2004-05, Savings By Design paid for a total of 351 Whole Building projects, or 32% of the total. PG&E had the most Whole Building Approach projects of any utility, with 140. SDG&E had the highest Whole Building total energy savings and the highest energy savings per project.

Statewide, Whole Building projects are expected to save more energy per square foot than are system projects. This holds true for SCE, SoCalGas, and SDG&E, but not for PG&E which had a higher savings ratio for system projects - 46 kBtu/sqft. On average, the SBD program-tracking database estimates 54 kBtu savings per square foot for all participants.

| Approach | PG&E | | | SCE | | | SoCal Gas | | | SDG&E | | | Statewide | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | # Projects | MBtu Savings | kBtu/ Sqft | # Projects | MBtu Savings | kBtu/ Sqft | # Projects | MBtu Savings | kBtu/ Sqft | # Projects | MBtu Savings | kBtu/ Sqft | # Projects | MBtu Savings | kBtu/ Sqft |
| Systems Approach | 279 | 1,172,059 | 46 | 335 | 1,129,411 | 46 | 41 | 79,530 | 47 | 90 | 301,681 | 63 | 745 | 2,682,681 | 47 |
| Whole Building Approach | 140 | 556,244 | 44 | 93 | 476,616 | 74 | 29 | 115,208 | 59 | 89 | 572,616 | 98 | 351 | 1,720,684 | 65 |
| **Overall** | **419** | **1,728,302** | **45** | **428** | **1,606,028** | **54** | **70** | **194,738** | **53** | **179** | **874,296** | **83** | **1,096** | **4,403,365** | **54** |

**Table 18: Savings By Design Participation Approach: System vs. Whole Building**

## Program Participation & SBD Sample Size

Table 19 shows the Savings By Design program installations and evaluation sample sizes by utility. Also, note that the large projects were over-sampled for each utility, which resulted in a higher than average sampled MBtu savings per project.

| | PG&E | | SCE | | SoCalGas | | SDG&E | | Statewide | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Population | Sample | Population | Sample | Population | Sample | Population | Sample | Population | Sample |
| Number of Projects | 419 | 65 | 428 | 65 | 70 | 15 | 179 | 35 | 1,096 | 180 |
| MBtu Savings | 1,728,302 | 594,749 | 1,606,028 | 578,495 | 194,738 | 80,073 | 874,296 | 534,270 | 4,403,365 | 1,787,586 |
| Savings per Project (MBtu) | 4,125 | 9,150 | 3,752 | 8,900 | 2,782 | 5,338 | 4,884 | 15,265 | 4,018 | 9,931 |

**Table 19: Savings By Design Program Participation by Utility**

Table 20 shows SBD program population and sample sizes by stratum and utility service territory. Stratum 1 is for small sites, in terms of ex-ante gross energy savings and Stratum 5 is for large sites. For a complete description of the stratum definitions, see Sample Design (Page 60) section of this report. The sample was designed by utility; therefore each utility has different cut points for each stratum. PG&E funded an additional 20 sites listed in Table 20 as procurement. The primary purpose of adding end-use metering is to improve the site level engineering measurements of energy and demand savings. This is accomplished since end-use metering increases the site level rigor of the engineering approach used for non-metered sites. A specific investigation of the impact of these additional sites will be provided in a future report for PG&E.

| | PG&E | | | SCE | | SoCalGas | | SDG&E | |
|---|---|---|---|---|---|---|---|---|---|
| Stratum | Population | Sample | Procurement | Population | Sample | Population | Sample | Population | Sample |
| 1 | 206 | 13 | 4 | 219 | 13 | 35 | 3 | 94 | 7 |
| 2 | 81 | 13 | 4 | 83 | 13 | 15 | 3 | 37 | 7 |
| 3 | 60 | 13 | 4 | 56 | 13 | 8 | 3 | 24 | 7 |
| 4 | 47 | 13 | 4 | 44 | 13 | 7 | 3 | 16 | 7 |
| 5 | 25 | 13 | 4 | 26 | 13 | 5 | 3 | 8 | 7 |
| **Overall** | 419 | 65 | 20 | 428 | 65 | 70 | 15 | 179 | 35 |

**Table 20: Savings By Design Program Participation by Stratum and Utility**

# Gross Savings Results

This section presents the gross energy savings and peak demand reduction results. These include the findings for the shell, lighting power density, daylighting controls, other lighting controls, motors, HVAC, and refrigeration measures as well as the combined building total. Projects that were incented under the Whole Building Approach are reported under the measure group labeled "Whole Building". The combined total energy savings and demand reduction are defined to be the difference between the energy use or demand for the entire building under the T24 baseline and as-built simulations. The results were determined for each sample site both on a whole building basis as well as within each end use. Positive savings indicate that the building was more efficient – used less energy or demanded less – than its baseline case. As in the 2002 and 2003 Building Efficiency Assessments, we have reported industrial measures in a separate category named "Industrial" due to the unique nature of industrial measures such as those installed in waste water facilities and dairies. Some commercial projects included industrial measures, for example, labs with fume hoods. As mentioned in the previous section, the modeling results for these sites were disaggregated into commercial and industrial measures for the analysis, and the resulting industrial findings are included within the industrial results tables.

Two different approaches were taken in analyzing the energy savings and demand reduction data. The fundamental difference between the two approaches is the determination of savings constituents. Previous studies have included both approaches, whereas this year's study focuses on the "All Measures" approach explained below.

The "All Measures" approach, listed below, aggregates savings from all measure categories regardless of the specific measures for which a site received an incentive. For example, if a site received an incentive for HVAC but also achieved savings due to increased LPD efficiency, the total savings for that site would be the sum of both HVAC and LPD savings. The reason that this approach was adopted was to prevent trade-offs where sites could receive incentives for increased efficiency in one measure category while having sub-code efficiency in other measure categories.

The "Incented Measure" approach, listed in the appendix, only considers savings for each measure category for which a site received an incentive. In the "All Measures" example where both HVAC and LPD measures were better than baseline, the savings for that site would only consist of the HVAC measure for which the site received a rebate. These estimates of savings can be useful to show how cost effective certain measures are, but in order to prevent trade-off between measures the SBD program has established the "All Measures" as the approach used to report savings for the program.

## Statewide Energy Findings

Table 21 shows the estimated combined total gross energy savings relative to the energy savings from the program tracking databases, calculated at the utility level. For all program participants, the combined total annual gross energy savings were estimated in this evaluation to be 355,453 MWh, representing a gross realization rate of 103.1%.

| Utility | Ex-Ante Gross Energy Savings (MWh) | Sampled Energy Savings (MWh) | % Sampled Energy Savings | Ex-Post Gross Energy Savings (MWh) | Error Bound | Relative Precision | Gross Realization Rate |
|---|---|---|---|---|---|---|---|
| PGE | 108,856 | 44,534 | 40.9% | 103,222 | 7,962 | 7.7% | 94.8% |
| SCE | 153,610 | 56,096 | 36.5% | 164,540 | 24,135 | 14.7% | 107.1% |
| SoCalGas | 18,322 | 7,582 | 41.4% | 16,862 | 2,537 | 15.0% | 92.0% |
| SDGE | 63,959 | 36,127 | 56.5% | 70,829 | 8,909 | 12.6% | 110.7% |
| Total | 344,748 | 144,339 | 41.9% | 355,453 | 27,050 | 7.6% | 103.1% |

**Table 21: Combined Total Annual Gross Energy Savings**

Figure 2 and Table 23 show the composition of annual gross energy savings by measure type at the statewide level. The analysis of the SBD program was conducted using ratio estimation. For a statewide analysis one ratio is calculated and applied to all utilities. For a utility specific evaluation separate ratios are calculated for each utility. Depending on how much variation there is among utility ratios, utility ratio estimates can vary greatly from the statewide ratio. For annual energy savings the statewide and utility specific ratios were very similar. The statewide estimate of savings shown in Table 22 is 355,771 MWh with a relative precision of 7.7%, yielding a difference of less than 300 MWh in savings and 0.01% relative precision from Table 1 and Table 21.

Utility specific compositions are provided in the appendix. Whole Building Approach projects continue to comprise nearly 40% of the annual energy savings among program participants as it did in the 2003 evaluation. This is a significant increase over the 2002 findings (23%)[7] and 2001 (20%)[8]. The industrial measures account for 26% of the annual energy savings up slightly from 22% in 2003. Lighting power density grew to 18% from 10% in 2003 while all of the other saving categories fell with only HVAC and motors exceeding 10% of the total.

| Program Estimated Energy Savings (MWh) | Sampled Energy Savings (MWh) | % Energy Savings Sampled | Ex-Post Gross Energy Savings (MWh) | Relative Precision | Realization Rate |
|---|---|---|---|---|---|
| 344,748 | 144,339 | 42% | 355,771 | 7.7% | 103.2% |

**Table 22: Statewide Annual Gross Energy Savings**

[7] 2002 Building Efficiency Assessment, An Evaluation of the Savings By Design Program, RLW Analytics, Inc., July 2004, page 19.

[8] 1999-2001 Building Efficiency Assessment, An Evaluation of the Savings By Design Program, RLW Analytics, Inc., April 2003, page 20.

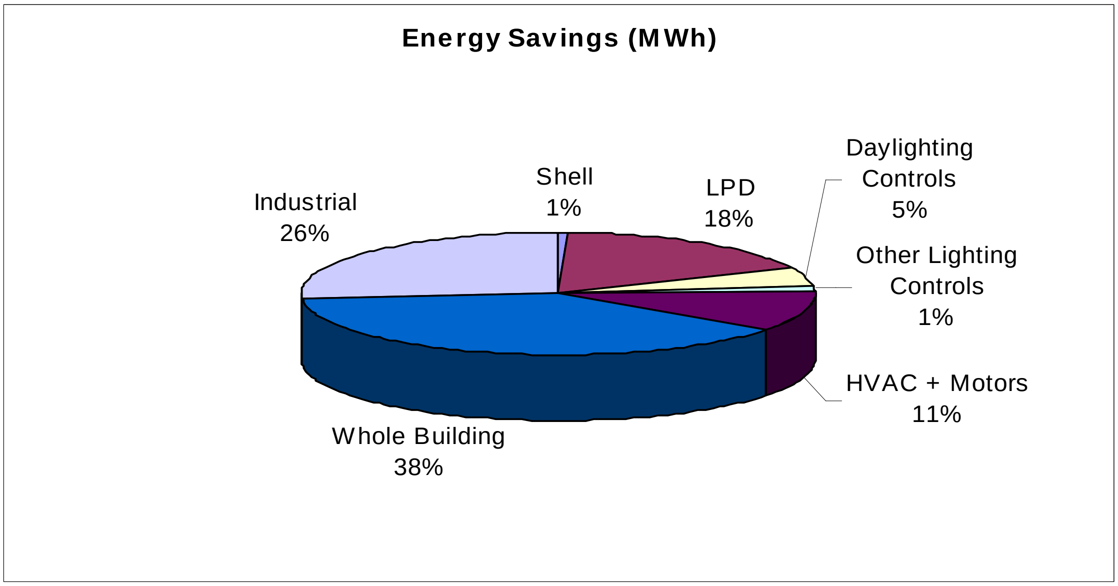


**Figure 2: Composition of Annual Ex-Post Gross Energy Savings as a Percent of Combined Total**

Table 23 shows the estimated energy savings and error bound by measure type as well as for the combined commercial total. The combined commercial total energy savings were 265,080 MWh, with an error bound of 31,189 MWh, yielding a 90% confidence interval of 233,891 to 296,269 MWh. Industrial measures achieved gross energy savings of 90,691 MWh, with an error bound of 15,505 MWh, yielding a 90% confidence interval of 75,186 to 106,196 MWh.

Each end use is a category of energy consuming measures that contribute to the total energy consumption of a building. The "measure categories" in this report refer to the measures that define each of the DOE-2 parametrics. The "shell" measure category has no value in the final column labeled "Savings as % of End Use Baseline" because shell measures do not directly consume energy and thus have no associated baseline consumption. The industrial measure category also has no value in this column because industrial measures utilize measure specific standard practice for determining energy savings, as opposed to a predefined Title 24 baseline.

| | Measure Category | Ex-Post Gross Energy Savings (MWh) | Error Bound | Relative Precision | End Use % Savings |
|---|---|---|---|---|---|
| Systems Approach | Shell | 1,663 | 1,757 | 105.7% | NA |
| | LPD | 60,596 | 19,739 | 32.6% | 30.6% |
| | Daylighting Controls | 17,643 | 10,959 | 62.1% | 8.9% |
| | Other Lighting Controls | 4,916 | 2,050 | 41.7% | 2.5% |
| | HVAC + Motors | 39,875 | 16,246 | 40.7% | 17.9% |
| | Refrigeration | - | - | - | - |
| | Domestic Hot Water | (9) | 13 | 155.4% | NA |
| | Whole Building | 140,395 | 11,725 | 8.4% | 17.5% |
| | **Combined Commercial Total** | **265,080** | **31,189** | **11.8%** | **20.9%** |
| | | | | | |
| | Industrial | 90,691 | 15,505 | 17.1% | NA |

**Table 23: Annual Gross Energy Savings by Measure**

## Statewide Demand Reduction Findings

This section presents the gross summer peak demand reduction for the program participants.

Table 24 shows the estimated combined total summer peak gross demand reduction relative to the summer peak demand reduction from the program tracking databases, calculated at the utility level. For all program participants, the combined total summer peak gross demand reduction is estimated to be 56.4 MW, representing a gross realization rate of 82.1%.

| Utility | Ex-Ante Gross Demand Reduction (MW) | Sampled Demand Reduction (MW) | % Sampled Demand Reduction | Ex-Post Gross Demand Reduction (MW) | Error Bound | Relative Precision | Gross Realization Rate |
|---|---|---|---|---|---|---|---|
| PGE | 23.1 | 9.5 | 40.9% | 19.0 | 2.8 | 14.5% | 82.1% |
| SCE | 27.9 | 8.9 | 32.1% | 23.7 | 8.3 | 35.1% | 84.9% |
| SoCalGas | 3.5 | 1.6 | 46.9% | 2.8 | 0.4 | 12.6% | 80.3% |
| SDGE | 14.3 | 7.2 | 50.8% | 11.0 | 1.9 | 17.4% | 76.9% |
| Total | 68.7 | 27.3 | 39.7% | 56.4 | 9.0 | 15.9% | 82.1% |

**Table 24: Combined Total Summer Peak Gross Demand Reduction**

Table 25 shows the demand reduction calculated using a statewide ratio. The ex-post gross demand savings are 57.4 MW, which is 0.7 MW greater than the estimate calculated with utility specific ratios. The demand saving estimate calculated with the statewide ratio has a relative precision that is 1.6% higher than the utility specific ratios shown in Table 24. The reason that the overall relative precision improved with the utility specific ratios when compared to the estimate calculated statewide ratio, is that the statewide utilized a single ratio which it applied to all utilities. The statewide ratio that was applied to each utility was had more variation than a separate ratio calculated for each individual utility, showing that some utilities over predict tracking savings and others under predict.

| Program Estimated Demand Reduction (MW) | Sampled Demand Reduction (MW) | % Demand Reduction Sampled | Ex-Post Gross Demand Reduction (MW) | Relative Precision | Realization Rate |
|---|---|---|---|---|---|
| 68.7 | 27.3 | 40% | 57.4 | 17.5% | 83.5% |

**Table 25: Statewide Summer Peak Gross Demand Reduction**

Figure 3 shows the breakdown of summer peak demand reduction by measure category at the statewide level. As with the energy savings results, Whole Building Approach projects account for almost 45% of the summer peak demand reduction among program participants. About 24% of the reduction is due to lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls), while HVAC + Motors measures comprise an additional 13% of the reduction. Industrial accounts for 18% of the summer peak demand reduction.

The comparison of Figure 2 and Figure 3 reveals that the demand savings contribution by end use for Whole Building is larger than the corresponding energy savings. Lighting in total has similar demand and energy savings but the impact of daylighting controls has a larger demand impact and LPD has a larger energy savings impact. The Industrial measure category is experiencing the largest differential between the demand and energy savings percentage at 18% and 26%, respectively.

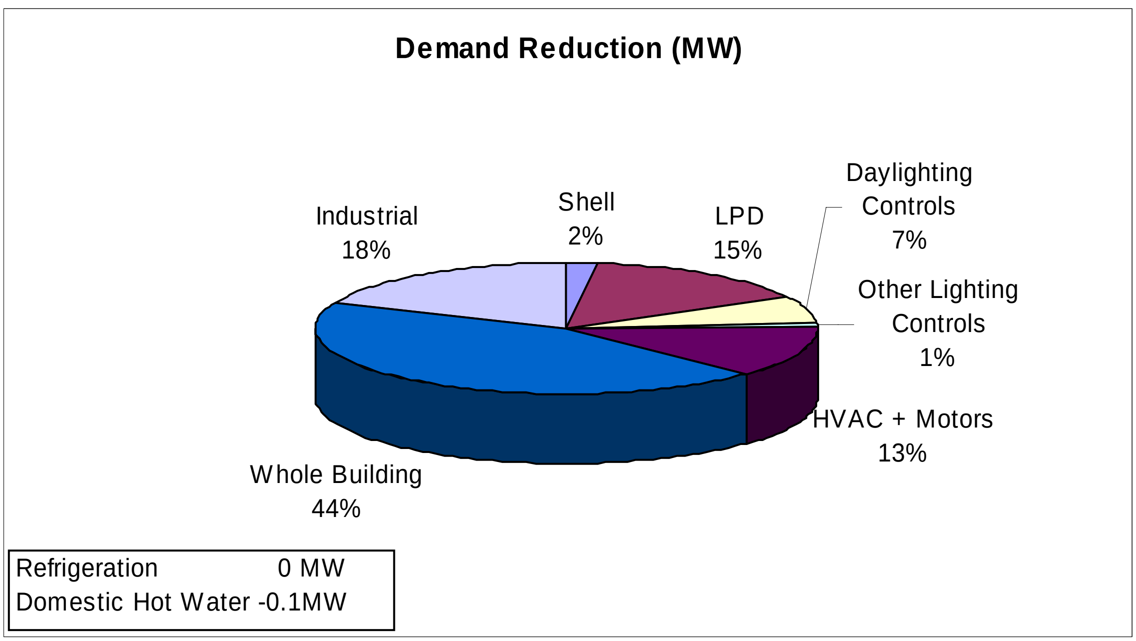


**Figure 3: Composition of Summer Ex-Post Gross Peak Demand Reduction as a Percent of Combined Total**

Table 26 shows the estimated gross summer peak demand reduction and error bound by measure type, as well as for combined commercial total, calculated at the statewide level. The combined commercial total gross summer peak demand reduction was 46.8 MW, with an error bound of 7.9 MW, yielding a 90% confidence interval of 38.9, 54.7 MW. Industrial measures achieved summer peak demand reduction of 10.6 MW, with an error bound of 3.7 MW, yielding a 90% confidence interval of 6.9, 14.3 MW.

In general, the demand reduction for each measure category as a percentage of its end use baseline demand is very similar to the energy savings as a percentage of its end use baseline consumption. LPD measures are producing the most demand reduction for any systems measures (8.7 MW). Whole Building projects are producing over one-half of the demand savings for all commercial measures, accounting for 25.4 MW out of a total 46.8 MW.

| | **Measure Category** | **Ex-Post Gross Demand Reduction (MW)** | **Error Bound** | **Relative Precision** | **End Use % Reduction** |
|---|---|---|---|---|---|
| **Systems Approach** | Shell | 1.1 | 0.5 | 49.3% | NA |
| | LPD | 8.7 | 3.7 | 42.7% | 27.9% |
| | Daylighting Controls | 3.9 | 2.4 | 61.6% | 12.5% |
| | Other Lighting Controls | 0.3 | 0.5 | 130.9% | 1.1% |
| | HVAC + Motors | 7.3 | 3.2 | 43.7% | 14.9% |
| | Refrigeration | - | - | - | - |
| | Domestic Hot Water | (0.1) | 0.1 | 155.3% | NA |
| | Whole Building | 25.4 | 3.2 | 12.4% | 18.8% |
| | **Combined Commercial Total** | **46.8** | **7.9** | **16.9%** | **20.1%** |
| | | | | | |
| | Industrial | 10.6 | 3.7 | 34.9% | NA |

**Table 26: Summer Peak Gross Demand Reduction By Measure**

## Statewide Gas Savings Findings

*Note: Prior Savings By Design Evaluations did not include an analysis of gas savings. Due to the small sample size including gas savings and large percentage of sample sites with tracking or evaluated savings of zero, it was discovered that ratio analysis could not be used on certain measure categories. As a result of this finding, mean per unit estimation was used for all utility specific measure categories where ratio analysis was not a viable option. Because of the combination of ratio analysis and weighted mean per unit estimation, an overall error bound and relative precision could not be calculated for gas savings.*

The 2004-2005 impact evaluation includes for the first time the evaluation of natural gas savings. Since natural gas is predominately a heating fuel, measures which reduce internal heat gain from losses, such as lighting, show negative gas savings. In addition, interactive effects result in small gas savings attributable to measures which do not have a direct gas component such as refrigeration.

As shown in Table 27 the total ex-ante gross gas savings for the program is 10,901,876 therms with a realization rate of 125.9%. The evaluation is based on a sample representing approximately 48% of the ex-ante gross gas savings. SCE's large realization rate was driven by HVAC savings which accounted for 98% of the total savings and had a relative precision of 138%, which means that the prediction has a large amount of uncertainty. SCE's HVAC/Motors savings also accounts for 37% of the total gas savings of the program, but has little meaning as a result of the high degree of uncertainty associated with such a large relative precision.

| Utility | Ex-Ante Gross Energy Savings (Therms) | Sampled Energy Savings (Therms) | % Sampled Energy Savings | Ex-Post Gross Energy Savings (Therms) | Gross Realization Rate |
|---|---|---|---|---|---|
| PGE | 6,137,245 | 2,539,961 | 41.4% | 4,631,354 | 75.5% |
| SCE | 332,143 | 61,467 | 18.5% | 4,082,376 | 1229.1% |
| SoCalGas | 71,357 | 24,769 | 34.7% | 14,777 | 20.7% |
| SDGE | 2,121,796 | 1,568,406 | 73.9% | 2,173,369 | 102.4% |
| Total | 8,662,541 | 4,194,603 | 48.4% | 10,901,876 | 125.9% |

**Table 27: Combined Total Annual Gross Gas Savings**

Table 28 shows that the statewide gross therms savings of 11,341,219 therms, a difference of 3.9% from the by utility estimate of 10,901,876 therms. Ratio analysis could be used to estimate statewide overall savings because the ex-Ante gross estimates and ex-post Gross estimates of savings had consistent signs (both were positive or both were negative); therefore an overall relative precision was able to be calculated. However, the utility specific estimates of savings used a combination of ratio analysis and mean per unit estimation and as a result an overall relative precision could not be calculated for these estimates.

| Program Estimated Energy Savings (Therms) | Sampled Energy Savings (Therms) | % Energy Savings Sampled | Ex-Post Gross Energy Savings (Therms) | Relative Precision | Realization Rate |
|---|---|---|---|---|---|
| 8,662,541 | 4,194,603 | 48% | 11,341,219 | 56.9% | 131% |

**Table 28: Statewide Annual Gross Gas Savings**

Table 29 and Figure 4 illustrate the total gas program savings by measure category, at the statewide level. The interactive effects are particularly obvious in the table with negative gas savings attributable to lighting energy efficiency measures. The largest percentage of gas savings are from HVAC specific measures representing almost 47.4% of all measures categories with positive savings. Most of the remaining savings are attributable to industrial and whole building measures. For gas measures with negative savings, denoted with a (*), weighted mean per unit analysis was used. When attempting to use ratio estimation, the denominator (total ex-ante gross savings) was positive and numerator (total ex-post gross savings) was negative which caused incorrect results.

One reason that the relative precisions are poor for gas measure categories is that the ex-ante gross savings or ex-post gross savings are often zero. Ratio analysis develops a trend line to best fit the data, where the precision is determined by the variance of each point from that trend line. If a large percentage of those points are on the axis then the trend line will be a poor predictor of actual savings and thus have a low relative precision.

| | Measure Category | Ex-Post Gross Energy Savings (Therms) | Error Bound | Relative Precision | End Use % Savings |
|---|---|---|---|---|---|
| Systems Approach | Shell | 443,196 | 355,655 | 80.2% | NA |
| | LPD* | (206,545) | NA | NA | NA |
| | Daylighting Controls* | (78,534) | NA | NA | NA |
| | Other Lighting Controls* | (18,232) | NA | NA | NA |
| | HVAC + Motors | 5,852,558 | 6,517,364 | 111.4% | 47.7% |
| | Refrigeration | 38,937 | 29,370 | 75.4% | 0.3% |
| | Domestic Hot Water | 37,164 | 23,922 | 64.4% | 1.2% |
| | Whole Building | 1,213,583 | 268,907 | 22.2% | 31.1% |
| | **Combined Commercial Total** | **7,282,128** | NA | NA | NA |
| | | | | | |
| | Industrial | 4,059,091 | 569,943 | 14.0% | NA |

**Table 29: Annual Gross Gas Savings by Measure[9]**

[9] For gas measures denoted with a (*), weighted mean per unit analysis was used.

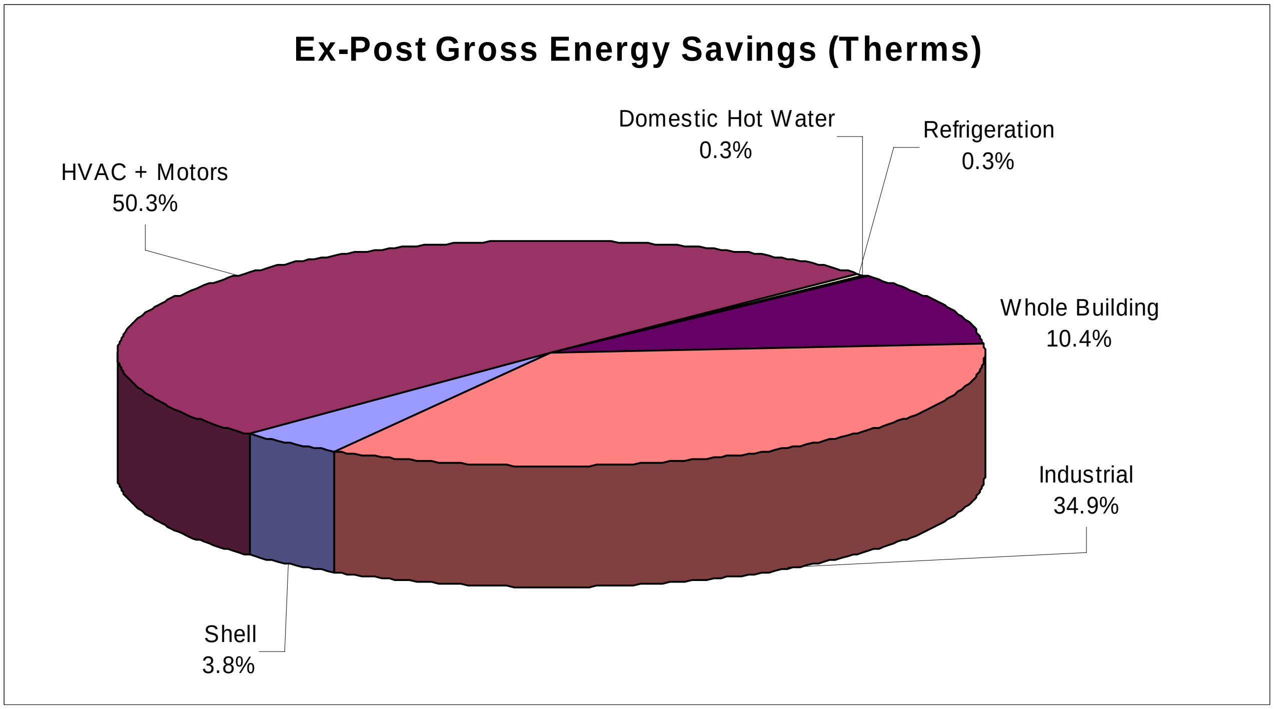


**Figure 4: Composition of Annual Ex-Post Gross Gas Savings as a Percent of Combined Total (Therms)[10]**

[10] Figure 4 shows each measure as a percentage of total savings for all measures with positive savings.

# Net Savings Results

Net savings results for both annual energy savings and summer peak demand reduction are presented in this chapter. Furthermore, results are shown by end-use and System vs. Whole Building projects. Assessments of free-ridership by measure category are shown, where possible.

## Energy Findings

### *Free-ridership Net Savings Results*

To calculate free-ridership RLW surveyed decision-makers on their efficiency choices for incented measures. Based on the survey responses the engineering simulation models were adjusted to reflect these efficiency choices absent the Savings By Design program. The engineering models were then re-simulated. The results of these simulations were analyzed to obtain the net savings for participants.

Table 30 shows the combined total annual net and gross savings by utility, calculated at the utility level. Across the four utilities the SBD program had an ex-post net savings of approximately 260,000 MWh and a 73% net to gross ratio. SoCalGas had the largest net to gross ratio at 91%, though it also had the lowest ex-post net savings at slightly over 15,000 MWh.

| Utility | Ex-Post Net Energy Savings (MWh) | Relative Precision | Ex-Post Gross Energy Savings (MWh) | Relative Precision | Net-to-Gross Ratio |
|---|---|---|---|---|---|
| **PGE** | 74,989 | 10.4% | 103,222 | 7.7% | 72.6% |
| **SCE** | 126,964 | 18.7% | 164,540 | 14.7% | 77.2% |
| **SoCalGas** | 15,337 | 25.2% | 16,862 | 15.0% | 91.0% |
| **SDGE** | 42,240 | 19.2% | 70,829 | 12.6% | 59.6% |
| **Total** | 259,530 | 10.2% | 355,453 | 7.6% | 73.0% |

**Table 30: Combined Total Net Savings by Utility**

Table 31 shows the total net program impacts taking into account participant free-ridership. Using this methodology, the commercial ex-post net participant savings are 203,409 MWh, which corresponds to a net-to-gross ratio of 75.7%. Industrial measures achieved net savings 56,121 MWh, corresponding to a net-to-gross ratio of 64.7%.

| | Commercial Energy Impacts (MWh) | Industrial Energy Impacts (MWh) | Calculation |
|---|---|---|---|
| Ex-Ante Gross Savings | 231,036 | 113,712 | A |
| Ex-Post Gross Savings | 268,758 | 86,696 | B |
| Gross Realization Rate | 116.3% | 76.2% | (B/A) |
| Ex-Post Net Savings | 203,409 | 56,121 | C |
| Net-to-Gross Ratio | 75.7% | 64.7% | (C/B) |

**Table 31: Total Net Energy Program Impacts**

Table 32 shows the total net program impacts by measure type, calculated at the statewide level. Savings estimates in Table 32 differ from Table 30 and Table 31, because they are calculated using different ratio estimates (statewide versus utility specific estimates). Since the whole building approach accounts for over half the net savings, its net-to-gross ratio of 68.3% has a large impact on the ratio for the entire program. Similarly the large contributions to total savings from LPD and HVAC + Motors (NTGR of 75.3% and 79.0%, respectively) also have a significant impact on the total program net-to-gross ratio. The higher ratios from other measures do not have a significant effect on total program ratio because they account for a small fraction of total program savings.

| | Measure Category | Ex-Post Net Savings (MWh) | Relative Precision | Ex-Post Gross Savings (MWh) | Relative Precision | Net-to-Gross Ratio |
|---|---|---|---|---|---|---|
| Systems Approach | Shell | 1,626 | 107.5% | 1,663 | 105.7% | 97.8% |
| | LPD | 45,604 | 34.8% | 60,596 | 32.6% | 75.3% |
| | Daylighting Controls | 17,486 | 62.8% | 17,643 | 62.1% | 99.1% |
| | Other Lighting Controls | 4,503 | 45.0% | 4,916 | 41.7% | 91.6% |
| | HVAC + Motors | 31,493 | 50.3% | 39,875 | 40.7% | 79.0% |
| | Refrigeration | - | - | - | - | NA |
| | Domestic Hot Water* | (9) | 155.5% | (9) | 155.4% | NA |
| | Whole Building | 95,831 | 11.0% | 140,395 | 8.4% | 68.3% |
| | **Combined Commercial Total** | **196,534** | **14.5%** | **265,080** | **11.8%** | **74.1%** |
| | | | | | | |
| | Industrial | 59,209 | 18.9% | 90,691 | 17.1% | 65.3% |

**Table 32: Total Net Energy Program Impacts by Measure Type**

Industrial projects represent 23.2% of the overall net energy savings, up from 22% in the 2003 SBD study. In the 1999-2001 SBD study, there were no industrial projects, whereas in the 2002 and 2003 studies the energy savings due to industrial measures were considerable.

Industrial measures were diverse and the net savings analysis often called for in-depth qualitative questioning that went beyond the scope of the original survey questionnaire. Many of the industrial measures were extremely large in terms of energy savings; therefore it was extremely important to have comprehensive discussions regarding the decision making that occurred at the time of the measure installation. However, these measures were typically important to the customer's process, large in terms of energy consumption, and expensive to procure. Therefore decision-makers were easily able to recall and discuss the decision making process that led them to install the equipment incented by Savings By Design. These issues also contributed to the relatively high free-ridership of 34.7%.

The final industrial net to gross ratio of 65.3% represents an improvement over 2003 (59%). Further information on each industrial site evaluated is available in the industrial sites write-ups provided in the appendix. Some specific findings that contributed to the low NTG included:

- Decisions to install energy efficient equipment were sometimes made before initial contact with the SBD representative, and
- The industrial site with the largest savings was only partially influenced by Savings By Design.

## Summer Peak Demand Findings

### *Free-ridership Net Savings Results*

Table 33 shows the combined summer net and gross peak demand reduction by utility. The overall net participant savings is 42.3 MW. SoCalGas had the largest net to gross ratio at 76.4% but had the lowest net demand reduction at 2.3 MW.

| Utility | Ex-Post Net Demand Reduction (MW) | Relative Precision | Ex-Post Gross Demand Reduction (MW) | Relative Precision | Net-to-Gross Ratio |
|---|---|---|---|---|---|
| **PGE** | 13.8 | 17.8% | 18.8 | 13.6% | 73.5% |
| **SCE** | 18.8 | 36.2% | 23.0 | 34.5% | 81.5% |
| **SoCalGas** | 2.3 | 28.7% | 3.1 | 11.2% | 76.4% |
| **SDGE** | 7.3 | 23.5% | 10.4 | 18.1% | 70.6% |
| **Total** | 42.3 | 17.6% | 55.3 | 15.5% | 76.4% |

**Table 33: Combined Total Net Demand Reduction by Utility**

Table 34 shows the total net program impacts for summer peak demand reduction, taking into account participant free-ridership. The commercial net participant reduction is 34.7 MW, which corresponds to a participant net-to-gross ratio of roughly 79%. Industrial measures achieved a net reduction of 7.6 MW, corresponding to a net-to-gross ratio of approximately 66%.

| | Commercial Energy Impacts (MW) | Industrial Energy Impacts (MW) | Calculation |
|---|---|---|---|
| Ex-Ante Gross Savings | 58.5 | 10.3 | A |
| Ex-Post Gross Savings | 43.9 | 11.4 | B |
| Gross Realization Rate | 75.1% | 110.8% | (B/A) |
| Ex-Post Net Savings | 34.7 | 7.6 | C |
| Net-to-Gross Ratio | 79.0% | 66.4% | (C/B) |

**Table 34: Total Net Demand Program Impacts**

Table 35 shows the total net program demand reduction by measure type, calculated at the statewide level. The dominant commercial measure category is whole building (accounting for 51% of net program demand reduction) which has a 71.9% net-to-gross ratio. The other large contributors to total demand reduction, LPD and HVAC + Motors, have similar net-to-gross ratios of 78.3 and 72.4%, respectively. The remaining measure categories have net-to-gross ratios closer to 100% but they are not sufficiently large in total savings to significantly impact the total program net-to-gross value of 76.7%. The industrial measure category has a net-to-gross ratio of 65.9%, which is similar to energy findings.

| | Measure Category | Ex-Post Net Demand Reduction (MW) | Relative Precision | Ex-Post Gross Demand Reduction (MW) | Relative Precision | Net-to-Gross Ratio |
|---|---|---|---|---|---|---|
| Systems Approach | Shell | 1.1 | 48.6% | 1.1 | 49.3% | 99.9% |
| | LPD | 6.8 | 44.4% | 8.7 | 42.7% | 78.3% |
| | Daylighting Controls | 3.9 | 61.5% | 3.9 | 61.6% | 100.8% |
| | Other Lighting Controls | 0.5 | 65.0% | 0.3 | 130.9% | 143.0% |
| | HVAC + Motors | 5.3 | 48.6% | 7.3 | 43.7% | 72.4% |
| | Refrigeration | - | - | - | 0.0% | NA |
| | Domestic Hot Water* | (0.1) | 155.3% | (0.1) | 155.3% | NA |
| | Whole Building | 18.3 | 16.2% | 25.4 | 12.4% | 71.9% |
| | **Combined Commercial Total** | **35.9** | **19.4%** | **46.8** | **16.9%** | **76.7%** |
| | | | | | | |
| | Industrial | 7.0 | 35.5% | 10.6 | 34.9% | 65.9% |

**Table 35: Total Net Demand Program Reduction by Measure Type**

## Gas Findings

### *Free-ridership Net Savings Results*

Table 36 shows the total net program impacts for annual gas savings, taking into account participant free-ridership. The overall ex-post net participant savings are close to 9.5 million therms, which correspond to a participant net-to-gross ratio of approximately 87.4%. Table 36 provides utility level estimates of savings, whereas the Table 38 estimates for specific measure categories are produced at the statewide level. Individual utility estimates of savings by measure category are provided in the appendix. Table 37 separates out gross and net savings by commercial and industrial projects. As mentioned previously, since two different approaches were employed in evaluating savings (ratio analysis and mean per unit estimation) an overall relative precision and error could not be calculated.

Net savings estimates for commercial sites were estimated via manipulation of sample site simulation models. Using this technique, there are occurrences where interactive effects will indicate a net-to-gross ratio greater than 100%. For example, when the glazing solar heat gain coefficient is de-rated for free-ridership, the cooling electrical usage increases, thus decreasing the electrical energy savings relative to baseline. However, the de-rated glazing allows more passive solar heating thereby reducing the building heating load, and increasing the gas savings relative to gross. This type of interactive effect occurred often enough to produce net to gross ratios greater than 100% for some of the market sectors below.

| Utility | Ex-Post Net Energy Savings (Therms) | Ex-Post Gross Energy Savings (Therms) | Net-to-Gross Ratio |
|---|---|---|---|
| **PGE** | 3,038,243 | 4,631,354 | 65.6% |
| **SCE** | 4,129,443 | 4,082,376 | 101.2% |
| **SoCalGas** | 3,713 | 14,777 | 25.1% |
| **SDGE** | 2,362,047 | 2,173,369 | 108.7% |
| **Total** | 9,533,445 | 10,901,876 | 87.4% |

**Table 36: Net Therm Savings by Utility**

| | Commercial Energy Impacts (Therms) | Industrial Energy Impacts (Therms) | Calculation |
|---|---|---|---|
| Ex-Ante Gross Savings | 2,878,393 | 5,784,148 | A |
| Ex-Post Gross Savings | 6,489,318 | 4,412,558 | B |
| Gross Realization Rate | 225.4% | 76.3% | (B/A) |
| Ex-Post Net Savings | 6,801,954 | 2,731,491 | C |
| Net-to-Gross Ratio | 104.8% | 61.9% | (C/B) |

**Table 37: Total Net Gas Savings Impacts**

| | Measure Category | Ex-Post Net Savings (Therms) | Relative Precision | Ex-Post Gross Savings (Therms) | Relative Precision | Net-to-Gross Ratio |
|---|---|---|---|---|---|---|
| Systems Approach | Shell | 469,691 | 76.7% | 443,196 | 80.2% | 106.0% |
| | LPD* | (150,598) | NA | (206,545) | NA | 72.9% |
| | Daylighting Controls* | (65,862) | NA | (78,534) | NA | 83.9% |
| | Other Lighting Controls* | (16,317) | NA | (18,232) | NA | 89.5% |
| | HVAC + Motors | 5,893,297 | 110.7% | 5,852,558 | 111.4% | 100.7% |
| | Refrigeration | 36,147 | 75.3% | 38,937 | 75.4% | 92.8% |
| | Domestic Hot Water | 37,164 | 64.4% | 37,164 | 64.4% | 100.0% |
| | Whole Building | 1,393,582 | 21.1% | 1,213,583 | 22.2% | 114.8% |
| | **Combined Commercial Total** | **7,597,104** | NA | **7,282,128** | NA | **104.3%** |
| | | | | | | |
| | Industrial | 2,512,685 | 19.7% | 4,059,091 | 14.0% | 61.9% |

**Table 38: Gas Net Savings by Measure**[11]

[11] For gas measures with negative savings, denoted with a (*), weighted mean per unit analysis was used. When attempting to use ratio estimation, the denominator (total ex-ante gross savings) was positive and the numerator (total ex-post gross savings) was negative which caused incorrect results.

# Process Findings

RLW designed decision-maker (DM) surveys to help determine the net savings attributable to the program. The questions were designed to learn more about program awareness and attitudes, specific building characteristics, and design and construction practices. The following sections report these results and correlate directly with the flow of the decision-maker survey. This section addresses the following areas of interest:

- Interviewee information,
- Building descriptive statistics,
- Savings By Design program attitudes and awareness,
- Importance of Dollar Incentives, Design Assistance and Design Analysis,
- Prototype Modules.

## Survey Respondents

The target number of total interviews was approximately 200. The final dataset, however, contained survey responses from 197 participants. Out of the 197, 11 surveys were incomplete. In other words, not all questions were answered because either the decision-maker wasn't with the company for a long enough time to answer questions appropriately or the primary respondent was not available. Sometimes the interviewee was also found to be non-responsive; he or she did not complete the survey [left the interview midway] and later was not available to answer questions despite the repeated attempts to reach him or her. The industrial participants were also administered the standard decision-maker survey, however some survey questions were omitted if they were not applicable.

All of the decision-maker responses have been weighted to the population. Case weights were developed (in the same way as the gross savings analysis) so that the 197 survey participants were representative of the entire population.

The goal of the sample was to infer information about SBD participants. The information was gathered from interviewing the decision-makers, which included the building owners and, in many cases, members of the design team for the buildings in the sample. Frequently multiple people were interviewed to complete a single survey. For example, numerous interviews included the mechanical engineer responsible for designing the HVAC system in addition to the building owner or facilities manager who answered the less technical questions.

Many of the SBD program participants were responsible for multiple buildings within our sample, especially where a set of prototype plans were used. In some cases, one person answered several surveys, one survey for each of the sampled projects under their control. In fact, the same questions were asked multiple times in order to get project specific information since different projects may have required different responses. For example, one participant may have had two HVAC projects, each in a different climate. Therefore some responses would be considerably different and thus require independent answers for each project.

# Methodology

### Weighted Responses

In order to produce an unbiased extrapolation to the population, all responses have been weighted to the population. Each survey (sample element) has a weight, calculated using MBSS techniques, and associated with the responses which tell how many individuals a single sample element represents. Qualitatively, the weights say how much each survey "counts" toward representing the population.

Results are reported by "% of respondents," calculated using the following equation:

(Weighted number of respondents) ÷ (Total weighted sample).

### Percentage of Respondents

Due to the design of the survey and response categories, all column totals equal 100%, except where noted otherwise.

### Sample Size

"Sample size", as reported in all tables in this section, represents the actual un-weighted number of respondents who answered the question, and is reported separately for each question. This is necessary since not every question was answered by every person, due to refusal or inapplicability.

### Survey Responses

Often times, not every question was answered with a specific response and some questions even went unanswered due to refusal, non-applicability, skip patterns, or other reasons. "Don't know" answers are included in the sample size for each question and are considered a legitimate category of response. Each answer with non-responses (missing values) has been eliminated and the sample size for that question has been appropriately reduced. The variation in the sample sizes for various questions can be explained by this. For example, the questions on prototype plans have smaller sample sizes because not all buildings used prototype plans.

For non-quantitative, or qualitative, results, verbatim responses are provided throughout this report. Some questions list all responses, while other questions provide only a sample of responses. In some cases, sample responses were selected for their content and may not be representative of all the responses for that question. A complete list of responses for each question can be made available upon request.

# Survey Results

### Interviewee Information

This subsection provides information on the interviewee. Table 39 shows that 94.4% of the people who were interviewed were either the owner of the building or the owner's representative. The last line of Table 39 shows that responses for this question were recorded from a total of 194 people.

| Interviewee | % of Respondents |
|---|---|
| Owner or Owner's Representative | 94.4% |
| Others | 5.6% |
| Don't Know | - |
| Refused | - |
| Sample Size | 194 |

**Table 39: Interviewee Information (q1)**

The interviewees were also asked if they recalled participation in the SBD program. As Table 40 shows, 96.3% of all interviewees recalled participation.

| Interviewee | % of Respondents |
|---|---|
| Recalled Participation in SBD Program | 96.3% |
| Didn't Recall Participation in SBD Program | 2.6% |
| Don't Know | 1.0% |
| Refused | - |
| Sample Size | 194 |

**Table 40: If Interviewee Recalled Participation in SBD Program (q2)**

### *Building Descriptive Statistics*

This subsection focuses on descriptive statistics of the surveyed buildings. Table 41 shows that 82.6% of the buildings matched the correct building descriptions exactly as specified in the program. For the remaining buildings there were two possible scenarios. First, the building descriptions didn’t match exactly because the buildings were mixed occupancies, which led to multiple descriptions of the building. Second, the buildings were described as something different from what was specified in the program.  All building types are shown in Table 42.

| Type of Building | % of Respondents |
|---|---|
| Description Same as Program | 82.6% |
| Description Not Exactly Same as Program | 17.4% |
| Sample Size | 192 |

**Table 41: Type of Building (q3)**

The descriptions of the buildings[12] are listed in Table 42. This also shows that 21.2% of the buildings were retail and wholesale stores, 13.6% were General C&I Work, 14.3% were schools and 9.3% were offices.

| Type of Building | % of Respondents |
|---|---|
| Retail and Wholesale Store | 21.2% |
| School | 14.3% |
| General C&I Work | 13.6% |
| Other | 9.6% |
| Office | 9.3% |
| C&I Storage | 5.7% |
| Grocery Store | 5.2% |
| Fire/Police/Jails | 2.6% |
| Medical/Clinical | 2.1% |
| Community Center | 2.0% |
| Library | 1.6% |
| Hotels/Motels | 1.3% |
| Government Training, Office/Detention Facility, Primarily Jail & Office | 1.1% |
| Religious Worship, Auditorium, Convention | 1.1% |
| Restaurant | 1.1% |
| Storage | 1.1% |
| Administrative Offices | 1.1% |
| Residential, Retail, & Parking Garage | 0.9% |
| Office, Gym, Portable classrooms, & Media Center | 0.8% |
| Warehouse/Office | 0.8% |
| Warehouse/Distribution Center | 0.8% |
| Miscellaneous | 0.5% |
| Wastewater Treatment Plant | 0.3% |
| Other-General C&I Work | 0.3% |
| Refrigerated Storage | 0.3% |
| Processing produce - General C&I Work | 0.3% |
| C&I Work | 0.2% |
| Milk Storage | 0.2% |
| Refrigerated Warehouse | 0.2% |
| C&I storage, Distribution Warehouse | 0.1% |
| Other-Bio tech R&D | 0.1% |
| Research & Development(60%) and Administrative bldg(40%) | 0.1% |

**Table 42: Building Description (q3)**

Table 43 classifies the buildings by project type. Over 70% of all SBD projects were new buildings.

[12] If an interviewee reported a building description different from what is stated by the program, the updated response provided by the interviewee is listed in Table 42.

| Type of Project | % of Respondents |
|---|---|
| New Building (Brand New Construction) | 70.2% |
| Renovation or remodel of an existing building | 9.1% |
| Addition to an existing building | 6.9% |
| First Tenant improvement or newly conditioned space in an existing shell building | 6.1% |
| Gut rehabilation of existing building | 4.2% |
| Renovation and addition | 3.4% |
| Sample Size | 195 |

**Table 43: Type of Project (q4)**

Some of the buildings were additions to existing buildings or renovations. A small fraction of interviewees (16 surveys) also provided details as to where in the building the additions or renovations took place. Below are some chosen responses.

*Selected Participant Responses (q4a)*

*Central Plant*

*Ethanol Plant Constructed on Existing Site*

*Manufacturing Area*

*New Part is the gym and the other special purpose buildings plus five classrooms and the other classrooms were renovated*

The building completion year ranged from 2001 to 2006. Figure 5 shows that over 88.4% of the buildings were completed in 2003, 2004 or 2005. In total, almost half (48.9%) of the buildings were completed in the year 2004. Table 44 shows that the sample size was 155. The interviewees also reported that almost all (approximately 99%) opened for occupancy immediately (within a month) after completion. Buildings completed in 2006 were measures installed prior to building completion. Some in this category were industrial sites where measures were installed before the final construction dates of the building. For example, in a wastewater treatment plant, secondary effluent pumps were installed outside the building, prior to final completion of building construction. Similarly, buildings completed in 2001-02 where additions to buildings were constructed later. For example, an existing school had a gymnasium and special purpose building constructed as well as renovation on five existing classrooms.

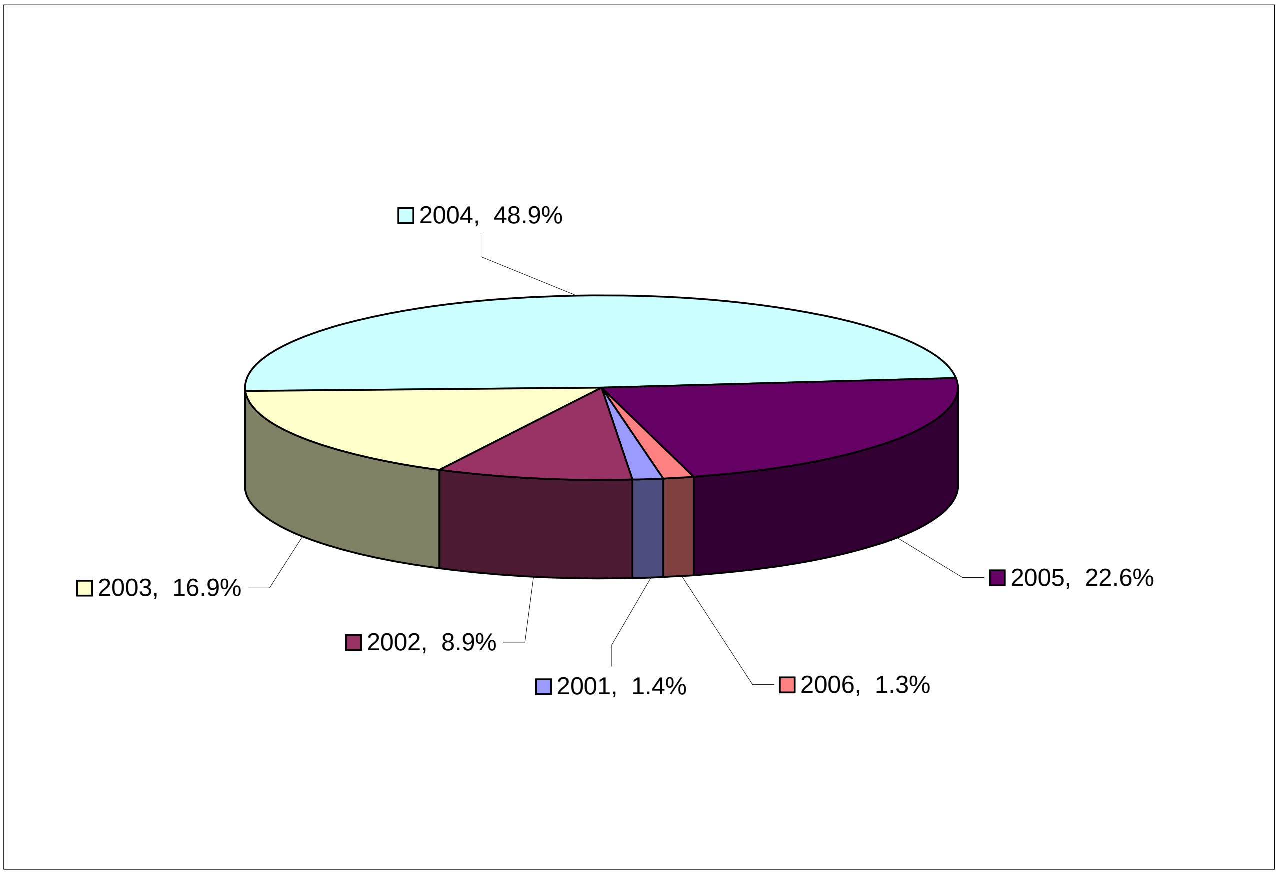


**Figure 5: Building Completion Year**

| Building Completion Year | % of Respondents |
|---|---|
| 2001 | 1.4% |
| 2002 | 8.9% |
| 2003 | 16.9% |
| 2004 | 48.9% |
| 2005 | 22.6% |
| 2006 | 1.3% |
| Sample Size | 155 |

**Table 44: Building Completion Year (q5)**

Table 45 shows that over 97% of all buildings were completely built out. Construction was not complete for the remaining 3%.

| Building Completely Built Out | % of Respondents |
|---|---|
| Yes | 97.0% |
| No | 3.0% |
| Sample Size | 193 |

**Table 45: Building Completely Built Out (q6)**

Table 46 shows that 92.6% of all buildings were fully occupied at the time of the survey.

| Building Completely Occupied | % of Respondents |
|---|---|
| Yes | 92.6% |
| No | 7.2% |
| Sample Size | 192 |

**Table 46: Building Occupancy (q7)**

Table 47 provides information on building ownership. Approximately 69% of all buildings were owned by private companies, whereas the remainders were owned by public agencies.

| Ownership of Building | % of Respondents |
|---|---|
| Private | 68.9% |
| Public | 31.1% |
| Don't Know | - |
| Refused | - |
| Sample Size | 197 |

**Table 47: Ownership Intent (q8)**

The reason for the construction or renovation of these buildings is summarized in Table 48. As can been seen from this table, 87.4% were built to be owner occupied. Approximately 12.2% of the buildings were built by a developer with the intent to lease space. Findings from previous SBD studies have shown that owner occupied buildings are more likely to make construction decisions using more sophisticated investment decision making procedures, such as return on investment (ROI) or lowest lifecycle cost, whereas speculative building decision-makers more frequently used lowest first cost decision making.

| Occupancy Intent | % of Respondents |
|---|---|
| Built to be Owner occupied | 87.4% |
| Built by a developer with the intent to lease space | 12.2% |
| Built and Occupied By Developer with intent not lease remaining space | 0.3% |
| Don't Know | - |
| Refused | - |
| Sample Size | 197 |

**Table 48: Occupancy Intent during Construction (q9)**

As expected, all public agencies built their buildings to be owner occupied, while only 81.7% of private companies built their buildings to be owner occupied. The results are shown in Table 49.

| Ownership of Building | Occupancy Intent | | | Total |
|---|---|---|---|---|
| | Owner Occupied | Lease Space | Developer Occupied | |
| Private | 81.7% | 17.8% | 0.5% | 100.0% |
| Public | 100.0% | 0.0% | 0.0% | 100.0% |

**Table 49: Building Ownership by Occupancy Intent (q8 & q9)**

Table 50 shows that the building plans were available for 61% of the projects. The plans were not available for the 27% of the respondents.

| Availability of Building Plans | % of Respondents |
|---|---|
| Yes | 61.0% |
| No | 27.0% |
| Don't Know | 12.0% |
| Refused | - |
| Sample Size | 196 |

**Table 50: Availability of Building plans (q10)**

### *Savings by Design Program Attitudes and Awareness*

All SBD program participants were asked how they first became aware of the SBD program, services, and owner incentives that were available. As can be seen from Table 51, about 77% of the respondents heard of the program through utility representatives or previous utility program participation. This percentage is very similar to last year's findings.

The large proportion of participants that previously participated in utility programs (44.6%) suggests that the program may need to change its marketing strategy to attract a broader audience and get more customers that have not previously participated. However, the percentage for "learning from utility representatives" (32.1%) is higher than the 2002 results (26.1%) but lower than 2003 results (35.5%). The lack of responses in support of web sites or marketing materials suggests that the utilities need to revisit the intent and content of these sources.

| Source | % of Respondents |
|---|---|
| Previous Utility Program Participation | 44.6% |
| Utility Representative | 32.1% |
| Architect | 4.9% |
| Manufacturer Rep. | 4.9% |
| Other | 4.0% |
| Don't Know | 2.5% |
| Marketing Material | 2.2% |
| Utility Seminar PEC Center or SCE | 1.6% |
| Engineer | 1.4% |
| Construction Manager | 1.1% |
| Web Site | 0.4% |
| Energy Manager | 0.3% |
| Sample Size | 194 |

**Table 51: Source of Awareness of Savings by Design (q11)**

When asked whether the interviewee worked directly with SBD representative, 82.4% said yes. The remaining 17.6% did not work directly with SBD representatives. These results are shown in Table 52.

| Worked Directly With SBD Representative | % of Respondents |
|---|---|
| Yes | 82.4% |
| No | 17.6% |
| Don't Know | - |
| Refused | - |
| Sample Size | 194 |

**Table 52: If Worked Directly With SBD Representative (q12)**

All SBD participants were asked at what stage of the design and construction process they became actively involved with the SBD representatives. Interviewees were read the list of options in Table 53. The results indicate that 75.8% became involved with the program early in the design process (16.4% during project conception, 18.1% during project development, 13% during schematic design, and 28.3% during the design development phase). SBD involvement began during the construction documents phase for only 6.1% of respondents. However, 9.9% of projects involved SBD representatives late in the process, 9.2% during construction, and 0.7% following completion of construction, suggesting that design and equipment decisions were made prior to SBD involvement. These participants could be considered free riders. Figure 6 presents the results.

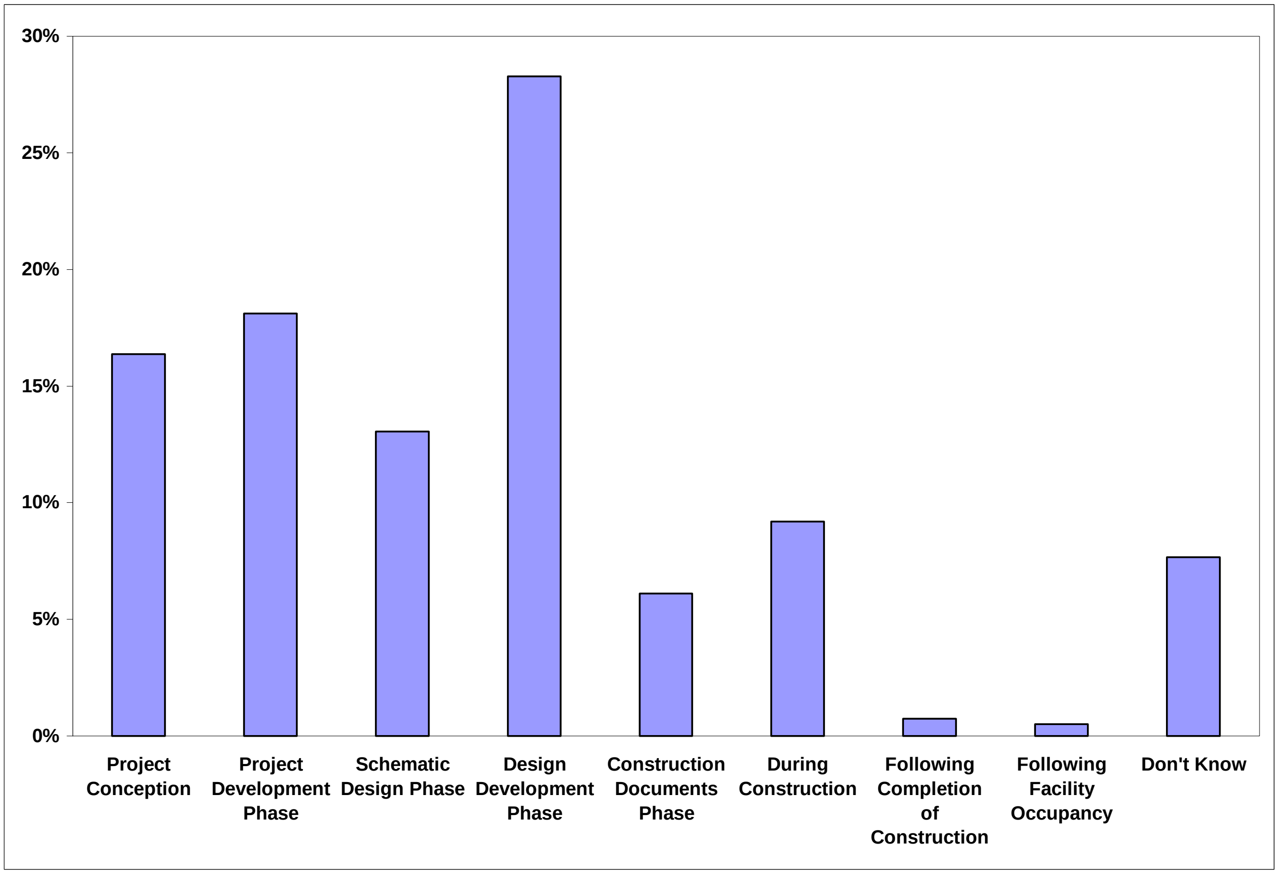


**Figure 6: Stage of Involvement with SBD representatives (q13)**

| Stage | % of Respondents |
|---|---|
| Design Development Phase | 28.3% |
| Project Development Phase | 18.1% |
| Project Conception | 16.4% |
| Schematic Design Phase | 13.0% |
| During Construction | 9.2% |
| Don't Know | 7.7% |
| Construction Documents Phase | 6.1% |
| Following Completion of Construction | 0.7% |
| Following Facility Occupancy | 0.5% |
| Sample Size | 192 |

**Table 53: Stage of Involvement with SBD representatives (q13)**

Table 54 summarizes the responses given when SBD participants were asked (unprompted) which member of their project team was the single biggest advocate for participating in the program. Over 60% of the participants said that the owners or the developers were the biggest advocates for SBD participation. This supports the finding of the NRNC baseline study[13] that asserts that architects and engineers feel that the owners are the key decision-makers. Other notable advocates were architects, energy managers and mechanical engineers. The interviewees who chose the option "other" in Table 54 were asked to name or describe who they consider to be the biggest advocate. Their responses included Assistant VP of Energy, Public Works Director, employees of the Finance Department and some other specific designations or names.

| Single Biggest Advocate | % of Respondents |
|---|---|
| Owner/Developer | 62.3% |
| Architect | 10.5% |
| Mechanical Engineer | 6.1% |
| Other | 5.5% |
| Energy Manager | 4.6% |
| Construction Manager | 4.2% |
| Electrical Engineer | 2.8% |
| Manufacturer Rep. | 2.0% |
| Don't Know | 1.5% |
| Lighting Designer | 0.5% |
| Sample Size | 191 |

**Table 54: Single Biggest Advocate for Participating in SBD (q14)**

### *Importance of Dollar Incentives, Design Assistance, and Design Analysis*

All SBD participants were asked to rate the level of importance of the incentives paid to the owner in motivating their organization to participate. As shown in Table 55 and Figure 7, approximately 86.8% said the incentive was either "very important" or "somewhat important", while only 4.7% rated the incentive very unimportant or somewhat unimportant. This suggests that incentives are a critical tool for engaging program participation of building owners.

[13] 1999 Non-Residential New Construction Baseline Study.

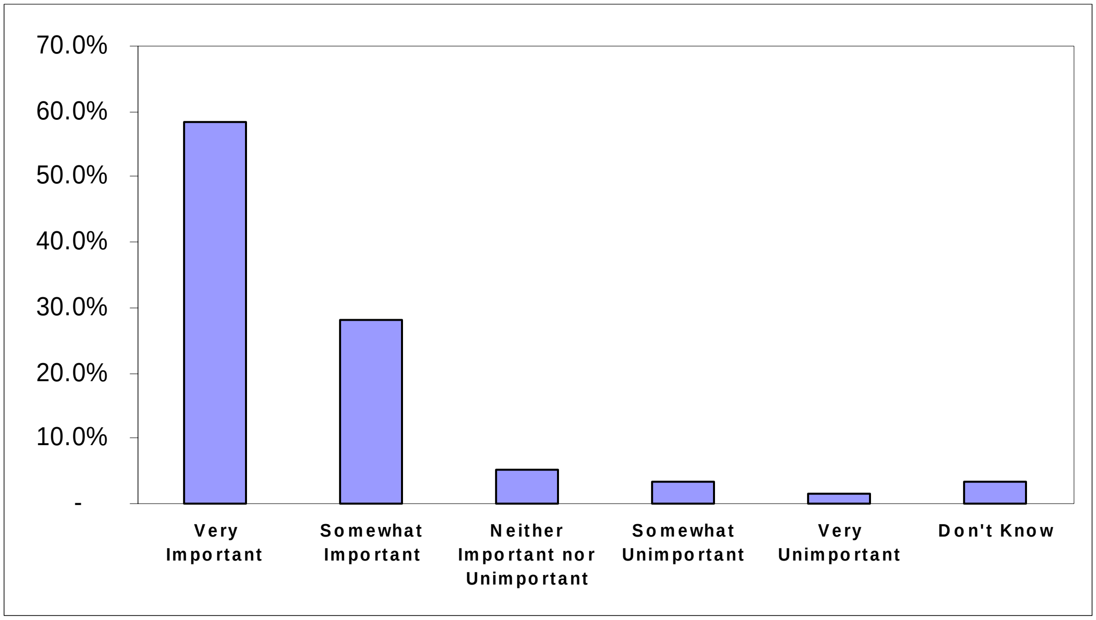


**Figure 7: Importance of Owner Incentive in Participation (q15)**

| Importance of Dollar Incentive | % of Respondents |
|---|---|
| Very Important | 58.5% |
| Somewhat Important | 28.3% |
| Neither Important nor Unimportant | 5.2% |
| Somewhat Unimportant | 3.2% |
| Very Unimportant | 1.5% |
| Don't Know | 3.4% |
| Sample Size | 192 |

**Table 55: Importance of Owner Incentive in Participation (q15)**

All SBD participants were asked to rate the level of importance of the design assistance provided by SBD in motivating their participation in the program. Table 56 and Figure 8 show that 75.7% of respondents rated the assistance as very or somewhat important, while only 5.4% rated the assistance as very or somewhat unimportant.

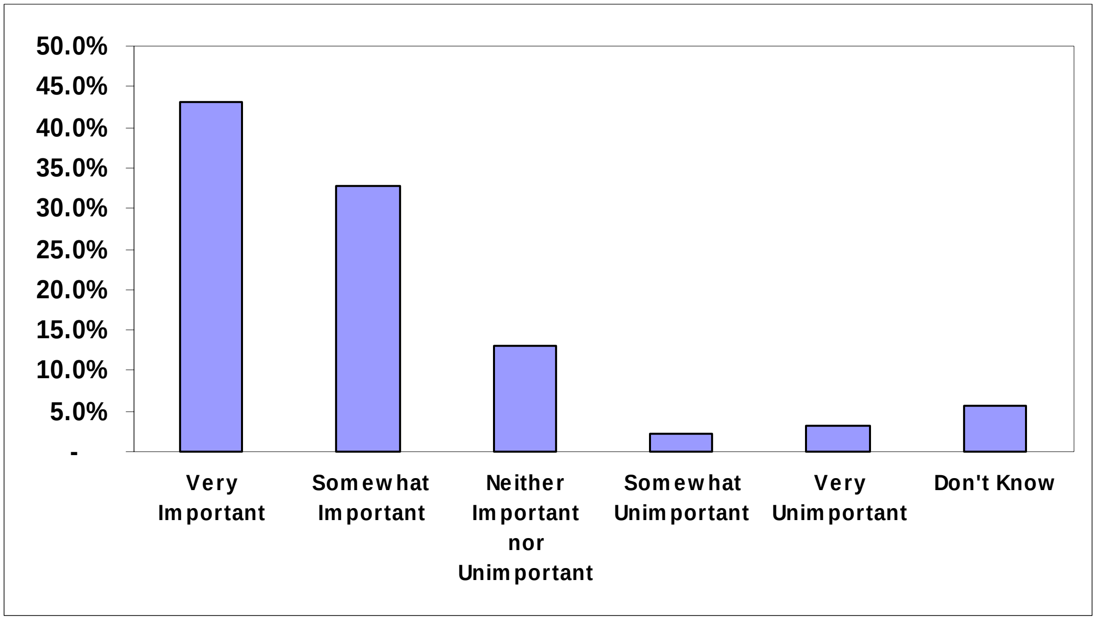


**Figure 8: Importance of Design Assistance for Participation (q16)**

| Importance of Design Assistance and Analysis | % of Respondents |
|---|---|
| Very Important | 43.0% |
| Somewhat Important | 32.7% |
| Neither Important nor Unimportant | 13.2% |
| Somewhat Unimportant | 2.1% |
| Very Unimportant | 3.3% |
| Don't Know | 5.6% |
| Sample Size | 190 |

**Table 56: Importance of Design Assistance for Participation (q16)**

As shown in Table 57, 77.4% of the participants stated that SBD participation influenced them to change their standard building practices to construct more efficient buildings in the future. 15.5% of the respondents answered that SBD participation did not influence changes in their standard practice. Almost 2% said that they had no plans to build any more buildings in future.

| If Participation Changed Standard Building Practice | % of Respondents |
|---|---|
| Yes | 77.4% |
| No | 15.5% |
| No Plans to build any more buildings | 1.7% |
| Don't Know | 5.4% |
| Sample Size | 191 |

**Table 57: Changed Standard Practice to Higher Energy Efficiency due to SBD Participation (q17)**

Participants who answered “yes” in Table 57 were asked about the changes they have made to the standard practice that would lead to a more energy efficient building design. Their diverse comments are below.

*All Participant Responses (q18)*

*The program has influenced us to improve the HVAC EER, lighting watts per fixture as well as add occupancy sensors. (COMMON RESPONSE)*

*This was a flagship building and now we are installing VFDs in new projects. (COMMON RESPONSE)*

*Due to our participation we now have policies that we must exceed T24 by 20% across the board.*

*The changes we made (during the program) realigned our thinking to incorporate all facilities, design, maintenance and construction operations. We have now set the standard for LEED certification.*

*Over the last three years, many of the measures have become standard practice by either market transformation or utility influence.*

*The biggest thing it's changed is our mind set; we are now more inclined to consider different ideas to conserve energy and in turn save money.*

*Had we know about the program sooner we would have installed a more efficient boiler and lighting system rather than buying used equipment.*

*SBD has provided us a greater awareness of managing our day to day operations of the VSD and lighting.*

*The program reinforced good decision making. PG&E saying, "this is a good thing to do," validates our decisions and shows our management that energy efficiency features are important and not excessive.*

*SBD is a tremendous resource for us. It provides our engineers with the framework to contemplate how the plants are going to operate efficiently early on. It pulls our whole team together to consider the conceptual design. Our SBD rep comes a few times a year to refine our projects and by the time they are ready to be submitted to those that allocate the* *funding, we know we have the best design possible. My job would be a lot more difficult without the resources of SBD. We are very concerned they have proposed moving us to Standard Performance Contracts as we don't want to loose our SBD rep he does an excellent job quantifying the benefits and researching for us things we don't know.*

*They have provided a lot of insight on things we could be doing. The problem is equipment manufacturers are not keeping up with the technology. We have implemented many items because of the program such as anti-sweat heater controls, increased insulation, efficient ventilation and lighting along with energy management controls on case and evaporative and condenser fans.*

*We are still referring to the design analysis for all new projects we do. The analysis was done for a prototype building and although Colma was not a prototype project, we still are benefiting from the analysis and using it at our other buildings.*

*We are trying to incorporate time of use and peak loads into our operations.*

*Without this kind of program, dairy owners would buy the cheapest thing on the market.*

*We continue to install tank insulation in our other winery locations*

*We have started using more EE lighting fixtures in our warehouses and we encourage our tenants to use light colored paint on the interiors to reflect the light from the skylights.*

*We have implemented Cool ducts - 100% seal, R-40 roof insulation, green sandwich panels, and biomass materials.*

Similarly, the participants who answered "No" in Table 57 were asked to give reasons in support of their response. Some of their comments are below.

<u>*Selected Participant Responses (q17 why)*</u>

*This (energy efficiency) is standard practice for us because…we need to be efficient. (COMMON RESPONSE)*

*We try and have efficient designs already in place; it's part of our culture. (COMMON RESPONSE)*

*The program didn't directly influence us; the influence comes from doing that which is sustainable.*

*Early on we were looking at more efficient lighting (we've done a $10mil energy conservation project) and gone to T-5 fixtures with instant on/off and higher EER for HVAC units.*

*Energy efficiency was not a priority as much as making sure the building could meet our process demands.*

*Our O&M department keeps us up to date on the most recent technological developments. For instance we are using Novar EMS to control our HVAC and Lighting.*

*Our design simply meets the SBD criteria there was no influence beyond that.*

*We are a large company; those that allocate the funds are note always in tune with the savings associated with energy efficiency upgrades. SBD input helps to ensure we get better equipment.*

Participants were asked to rate the value of SBD “Incentives”, “Design Assistance”, and “Design Analysis”. The results, shown in Table 58, indicate high satisfaction with all three components. A significant majority of respondents gave a rating of 1 or 2, where a rating of 1 is “very valuable”. The ratings in 2004-05 are the highest for “Incentives” where over 83% rated this service 1 or 2. The average score “Incentives” and “Design Assistance” improved slightly when compared with the 2003 study results of the same question. “Incentives” was rated 1.75, up from 2.19 for the 2003 study, and “Design Assistance” was rated 2.22 up 2.53 from the previous study. The average score for “Design Analysis” stayed relatively the same, a 2.05 compared with a 2.09 for the 2003 study.

| % of Participants 1="Very Valuable" 5="Not at all Valuable" | Incentives | Design Assistance | Design Analysis |
|---|---|---|---|
| 1 | 47.3% | 26.5% | 24.8% |
| 2 | 35.8% | 32.7% | 15.6% |
| 3 | 7.4% | 15.0% | 8.3% |
| 4 | 4.0% | 12.0% | 8.6% |
| 5 | 2.5% | 2.3% | 1.5% |
| Don't Know | 3.0% | 7.3% | 5.9% |
| NA | - | 4.0% | 19.1% |
| Not Provided | - | 0.3% | 16.3% |
| Total | 100.0% | 100.0% | 100.0% |
| Sample Size | 191 | 191 | 189 |
| Average Score | 1.75 | 2.22 | 2.09 |
| Standard Deviation | 2.21 | 2.52 | 2.56 |

**Table 58: Value of Incentives, Design Assistance, and Design Analysis (q19)**

All participants were asked to provide recommendations for changes to the SBD program in order to improve its delivery to customers. These answers were unprompted, and multiple responses were accepted. The answers have been categorized based on common responses. Percentages reported were calculated using the following equation:

(weighted number of respondents with a particular answer) ÷

(total weighted number of respondents who answered the question).

One hundred ninety-one survey respondents answered this question. Table 59 shows that almost 51% of the participants felt that no changes were needed. Suggestions that received support included “more marketing to increase awareness of program” (9.8%), “utilities should try to get involved earlier in projects” (9%) and “other” (21.5%). Interestingly, only 9.5% of the respondents recommended an “increase (in) incentives,” while most others seemed to be pleased with the incentives. This is a significant change from the 2002 results where 27.5% of respondents recommended increased incentives. However, in 2003 this percentage was only 2.9%. As multiple answers were accepted on this question, the percentages in Table 59 do not add up to 100%.

| Recommendations | % of Respondents |
|---|---|
| No Changes Needed | 50.8% |
| Other | 19.0% |
| More marketing to increase awareness of program | 9.8% |
| Increase Incentives | 9.5% |
| Utilities should try to get involved earlier in projects | 9.0% |
| Don't Know | 7.2% |
| More interaction with design team | 7.0% |
| Review and response from utility needs to be more timely | 5.1% |
| Utility Reps need to present benefits more clearly | 1.7% |
| They could have been more involved and also had a little quicker response time | 1.4% |
| It would be nice if we could… get design assistance earlier in the project | 1.1% |
| Less paperwork and red tape | 1.3% |
| Increase post project feedback, better "closure" | 0.6% |
| Refused | - |
| Sample Size | 191 |

**Table 59: Recommended Changes to Savings by Design (q20)**

Respondents who chose “Other” in Table 59 were asked to state their specific recommendation(s). Selected “Other” comments and recommendations are listed below.

*Other Selected Recommendations (q20 Other)*

> *Develop a check list of participant actions, timing, etc. for all phases, from design to construction. Guarantee funding; often there is uncertainty over funding.*
>
> *Provide a check list or outline of key considerations for products and services such as the correct application for parking lot lighting. Ideally the list would provide a preliminary cost/benefit analysis.*
>
> *Assign more staff to the SBD program. Although their people did a great job, it took a long time to process the project and we can see they are stretched really thin.*
>
> *We would like to have more face to face interaction with the utility. They should come see us and talk about our up-and-coming projects.*
>
> *SBD could be a lot more aggressive. They are too passive in the role they play now. For example, they should attend design meetings.*
>
> *We are open to any support they can provide us to increase energy savings as long as it doesn't interfere with the guests’ experience in our hotels.*
>
> *It would be good to know, now that the building has been operating for a few years, what other things we can do to make our building more efficient. The new construction services department knows so much about our building that it would be nice to have the utility return and provide additional suggestions.*

*Provide a list of companies to work with other than [vendor]. We were forced to use [vendor] and felt they have very poor customer service and very unresponsive. We are now spending $20,000 to upgrade the computer algorithms since we learned the design did not minimize our impact during peak load. (reworded)*

*Increase marketing to architects.*

*The SBD program ought to provide incentives and design assistance according to facility type, like restaurants. Then we can get better assistance and more innovative ideas to improve the efficiency of our projects.*

*The missing piece is that they need to give more incentives for PV. Our air quality is really bad out here in the central valley, so we could win on two counts by reducing pollution from power plants (and saving energy). Without financial incentives, it is too expensive.*

*The post-measurement team that verified the installation made it an awkward process because afterwards they took 3-4 months to calculate the incentive and 2 or 3 times before they got the amount right. We think they should send people out that know about the systems in advance.*

*The technology was hard to work with. Analysis software EnergyPro was a hassle.*

*Work with manufacturers to get energy efficient equipment on the market readily available.*

*2005 building energy codes are more difficult to meet much less exceeds. The requirements set by SBD in light of the Title-24 changes are getting far too difficult to meet and the incentive amounts are not clear enough.*

One might expect the customers that value the incentives to recommend an increase in incentive amounts. Yet, of all the respondents that valued incentives, only 7.8% of them recommended an increase in the incentive amount. Even though this number is still similar to the overall population (Table 59, 9.5%), it indicates that participants who are most influenced by the incentive are generally satisfied with the incentive amount. Table 60 shows the results.

| Importance of Dollar Incentive | Recommendation | | Total |
|---|---|---|---|
| | Increase Incentive | Other | |
| Very Important | 4.2% | 95.8% | 100.0% |
| Somewhat Important | 3.6% | 96.4% | 100.0% |

**Table 60: Importance of Incentive by Recommendation to Increase Incentive**

## Prototype Projects

Prototype plans refer to a master set of plans that are used for construction of multiple buildings. This is common practice among large retail and restaurant chains, many of which participated in the SBD program. The questions in this section were developed in order to provide program planners with some basic information regarding prototype projects.

The Program's rules for prototypes have evolved since 1999, and led to a "prototype building" policy targeted to chain accounts with centralized design authority being defined and implemented. Up until 2002 some utilities allowed all buildings to qualify for the incentive, while others applied Whole Building incentives to the initial project, with subsequent projects receiving the Systems Approach rate incentives. Currently, all three utilities allow all prototype buildings to qualify for Whole Building incentives.

Participants were first asked if they used a set of prototype plans or master specifications in the design and construction of their building – only 16.9% responded yes as shown in Table 61. Figure 9 presents the results.

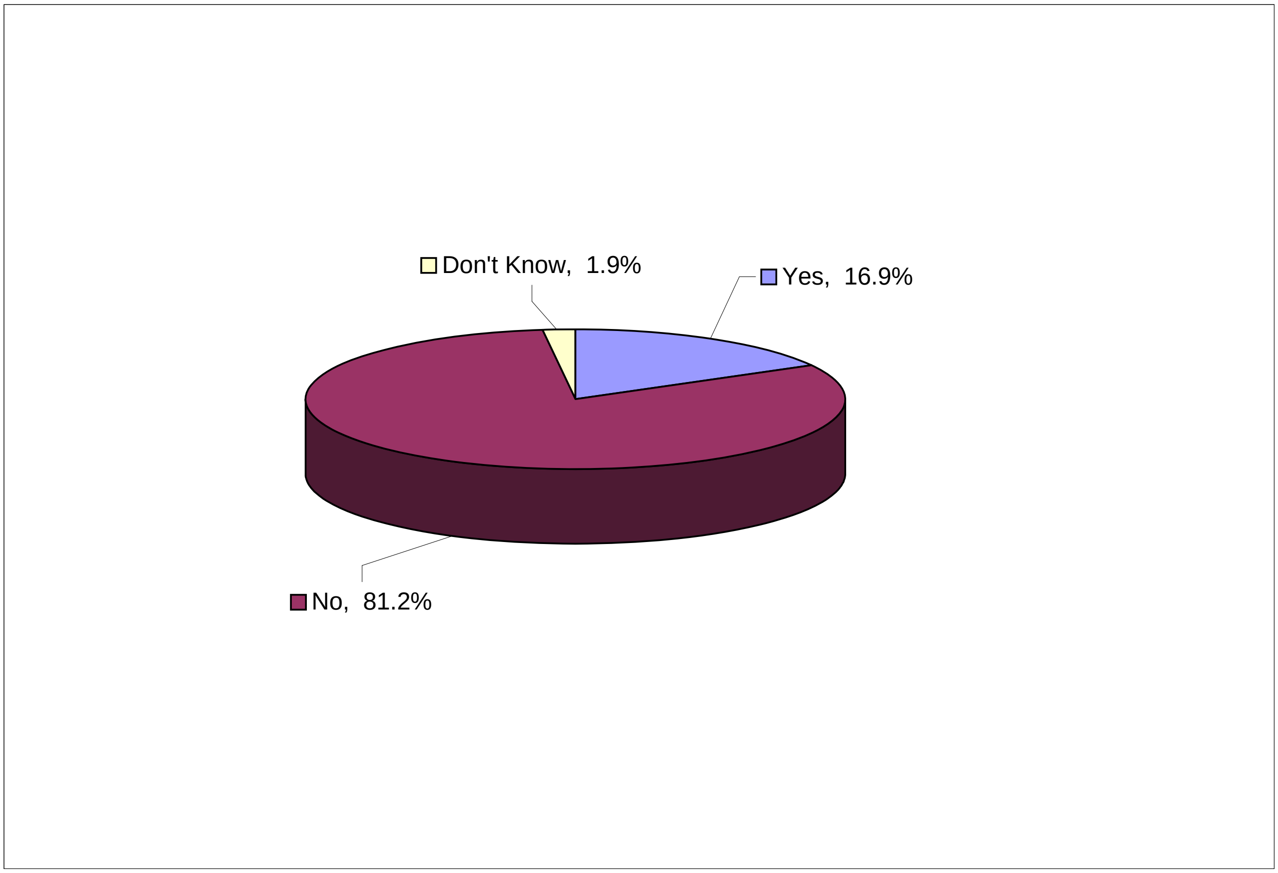


**Figure 9: Used Prototype Plans (q21)**

| Prototype Plans Used | % of Respondents |
|---|---|
| Yes | 16.9% |
| No | 81.2% |
| Don't Know | 1.9% |
| Refused | - |
| Sample Size | 193 |

**Table 61: Used a set of Prototype Plans (q21)**

Participants who used a set of prototype plans were asked if at any time SBD was actively involved with design assistance or design analysis in the development, refinement and/or enhancement of the prototype plans. As shown in Table 62 94.7% responded yes. As noted in the beginning of this chapter, all percentages listed are weighted percentages, and as such 16.9% is the weighted percentage of the population that used prototype plans, not the percentage of the sample. As a result, the sample sizes of 39 in Table 62 & Table 63 are 20.2% of the 193 sample size from Table 61, which is slightly higher than the stated 16.9%.

| | **% of Respondents** |
|---|---|
| Yes | 94.7% |
| No | 3.5% |
| Don't Know | 1.8% |
| Sample Size | 39 |

**Table 62: Received Design Assistance or Analysis through SBD (q28)**

Participants who used a set of prototype plans were also asked if future SBD incentives would be an important consideration in the development, refinement, and/or enhancement of the prototype plans for these projects. The answers of the participants are summarized in Table 63. Almost 90% considered future SBD incentives important.

| | **% of Respondents** |
|---|---|
| Yes | 89.7% |
| No | 8.6% |
| Don't Know | 1.8% |
| Sample Size | 39 |

**Table 63: Future SBD incentives Important (q29)**

## Conclusions

The survey results indicate that a little over two-thirds of the buildings were owned by private companies and the remaining were owned by public companies. The results also show that a majority of the interviewees heard of the program through utility representatives or utility program participations.

The program participants were generally satisfied with the program. This is indicated by the frequent “no changes needed” responses when asked what the program should improve. Also, there were encouraging scores on the value of incentives, design assistance and analysis (Table 58 and Table 59). Some of the requests for change came in the following areas: making the program easier and faster to use, involving the utilities earlier in the projects, increasing marketing efforts, and increasing interaction with the design team.

The issue of incentives came up directly in multiple questions. While it is reasonable to conclude that everyone values financial incentives, the degree to which those incentives are influencing measure implementation is not clear. In other words, while the incentives may be necessary for enlisting program participation, when standard practice exceeds the minimum code compliance, an incentive is not necessary. This may explain situations where the respondent expressed the importance of incentives while stating that their measure choices were standard practice. Even still, the majority of respondents indicated the program influenced them to change their standard building practice. This is illustrated in Figure 10. Along with incentives, design assistance and analyses were also found to be very valuable by the program participants.

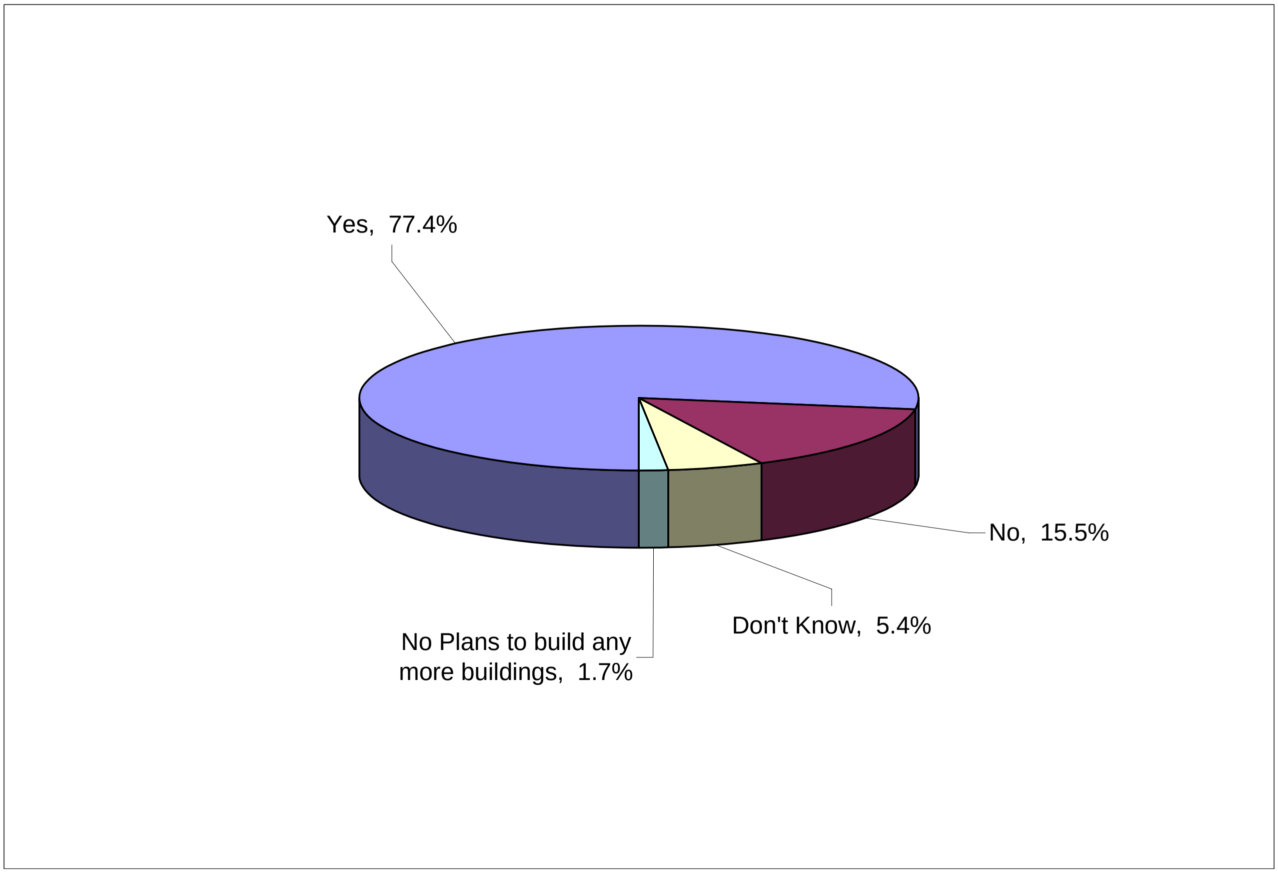


**Figure 10: Changed Standard Practice to Higher Energy Efficiency due to SBD Participation (q17)**

A small percentage (16.9%) of participants used a set of prototype plans or master specifications in the design and construction of their building. The majority of survey respondents for these prototype plans were actively involved with SBD design assistance or design analysis. The majority also feels that future SBD incentives are an important consideration in the development, refinement, and/or enhancement of the prototype plans used for new projects.

Finally, there were several instances last year where non-participants indicated to the interviewer that they would like to learn more about the SBD program for possible future participation, indicating an opportunity for SBD program marketing. This corresponds to the narrow range of responses about the source of awareness of Savings By Design and the lack of mention of marketing material and web sites by respondents. These results indicate that a broader marketing program would be beneficial.

# Data Sources and Sampling Plan

## Data Sources

RLW Analytics and AEC used several secondary and primary data sources to complete this project. The secondary data sources include:

- Statewide SBD program databases and files
- Engineering and manufacturers' reference material, and
- California Energy Commission weather data

California's Investor Owned Utilities (IOU) databases, Title-24 compliance certificates, and program files are used to identify participating buildings, estimated savings, and incented measures. The other secondary sources were used to support the modeling and calibration effort.

Primary data sources include:

- New construction decision-makers, and
- Newly constructed buildings

Data were obtained from the primary sources through quantitative interviews and surveys. Buildings were surveyed and simulated. The new construction decision-makers include building owners/managers, architects, and specifying engineers.

## Sampling Plan

The selection of the sites was guided by a model-based statistical sampling plan as in the 1994-96 evaluation studies, the 1998 baseline study, and the 1999-2001, 2002 and 2003 SBD studies.

Model-based sampling methods were also used to analyze the data, i.e., to extrapolate the findings from the sample sites to the target population of all program participants and to evaluate the statistical precision of the results. MBSS™ methods of statistical sampling and analysis were completed in substantially the same way as in the 1994, 1996 and 1998 NRNC evaluations and the 1999-2001, 2002 and 2003 SBD studies.

Once the program tracking data were available, model-based methods were used to combine the tracking data with the findings from prior studies about the sample design parameters – the error ratio and gamma parameter. Using these data, we determined the statistical precision to be expected on gross annual energy savings from the planned sample size for the participant sample.

Once the sample size had been determined, we developed the sample design. We used a sample that was efficiently stratified by the tracking estimate of annual energy savings, with proportional representation of utilities in the combined participant population.

### *Theoretical Foundation*

MBSS™ methodology was used to develop efficient sample designs and to assess the likely statistical precision. The target variable of analysis, denoted $y$, is the energy savings of the project. The primary stratification variable, the estimated energy savings of the project, is denoted *x*. A ratio model was formulated to describe the relationship between *y* and *x* for all units in the population, e.g., all program participants.

The MBSS™ ratio model consists of two equations called the primary and secondary equations:

$$\begin{aligned} y_k &= \beta x_k + \varepsilon_k \\ \sigma_k &= sd(y_k) = \sigma_0 x_k^{\gamma} \end{aligned}$$

Here $x_k > 0$ is known throughout the population. *k* denotes the sampling unit, i.e., the project. $\{\varepsilon_1, \ldots, \varepsilon_N\}$ are independent random variables with *an* expected value of zero, and $\beta$, $\sigma_0$, and $\gamma$ (gamma) are parameters of the model. The primary equation can also be written as

$$\mu_k = \beta x_k$$

Under the MBSS ratio model, it is assumed that the expected value of *y* is a simple ratio or multiple of *x.*

Here, $y_k$ is a random variable with expected value $\mu_k$ and standard deviation $\sigma_k$. Both the expected value and standard deviation generally vary from one unit to another depending on $x_k$, following the primary and secondary equations of the model. In statistical jargon, the ratio model is (usually) a heteroscedastic regression model with zero intercept.

One of the key parameters of the ratio model is the error ratio, denoted *er*. The error ratio is a measure of the strength of the association between *y* and *x*. The error ratio is suitable for measuring the strength of a heteroscedastic relationship and for choosing sample sizes. It is *not* equal to the correlation coefficient. It *is* somewhat analogous to a coefficient of variation except that it describes the association between two or more variables rather than the variation in a single variable.

Using the model discussed above, the error ratio, *er*, is defined to be:

$$er = \frac{\sum_{k=1}^{N} \sigma_k}{\sum_{k=1}^{N} \mu_k} = \frac{\frac{1}{N}\sum_{k=1}^{N} \sigma_k}{\frac{1}{N}\sum_{k=1}^{N} \mu_k}$$

Figure 11 gives some typical examples of ratio models with different error ratios. An error ratio of 0.2 represents a very strong association between *y* and *x*, whereas an error ratio of 0.8 represents a weak association. Loosely speaking, an error ratio of .75 implies that the measured savings is typically within ±75% of the tracking estimate of savings adjusted for the realization rate. The smaller the error ratio, the stronger the association between tracking and measured savings, and the smaller the sample size needed to estimate the program realization rate with a fixed precision.

As Figure 11 indicates, the error ratio is the principle determinant of the sample size required to satisfy the 90/10 criteria for estimating *y*. If the error ratio is small, then the required sample is correspondingly small.

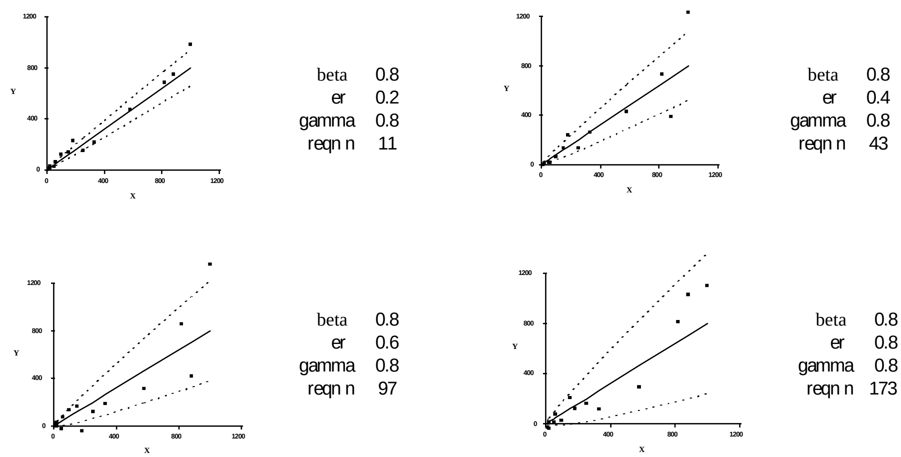


**Figure 11: Examples of MBSS Ratio Models**

The model parameters – b, g, and the error ratio -- were calculated from the 2003 SBD study. The model parameters are shown in Table 64. Based on the 2003 SBD sample projects, the error ratio is 0.69. *Using this value, our analysis indicated that a sample of 180 2004-05 SBD program participants would provide a relative precision of about ±7.8% at the 90% level of confidence*.

| Parameter | Value |
|---|---|
| b | 1.129 |
| g | 0.78 |
| Error ratio | 0.69 |

**Table 64: Sample Design Model Parameters**

In order to inform future sample designs, we have calculated the model parameters, b, g, and the error ratio, using the actual participant population and sample. Table 65 shows the results.

| Parameter | Value |
|---|---|
| b | 1.023 |
| g | 0.80 |
| Error ratio | 0.75 |

**Table 65: Actual Model Parameters**

## *Sample Design*

### *Planned Statewide Participant Sample Design*

For the purposes of this study, a building was defined to be a building that received an incentive through the Savings By Design program for installing energy efficient equipment during 2004-05.

At the sample design stage, we found that there were 1,096 projects paid in 2004-05, combining for a total ex-ante gross savings of 4,403,365 MBtu. Considering all 1,096 projects, the average savings was 4,018 MBtu per project.

Table 66 shows the original sample design. As is typical in a non-residential program, there were a large number of small projects but the relatively few large projects yielded much of the total savings. Table 66 shows that for PG&E, there were 206 projects with annual savings of 440 MBtu or less, with a total ex-ante gross savings of 90,700 MBtu. The maximum MBtu in each stratum is called the stratum cut point. These 206 projects were 49% of all PG&E projects, but they represented only 5% of all savings. By contrast, the fifth stratum that contains 25 projects for PG&E represents only about 6% of all PG&E projects, but yielded 51% of the total ex-ante gross savings. Because the population distribution of savings is much skewed, the sample design was carefully stratified by utility and size to produce the appropriate mix of small and large projects among each utility.

| Utility | Stratum | Population | | | Sample | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Savings per Project (MBtu) | Total MBtu | Number of Projects | Max MBtu Savings | Savings per Project (MBtu) | Total MBtu | Sample Size | Sample Fraction |
| PG&E | 1 | 440 | 90,700 | 206 | 1,257 | 592 | 7,699 | 13 | 0.06 |
| | 2 | 2,317 | 187,660 | 81 | 3,320 | 2,277 | 29,605 | 13 | 0.16 |
| | 3 | 4,165 | 249,886 | 60 | 5,339 | 4,232 | 55,021 | 13 | 0.22 |
| | 4 | 6,786 | 318,919 | 47 | 8,708 | 6,630 | 86,193 | 13 | 0.28 |
| | 5 | 35,245 | 881,136 | 25 | 143,546 | 32,018 | 416,230 | 13 | 0.52 |
| | PG&E Subtotal | 4,125 | 1,728,302 | 419 | | 9,150 | 594,749 | 65 | 0.16 |
| SCE | 6 | 393 | 86,011 | 219 | 1,035 | 287 | 3,734 | 13 | 0.06 |
| | 7 | 2,371 | 196,807 | 83 | 3,593 | 2,300 | 29,897 | 13 | 0.16 |
| | 8 | 5,145 | 288,117 | 56 | 6,591 | 5,202 | 67,629 | 13 | 0.23 |
| | 9 | 8,552 | 376,270 | 44 | 10,733 | 8,315 | 108,093 | 13 | 0.30 |
| | 10 | 25,339 | 658,823 | 26 | 50,135 | 28,396 | 369,142 | 13 | 0.50 |
| | SCE Subtotal | 3,752 | 1,606,028 | 428 | | 8,900 | 578,495 | 65 | 0.15 |
| SoCalGas | 11 | 272 | 9,527 | 35 | 491 | 361 | 1,082 | 3 | 0.09 |
| | 12 | 1,389 | 20,836 | 15 | 1,895 | 1,201 | 3,603 | 3 | 0.20 |
| | 13 | 4,332 | 34,658 | 8 | 4,912 | 4,490 | 13,470 | 3 | 0.38 |
| | 14 | 6,398 | 44,788 | 7 | 6,634 | 6,406 | 19,217 | 3 | 0.43 |
| | 15 | 16,986 | 84,929 | 5 | 26,406 | 14,233 | 42,700 | 3 | 0.60 |
| | SoCalGas Subtotal | 2,782 | 194,738 | 70 | | 5,338 | 80,073 | 15 | 0.21 |
| SDG&E | 16 | 403 | 37,920 | 94 | 1,100 | 478 | 3,344 | 7 | 0.07 |
| | 17 | 2,279 | 84,325 | 37 | 3,618 | 2,533 | 17,728 | 7 | 0.19 |
| | 18 | 5,030 | 120,732 | 24 | 5,890 | 5,120 | 35,837 | 7 | 0.29 |
| | 19 | 11,979 | 191,663 | 16 | 19,408 | 12,653 | 88,573 | 7 | 0.44 |
| | 20 | 54,957 | 439,657 | 8 | 153,685 | 55,541 | 388,787 | 7 | 0.88 |
| | SDG&E Subtotal | 4,884 | 874,296 | 179 | | 15,265 | 534,270 | 35 | 0.20 |
| **Statewide** | **Total** | **4,018** | **4,403,365** | **1,096** | | **9,931** | **1,787,586** | **180** | **0.16** |

**Table 66: Original Planned Sample Design**

We applied the sample design to the projects that were paid in 2004-05. The sample was selected in three steps:

1. Classify each of the projects into one of the twenty strata according to the size of the savings and the utility.
2. Calculate the number of projects to be sampled from each stratum by multiplying the total number of projects by the sampling fraction for the stratum shown in Table 66.
3. Randomly select the specified number of projects.

*Final Statewide Participant Sample Design*

The participant case weights were calculated using model based stratification. In this approach, the population is sorted by increasing residual standard deviation, $\sigma_k$, or equivalently, by increasing $x_k^\gamma$, as $x_k^\gamma$ and $\sigma_k$ only differ by a constant under the ratio model. Then strata cut points are formed by dividing the sum of the $x_k^\gamma$ equally among the strata, and the sample is allocated equally to each stratum. Then the population sizes are tabulated within each stratum. Finally the case weights are calculated in the usual way. The industrial sites were grouped in with the commercial sites in calculating the case weights because we were only able to identify mixed commercial and industrial savings in the sample and not in the population. We had to combine the groups since we could not make this distinction.

Table 67 shows the final participant sample design that was used to calculate the participant case weights. In this case, the sum of the population residual standard deviations has been divided equally among 20 strata. Within each utility, the sum of the residual standard deviations has been equally divided among the 5 strata. Then the stratum cut points shown in column three were calculated from the tracking estimates of MBtu for the population. Next, within each utility the sample was allocated equally to each stratum. The population sizes shown in column four were calculated from the stratum cut points. The final step was to calculate the case weights shown in the last column. For example, the case weight for the 31 sites in the first stratum is 268 / 31 = 8.65.

| Utility | Stratum | Max MBtu Savings | # of Projects | Sample Size | Weight | Sample Fraction |
|---|---|---|---|---|---|---|
| PG&E | 1 | 2,982,795 | 268 | 31 | 8.65 | 0.12 |
| | 2 | 4,761,125 | 72 | 19 | 3.79 | 0.26 |
| | 3 | 8,234,317 | 48 | 16 | 3.00 | 0.33 |
| | 4 | 22,140,507 | 27 | 16 | 1.69 | 0.59 |
| | 5 | 314,029,200 | 5 | 4 | 1.25 | 0.80 |
| | PG&E Subtotal | | 420 | 86 | 4.88 | 0.20 |
| SCE | 6 | 3,129,257 | 283 | 24 | 11.79 | 0.08 |
| | 7 | 5,707,915 | 63 | 11 | 5.73 | 0.17 |
| | 8 | 9,038,560 | 44 | 13 | 3.38 | 0.30 |
| | 9 | 21,349,647 | 25 | 7 | 3.57 | 0.28 |
| | 10 | 50,134,506 | 13 | 9 | 1.44 | 0.69 |
| | SCE Subtotal | | 428 | 64 | 6.69 | 0.15 |
| SoCalGas | 11 | 2,249,199 | 48 | 6 | 8.00 | 0.13 |
| | 12 | 4,912,124 | 9 | 3 | 3.00 | 0.33 |
| | 13 | 6,381,060 | 6 | 2 | 3.00 | 0.33 |
| | 14 | 11,876,094 | 5 | 3 | 1.67 | 0.60 |
| | 15 | 30,352,584 | 2 | 1 | 2.00 | 0.50 |
| | SoCalGas Subtotal | | 70 | 15 | 4.67 | 0.21 |
| SDG&E | 16 | 3,390,599 | 126 | 12 | 10.50 | 0.10 |
| | 17 | 6,444,517 | 29 | 9 | 3.22 | 0.31 |
| | 18 | 14,718,728 | 15 | 7 | 2.14 | 0.47 |
| | 19 | 50,869,993 | 7 | 5 | 1.40 | 0.71 |
| | 20 | 153,684,692 | 3 | 3 | 1.00 | 1.00 |
| | SDG&E Subtotal | | 180 | 36 | 5.00 | 0.20 |

**Table 67: Final Sample Design**

Table 68 presents the actual 2004-05 SBD population and sample by utility and the MBtu savings associated with these projects. In general, the larger projects in the program were SDG&E and PG&E projects. The SoCalGas projects tended to be smaller projects. Since the smaller projects have lower sampling fractions, SoCalGas had smaller sample sizes than SDG&E and PG&E.

| | PG&E | | SCE | | SoCalGas | | SDG&E | | Statewide | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Population | Sample | Population | Sample | Population | Sample | Population | Sample | Population | Sample |
| **Number of Projects** | 419 | 65 | 428 | 65 | 70 | 15 | 179 | 35 | 1,096 | 180 |
| **MBtu Savings** | 1,728,302 | 594,749 | 1,606,028 | 578,495 | 194,738 | 80,073 | 874,296 | 534,270 | 4,403,365 | 1,787,586 |
| **Savings per Project (MBtu)** | 4,125 | 9,150 | 3,752 | 8,900 | 2,782 | 5,338 | 4,884 | 15,265 | 4,018 | 9,931 |

**Table 68: Actual 2004-05 SBD Participation and Sample by Utility – MBtu Savings**

The commercial and industrial projects were combined in the tracking data and a single sample design was performed on all of the projects. As Table 66 shows, the sample design was based on a stratified sampling plan that over-sampled projects with greater MBtu ex-ante gross savings, and under-sampled sites with fewer MBtu ex-ante gross savings. As a result, many of the larger industrial projects were captured in the sample. This approach allows for the inclusion of fewer sample points in the study since a greater amount of the program variation is captured in the sample, thereby improving the precision of the overall program estimates.

Once the sites were broken into strata by the amount of their MBtu ex-ante gross savings, they were randomly sorted and selected into the sample. This sampling procedure ensures that the sample contains a random representation of the projects in the population. Therefore, the various types of participants and program measures get the appropriate proportional distribution of the sample relative to the number in the population.

The weights for the industrial and commercial sites were calculated in a manner similar to the sample design. All commercial and industrial sites were combined into a sample file and projected to the entire program population. The random selection of sample points then ensured that the weights on the industrial sites approximate the number of industrial sites in the program population. Since many of the industrial sites were the larger projects, their weights were relatively low, meaning that the sites and their corresponding savings did not represent many projects in the population.

# Gross Savings Methodology

This section describes the gross energy savings and demand reduction methodology. Energy savings and demand reduction results for the whole building as well as for shell, lighting power density, day lighting controls, other lighting controls, motors, HVAC, and refrigeration measure groups are presented in the next chapter.

## Definitions

Some definitions would be helpful to clarify the discussion.

*DOE-2 version* The DOE-2.2 program version 44E3 was used in the project. The modeling tool was upgraded from DOE-2.1E to DOE-2.2 to take advantage of the latest DOE-2 modeling capabilities, and to provide consistency with the calculation engine used in the CA NCCalc tool. DOE-2.2 provides a more robust simulation of buildings with built-up HVAC systems. The grocery store refrigeration model is also more robust than the standard DOE2.1E model[14] We had custom modifications made to the 44E3 version to simulate daylighting controls using a "daylight factor" approach. The daylighting simulation strategy is identical to the strategy used in previous Savings by Design evaluations. Migrating the modeling tool from DOE-2.1 E to DOE-2.2 was a significant software development project, requiring many hours of software development and testing time.

*Baseline* A consistent standard of energy efficiency against which all buildings are measured. This is defined as the output of a DOE-2.2 simulation run of a building using either 1998 or 2001 Title-24 required equipment efficiencies (where applicable) and using the operating schedule found by the on-site surveyor. For building types where Title-24 does not apply (e.g. hospitals), or end-uses not covered by Title-24 (e.g. hospitals, refrigeration systems, industrial processes), the baseline defined by the program for estimating the program savings are used. These non-code baselines have been created through studies of "common practice" of these applications.

*As Built* A DOE-2.2 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.

[14] We used a "custom" version of DOE-2.1E in previous evaluations to work around the grocery store refrigeration limitations.

## Model-Based Statistical Sampling

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 all of California's IOUs, 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, 1996, and 1998 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[15].

The general idea behind model-based statistics is that there is a relationship between the variable of interest – in this case, savings – and a variable that is known for the entire population – program estimate of savings. Using this prior information allows for greater precision with a given sample size because the prior information eliminates some of the statistical uncertainty.

The estimate of the total savings in the population can be expressed as the ratio of the sample average measured savings to the sample average estimated savings times the population total savings.

$$Y = y/x\ X$$

Where:

Y is the population total measured savings

y is the average measured savings in the sample

X is the population total ex-ante gross savings

x is the average ex-ante gross savings in the sample

The sample design discussion in the methodology section of this report described the sample designs used in this study. Therefore this section describes in more detail the methods used to extrapolate the results to the target population. Three topics are described:

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

## Statistical Terms Used in the Analysis

### *Standard Error*

$$se = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

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

Standard error is the square root of the sum of the squares of the average difference between the expected value of a variable y (denoted $\bar{y}$ and the n actual values of y ($y_i$) of the sample. It is a measure of how much variation there is in the sample data relative to the estimated sample mean.

### *Error Bound*

$$eb = 1.645 * se$$

If the underlying sample data is normally distributed, we expect the true value of y to be within 1.645*se of the estimate, $\bar{y}$, 90% of the time. In this report, this is often written as $\bar{y} +/- se$.

### *Relative Precision*

$$rp = \frac{eb}{\bar{y}}$$

Relative precision expresses the error bound as a percentage of the estimated population mean, $\bar{y}$. Thus, a 10% relative precision means that there is a 90% probability that the true value of a variable we are predicting is within 10% of our predicted value. An rp of 25% implies that 90% of the time, the true value will be within 25% (plus or minus) of the estimated value.

### *Weighted Mean Per Unit Estimation of Total*

**Population Total = Sum of Stratum Totals**

$$Y = \sum_{h=1}^{m} Y_h = \sum_{h=1}^{m} \left( \sum_{i=1}^{n} w_h y_{ih} \right)$$

**Assumption:** $n_h$ **is known for every stratum** $h$ **in the population**

**Where:** $w_h = \frac{N_h}{n_h}$

In our analysis, due to small sample size within each measure category at the utility level, we used a case weighted approach instead of a stratum based summation. This process is described in the following section.

## Case Weights

### *Theoretical Foundation*

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:

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

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.

### *Case Weights*

The case weights were calculated using model based stratification. In this approach, the population is sorted by increasing residual standard deviation, $\sigma_k$, or equivalently, by increasing $x_k^\gamma$, as $x_k^\gamma$ and $\sigma_k$ only differ by a constant under the ratio model. Then strata cut points are formed by dividing the sum of the $x_k^\gamma$ equally among the strata, and the sample is allocated equally to each stratum. Then the population sizes are tabulated within each stratum. Finally the case weights are calculated in the usual way.

The industrial sites were grouped in with the commercial sites in calculating the case weights because we were only able to identify mixed commercial and industrial savings in the sample and not in the population. We had to combine the groups since we could not make this distinction.

## 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:

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

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 project in the sample. The sample of baseline, as built, and savings estimates were projected to the population using the model-based statistical methods described above.

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. Eight end-use measure groups were examined as part of this study:

- Shell – High performance glass
- Lighting Power Density– Lamps and ballasts
- Daylight Controls-Daylighting controls such as continuous dimming daylight controls and stepped dimming daylight controls
- Other Lighting Controls- Other lighting controls such as occupancy sensors and lumen maintenance 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)
- Industrial – Process pumps, CO sensors, VSD fume hoods
- DHW – Water Heaters

# Net Savings Methodology

In this chapter, the methodology used to calculate the net savings results is presented. We have used a customer self-report methodology to calculate the net savings attributable to the SBD program. We also discuss our rationale for using this approach.

## Background

In the 1994, 1996 and 1998 NRNC program evaluations, econometric techniques were used to model the efficiency choice of the sample sites in order to estimate the direct net impacts and spillover effects for demand and energy savings. Basically, the approach was to regress the observed energy efficiency of each site against decision-maker information regarding the degree of involvement and influence of the program. To the extent that a correlation was found between energy efficiency and involvement influence among either participants or non-participants, the program was given credit for either net savings or spillover.

This approach depended on self-reported decision-maker information as well as large samples to ferret out a statistically significant association. As in most exercises in econometric modeling, the results were somewhat sensitive to the specification of the econometric model (choice of variables) as well as the weight given to each observation (influential observations). Moreover, the results were not traceable to specific buildings, measures or respondents. Therefore, they were difficult to defend.

The present study has a significant advantage over the prior impact evaluations in that the data collection took place much closer to the time that the actual decisions were made about each project. In the prior studies, we were often talking to decision-makers about projects that were completed several years prior to the survey. In this study, we were discussing projects that have just been completed in the prior year. Moreover, the self-report methodology allows us to provide an estimate of the net savings.

## Net Savings Methodology

We used a methodology based on self-reported decision-maker survey responses. The self-report methodology is used to calculate the estimates of free-ridership.

In this study we prepared a decision-maker survey that asked measure specific questions of program participants. The survey questions elicited information describing why the efficiency choices were made and the various influences on these decisions.

The purpose of the measure/end-use questions was to reconstruct what might have happened absent program influences. Using a scoring methodology developed early in the study, the surveys were scored and then given to the surveyor responsible for the project DOE-2 modeling. Using a "net savings report" furnished by the analyst, the surveyor adjusted the DOE-2 model to reflect program influences. The models were then re-simulated and compared to the as-built and baseline gross parametric models to develop end-use and measure level estimates of participant free-ridership.

We believe this technique produces reasonable estimates of free-ridership. Decision-makers often take credit for decisions made, even though in truth they may not have been responsible for the decision they now take credit for. Since the program participant may be more likely to take credit for a good decision than give credit to the program, we believe we are likely estimating net savings conservatively.

Decision-maker surveys were used to determine the measure-specific level of free-ridership occurring as a result of SBD. Free-ridership was quantified after the participant measures received a score for free-ridership. The scores were set using the methodology described in the appendix of this report. These scores were then applied by adjusting the corresponding measures in the "as surveyed" models to reflect free-ridership at the measure (end use) level. Results were calculated at the measure (end use) level in order to inform the SBD program staff of measures that were experiencing a high level of free-ridership.

Some definitions may be helpful.

| | |
|---|---|
| *Level of efficiency* | The reduction in energy or demand of the as-built site as a percentage of the Title-24 baseline, determined from the onsite audit and DOE-2 simulation. |
| *Program participants* | Sites that received a program incentives. |
| *Direct net impact* | The savings of the program participants relative to the level of efficiency expected in the absence of the program. |
| *Total net savings* | Equal to the direct net savings. |

## *Free-ridership Analysis Methodology*

The self-reported Net-To-Gross (NTG) analysis estimated the portion of the savings that can be directly credited to the program. To accomplish this, it was necessary to understand the free-ridership rate associated with each participant. This NTG analysis estimated free-ridership and adjusted the site's gross savings using responses to a decision-maker survey. This process is described below.

Free-ridership is calculated as the difference between the baseline and what would have been installed absent the program, divided by the difference between baseline and what actually was installed. For example, assume a project used a lighting baseline of 2.0 watts/sqft, and the participant received incentives for and installed lighting equipment resulting in 1.3 watts/sqft. If the participant would have installed lighting at 2.0 watts/sqft in the absence of the program, then the baseline is accurate and free-ridership would be zero. If lighting equipment equaling 1.3 watts/sqft had been installed in the absence of the program, then the free-ridership would be 100 percent. In reality, however, such a project may have had 1.8 watts/sqft equipment installed without the program; this would result in a free-ridership rate of 28.5%.[16]

Quantifying free-ridership in this manner underscores the integral relationship between the measure baseline determination and what actually would have happened absent the program. Such a "partial free-ridership" is appropriate since measure savings vary directly and continuously with the efficiency level chosen for the equipment installed. We have found that this method is more robust than a dichotomous treatment of conservation and load management free-riders, i.e., the participant either would or would not undertake a given conservation action in its entirety absent the program. While a dichotomous treatment is appropriate for some measures and some conservation programs, the researchers believe that in any performance-based program such as Savings By Design, probing the technical range of specifications and efficiencies provides a far more accurate picture of program-induced savings.

[16] $\frac{2.0\ \text{W/SF} - 1.8\ \text{W/SF}}{2.0\ \text{W/SF} - 1.3\ \text{W/SF}} = 0.285$

In this study, participants generally were willing and able to provide a sufficient level of detail for the analysis. This method of analysis relies on the ability of the survey respondent to recall information about the incented measures. However, it may be difficult for the survey respondents to respond accurately to a hypothetical question about what their actions would have been in the absence of the incentive and program support. In other words, some of the respondents may have had trouble 'backing out' knowledge about measures that they gained through the program. Therefore, our estimates of free ridership may be biased upward.

Senior level researchers conducted telephone and in-person interviews with the decision-makers directly involved with the project. The researchers used a series of questions designed to determine the important criteria to the owner in making the investment decision to install increasingly higher levels of energy efficiency. These questions are termed the financial aspect of free-ridership.

The specific energy conservation measure (ECM) or technology provided the analysis framework for the estimate of free-ridership. ECMs may be unique to each project. Some common ECMs are defined as follows:

- Lighting Controls (Occupancy Sensors, and Daylighting Controls),
- Lighting Systems w/reduced power density (LPD),
- High efficiency package units or heat pumps, and
- Premium Efficiency Motors.

Gross savings were determined by examining the difference between the actual efficiency level and the "baseline" efficiency level. Therefore, the net savings can be developed by examining the difference between a "modified" efficiency run and the "baseline" efficiency run. This modified efficiency was created by applying adjustments to the "as surveyed" models to reflect free-ridership at the measure level. Customer responses to the decision-maker interview were used according to the free-rider assessment methodology to create analogous modified or "free-rider" models.

The detailed methodology used to conduct the free-ridership assessment is presented in the appendix of this report.

# Engineering Models

## Overall Modeling Approach

The data requirements of the evaluation include kW, kWh and Therm savings for program and non-program measures during specific costing periods, including end-use interactions. Based on the California protocols and the prior NRNC evaluations, the gross impact analysis is conducted using the DOE-2.2 building energy simulation program. The DOE-2 program is well suited to analyzing the impacts of most measures included in the SBD new construction program. DOE-2 is a very flexible modeling tool, allowing the calculation of energy savings and demand reduction for lighting, lighting controls, shell measures, HVAC efficiency improvements and many HVAC control measures, among others. DOE-2.2 version 44E3 was used to take advantage of its abilities to model commercial refrigeration.

The keys to efficiently developing accurate and defensible DOE-2 models are:

1. Collection of appropriate building information during the on-site survey. This relies on competent, well-trained surveyors focused on collecting key building data. The team places the responsibility for creating and controlling for quality of the DOE-2 models in the hands of the surveyors responsible for data collection, i.e., the person most familiar with each site.
2. Quality control over the on-site data collection and data entry, including range, internal consistency, and reasonableness checks. These are incorporated into the data-entry software provided to the surveyors.
3. Computerized tools to calculate model input parameters from the on-site survey databases and automatically generate as-built and Title-24 DOE-2 input files.
4. A second level of model review and quality control by an experienced DOE-2 engineer. Senior engineering staff review and check the models after surveyor has constructed and checked the models for quality and validity.
5. For a large fraction of the simulated sites, focused short-term monitoring was conducted for the purpose of calibrating the engineering model. In addition concurrent weather and utility billing data was collected to improve the model match with real world site conditions in the model calibration process.
6. Automated data validation of model outputs and energy savings projections.
7. Computerized tools to automatically perform the required parametric runs and store the results in an electronic database.

The models were responsive to both the measures installed under the program and the building attributes covered under Title-24. High-quality DOE-2 models were generated from the on-site survey databases by providing input files with the following attributes:

## Loads

***Space definition and model zoning.*** The building was defined in terms of a series of spaces that represent the principal uses of the building. For example, a number of occupancy types, including office, laboratory and cafeteria may be found within a single building. Each space may be subject to a different baseline lighting power density allowance under Title-24. Within each space, building shell and internal load characteristics were calculated from the on-site survey data. For example, lighting power density was calculated from a fixture count, a lookup table of fixture wattage, and the space floor area. Lighting schedules were developed from the survey data and associated with the appropriate space in the building. Similarly, equipment power density was calculated from the equipment counts and connected loads in the on-site surveys. A diversity factor consistent with standard engineering practice was introduced to account for the discrepancy in nameplate versus actual running load inherent in certain types of equipment. An equipment operating schedule was developed from the survey data and associated with the appropriate space in the building.

Another important element in the generation of the input files was the accurate representation of the diversity of heating and cooling loads within the building. The subdivision of spaces also took into account the following:

- ***Unusual internal heat gain conditions***. Spaces with unusual internal heat gain conditions, such as computer rooms, kitchens, and laboratories were defined as separate spaces.
- ***HVAC system type and zoning***. HVAC systems inventoried during the on-site survey were associated with the applicable space. When the HVAC systems serving a particular space were different, the spaces were sub-divided. Reasonable HVAC system zoning practices were followed by the surveyors.

***Occupancy, lighting, and equipment schedules***. Each day of the week was assigned to one of three day types, as reported by the surveyor, full operation, light operation and closed. Hourly values for each day of the week were extracted from the on-site database according to the appropriate day type. These values were modified on a monthly basis, according to the monthly building occupancy history. Monitored data was especially valuable in refining these variables.

***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 contained the conductance and heat capacity properties of the exterior surfaces of 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 calculations 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.

***Solar and shading schedules***. The use of blinds by the occupants, as reported 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.

***Lighting kW.*** Installed lighting power was calculated from the lighting fixture inventory reported on the survey. A standard fixture wattage was assigned to all fixture types 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 Loads 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.

***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. Monitored data was used to refine these values to reflect actual field conditions.

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 surveyors entered the input rating of the equipment. 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.

***Zoned by exposure.*** 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 day type, as reported by the surveyor. The fan system on and off times from the on-site survey were assigned to a schedule according to day type. 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. Monitored data was used when appropriate to refine these schedules.

***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 day type. The thermostat set points 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 day length, 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)
- Central constant volume system (RHFS)
- Central VAV system (VAVS)
- Central VAV with fan-powered terminal boxes (PIU)
- Four-pipe fan coil (FPFC)

***Packaged HVAC system efficiency.*** Manufacturers' data were gathered for the equipment surveyed based on the make and model number observed by the surveyor. 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 2001 Alternate Compliance Method (ACM) manual.

***Pumps and fans.*** Input power for pumps, fans and other motor-driven equipment was calculated from motor nameplate horsepower 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 horsepower. 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 1998 ACM manual.

***Service hot water.*** Service hot water consumption was calculated based on average daily values from the 2001 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.

***Ventilation Air.*** Commercial HVAC systems are designed to introduce fresh air into the building to maintain a healthy indoor environment. The space type and its associated floor area were used to calculate outdoor air quantities according to Title-24 rules. Outdoor air fractions were calculated for each system from the total system airflow rate and the space outdoor air requirements.

***Commercial Refrigeration.*** The algorithms used in the DOE-2.2 version 44E3 program were used to evaluate the performance of commercial refrigeration systems found in grocery stores, commercial kitchens, schools, and so on. Refrigerated cases, compressor plant, condensers, and control system characteristics were surveyed. The automated modeling software provided DOE-2 models of both the building and the refrigeration systems, providing an accurate representation of the refrigeration system performance, and the interactions between the refrigeration system and the building HVAC system.

## 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.

## Model Review and Quality Checks

After the DOE-2 model was generated, the model was run using the CEC climate thermal zone (CTZ) long term average weather data corresponding to the climate zone where the project was located. The model either was run successfully generating a results page, or received errors and/or warnings. When warnings and/or errors were encountered, modifications to the data entry database were performed and another model for the site was created and run. This process was repeated until the model runs successfully and a results page is generated.

Sites with monitored data were calibrated using concurrent actual weather files. The calibrated models were then re-run using the CEC TMY weather files.

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 models were run successfully, the surveyor/modeler and senior engineering staff reviewed the results. A building characteristics and model results summary report was created for each site. The overall quality assurance process is outlined as follows:

A list of key physical attributes of the buildings were summarized and checked for reasonableness:

- Window to wall ratio
- Opaque wall and roof conductance
- Glazing conductance
- Glazing shading coefficient
- Lighting power density
- Equipment power density
- Floor area per ton of installed AC
- Cooling system efficiency
- Sizing ratio

The as-built characteristics were compared to Title-24 and/or common practice criteria. The energy performance of the building was also checked. Energy consumption statistics, such as the whole building EUI (kWh/sqft-yr.), and end-use shares were examined for reasonableness. The baseline model was run, and savings estimates for participants were compared to program expectations. Sites with large variances were further examined to investigate potential problems in the on-site data or modeling approach. For each site, the full set of end-use parametrics were run for each building as a component of the QC process. The measure and whole building savings by end-use were compared to program tracking system information and checked for reasonableness.

An example of some of the QC criteria that were utilized is shown below in Table 69. Data falling outside of the QC range were validated during the QC process.

| Building Parameter | Range | Definition |
|---|---|---|
| Cooling Ratio | 95 - 200% | capacity from annual run / capacity from sizing run |
| Cooling EER | 8 - 14 | capacity weighted cooling efficiency |
| Wall U-Value | 0.5 - 0.033 | area weighted average, includes air film |
| Roof U-Value | 0.5 - 0.033 | area weighted average, includes air film |
| Win U-Value | 0.3 - 0.88 | area weighted average, includes air film |
| Win-Shading Coefficient | 0.35 - 0.88 | area weighted average |
| Window to Wall Ratio | 0 - 70% | Percentage of gross wall area associated w/windows, expressed as a true percentage 0 –100 |
| Skylight U-Value | 0.3 - 0.9 | area weighted average of glazing contained in roof |
| Skylight-Shading Coefficient | 0.35 - 0.88 | area weighted SC for all horizontal glazing |
| Skylight Area To Roof Area Ratio | 0 - 10% | Percentage of gross roof area associated with sky light, expressed as a true percentage 0 –100 |
| Lighting Occupancy Controlled | 0 - 50% | Percentage of lighting watts controlled by occupancy sensors, expressed as a true percentage 0 –100 |
| Lighting Daylighting Controlled | 0 - 50% | Percentage of lighting watts controlled by daylighting sensors, expressed as a true percentage 0 –100 |
| Measures only savings relative to program expectations | 50% - 150% | measures-only savings / program expectations |
| Total Savings relative to Baseline (Gross) | 0% - 50% | Savings expressed as a percentage of baseline energy consumption |

**Table 69: Model Quality Control Criteria**

Building type specific performance data from the California NRNC Baseline study were used to develop additional QC criteria. Any site below the 25th percentile or greater than the 75th percentile for whole building EUI, end-use EUI, lighting power density, or equipment power density was flagged for closer study. The building type specific QC criteria are listed in Table 70.

| Building Type | Whole Building EUI (kWh/SF) | | Cooling EUI (kWh/SF) | | Fan EUI (kWh/SF) | | Lighting EUI (kWh/SF) | | Refrigeration EUI (kWh/SF) | | Other EUI (kWh/SF) | | Lighting Power Density (W/SF) | | Equip Power Density (W/SF) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25th pct | 75th pct | 25th pct | 75th pct | 25th pct | 75th pct | 25th pct | 75th pct | 25th pct | 75th pct | 25th pct | 75th pct | 25th pct | 75th pct | 25th pct | 75th pct |
| C&I Storage | 1.50 | 8.68 | 0.04 | 0.51 | 0.07 | 1.29 | 1.07 | 3.92 | 0.00 | 0.00 | 0.27 | 2.33 | 0.50 | 0.93 | 0.10 | 0.56 |
| Grocery Store | 40.30 | 53.62 | 0.38 | 1.19 | 1.77 | 3.61 | 7.38 | 11.77 | 22.88 | 34.65 | 2.60 | 7.12 | 1.25 | 1.70 | 0.04 | 0.19 |
| General C&I Work | 7.88 | 28.88 | 0.07 | 2.56 | 0.13 | 2.21 | 2.55 | 5.49 | 0.00 | 0.00 | 2.29 | 14.55 | 0.70 | 1.37 | 0.08 | 0.85 |
| Medical/Clinical | 13.26 | 28.65 | 2.13 | 5.82 | 1.71 | 9.18 | 2.97 | 6.59 | 0.00 | 0.00 | 1.74 | 7.88 | 0.94 | 1.45 | 0.63 | 1.79 |
| Office | 9.27 | 17.92 | 1.38 | 3.48 | 1.07 | 3.43 | 2.91 | 4.57 | 0.00 | 0.00 | 1.58 | 5.98 | 0.97 | 1.38 | 0.98 | 2.45 |
| Other | 6.55 | 29.87 | 0.00 | 4.33 | 0.50 | 4.32 | 2.37 | 5.34 | 0.00 | 0.00 | 1.74 | 18.00 | 0.85 | 1.44 | 0.06 | 1.09 |
| Religious Worship, Auditorium, Convention | 5.01 | 14.35 | 0.53 | 3.84 | 0.57 | 3.85 | 1.56 | 3.83 | 0.00 | 0.00 | 0.98 | 3.12 | 1.00 | 1.49 | 0.00 | 0.28 |
| Restaurant | 36.25 | 73.94 | 3.07 | 9.10 | 5.22 | 10.07 | 5.54 | 9.74 | 0.00 | 3.98 | 14.29 | 44.14 | 1.24 | 2.01 | 0.08 | 0.59 |
| Retail and Wholesale Store | 14.30 | 26.37 | 1.45 | 3.67 | 1.89 | 4.47 | 5.92 | 10.50 | 0.00 | 0.00 | 1.31 | 4.78 | 1.35 | 1.96 | 0.06 | 0.42 |
| School | 6.33 | 10.75 | 0.58 | 1.96 | 0.95 | 2.37 | 2.34 | 3.73 | 0.00 | 0.00 | 0.73 | 2.84 | 1.07 | 1.56 | 0.23 | 1.01 |
| Theater | 12.30 | 19.29 | 2.62 | 5.39 | 2.03 | 5.39 | 2.49 | 4.53 | 0.00 | 0.00 | 1.92 | 5.36 | 0.79 | 1.34 | 0.04 | 0.14 |
| Fire/Police/Jails | 9.32 | 18.62 | 0.98 | 2.44 | 1.40 | 3.28 | 3.27 | 5.00 | 0.00 | 0.00 | 2.28 | 5.46 | 0.69 | 1.00 | 0.44 | 1.20 |
| Community Center | 7.26 | 19.94 | 1.35 | 2.85 | 1.27 | 4.18 | 2.55 | 5.48 | 0.00 | 0.00 | 1.28 | 6.02 | 0.95 | 1.28 | 0.18 | 1.19 |
| Gymnasium | 7.80 | 13.96 | 0.03 | 2.28 | 0.76 | 5.98 | 2.76 | 4.07 | 0.00 | 0.00 | 1.48 | 2.67 | 1.04 | 1.54 | 0.03 | 0.28 |
| Libraries | 10.96 | 13.40 | 1.35 | 2.72 | 1.34 | 3.05 | 3.74 | 4.92 | 0.00 | 0.00 | 1.48 | 2.80 | 1.12 | 1.35 | 0.42 | 1.02 |

**Table 70: Survey It^tm Quality Control EUI Reference Table**

## Parametric Runs

Once the models were quality checked, an automated process was used to create a series of parametric simulation runs. These runs were used to simulate gross savings for participants on a whole building and measure-class basis by subtracting the as-built energy consumption and demand from the baseline energy consumption and demand. The parametric runs used in this study are listed below:

### *As-Built Parametric Run*

Once the models were completed and QC checked, the as-built parametric run was done. The energy performance of the as-built building was simulated using long-term average weather data from the National Weather Service.

### *Baseline Parametric Run*

Key building performance parameters were reset to a baseline condition to calculate gross energy savings for participants. The 2001 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 applies to most of the building types covered in the programs covered under this project, with the exception of:

- Hospitals
- Prisons/Correctional Institutions
- Industrial projects
- Unconditioned space (including warehouses)

Incentives are also offered by the program 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 for participants.

#### *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 removed from the baseline building. Glass conductance values as a function of climate zone were applied. For skylights, shading coefficients and overall conductance were 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 or 75,000 Btu/hr of cooling capacity (except for hospitals) were simulated with economizers in the baseline run. 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 each baseline and parametric run, 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.

*Lighting*

The Title-24 area category method was used to set the baseline lighting power for each space as a function of the observed occupancy, except in spaces using the Tailored lighting approach, where the allowed lighting power from the Title-24 documents was used. All lighting controls were turned off for the baseline simulation.

*Grocery Store Refrigeration Systems*

- Since there are no energy standards for grocery store refrigeration systems, the Savings By Design program baseline equipment specifications served as the baseline or reference point for the gross impact calculations.

### 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 / daylighting, and refrigeration measure groups. The baseline model was returned to the as-built design in a series of steps outlined as follows:

1. *Shell, 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 Power Density, measures only.* Run 2 above, plus baseline lighting power densities for spaces in the building that received incentives were returned to their as-built condition.

4. *All Lighting Power Density.* Run 2 above, plus all baseline lighting power densities were returned to their as-built condition.
5. *Daylighting Controls, measures only.* Run 4 above, plus daylighting controls that received incentives were returned to their as-built condition.
6. *All Daylighting Controls.* Run 4 above, plus all daylighting controls were returned to their as-built condition.
7. *Other Lighting Controls, measures only.* Run 6 above, plus all other lighting controls that received incentives were returned to their as-built condition.
8. *All Other Lighting Controls.* Run 6 above, plus all other lighting controls were returned to their as-built condition.
9. *Motors and Air Distribution, measures only.* Run 8 above, plus baseline motor efficiency, fan power indices (W/CFM), and motor controls for incented measures only were returned to their as-built condition.
10. *All Motors and Air Distribution.* Run 8 above, plus all baseline motor efficiency fan power indices (W/CFM), and motor controls were returned to their as-built condition.
11. *HVAC, measures only.* Run 10 above, plus HVAC parameters for incented measures only were returned to their as-built condition.
12. *All HVAC.* Run 10 above, plus all HVAC parameters were returned to their as-built condition.
13. *Refrigeration, measures only.* Run 12 above, plus refrigeration parameters for incented measures in buildings eligible for the grocery store refrigeration program only were returned to their as-built condition.
14. *All Refrigeration.* Run 12 above, plus all refrigeration parameters in buildings eligible for the grocery store refrigeration programs were returned to their as-built condition. Note: refrigeration parameters in buildings not eligible for the grocery store refrigeration programs remained at the as-built level for all parametric runs.
15. *DHW, measures only.* Run 14 above, plus hot water parameters for incented measures only were returned to their as-built condition.
16. *All DHW.* Run 14 above, plus all hot water parameters were returned to their as-built condition. *This run is equivalent to the full as-built run.*

When applicable, savings from projects participating under the “Other Systems” option were added to the applicable parametric categories defined above. For example, savings from refrigerated warehouse improvements were added to the refrigeration parametric.

# Data Collection

There were three on-going components to the data collection in this study. They were:

- Structured telephone surveys with program participants decision-makers
- On-site surveys with SBD program participant's operating new non-residential buildings and industrial projects completed in 2004 and 2005. Data collected on-site is used to generate site specific DOE-2 models.
- The industrial on-site surveys are comprised of verification of incented equipment and at some sites, when feasible, installation of data loggers to obtain run-time and energy consumption information to inform the engineering calculations.

These two components worked with the secondary sources of information – the program files, and Title-24 documentation to develop a complete picture of the Statewide SBD non-residential new construction program. The on-site surveys provided inputs for DOE-2 engineering models used to estimate the energy and demand use of each building. The structured qualitative/quantitative surveys with decision-makers provided data for the net savings and spillover analysis. Additionally, these surveys collected research information from the building owners to address the following general areas:

- Building classification
- Design and construction practices
- Energy attitudes
- Energy performance
- SBD program participation

The key feature in the process is that the building models are constructed and reviewed by the surveyor within days of the on-site visit. This course of action noticeably improves the team's ability to produce models that accurately reflect the building as it is actually operated. It also allows for timely feedback from the modeling to the site data collection effort, allowing for quick resolution of any data collection problems. The overall process is:

1. The site is recruited and the recruiter asks basic decision-maker questions of the building owner and designers as appropriate.
2. The surveyor reviews program project file prior to the site visit.
3. The surveyor responsible for the model collects the on-site data.

4. Decision-maker information available from the building owner or facility manager is collected during the on-site survey or later on the phone. This process minimizes customer “burn-out” due to multiple contacts.
5. The on-site surveyor enters the field data directly into the building database. All data problems and data inconsistencies are corrected within a few days of the on-site visit.
6. As soon as the data are keyed into the program, the automated model building software automatically creates the DOE-2 model and calculates the gross savings. The models are comprehensively checked for reasonableness, first by the modeler, and last by senior engineering staff. There is constant communication between the surveyor and senior engineering staff. Sites with large variances in the savings estimates relative to program expectations are investigated and resolved in a timely manner. Sites that fall out of the standard quality control range are re-evaluated and rechecked for reasonableness.
7. An audit savings report is produced for each site, summarizing savings and noting any discrepancies between the audit model and program estimates. The surveyor and senior engineering staff review these reports within a few days of the audit, resulting in rapid feedback and data validation.
8. One final simulation of the modified as-built is model is required to produce net savings estimates. These simulations are based on the decision-maker data, and are completed at the end-use level.

## Recruiting & Decision-Maker Surveys

Experienced energy program recruiters contacted building owners and attempted to secure their participation in the study. The recruiters were briefed on the required data collection activities and on the audit process in order to facilitate “selling” the prospective owner/manager on allowing the audit. Before any recruiting began, RLW provided each participating utility the list of customers they planned to contact in order to identify potentially sensitive sites.

The utilities received a list of the primary and backup sample sites from RLW before data collection. The list allowed the utility account representatives the chance to alert RLW of any potentially sensitive customers.

Our trained, experienced staff asked the owner several questions that accomplished the following objectives:

- Validated the site for inclusion in the study,
- Confirmed the location,
- Collected SBD process information to inform program managers, and
- Collected decision-maker survey data for the net savings and spillover analysis.

Once a site was recruited, the recruiter administered the decision-maker survey. If a respondent could not answer specific questions in the survey, the recruiter obtained contact information for other individuals who were able to provide the requested information. This frequently resulted in contacting the mechanical designer in addition to the owner. This methodology was proven to be effective in the prior NRNC studies conducted by RLW Analytics in collecting complete data from the correct decision-makers.

The recruiters used owner contact information provided in the tracking database and the project file to identify a decision-maker. These contacts were used as the initial contact. The recruiters followed up with additional contacts identified by the initial contact, as necessary. As in past studies, we found that it was necessary to interview more than one respondent for some of the projects. To expedite the on-site survey process, the recruiter asked the customers to have building plans available for the surveyors when they arrived at the site at the scheduled date and time.

### *Building characteristics*

Building characteristics refer to the size, type (e.g. grocery, restaurant, etc.), location, stand alone vs. multi-tenant, own/build vs. speculative, and other similar characteristics. Building characteristics does not mean equipment stock and schedule. This data is captured in the savings estimate and therefore does not have a role as an econometric predictor.

### *Interaction with utility*

In the 1996 study, the 1994 binary variables were replaced with scaled variables to more accurately capture interaction with utility staff. This methodology was retained for the 1998 evaluations. However, since this study required an end use or measure specific estimate of net savings and spillover, the survey instrument required a higher level of detail on utility interaction responses.

To support this requirement, questions were asked to determine the utilities' past and present role in the customer's energy related design decisions and overall awareness of the SBD program. We also explicitly asked about previous participation in utility programs in an attempt to include transformative affects from those interactions. The decision-maker was questioned on design plans prior to utility interaction and whether plans changed after utility interaction. This level of detail was required at the end-use level when it appeared that free-ridership and spillover had occurred.

### *Decision-maker (DM) Attitudes/Behaviors*

Participant decision-makers were surveyed to gather an understanding of what influences or market forces contribute to and guide the building design process. Decision-makers were asked to answer questions on their attitudes regarding the SBD program, its components and its delivery. Respondents were asked about design practices, in relation to energy efficiency, they commonly use when building new buildings. Measure specific and end-use specific questions aimed to identify common practices and behaviors regarding equipment choices and levels of efficiency installed were also included.

### *Energy Efficient Design Practices*

We used the decision-maker interviews to obtain data to assist the IOUs in understanding the SBD impacts on energy efficient design requirements submitted with new construction RFPs and RFQs. A set of questions were included that aimed to assess the level of importance energy efficient design during project planning, and design stages.

### *Scoring the Surveys*

The decision-maker (DM) surveys were scored at the measure and end-use level based upon completed survey data. A senior level analyst was responsible for reviewing each survey response and making a final determination for each score using a predetermined scoring method. These scores were then applied to the parametric run simulation results to determine total free-ridership and spillover in the SBD program area. The detailed scoring methodology for free-ridership can be found in the "Net Savings" section of this report.

### *Recruiting and Decision-maker Survey Data Entry*

An MS Access database was designed to house all data collected over the phone during the recruiting and DM survey process. Recruiting dispositions and DM survey data were entered daily into a set of 'forms' designed specifically for this study. Random data entry checks served as a quality control mechanism for maintaining consistent error free data entry. Moreover, where applicable, data entry forms were designed such that only valid parameters could be entered into the database vastly reducing data entry error.

## On-Site Surveys

Experienced surveyors/DOE-2 modelers from RLW, AEC, and EBA conducted the on-site surveys. The on-site visits required anywhere from three hours to a full day, by one or more surveyors, depending on the size and complexity of the building.

The on-site surveys began with a brief interview with the site contact to gather basic information about the building – operating schedules, number of occupants, control strategies, etc. The surveyor then walked through the building to examine the energy-using systems (e.g. lighting, HVAC, energy management systems, etc.) System types and sizes were cataloged, along with information about the condition of the equipment. The presence of incented measures were verified. If plans were available, the surveyor used the plans to gather information on building shell and inaccessible equipment.

The surveyors were instructed not to do anything to disrupt the normal operations of the building or any of the systems. The surveyors did not open equipment to collect nameplate data on inaccessible parts.

### *Training of On-Site Survey Staff*

The process of gathering accurate, timely field data was the foundation upon which the project's analysis ultimately rested. Training surveyors to collect the proper field information was the first step in the building this foundation. Lead surveyors/engineers from RLW Analytics and AEC conducted the training for the audit phase of the project. The training built upon the lessons learned during the evaluation of the 1994, 96, and 98 commercial new construction programs, the 1998 CBEE NRNC baseline study, the 1999-2001 and 2002 SBD studies, and upon the considerable building survey experience of the surveyors.

This training team conducted a one-day training session that covered relevant theory and new construction practice as well as the mechanics of completing the on-site forms. Items that received special emphasis based on the results of past evaluations were:

- Details of reading SBD program project documentation,
- Identification of project and non project areas within a single building,

- Importance of communication between the surveyors and senior technical staff, and
- Keys to gathering valid decision-maker data.
- Identification of lighting and HVAC technologies

Special attention was paid to the unique requirements of auditing commercial refrigeration systems, such as those found in grocery stores.

A second training session was held for the surveyors and technicians involved with the short-term metering component. The training was held at an at a large SBD participant building where facility staff had granted permission for the training

The second training focused on development of a monitoring plan, instruction on instantaneous measurement instrumentation, special instruction for the data loggers that were used in the study, as well as safety and site etiquette issues.

### *Engineering File Reviews*

In advance of each audit, the on-site surveyor conducted a complete file review on the building/facility to be visited. If the customer was a participant, the surveyor reviewed the program file to determine the following:

- Installed measures,
- Location of measures, and
- Any special circumstances.

### *Instruments*

The two data collection instruments used for the on-site data collection portion of this study were,

- On-site Survey Form,
- Refrigerated Warehouse On-site Survey Form.

The on-site survey form is similar to the one used in the 1998 PG&E NRNC evaluation, the 1998 CBEE baseline study, and the 1999-2001, 2002 and 2003 SBD studies. Some minor changes were made to reflect lessons learned in the 1994 and 1996 evaluations. An electronic version of the form was used to facilitate data entry and QA. This is a Microsoft Access database application that accepts data from the surveyor, performs basic QA on the data, and formats the data for input into the model generator.

The refrigerated warehouse survey form is the same as the one used in the 1999-2001, 2002 and 2003 SBD studies.

# Regulatory Summary

## Net Program Lifecycle Savings

The following 5 tables are what have been reported to the CPUC for net program lifecycle savings of the Savings By Design program. The first table lists the “statewide” savings, which is the aggregate of all four utilities; the subsequent four tables are the utility specific net program lifecycle savings. The lifecycle savings were estimated by projecting the net savings for the program for the length of the effective useful life (EUL) estimates as filed in the program cost-effectiveness workbooks. . SDG&E and SoCalGas used a EUL 15 years for all measures. PG&E and SCE input EULs varying from 15 to 20 years for different measure categories. To create those net savings tables, program impacts were parsed into the measure categories and projected into the future using the corresponding EUL. Since EUL values for measure categories varied across utilities, identical measures are credited differently in year 16 through 20. Although RLW recognizes that this is not ideal, EUL analyses were not in the scope of this evaluation, therefore utility supplied EULs were not subject to revision, even for the purpose of consistency.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Program IDs*:** | 1161-04 1183-04 1506-04 1127-04 1323-04 1346-04 1249-04 | | | | | | | |
| **Program Name:** | CA ES New Homes | | | | | | | |
| | **Year** | **Calendar Year** | **Ex-ante Gross Program-Projected Program MWh Savings (1)** | **Ex-Post Net Evaluation Confirmed Program MWh Savings (2)** | **Ex-Ante Gross Program-Projected Peak Program MW Savings (1**)** | **Ex-Post Evaluation Projected Peak MW Savings (2**)** | **Ex-Ante Gross Program-Projected Program Therm Savings (1)** | **Ex-Post Net Evaluation Confirmed Program Therm Savings (2)** |
| | 1 | 2004 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 2 | 2005 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 3 | 2006 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 4 | 2007 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 5 | 2008 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 6 | 2009 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 7 | 2010 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 8 | 2011 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 9 | 2012 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 10 | 2013 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 11 | 2014 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 12 | 2015 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 13 | 2016 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 14 | 2017 | 344,748 | 259,530 | 68.74 | 42.27 | 8,662,541 | 9,533,445 |
| | 15 | 2018 | 326,693 | 259,530 | 64.91 | 42.27 | 7,644,619 | 9,533,445 |
| | 16 | 2019 | 204,517 | 178,367 | 39.73 | 28.34 | 5,040,455 | 3,024,948 |
| | 17 | 2020 | 37,386 | 53,381 | 7.12 | 7.37 | 672,450 | 2,731,491 |
| | 18 | 2021 | 37,386 | 53,381 | 7.12 | 7.37 | 672,450 | 2,731,491 |
| | 19 | 2022 | 37,386 | 53,381 | 7.12 | 7.37 | 672,450 | 2,731,491 |
| | 20 | 2023 | 37,386 | 53,381 | 7.12 | 7.37 | 672,450 | 2,731,491 |
| | **TOTAL** | **2004-2023** | 5,469,833 | 4,231,455 | | | 135,977,998 | 154,221,099 |

**Table 71: Statewide 2004-2005 Net Program Lifecycle Savings**

**Program ID*:** 1506-04(proc) 1127-04

**Program Name:** Savings By Design

| Year | Calendar Year | Ex-ante Gross Program-Projected Program MWh Savings (1) | Ex-Post Net Evaluation Confirmed Program MWh Savings (2) | Ex-Ante Gross Program-Projected Peak Program MW Savings (1**) | Ex-Post Evaluation Projected Peak MW Savings (2**) | Ex-Ante Gross Program-Projected Program Therm Savings (1) | Ex-Post Net Evaluation Confirmed Program Therm Savings (2) |
|---|---|---|---|---|---|---|---|
| 1 | 2004 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 2 | 2005 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 3 | 2006 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 4 | 2007 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 5 | 2008 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 6 | 2009 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 7 | 2010 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 8 | 2011 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 9 | 2012 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 10 | 2013 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 11 | 2014 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 12 | 2015 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 13 | 2016 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 14 | 2017 | 108,856 | 74,989 | 23.11 | 13.84 | 6,137,245 | 3,038,243 |
| 15 | 2018 | 90,801 | 74,989 | 19.28 | 13.84 | 5,119,323 | 3,038,243 |
| 16 | 2019 | 84,811 | 75,171 | 18.00 | 13.22 | 4,781,623 | 3,040,725 |
| 17 | 2020 | 10,912 | 23,753 | 2.32 | 4.87 | 615,207 | 2,731,491 |
| 18 | 2021 | 10,912 | 23,753 | 2.32 | 4.87 | 615,207 | 2,731,491 |
| 19 | 2022 | 10,912 | 23,753 | 2.32 | 4.87 | 615,207 | 2,731,491 |
| 20 | 2023 | 10,912 | 23,753 | 2.32 | 4.87 | 615,207 | 2,731,491 |
| TOTAL | 2004-2023 | 1,732,334 | 1,271,269 | | | 97,667,996 | 56,808,843 |

## Table 72: PG&E 2004-2005 Net Program Lifecycle Savings.

**Program ID*:** 1183-04(procurement) and 1161-04

**Program Name:** Savings By Design

| Year | Calendar Year | Ex-ante Gross Program-Projected Program MWh Savings (1) | Ex-Post Net Evaluation Confirmed Program MWh Savings (2) | Ex-Ante Gross Program-Projected Peak Program MW Savings (1**) | Ex-Post Evaluation Projected Peak MW Savings (2**) | Ex-Ante Gross Program-Projected Program Therm Savings (1) | Ex-Post Net Evaluation Confirmed Program Therm Savings (2) |
|---|---|---|---|---|---|---|---|
| 1 | 2004 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 2 | 2005 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 3 | 2006 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 4 | 2007 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 5 | 2008 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 6 | 2009 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 7 | 2010 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 8 | 2011 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 9 | 2012 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 10 | 2013 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 11 | 2014 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 12 | 2015 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 13 | 2016 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 14 | 2017 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 15 | 2018 | 153,610 | 126,964 | 27.87 | 18.76 | 332,143 | 4,129,443 |
| 16 | 2019 | 119,705 | 103,196 | 22 | 15.12 | 258,832 | (15,778) |
| 17 | 2020 | 26,474 | 29,628 | 5 | 2.50 | 57,243 | - |
| 18 | 2021 | 26,474 | 29,628 | 5 | 2.50 | 57,243 | - |
| 19 | 2022 | 26,474 | 29,628 | 5 | 2.50 | 57,243 | - |
| 20 | 2023 | 26,474 | 29,628 | 5 | 2.50 | 57,243 | - |
| TOTAL | 2004-2023 | 2,503,278 | 2,096,540 | | | 5,412,706 | 61,925,861 |

## Table 73: SCE Net Program Lifecycle Savings

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Program ID*:** | 1323-04 (proc) 1346-04 | | | | | | | |
| **Program Name:** | Savings By Design | | | | | | | |
| | Year | Calendar Year | Ex-ante Gross Program-Projected Program MWh Savings (1) | Ex-Post Net Evaluation Confirmed Program MWh Savings (2) | Ex-Ante Gross Program-Projected Peak Program MW Savings (1**) | Ex-Post Evaluation Projected Peak MW Savings (2**) | Ex-Ante Gross Program-Projected Program Therm Savings (1) | Ex-Post Net Evaluation Confirmed Program Therm Savings (2) |
| | 1 | 2004 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 2 | 2005 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 3 | 2006 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 4 | 2007 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 5 | 2008 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 6 | 2009 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 7 | 2010 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 8 | 2011 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 9 | 2012 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 10 | 2013 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 11 | 2014 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 12 | 2015 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 13 | 2016 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 14 | 2017 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 15 | 2018 | 63,959 | 42,240 | 14.26 | 7.31 | 2,121,796 | 2,362,047 |
| | 16 | 2019 | | | | | | |
| | 17 | 2020 | | | | | | |
| | 18 | 2021 | | | | | | |
| | 19 | 2022 | | | | | | |
| | 20 | 2023 | | | | | | |
| | **TOTAL** | **2004-2023** | 959,385 | 633,597 | | | 31,826,940 | 35,430,705 |

**Table 74: SDG&E Net Program Lifecycle Savings**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Program ID*:** | 1249-04 | | | | | | | |
| **Program Name:** | Savings By Design | | | | | | | |
| | Year | Calendar Year | Ex-ante Gross Program-Projected Program MWh Savings (1) | Ex-Post Net Evaluation Confirmed Program MWh Savings (2) | Ex-Ante Gross Program-Projected Peak Program MW Savings (1**) | Ex-Post Evaluation Projected Peak MW Savings (2**) | Ex-Ante Gross Program-Projected Program Therm Savings (1) | Ex-Post Net Evaluation Confirmed Program Therm Savings (2) |
| | 1 | 2004 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 2 | 2005 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 3 | 2006 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 4 | 2007 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 5 | 2008 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 6 | 2009 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 7 | 2010 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 8 | 2011 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 9 | 2012 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 10 | 2013 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 11 | 2014 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 12 | 2015 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 13 | 2016 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 14 | 2017 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 15 | 2018 | 18,322 | 15,337 | 3.50 | 2.35 | 71,357 | 3,713 |
| | 16 | 2019 | | | | | | |
| | 17 | 2020 | | | | | | |
| | 18 | 2021 | | | | | | |
| | 19 | 2022 | | | | | | |
| | 20 | 2023 | | | | | | |
| | **TOTAL** | **2004-2023** | 274,836 | 230,048 | | | 1,070,355 | 55,690 |

**Table 75: SoCalGas Net Program Lifecycle Savings**

## Total Resource Cost Results

The Total Resource Cost (TRC) is a ratio of net benefits to the net costs, including both the participants' and the utility and benefits, of a demand-side management program. A TRC value greater than one means that the sum of benefits are greater than the sum of costs, and the program is considered "cost effective".

Ex ante TRCs were for each utility were calculated with the CPUC cost effectiveness calculator or program workbook. RLW used each utilities workbook and updated the savings values and the net to gross ratio for each measure category with those found in this study. Table 13 shows that all of the utilities have a total resource cost (TRC) value greater than one. SCE has the greatest TRC ratio at 3.29, but a large factor (0.7) was a result of 4,000,000 therms savings from HVAC measures which had an error bound as large as the estimated value, showing a very low relative precision. The TRC values listed below were calculated using the utility workbooks described earlier in this section. This means that there was variation in measure categories for EUL's and incremental measure costs across utilities.

The electric utilities had two workbooks filed for their SBD program, a portion of the program funded by public goods charges and a procurement funded portion. TRC ratios are the aggregate of benefits of both workbooks divided by aggregate costs of both workbooks. Note that SCE procurement portion program workbook did not have recorded activities and consequently no and the associated ex-ante TRC ratios only considered cost from that portion.

| Utility | Utility Projected TRC Ratio | Utility Ex-Ante TRC Ratio | Ex-Post TRC Ratio |
|---|---|---|---|
| PGE | * 2.10 | * 2.60 | 2.12 |
| SCE | * 2.56 | * 2.45 | 3.29 |
| SDGE | * 1.91 | * 3.37 | 2.34 |
| SoCalGas | 2.59 | 2.89 | 2.64 |
| Overall | 2.27 | 2.60 | 2.64 |

**Table 76: Total Resource Cost (TRC) by Utility[17]**

[17] *Combined TRC of utility's SBD public goods and procurement funded projects

# Program Observations and Recommendations

This chapter presents observations made about SBD through the course of conducting this project. Recommendations to improve SBD are also presented. Furthermore, some of the recommendations in this section are similar, if not the same as those reported in the 2003 SBD EM&V report. RLW has chosen to include previous recommendations either because they continued to arise in the 2004-2005 evaluation, or because the issue is important and on-going, and should be a consideration for future program planning.

## Judging Continuing Need for the Savings By Design Program

Judging continuing need for the Savings By Design program cannot easily be summed up given the lack of information regarding program cost effectiveness. Many of the metrics used to measure the cost effectiveness and the continuing need for the SBD program are not easily obtainable given the timing of the evaluation and the duration of NRNC cycles. In this section we discuss these issues and possible ways to modify and enhance future evaluations to answer cost effectiveness questions. In lieu of such information, this section also touches on other findings from this evaluation that do address continuing need for Savings By Design.

Due to the nature of the market (NRNC) served by the program it would be very difficult to calculate cost effectiveness of the Savings By Design program. This evaluation considers only projects that were paid incentives within the evaluation years (2004 and 2005), which means we are evaluating projects that initially signed onto the program several years ago or as late as 2005. Due to the long NRNC construction cycles that characterize this program, it becomes extremely difficult to account for the costs that would be associated with only the projects that were paid in 2004 and 2005.

The utilities and the CPUC should consider this when writing the RFP for future SBD evaluations, acknowledging the fact that it may be years after the program year before it would be possible to complete the cost effectiveness testing of the Savings By Design Program without significant revisions to the design of the evaluation.

Testing the true cost effectiveness of the program would require significant revision to the evaluation design. As reported in previous evaluations, there is a reasonable approach to overcoming the problem of testing cost effectiveness as part of the evaluation activities. The utilities could allocate the total program costs for a particular program year to each of the projects committed in that particular program year. This information would be tracked in the program tracking system, which would be provided to the evaluation consultant. The evaluation consultant would then have the ability to sum all program costs for the participants that are included in the evaluation (i.e., projects paid incentives in any given year), resulting in a quasi paid year SBD program budget. Therefore, a relatively easy program cost accounting by project would produce the basic cost information needed for testing cost effectiveness as part of the evaluation activities.

Other inputs that go into the cost effectiveness test (such as Gross IMC, NTG, EUL), would certainly introduce another level of complexity to the evaluation. Therefore, if cost effectiveness testing were to be undertaken in future evaluations these inputs would also require thorough review. For this particular program, a significant investment would likely be necessary if the evaluations were to undertake review and evaluation of all cost-effectiveness inputs, most notably Gross IMC.

Cost effectiveness aside, it is clear through these evaluation activities that the Savings By Design program is delivering energy efficiency and long-term energy savings to the non-residential new construction commercial sector market. For the time being, however, we must rely on indicators other than cost effectiveness to verify whether there is a continuing need for the program. Many findings from this evaluation substantiate a continuing need for the Savings By Design program. The great majority of the measures promoted by the program are long-life measures that should deliver energy savings for a long time to come. At the same time many of the program's measures are innovative and push the energy efficiency envelope, effectively preparing the NRNC market for future code changes. Net-to-gross ratios are in an acceptable range for most measures, and for the program as a whole. The dominant role of the incentives in motivating the implementation of measures is less certain. An emerging finding is that market actors participating in the program are reporting near equal satisfaction with other aspects of the SBD program that are designed to increase energy savings at the project level and lead to market transformation, such as the design analysis offerings.

Participating building designers and owners are gaining valuable building science expertise through the program's design assistance and design analysis components, which may lead to future generations of energy efficiency infrastructure even without a NRNC program. Incentives offered by the program go further to encourage whole building design practice over 'systems' projects, aptly putting emphasis on the whole building integrated systems design philosophy.

## Evaluation of Complex Building Models

The SBD sample frequently captured state-of-the-art buildings which had been designed based on complex building energy modeling. The resources which were invested in this modeling far exceed the level of investment available for the evaluation model. Study resources would be more effectively utilized by accepting the design team model rather than creating a competing energy model.

## Industrial Projects

Although the aggregate net-to-gross ratio of industrial projects has improved since 2002, freeridership is still prevalent in many industrial projects. Similar to previous years' evaluations, decision maker interviews uncovered industrial projects that would have been installed exactly the same absent program interaction including incentives. This was especially true of projects conceived "in-house" by the participants and were well developed before any interaction with Savings By Design representatives and consultants, rather than being a result of interaction with Savings By Design. In most cases we found these particular participants to be highly aware of the trade-offs between energy efficient and baseline equipment, including the cost differences and payback between the two.

## Project File Information

The self reported net savings methodology, more accurately net-of -freeridership, relies upon interviews with participant decision-makers. The evaluators realize this is a critical component and go to great lengths to find the most qualified survey respondent, typically the owner or the owner's representative that was present and involved when the measure implementation decisions were made. However, determining and locating the decision-maker is not always easy. Often, the project file gives "site contact" contact information of an individual or individuals which may or may not have been the decision-maker. The evaluator must determine whether this person is best one to answer the questions, often through administration of the decision-maker survey. Therefore, if a site contacts present themselves as decision-makers and answer the survey without hesitation, there answers to the survey will be used to produce the net savings results. Additionally, in many cases, decision-makers are no longer with the company by the time evaluators come to assess the project. Then, the evaluators are faced with either locating the decision-maker at their current place of employment (or in their retirement) or settling for the second best person to respond to the survey. Neither situation is desirable. Furthermore, chasing down a decision-maker that has moved on can be quite onerous, and at times, impossible.

However, if project decision makers are clearly identified in the project file and/or project database, the effort of identifying project decision-makers could be avoided. Additionally, the best respondent for the survey will be approached first and the evaluation team will not be "duped" by anyone presenting them self as more involved with the project than they actually were. Ideally, each project would have all of the owner-side decision-makers identified, and they would be ranked by their knowledge of the project. Furthermore, if a means of locating the decision-makers once they have moved on from their present positions were obtained, such as personal email and telephone numbers, evaluators would reduce their need to rely on the "best person left" to complete the all-important survey.

Likewise, a short summary of utility and/or Program influence on the project would be very helpful to evaluate Program freeridership. The summary could be very brief and document the point of the project cycle where interaction began, who was engaged and the basic nature of the influence, such as the following:

- First suggested measure(s) under consideration
- Provided testimonial support of measure success/effectiveness of measure(s) under consideration
- Incentives made measure(s) cost-effective
- Other influences

This documentation forces the some self-assessment on the part of the Program with regards to freeridership to the representative level. With a big focus on program savings goals; there exists an incentive to pull projects that have little or no in Program influence. In the documentation of Program influence, the representative will have to confront the issue head on, and not let the distraction of project processing activities allow avoidance of the issue.

The summary of Program influence could be a very important mnemonic device for projects where the decisions were make several years ago and memories have gone hazy. This summary could be referenced during the decision-maker survey to help remind the decision-maker of Program activities they may have forgotten in the interim period. With the long project cycles of non-residential new construction, any "bridge to the past" could assist the accuracy of the evaluation. The current decision-maker survey relies on warm-up questions to "bring the decision-maker's head back to the design table". The effect of bringing names, dates, locations, and conversations into the discussion should only help recall.