Final Report

2002 Building Efficiency Assessment Study

An Evaluation of the Savings By Design Program

Prepared for the following California Investor Owned Utilities:

Pacific Gas and Electric
San Diego Gas and Electric
Southern California Edison

July 2004

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Acknowledgements

The 2002 Building Efficiency Assessment Study was performed on behalf of Southern California Edison Company, under the direction of Douglas Mahone and Cathy Chappell of the Heschong Mahone Group. RLW would like to thank Marian Brown and Richard Pulliam of SCE for sponsoring the study and helping to make the study a success. RLW would also like to acknowledge the statewide Savings By Design program implementation and M&E staff for their insights and assistance in helping RLW conduct and complete the BEA study. Specifically, we would like to thank Jan Johnson and Gary Suzuki of SCE, Lisa Fabula and Mary Wold of SDG&E, and Grant Duhon and Mary Kay Gobris of PG&E. For further information on this report please contact Marian Brown at SCE.

Dr. Roger Wright of RLW Analytics directed the evaluation and Matt Brost was acting Project Manager. RLW would also like to thank our sub-contractors for their excellent contributions to the project. Pete Jacobs of Architectural Energy Corporation led the engineering simulation modeling efforts, and both Architectural Energy Corporation and Eskinder Berhanu and Associates staff assisted in the on-site data collection and end-use metering tasks.

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Executive Summary

This document is the final report for the Building Efficiency Assessment (BEA) study for the statewide Non-Residential New Construction (NRNC) program area for 2002. This report contains summary results for both program participants of Savings By Design (SBD) and program non-participants. 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). The 2002 Building Efficiency Assessment Study does not include Southern California Gas Company program participants.

The key objectives of the study are to:

- Develop impact estimates for the gross whole building energy and demand savings resulting from the Savings By Design program,
- Develop impact estimates of both incented and non-incented measure categories,
- Develop estimates of both free-ridership and spillover at the measure and end-use level,
- Develop net savings results, and
- Provide a process evaluation of the SBD program from the perspective of the program participants.

The inclusion of industrial projects and measures are new to the 2002 Building Efficiency Assessment. The SBD program has seen 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. A new measure category has been added to the study to accommodate reporting of industrial 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 2002 BEA Study is an evaluation of Savings By Design projects that were paid incentives in program year (PY) 2002. Only projects that were paid incentives within the evaluation year (2002) were considered, though the evaluated projects initially signed onto the program as early as 1999, or as late as 2002. DOE-2 engineering models and engineering calculations that are informed by detailed onsite surveys and end-use metered data are the basis of the energy and demand savings methodology. 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 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 of the Executive Summary describe the high-level findings identified by the evaluators in the course of the 2002 BEA Study. Results are presented at the statewide level (e.g. in aggregate for all utilities) because the sample sizes were not large enough to support a presentation of results at the utility level (e.g., individual results for PG&E, SCE, and SDG&E).

Gross Impact Findings

This section presents gross impact findings for the statewide Savings By Design program, including both commercial and industrial projects. The evaluation results show that the utilities tracking estimates are slightly exceeded by the gross energy and demand savings estimates developed from our evaluation methodology, resulting in a 105% and 108% gross realization rate respectively for energy and demand, as shown in Table 1. These findings are based on sample sizes that comprise 45% of the program's tracked energy savings and approximately 40% of the program's tracked demand savings.

	Program Tracking Savings	Sampled Savings	% Sampled Savings	Estimated Gross Savings	Gross Realization Rate	Measures Only Savings	Measures Only Realization Rate
Energy (MWh)	121,531	54,728	45%	127,216	105%	106,133	87%
Demand (MW)	26.6	10.1	38%	28.6	108%	23.1	87%

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

The gross savings methodology includes energy and demand savings resulting from participant spillover. Under the BEA gross impact evaluation methodology, the utilities are credited for participant non-incented end-use efficiencies that are more efficient than baseline. Conversely, the utilities are penalized for participant end-use efficiencies that are found to be less efficient than baseline. The final two columns of Table 1 presents the program impacts for energy and demand when participant spillover is removed, otherwise referred to as 'measure only savings'. The evaluation findings suggest that under the measures only methodology, 87% of both energy and demand tracking savings are being realized for all measures incented through the SBD program. These results imply that 13% of the gross savings are due to participant spillover. They also imply that the utilities are slightly overestimating the energy and demand savings attributable to incented measures.

Unlike the commercial component of the program that contributes to spillover, utilities are not credited for industrial project spillover. This is because industrial projects focus on specific industrial processes, many of which were retrofit projects. Extending the investigation to all processes within each participant facility would be of questionable value and would consume a considerable portion of the study budget. Energy and demand findings presented in Table 2 show the energy and demand impacts attributed to commercial projects and industrial projects separately. The table shows the estimated gross realization rate for industrial projects is 97% and 115% respectively for energy and demand. In contrast to the commercial measures only realization rate, industrial projects are closer to the mark in terms of meeting energy savings expectations (97%), and are exceeding tracking demand savings (115%). The results also show that approximately 24% and 26% of gross energy and demand savings for the commercial component are due to participant spillover, respectively.

		Program Tracking Savings	Estimated Gross Savings	Gross Realization Rate	Measures Only Savings	Measures Only Realization Rate
Commercial	**Energy (MWh)**	87,967	94,607	108%	73,524	84%
	Demand (MW)	22.6	24.1	107%	18.5	82%
Industrial	**Energy (MWh)**	33,564	32,610	97%	32,610	97%
	Demand (MW)	4.0	4.6	115%	4.6	115%

Table 2: Evaluated Gross Energy and Demand Impacts – Commercial and Industrial[1]

Net Impact Findings

Table 3 presents program net savings using a decision maker self-reported methodology. In short, RLW surveyed decision makers on their efficiency choices for incented measures and measures more efficient than baseline, for participants and non-participants respectively. Based on the survey responses the engineering simulation models were adjusted to reflect these efficiency choices absent Savings By Design. The engineering models were then re-simulated. The results of these simulations were analyzed to obtain estimates of net energy and demand savings impacts for participants and spillover savings for non-participants. Table 3 presents the findings of this analysis, which produces two separate indicators of net program impacts:

1. **Participant net-to-gross ratio** – total program induced savings removing participant free-ridership and including participant spillover, relative to participant gross savings.
2. **Participant net realization rate** – total program induced savings removing participant free-ridership and including participant spillover, relative to program tracking savings.
3. **Comprehensive net-to-gross ratio –** total program induced savings for both participants and non-participants, which includes participant and non-participant spillover, relative to participant gross savings.
4. **Comprehensive net realization rate** – total program induced savings for both participants and non-participants, which includes participant and non-participant spillover, relative to program tracking savings.

First lets focus on the participant net-to-gross ratio. 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. This ratio is most closely comparable to net-to-gross ratios calculated for past NRNC program evaluations conducted in California. Referring to Table 3, the participant net-to-gross ratio is 60.0%, which means 60% of the energy savings are a direct result of the SBD program, while the difference (40% of the savings) is considered program free-ridership.

[1] The commercial results include spillover. The industrial results do not include spillover as explained in the paragraph preceding Table 2.

	Self-Report Estimate (MWh)	Calculation
Program Tracking Savings	121,531	A
Gross Savings	127,216	B
Gross Realization Rate	104.7%	(B/A)
Net Participant Savings	76,296	C
Participant Net Realization Rate	62.8%	(C/A)
Participant Net-to-Gross Ratio	60.0%	(C/B)
NP Spillover Savings	6,401	D
Total Net Savings	82,697	(C+D)
Comprehensive Net Realization Rate	68.0%	(C+D)/A
Comprehensive Net-to-Gross Ratio	65.0%	(C+D)/B

Table 3: Program Net Savings

Although a participant net-to-gross ratio of 60% at first seems to indicate high free-ridership, this degree of free-ridership is consistent with the historical net-to-gross ratio for statewide NRNC programs. Table 4 shows historical net-to-gross ratios from past NRNC evaluation studies in addition to the simple average net-to-gross ratio. The net-to-gross ratio of 60% for the 2002 BEA study is statistically identical to the simple average net-to-gross ratio and is one percentage higher than the 99-01 BEA study.

NRNC Study	Net to Gross
94 SCE	50%
94 PG&E	80%
95 SDG&E	59%
96 SCE	62%
96 PG&E	47%
98 SCE	62%
98 PG&E	41%
99 PG&E	76%
99-01 BEA	59%
02 BEA	60%
Average	**60%**

Table 4: Historic Net to Gross Ratios for NRNC Studies

As was reported in the final report for the 99-01 BEA study, we believe that the events that took place in the energy industry between 1999 and 2001 certainly had a hand in reshaping the way buildings are designed and operated. The NRNC industry was first impacted beginning in 2000 with rolling blackouts and steep price increases in the SDG&E service territory, followed by planned SCE/PG&E rate increases. We believe this uncertainty induced building designers and owners to more actively pursue energy efficiency design in non-residential new construction. Keep in mind that a good number of the buildings evaluated for this study were also conceptualized, designed and constructed during this period of volatility and uncertainty in the energy market.

While it is plausible that the effects of the "California energy crisis" may be still shaping the way buildings are constructed and operated, data from this BEA study indicates that non-participant building efficiency has slightly decreased, when compared to the 1999-2001 BEA Study. However, on average non-participants continue to exceed baseline requirements in excess of 10%. Figure 1 compares participant and non-participant efficiency as a percentage of baseline energy consumption[2]. The data shows that 2002 BEA study non-participants consumed 12% less energy than their baseline counterpart. This is a reduction in non-participant efficiency compared to the 99-01 BEA study, which at the time showed non-participants to be using 14% less energy than their baseline counterpart. This drop in non-participant efficiency may be attributed to more stringent Title 24 codes and possibly to a fading sense of urgency related to the "California energy crisis". Contrary to the non-participant findings, the participant efficiency relative to Title 24 baseline counterpart has increased from 16% to 18%.

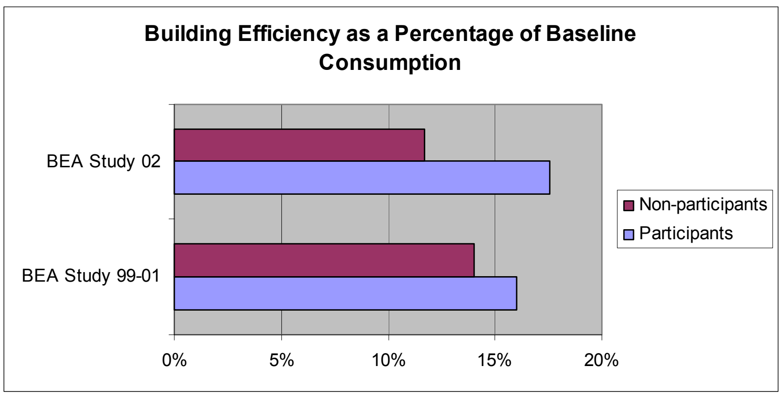

Figure 1: Comparison of Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption for Commercial Projects

Table 5 shows the total net program impacts by measure type, taking into account both participant free-ridership and non-participant spillover. Not surprisingly, the LPD measure results show non-participants have been influenced by the program, nearly 1,600 MWh of spillover energy savings were reported. However the net–to-gross ratio is below 70% because a number of participants reported the program not influencing their decision to install an energy efficiency lighting system. The industrial end-use has the worst net-to-gross ratio, 35.2%, which is having a significant negative effect on the overall net-to-gross ratio for the program because the industrial end-use comprises roughly one quarter of the total gross savings. However, unlike commercial measures, industrial measures did not accrue benefits from spillover because the methodology used to determine spillover savings for commercial projects is not applicable to industrial projects.

Considering only the commercial end-uses, the program is producing a healthy net-to-gross ratio of 75.3%. Just over 5% (6,401 MWh) of the 75% is a result of spillover savings. Without the spillover impact, the program would have experienced approximately 30% free-ridership. For comparison sake, the previous BEA study found the participant net-to-gross ratio to be 59% for commercial buildings, excluding spillover savings[3]. This finding indicates that in terms of the

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[2] Projects that were permitted prior to June 1, 2001 were subject to the 1998 Title 24 code, while projects permitted after this date were subject to the more strict 2001 Title 24 code requirements.

[3] There were no industrial projects in the previous BEA study to compare these results to. The "participant net to gross" only accounts for free-ridership, it does not include spillover savings.

commercial program, free-ridership has been reduced by approximately 10% when compared to the previous two years of implementation.

	Net Participant Savings (MWh)	Relative Precision of Net Participant Savings	NP Spillover Savings (MWh)	Total Net Savings (MWh)	Gross Savings (MWh)	Net-to-Gross Ratio
Shell	4,778	45.8%	-3	4,774	5,466	87.4%
LPD	16,607	28.0%	1,575	18,182	26,649	68.2%
Daylighting Controls	8,820	46.5%	0	8,820	15,537	56.8%
Other Lighting Controls	3,126	34.4%	-1	3,125	3,989	78.4%
HVAC + Motors	21,916	30.4%	79	21,995	33,401	65.9%
Refrigeration	9,577	65.9%	4,751	14,328	9,566	149.8%
Combined Commercial Total	**64,824**	**17.5%**	**6,401**	**71,225**	**94,607**	**75.3%**
Industrial	11,472	44.3%	NA	11,472	32,610	35.2%
Combined C&I Total	**76,296**	**16.3%**	**6,401**	**82,697**	**127,216**	**65.0%**

Table 5: Total Net Energy Program Impacts by Measure Type

Non-participant Spillover

The customer reported methodology used to calculate participant net savings is used in a similar way to calculate non-participant net savings. Non-participant net savings are savings that occur as a result of prior program influence or influence from the new construction representative or program material. Using the non-participant survey responses, the non-participant engineering models were adjusted to reflect what non-participant owners and other key decision makers reported they would have done absent any prior program influence. The results for the non-participant sample were then weighted to the non-participant population to produce an independent estimate of program-induced savings in the non-participant population[4]. Therefore, including non-participant spillover in the net savings calculation results in a second estimate of net savings, referred to in Table 3 as the comprehensive net-to-gross ratio. Industrial projects were not matched to a non-participant; therefore there are no spillover savings for the industrial component of the program.

As seen in Table 3, the comprehensive net-to-gross ratio adds 6,401 MWh of energy savings attributed to spillover to the 76,296 MWh of participant net savings. The sum of these two estimates is then divided by the program gross evaluated savings, which produces a comprehensive net-to-gross ratio of 65%.

The net savings approach not only provided a means for tracking non-participant spillover, it also provided the added benefit of evaluating specific areas the program has influenced the most. A significant change from the 99-01 BEA study findings to the 2002 BEA study findings is the measure category that is contributing the highest percentage of spillover. Non-participant spillover from the 99-01 BEA study was attributed to mostly lighting energy savings, or 85% of

[4] F.W. Dodge data was used to determine the non-participant population and was also used to select the non-participant sample.

total spillover. Whereas the non-participant spillover from the 2002 BEA study can mostly be attributed to refrigeration savings, or 74% of all spillover savings.

Process Findings

The BEA Study included a process evaluation component in which telephone surveys were conducted with either the building owners, or primary decision makers. The process questions addressed several general categories of interest:

- **Financial Criteria** – General building information such as ownership type and financial criteria used in energy efficient investments;
- **Energy Efficiency Attitudes** – The importance of energy efficiency to the company and any policies used to encourage efficiency
- **Design Team Qualifications** – The criteria used in the selection of the design team and use of an integrated design approach;
- **Energy Performance** – Decision-makers' perceptions of the energy efficiency of their building;
- **Savings By Design Program Questions** – Awareness of program, motivations to participate, and barriers to participation.

Financial Criteria

The percent of participants with the intent to lease their new space (as opposed to owner occupied) has decreased since the previous BEA study, from 40% to 21%. This finding suggests that the market may be experiencing a decline in speculative building construction. However, it may also be that the program isn't penetrating the speculative building market as much as it previously had. Given the current amount of unoccupied commercial lease space that exists as a result of the downswing in the economy, it is more likely that there is less new construction of buildings with the intent to lease[5]. Moreover, the previous evaluation included many buildings that were still riding the coat tails of the late 1990's economic boom, so it is highly conceivable that there has been a sharp decrease in new construction of space with the intent to lease.

Previous findings from the 99-01 BEA study showed 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. This may be a contributing factor as to why the 2002 BEA participant group is more efficient than the 99-01 BEA participant group (see Figure 1).

Design Team Requests

Sixty-seven percent (67%) of participant owners asked the members of their design team to consider energy efficiency above and beyond Title 24 requirements, compared to 40% of non-participant owners. Participant owners are shown to have greater interest in selecting

[5] Evidence showing increased vacancy rates in commercial office space in California. http://www.dof.ca.gov/HTML/FINBULL/TABLES/sep02ch1.gif

design teams with experience and qualifications in energy efficient design practice. This may be in part due to the fact that owners have more of a vested interest in exceeding Title-24 in order to qualify for the SBD incentive. However the data shows an emerging trend. Compared to the 99-01 study there has been nearly a 10% increase in the number of non-participants that are asking their design teams to consider energy efficiency beyond Title 24 requirements.

The practice of building commissioning is greater among non-participants. The results of the decision maker survey reveals 39% of non-participants claim to have a third-party agent conducting building commissioning, as opposed to 18% of participants. These percentages seem greater than one would expect, so perhaps there continues to be confusion in what the true definition of building commissioning is among respondents[6].

Energy Efficiency Attitudes

Program participants and non-participants have similar attitudes toward energy efficiency. Participants and non-participants alike put a high value on the efficiency of the building during design and construction and also during daily building operation. Approximately 51% of participants and 44% of non-participants consider energy efficiency to be "very important".

Energy Performance

Participants and non-participants believe that their buildings are efficient. Survey respondents were asked to evaluate how efficient they thought their buildings were compared to code. Interestingly, 20% of non-participants responded with a "Don't Know" indicating they aren't as involved in energy efficient aspects as are participants. Participants were much more likely to say that their building was much better than code, while non-participants were significantly less likely to believe their buildings were much better than code. Participants and non-participants were equally as likely to believe their buildings are somewhat more efficient than required by code.

Savings By Design Program Questions

Far and away, the number one source of program awareness for program participants is previous participation in the Savings By Design, or NRNC programs. Nearly half of all participants report that they became aware of the program through previous program participation. Next in order of significance is the utility representative where 26% of respondents report the utility representative as their source of program awareness. This suggests that past participants must be satisfied with the program's services and offerings since nearly half of all participants are return participants.

The Savings By Design incentive continues to be a key factor that influences energy efficient building design and construction. However, other aspects of the program are also demonstrating great value:

- Sixty percent (60%) of participant owners claim that the owner incentive and the SBD representative's recommendations were instrumental in changing their design practices to be more energy efficient. Although this response was not used to calculate free-ridership, it reinforces the participant net-to-gross ratio of 60% (see Table 3).

[6] The surveyor does read a definition for commissioning (ASHRAE Guideline 1) before obtaining responses to the questions.

- More than 53% of participants say that the incentive was very important as a factor in their participation in the SBD program. This finding suggests that program participants must be finding good value in other aspects of the program. .
- Participants ranked the influence of the incentive equal to design assistance/analysis, suggesting that other areas of the program are as important as incentives.
- Forty two (42%) of non-participants who were completely unaware of SBD before their project started report a high likelihood of designing their building to perform better than Title-24 had they known about the availability of Savings By Design and its incentives.

There is an increased awareness of the Savings By Design program among non-participants. In the 99-01 study 37% of non-participants were aware of SBD before construction began. The 2002 study reveals nearly 55% of non-participants were aware of SBD prior to beginning design and construction. This sharp increase in program awareness suggests effective marketing (e.g., awareness building) of the program.

Funding uncertainty and incentive amounts present SBD with participation barriers. Fifty-four percent (54%) of non-participants were aware of the program before design and construction began. Detailed responses suggest that there are two primary reasons for not participating: 1) Customers were turned away from the program due to insufficient program funds, and 2) Customers stated that the amount of the incentive was not worth their time for participating. Perhaps issue one from above will be effectively managed now that program cycles are on a two-year schedule. To overcome the second barrier, perhaps program marketing should strive to emphasize the value existing participants are getting out the design assistance and design analysis program features, in addition to the monetary incentive.

Introduction

RLW Analytics, Inc. (RLW) conducted an impact and a process evaluation of the 2002 Savings By Design (SBD) Program, California's statewide non-residential new construction (NRNC) energy efficiency program, administered by PG&E, SCE, and SDG&E. Southern California Gas (SCG) also implements the program, however their projects are not included in this study.

This document is the final report for the Building Efficiency Assessment (BEA) study for the statewide Non-Residential New Construction (NRNC) program area, covering program year 2002. This report contains summary results for both program participants of Savings By Design (SBD) and program non-participants from 1999 to 2002. The key objectives of the study are to:

- Develop on-going gross whole-building energy and demand impact estimates for the Savings By Design program,
- Develop on-going impact estimates of both incented and non-incented measure categories,
- Develop on-going estimates of both free-ridership and spillover at the measure and end-use level,
- Provide an on-going process evaluation of the SBD program from the perspective of the program participants.

Evaluation Overview

RLW Analytics (RLW) of Sonoma, California 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, is assisting RLW and AEC in the data collection and engineering modeling.

The RLW Team has developed a sound and reliable process for estimating the 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 BEA study. Moreover, the same approach was also applied to the last three years of program activities, including 1999 through 2001. Findings from these studies are presented in the previous two Building Efficiency Assessment Study reports. This is the third in a series of BEA study reports. The participant population for this study consisted of 426 sites paid in the statewide SBD program during 2002.

The BEA Study defines participants by the year in which they were paid their incentive. The utilities, on the other hand, define program participation year based upon the year the participant applied for program incentives. Therefore the 2002 BEA study is not a true study of PY 2002 program activities. However, because BEA is an on-going evaluation of SBD, a complete picture of SBD and corresponding non-participant projects evolves 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 79 sites.

This study is different from prior NRNC program and BEA evaluations in that it includes 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 used a matched sample of participants and non-participants for the commercial and combined commercial/industrial projects only. The 2001-2002 F.W. Dodge New Construction Database was used to obtain the non-participant population. The non-participant sample was selected from those Dodge projects that have the same building type, title-24 compliance year, construction start year, climate zone, and approximately the same square footage as the participant. The final non-participant sample size was 67 sites.

The gross savings evaluation is based on DOE-2 engineering models and engineering calculations that are informed by detailed on-site surveys that are 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. As part of the whole building evaluation philosophy used by the BEA study, participants are also credited or penalized for non-incented measures that are more (participant spillover) or less energy efficient than baseline.

The net savings component of the evaluation considers both free-ridership (i.e., savings that would have occurred even if the customer had not participated in the program) and non-participant spillover (i.e., savings that would not have occurred absent prior influence by the program), at the measure and end-use level, respectively. Both free-ridership and spillover 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 and non-participants.

The BEA study also includes an analysis of process findings as reported by the participant and non-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. Non-participants are also surveyed in order to better understand participation barriers and program awareness. This aspect of the evaluation also includes questions for both participants and non-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 three participation paths, the systems approach, the whole building (performance) approach, and industrial. The incentive structure targets both the building owner and the building design team.

Systems Approach

The Systems Approach uses a set of pre-calculated energy savings values for efficient systems that are broadly available though not currently standard practice. System savings are calculated by the program representatives using “CaNCCalc”. “CaNCCalc” is a set of prototype models developed for SBD that produce pre-calculated energy savings values based on a set of inputs common to the building systems being evaluated. Building Systems covered under this approach include:

Shell Measures

Buildings incorporating high performance glazing into their building designs are eligible for incentives. Energy savings are based on the number of glazing layers, visible transmittance (Tvis), and solar heat gain coefficient (SHGC).

Daylighting Systems

Buildings incorporating 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.

Interior 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
- Occupancy sensors
- Phototelectric dimming controls
- 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
- Variable-speed motor drives on system fans and pumps
- Premium-efficiency motors
- Low solar heat gain coefficient (SHGC) glazing[7]

[7] Glazing that reduces unwanted solar heat gain lowers the load on the air-conditioning system thus saving energy. Only glass with a SHGC lower than the Title-24 standard requirement is eligible for incentives.

Refrigeration Systems

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

- Floating head pressure
- Condensers with variable set points and variable-speed drives
- Compressors with variable-speed drives
- Time controls on electric defrost elements
- Gas defrosters
- High-efficiency liquid suction heat exchangers.

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 building energy simulation modeling to help provide an optimized “whole-building” design. In addition to informing the design process, the simulation models are used to calculate the estimated total annual energy savings for the building compared to the Title-24 minimum requirements. The analysis can be prepared by the design team, or by an energy consultant provided by the utility, or by the utility, using an approved hourly simulation computer tool. DOE-2, eQUEST, and EnergyPro are examples of computer tools approved for use by the program.

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. Industrial savings are typically informed by engineering calculations provided by the facility owner and subsequently approved by the utility. In most cases, the industrial measures are completely isolated from a commercial building. However, some incented measures were integrated into commercial buildings participating in the Savings By Design program. These projects are referred to as combined commercial/industrial projects. The primary example is variable speed motor drives for fume hood applications utilized in laboratories within R&D facilities. The R&D facilities also participated under the Whole Building Approach implementing common energy efficient measures. Measures incented include but are not limited to:

- Energy recovery
- Carbon monoxide sensors for parking garage fans
- Variable-speed motor drives, dairy farm milking machines for example
- Premium efficiency motors, air compressor motors for example
- Refrigerated warehouses
- Variable-speed motor drives for fume hood applications

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/annualized kWh savings to $0.18/annualized kWh savings, dependant on the amount of savings relative to Title-24. The maximum incentive is $150,000 per freestanding building or individual meter.

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 $0.03/annualized kWh to $0.12/ annualized kWh savings depending on the end-use system type, with a maximum incentive of $75,000 per freestanding building or individual meter.

When Other Systems or Processes are involved, energy savings and incentives are calculated based on the quantities and efficiencies of qualifying components. Owner incentives are calculated at a rate of $0.03/annualized kWh to $0.12/ annualized kWh savings, with a maximum incentive of $100,000 per project.

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/Annualized kWh Savings to $0.06/Annualized kWh 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 receive.

Program Activity and Sample Summary

This section provides an overview of the statewide Savings By Design (SBD) program for projects paid in 2002. Only projects that were paid incentives within the evaluation year (2002) were considered, though the evaluated projects initially signed onto the program as early as 1999, or as late as 2002. 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.

Program Tracking Savings

Table 6 shows the number of projects, the total associated program tracking energy savings, and the energy savings per square foot by utility for the Savings By Design program. SCE projects account for nearly 64% of the energy savings, even though they only account for approximately 46% of the projects, suggesting that the SCE projects tend to save more energy per project than those from the other utilities. This is supported by the fact that SCE has the highest amount of energy savings per square-feet for participant projects at 3.66.

Utility	# Projects	Total MWh	Average MWh	kWh/ SQFT
PG&E	133	16,877	126.89	1.64
SCE	198	77,467	391.25	3.66
SDG&E	95	27,187	286.18	3.12
Statewide	426	121,531	285.28	3.03

Table 6: Savings By Design Program Tracking Savings[8]

Table 7 presents participation rates for the Savings By Design program, and previous NRNC programs, by year and by utility. In 2002, the SBD program completed 426 projects, slightly less than the number of participants that were completed between 1999 and 2001 (486). NRNC programs prior to SBD completed between 335 and 741 projects per program year.

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[8] All SCE Checkpoint projects were removed from the population of SCE. In addition, all projects committed during the 1st quarter of 2002 at any utility offering Savings By Design were done under Bridge Funding. The projects participated using approved funding but were not eligible for being counted towards the energy savings approved by the CPUC; therefore savings were never officially claimed. RLW maintained these projects in the program population and sample since there was not any significant difference in the way the IOUs offered customers the program previously, or post bridge funding.

Utility	BEA				NRNC					
	2002		Q4 1999 - 2001		1998		1996		1994	
	# Projects	Total MWh	# Projects	Total MWh	# Projects	Total MWh	# Projects	Total MWh	# Projects	Total MWh
PG&E	133	16,877	127	19,418	236	91,658	405	78,723	469	81,350
SCE	198	77,467	169	53,835	99	27,522	133	40,491	272	67,850
SDG&E	95	27,187	190	17,034						
Total	426	121,531	486	90,287	335	119,180	538	119,214	741	149,200

Table 7: Non-residential New Construction Participation Trends

Program Participation Method

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 8 shows the number of projects, the associated energy savings and savings per square foot by participation approach. During 2002, Savings By Design had a total of 51 Whole Building projects, or 12% of the total. SDG&E had the most Whole Building Approach projects of any utility, with 18, but SDG&E had only the second largest amount of energy savings. SCE had the highest Whole Building 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 all three utilities. On average, the SBD program-tracking database estimates 3.03 kWh savings per square foot for all participants.

Approach	PG&E			SCE			SDG&E			Statewide		
	# Projects	MWh Savings	kWh/ SQFT	# Projects	MWh Savings	kWh/ SQFT	# Projects	MWh Savings	kWh/ SQFT	# Projects	MWh Savings	kWh/ SQFT
Systems Approach	117	11,007	1.51	144	37,312	2.30	57	10,398	1.73	318	58,717	1.99
Whole Building Approach	16	5,869	1.98	17	16,082	9.24	18	4,168	3.60	51	26,119	4.45
Industrial Only	-	-	-	32	20,308	7.91	10	8,070	9.87	42	28,378	8.39
Combined Comm/Ind	-	-	-	5	3,765	5.96	10	4,552	6.11	15	8,317	6.05
Overall	**133**	**16,877**	**1.64**	**198**	**77,467**	**3.66**	**95**	**27,187**	**3.12**	**426**	**121,531**	**3.03**

Table 8: Savings By Design Participation Approach: System vs. Whole Building

Program Participation & BEA Sample Size

Table 9 shows Savings By Design 2002 program participation and evaluation sample sizes by utility. Notice that PG&E had the lowest MWh savings per project at 127 MWh. Also note that we over-sampled the large projects for each utility, resulting in a higher than average sampled MWh savings per project.

2002	PG&E		SCE		SDG&E		Statewide	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample
Number of Projects	133	17	198	43	95	19	426	79
MWh Savings	16,877	4,567	77,467	37,195	27,187	12,966	121,531	54,728
Savings per Project (MWh)	127	269	391	865	286	682	285	693

Table 9: Savings By Design Program Participation by Utility

Table 10 shows SBD program population and sample sizes by stratum and utility service territory. Stratum 1 is for small sites, in terms of energy savings and 5 is for large sites. For a complete description of the stratum definitions, refer to the participant sample design section of this report. The sample was designed by utility; therefore each utility has different cut points for each stratum.

	PG&E		SCE		SDG&E		Statewide	
Stratum	**Population**	**Sample**	**Population**	**Sample**	**Population**	**Sample**	**Population**	**Sample**
1	68	4	106	9	44	4	218	17
2	35	4	41	9	22	4	98	17
3	16	3	23	9	15	4	54	16
4	7	3	18	8	9	4	34	15
5	7	3	10	8	5	3	22	14
Overall	**133**	**17**	**198**	**43**	**95**	**19**	**426**	**79**

Table 10: Savings By Design Program Participation by Stratum and Utility

Table 11 presents the number of sites and average square footage for the participant sample for 2002, by building type and utility. A larger percentage of SCE sites were sampled than PG&E and SDG&E sites since the sample was designed using energy savings as the stratification variable.

Building Type	PG&E		SCE		SDG&E		Statewide	
	# Sites	**Ave SQFT**	**# Sites**	**Ave SQFT**	**# Sites**	**Ave SQFT**	**# Sites**	**Ave SQFT**
C&I Storage	2	218,647	9	291,386	1	108,584	12	264,030
General C&I Work	3	79,367	8	143,512	4	66,505	15	110,148
Grocery Store	-	-	6	44,698	1	12,160	7	40,050
Hotels/Motels	-	-	1	962,000	1	626,172	2	794,086
Medical/Clinical	-	-	1	53,480	1	86,157	2	69,819
Office	8	121,156	5	203,461	4	101,148	17	140,655
Other	-	-	-	-	2	123,464	2	123,464
Religious Worship, Auditorium, Convention	-	-	1	59,110	1	4,246	2	31,678
Restaurant	1	2,412	1	2,646	-	-	2	2,529
Retail and Wholesale Store	1	148,128	6	95,194	2	163,661	9	116,290
School	2	91,309	5	41,563	2	43,019	9	52,941
Total	**17**	**116,341**	**43**	**160,751**	**19**	**114,117**	**79**	**139,978**

Table 11: Participant Sample by Building Type and Utility

Gross Savings Results

This section presents the gross energy savings and 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 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.

The inclusion of industrial projects and measures are new to the 2003 Building Efficiency Assessment. A new measure category has been added to the BEA report to accommodate reporting of industrial measures.

Statewide Energy Findings

All Measures

We begin the energy impacts section by reporting findings for all measures. Table 12 shows the estimated combined total gross energy savings relative to the energy savings from the program tracking databases. For all program participants, the combined total annual gross energy savings were estimated to be 127,216 MWh, representing a gross realization rate of 104.7%.

Program Tracking Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Estimated Energy Savings (MWh)	Realization Rate
121,531	54,728	45.0%	127,216	104.7%

Table 12: Combined Total Annual Gross Energy Savings

Figure 2 shows the composition of annual gross energy savings by measure type. Both lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls) and industrial measures each account for just over 25% of the annual energy savings among program participants. Approximately 23% of the savings are due to Whole Building Approach projects, while HVAC + Motors measures comprise an additional 15% of the annual gross energy savings. Shell measures, such as fenestration, have the smallest share of energy savings.

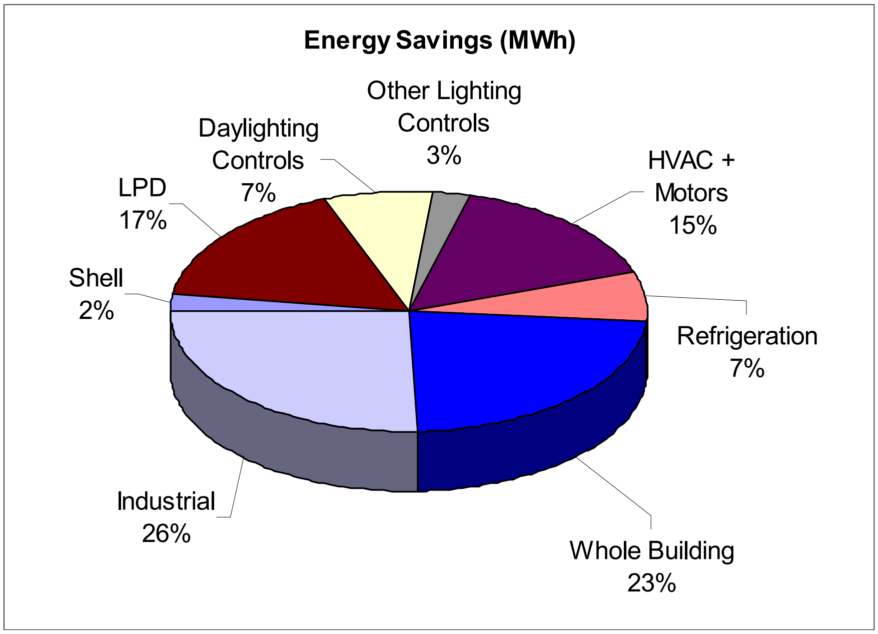

Figure 2: Composition of Annual Gross Energy Savings as % of the Combined Total

Table 13 shows the estimated energy savings and error bound by measure type as well as for the combined total. The combined total energy savings were 127,216 MWh, with an error bound of 16,502 MWh, yielding a 90% confidence interval of (110,714, 143,718) 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 baseline consumption for this particular end use. Similar to shell measures, the industrial measure category has no value in the final column labeled 'Savings as % of End Use Baseline' because industrial measures utilize measure specific standard practice for determining energy savings, as opposed to a predefined Title 24 baseline. As a result, the row containing combined commercial and industrial ('combined C&I Total') also contains an NA for the reasons explained.

	Measure Category	Energy Savings (MWh)	Error Bound	Relative Precision	Savings as % of End Use Baseline
Systems Approach	Shell	2,679	1,890	70.5%	NA
	LPD	21,697	5,730	26.4%	16.8%
	Daylighting Controls	9,456	3,967	42.0%	7.3%
	Other Lighting Controls	3,426	1,181	34.5%	2.7%
	HVAC + Motors	19,542	6,392	32.7%	14.0%
	Refrigeration	8,403	6,320	75.2%	15.1%
	Whole Building	29,404	9,109	31.0%	21.8%
	Combined Commercial Total	**94,607**	**12,982**	**13.7%**	**17.5%**
	Industrial	32,610	7,416	22.7%	NA
	Combined C&I Total	**127,216**	**16,502**	**13.0%**	**NA**

Table 13: Annual Gross Energy Savings

Statewide Energy Savings as a Percentage of Baseline

This section compares the participant savings to the non-participant savings for commercial buildings (i.e., industrial projects and measures are not included). The mix of participants and non-participants that have been included in this study were subject to different Title 24 requirements depending upon when the building permit was obtained. Projects that were permitted prior to June 1, 2001 were subject to the 1998 Title 24 code, while projects permitted after this data were subject to the 2001 Title 24 code requirements[9]. Non-participants that were selected for this study were matched to the participant characteristics, including Title 24 code year. Therefore the data presented in Figure 3 has an approximately equal number of participants and non-participants for the two versions of Title 24.

In total, the participant group was *more* energy efficient than the non-participant group. Figure 3 shows the savings of both program participants and non-participants expressed as a percentage of baseline for each group. The figure also presents the relative performance of each group's building total baseline usage. The participants were 17.5% better than baseline on average, while the non-participant comparison group was 11.7% better than baseline. For this analysis we have included the Whole Building projects with the Systems Approach projects by disaggregating the end-uses into the categories presented below.

The participants are more efficient than the non-participants in all end-uses except the LPD end-use. Title 24 allows lighting controls, such as occupancy sensors, to be used for reducing overall LPD. Combining the two, 'other lighting controls' and 'LPD', is perhaps a better way to understand the efficiency of the lighting system in buildings. Doing so slightly improves the comparison of participants to non-participants because, as the data shows, participants are slightly more efficient in this end-use category. The data is also showing that participants and non-participants are using control measures about equally to reduce overall LPD for compliance with Title 24.

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9 Updated to Title 24 resulting from Assembly Bill 970 became effective June 1, 2001. An exception to this date was HVAC efficiency changes, which became effective October 1, 2001.

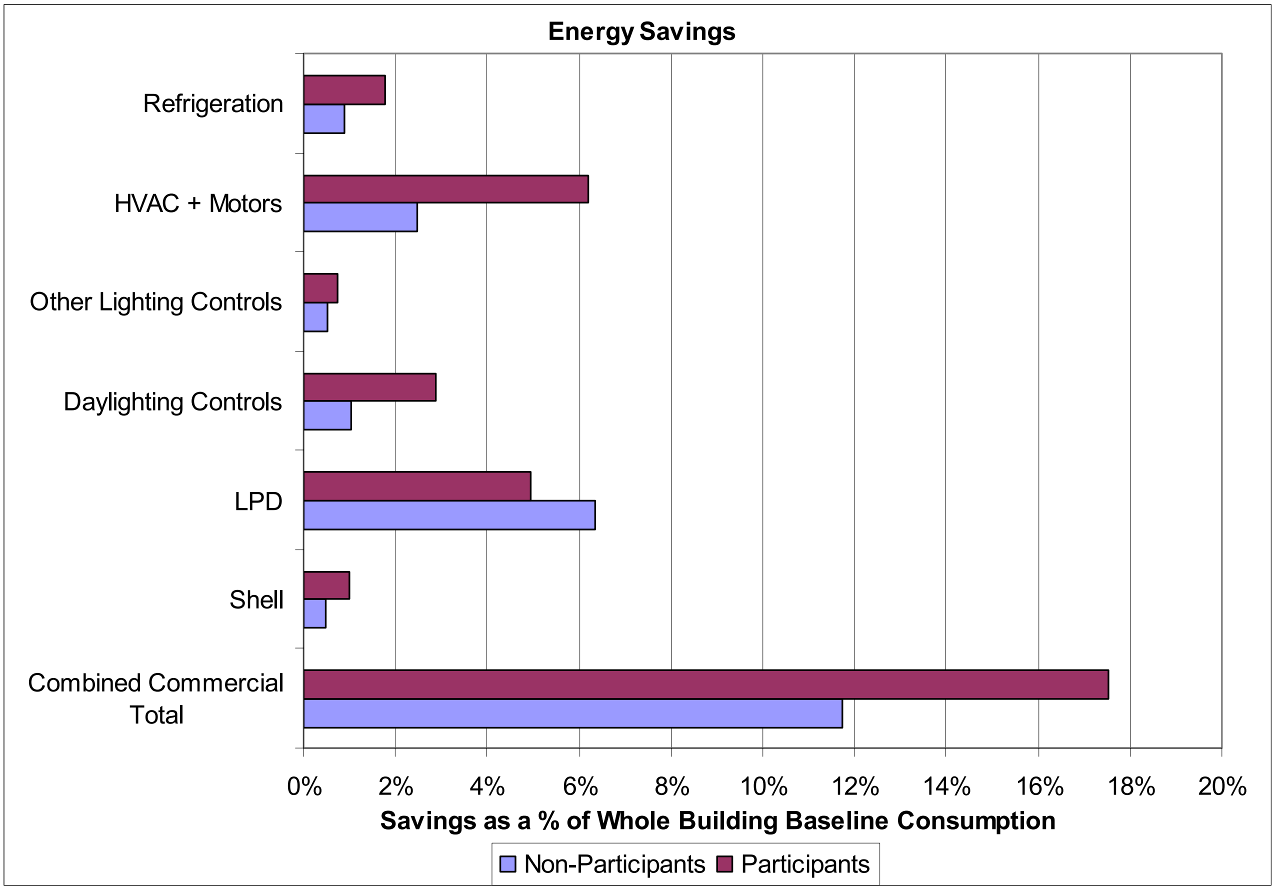


Figure 3: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption – Commercial Sites Only

Figure 4 through Figure 6 show participant and non-participant energy savings as a percentage of baseline consumption by Title 24 energy code type (1998 versus 2001)[10]. Unlike all other results presented throughout this report, the results in these charts are unweighted. In order to properly weight these results, we would need to know which Title 24 energy code type was utilized for each site in the non-participant population. Since we did not have these requisite data easily available, we have opted to calculate these results without the use of case weights.

Regardless of which Title 24 code were used for building compliance, either the 2001 or 1998 Title 24 code, the participant buildings are more efficient than the non-participant buildings. As is expected with implementation of stricter codes the efficiency of the buildings expressed as percent of whole building consumption for both groups declined, as shown below in Figure 4. The decline in efficiency relative to baseline is on a smaller magnitude for the participant buildings (18% to 16%) than it is for non-participant buildings (13% to 8%).

[10] There were 3 participant sites that utilized a combination of Title 24 energy code types. Specifically, for these 3 participants, one portion was designed according to the 1998 Title 24 energy code and another portion of the building was designed according to the 2001 Title 24 energy code. These 3 participant sites have been excluded from Figure 4 through Figure 6. Rather, the results for these 3 sites were calculated separately and are shown in Table 14.

These results seem to indicate that the SBD program is more effective in the early stages of a code cycle than it is near the end of a code cycle. Therefore, it appears that these findings are consistent with what one might expect when comparing similar projects that straddle a code cycle. One of the purposes of the SBD program is to prepare the market for cyclical improvements to California's energy code (Title 24). These results illustrate the impact of a code cycle on non-participants and participants. Non-participants are about 40% less efficient when comparing buildings built under the 1998 and the 2001 code, whereas participants are only about 10% less efficient. Therefore one might conclude that the SBD program is more effective at reducing energy consumption early in a code cycle. Evidence in the following section of this report supports this idea. Net-to-gross results for the 2002 commercial study participants has improved over the previous BEA study findings, which was inclusive of only 1998 Title 24 projects.

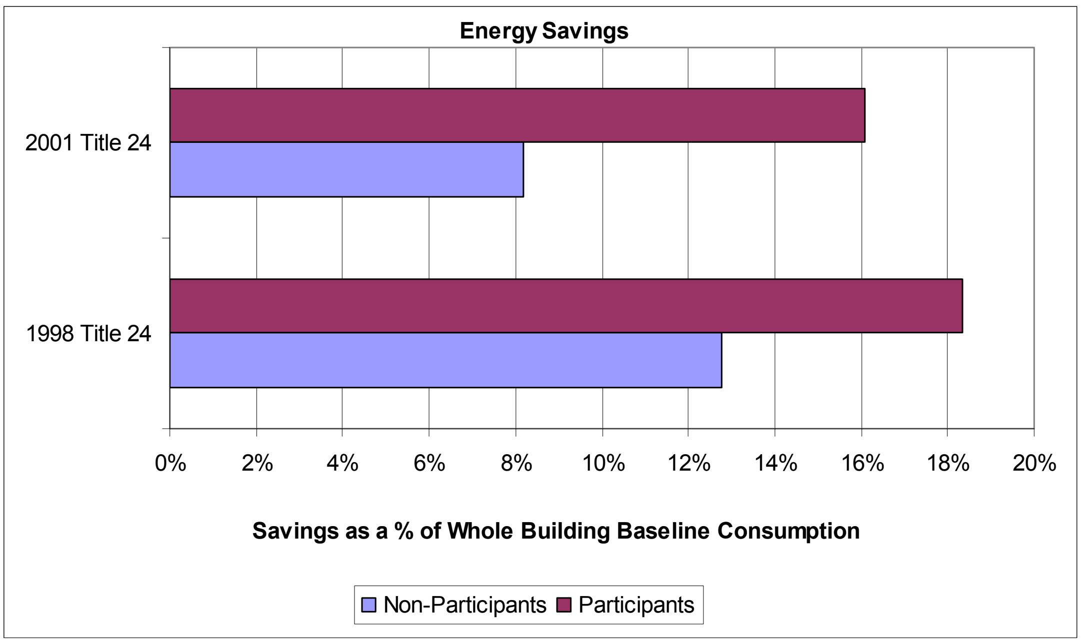
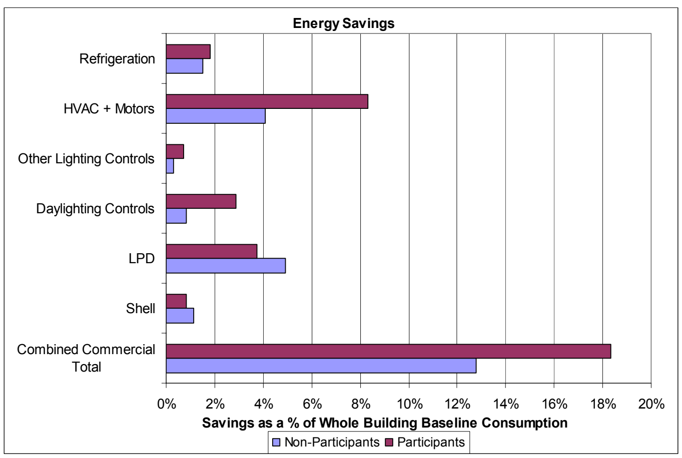


Figure 4: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption – 2001 Title 24 versus 1998 Title 24, Commercial Sites Only (Unweighted)

Figure 5 and Figure 6 presents building performance as a percentage of whole building baseline consumption for projects complying with the 1998 Title 24 code and the 2001 Title 24 code, respectively. Figure 5 shows that when comparing end-use savings as a percentage of whole building baseline consumption, participant buildings are approximately 6% more efficient than non-participant buildings. Comparisons at the end use level show the greatest difference between the participants and non-participants is in the HVAC + Motors end use. Here participants are 4% more efficient than the non-participants. Although non-participant LPD is more efficient than participant LPD, the participant group is more efficient than the non-participant group when comparing the total lighting system efficiency: other lighting controls, daylighting, and LPD.

Figure 6 shows building performance as a percentage of whole building baseline consumption for projects that complied under the 2001 Title 24 code. The LPD end use efficiency is practically identical between the participants and non-participants, whereas, for buildings that complied under the 1998 Title 24 code the non-participants LPD was more efficient. Moreover, comparing the total lighting system efficiency (other lighting controls, daylighting, and LPD), the participants are significantly more efficient than the non-participants. Daylighting controls account for the majority of the lighting system energy savings within the participant group, performing almost 5% better than their Title 24 baseline counterpart. The 2001 code included a strengthening of the HVAC efficiency standards, and the result of this change in the code is evident. Non-participants are only slightly better than 0%, while participants are nearly 5% better.

Given the information presented in the last three figures, one would conclude that the 2001 Title 24 code did have an impact on both the SBD programs ability to create energy savings beyond baseline, and non-participant building efficiency was more greatly impacted by the code strengthening. However, one might also surmise that there continues to be room for code enhancements since the data in Figure 6 shows non-participants are continuing to exceed code requirements even early in a new Title 24 code cycle.



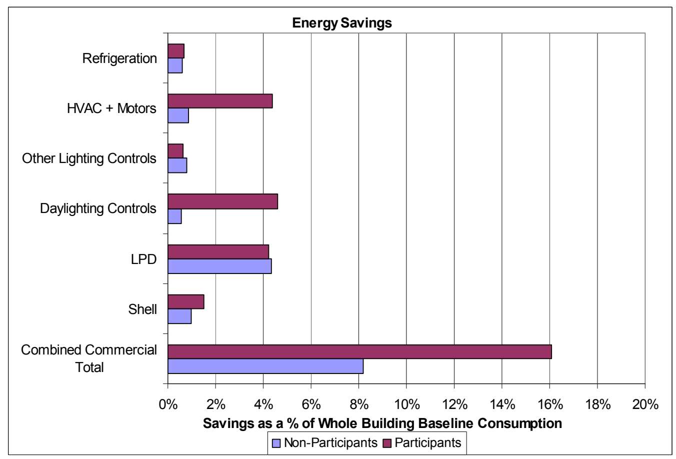


Figure 5: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption – 1998 Title 24 Commercial Sites Only (Unweighted)

Figure 6: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption – 2001 Title 24 Commercial Sites Only (Unweighted)

Table 14 shows the energy savings as a percentage of baseline consumption by end use as well as overall for the three participant sites that utilized a combination of 1998 Title 24 energy code and 2001 Title 24 energy code. HVAC + Motors still account for the majority of the energy savings for the buildings utilizing both 1998 and 2001 Title 24 codes. Shell and LPD are both contributing approximately the same amount of energy savings, or 6.0% and 7.3% better than baseline, to the combined building efficiency of 38% better than baseline. These results indicate the utilities are emphasizing energy efficiency in the HVAC/motors end-use, one area that has been strengthened by 2001 code. Data shown previously in Figure 6 also suggests the utilities are influencing design decision regarding HVAC applications in projects that are exclusively compliant to the 2001 code.

	% Better than Baseline
Shell	6.0%
LPD	7.3%
Daylighting Controls	0.3%
Other Lighting Controls	3.3%
HVAC + Motors	21.1%
Refrigeration	-0.1%
Combined Commercial Total	**38.0%**

Table 14: Energy Savings as a Percentage of Baseline Consumption – Participant Sites Utilizing Both 1998 Title 24 and 2001 Title 24, Commercial Sites Only (Unweighted)

Incented Measures

Incented measures refer only to the measures explicitly paid for within a specified end-use. Table 15 summarizes the annual gross energy savings due to incented measures relative to the energy savings from the program tracking databases. For all program participants, the combined total annual gross energy savings due to incented measures were estimated to be 106,133 MWh, representing a gross realization rate of 87.3%.

Program Tracking Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Estimated Energy Savings (MWh)	Measures Only Realization Rate
121,531	54,728	45.0%	106,133	87.3%

Table 15: Annual Gross Energy Savings – Incented Measures Only

Table 16 shows the estimated annual gross energy savings and gross realization rates for incented measures only. Whole building projects and industrial measures account for the majority of measure only savings. Together they combine for more than half of the measures only gross savings produced by the program. The lighting power density and daylighting controls measures comprise nearly an additional 24% of the savings due to incented measures with each accounting for over 17,000 MWh and 8,000 MWh of savings, respectively. Table 16 also displays daylighting control measures yielding the largest program savings producing approximately 36% savings above the end use baseline energy usage. Whole Building projects follow daylighting controls for producing the second highest savings as a percent of the end-use baseline; these projects are proving to be approximately 22% better than code.

The final column in Table 16 shows that shell, refrigeration, and Whole Building measures are the only measure categories with a gross realization rate of 100% or greater. HVAC + Motors measure is experiencing the lowest gross realization rate at 52.5%. This would suggest that perhaps the utilities should review the energy savings assumptions used for these types of measures. All other measure categories are within a reasonable energy savings range.

	Measure Category	Energy Savings (MWh)	Error Bound	Relative Precision	Savings as % of End Use Baseline	Program Tracking Energy Savings (MWh)	Gross Realization Rate
Systems Approach	Shell	338	328	96.9%	-	224	150.7%
	LPD	17,253	4,981	28.9%	20.9%	20,446	84.4%
	Daylighting Controls	8,037	3,580	44.5%	35.6%	11,412	70.4%
	Other Lighting Controls	-	-	0.0%	0.0%	-	-
	HVAC + Motors	12,840	4,489	35.0%	11.4%	24,452	52.5%
	Refrigeration	5,652	4,817	85.2%	11.8%	4,145	136.4%
	Whole Building	29,404	9,109	31.0%	21.8%	27,289	107.8%
	Combined Commercial Total	**73,524**	**12,809**	**17.4%**	**13.6%**	**87,967**	**83.6%**
	Industrial	32,610	7,416	22.7%	-	33,564	97.2%
	Combined C&I Total	**106,133**	**14,801**	**13.9%**	**-**	**121,531**	**87.3%**

Table 16: Annual Gross Energy Savings and Realization Rates by Measure Category – Incented Measures Only[11]

Figure 7 shows the composition of the total estimated annual gross energy savings for incented measures only. Nearly 60% of the energy savings, considering only incented measures, is resulting from Industrial and Whole Building Approach measures and projects. Refrigeration and HVAC/motors account for nearly 20% of the incented measure savings.

The utilities do not track 'other lighting controls', such as occupancy sensors, separate from LPD measures. Instead, the utilities include savings from these controls in the LPD category, primarily because lighting controls are used as a mechanism for reducing LPD for compliance with Title-24. Therefore, because they are not shown as measures in the utility tracking system the evaluation team does not indicate them as being program measures during the DOE-2 modeling process. Previously, in Table 13, we showed 3% (3,426 MWh) of the all measures energy savings resulting from 'other lighting controls'. To be consistent with the program's methodology for computing measures savings, the energy and demand savings resulting from other lighting controls could be included in this section. By doing so, an added 3,426 MWh of savings would be included in the 'other lighting controls' section for incented measures only.

[11] For lighting measures, the savings as a percentage of baseline consumption is expressed relative to the lighting baseline consumption for the sites that had the measure installed.

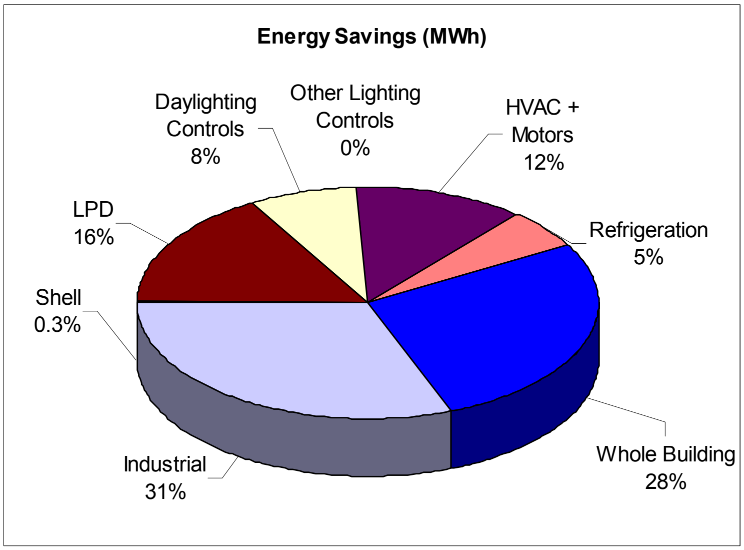


Figure 7: Composition of Estimated Annual Energy Savings – Incented Measures Only

Figure 8 shows the annual gross savings for incented measures expressed as a percentage of each end-use baseline usage. As Figure 8 shows, daylighting controls were more efficient relative to baseline consumption than were other measures. For the Whole Building measure and LPD categories, the annual gross savings relative to baseline consumption was approximately 21%; HVAC and refrigeration measures were also nearly equal, saving about 10% more energy than baseline.

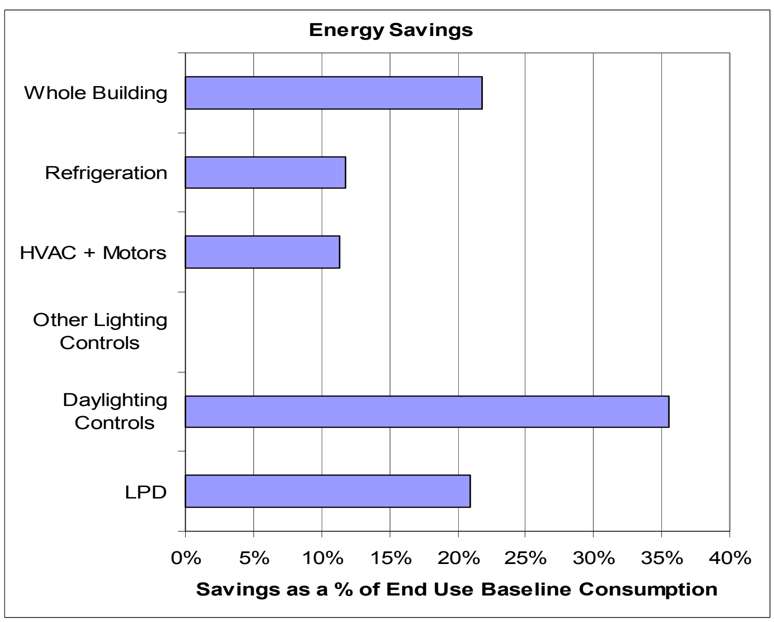


Figure 8: Energy Savings as Percentages of End-Use Baseline – Incented Measures Only

Statewide Demand Reduction Findings

This section presents the gross summer peak demand reduction for the program participants. Similar to the energy findings, we begin the section with the results for all measures and then present results for incented measures only. These results show that, similar to the energy findings, lighting measures account for the majority of the summer peak demand reduction among program participants and refrigeration accounts for the least of demand reduction.

All Measures

Table 17 shows the estimated combined total summer peak gross demand reduction relative to the summer peak demand reduction from the program tracking databases. For all program participants, the combined total summer peak gross demand reduction is estimated to be 28.6 MW, representing a gross realization rate of 107.5%.

Program Tracking Demand Reduction (MW)	Sampled Demand Reduction (MW)	% Demand Reduction Sampled	Estimated Demand Reduction (MW)	Realization Rate
26.6	10.1	38.0%	28.6	107.5%

Table 17: Combined Total Summer Peak Demand Reduction

It is important to point out that the demand savings is calculated based on the utility coincident peak, while the program calculates demand savings based on building peak demand. The coincident peak day and hour is tied to the CEC CTZ weather files and varies by climate zone. Table 18 below provides the peak days used for this study.

CTZ	Peak Day
1	7/21/1995
2	7/24/1995
3	7/18/1995
4	7/18/1995
5	9/5/1995
6	9/8/1995
7	7/31/1995
8	7/20/1995
9	8/8/1995
10	8/14/1995
11	8/3/1995
12	7/24/1995
13	8/15/1995
14	8/7/1995
15	7/21/1995
16	8/7/1995

Table 18: Day of Year for Coincident Peak Analysis

Figure 9 shows the breakdown of summer peak demand reduction by measure category. As with the energy savings results, lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls) account for about 28% of the summer peak demand reduction among program participants. Approximately 29% of the reduction is due to Whole Building Approach projects, while HVAC + Motors measures comprise an additional 19% of the savings. Comparing the data found in Figure 7 and Figure 9 it can be seen that the end-use components comprising total demand and energy savings reduction are almost the same for Whole Building, refrigeration, daylighting controls, and LPD. The industrial measure category is experiencing the largest differential between the demand and energy savings at 16% and 31%, respectively. So it appears that commercial measures are better at reducing demand, while industrial measures are better at achieving energy savings.

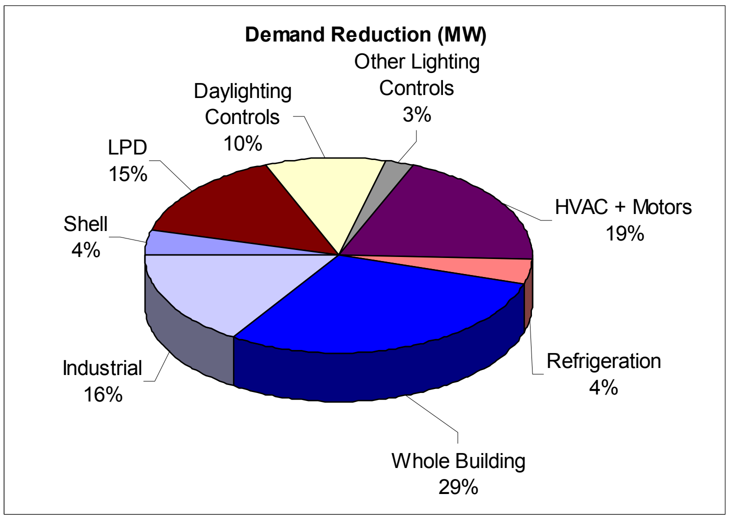


Figure 9: Composition of Summer Peak Demand Reduction

Table 19 shows the estimated gross summer peak demand reduction and error bound by measure type, as well as for combined total. The combined total gross summer peak demand reduction was 28.6 MW, with an error bound of 4.3 MW, yielding a 90% confidence interval of (24.3, 32.9) 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, with the exception of industrial. As one might expect, HVAC and motors are producing the most demand reduction for any systems measures (5.5 MW). Whole Building projects are producing one third of the demand savings for all commercial measures, which account for 8.4 MW out of a total 24.1 MW.

	Measure Category	Demand Reduction (MW)	Error Bound	Relative Precision	Reduction as % of End Use Baseline
Systems Approach	Shell	1.2	0.8	71.6%	NA
	LPD	4.2	1.3	30.7%	19.2%
	Daylighting Controls	2.9	1.3	46.2%	13.1%
	Other Lighting Controls	0.7	0.3	42.0%	3.4%
	HVAC + Motors	5.5	1.8	32.9%	12.9%
	Refrigeration	1.2	1.1	89.8%	16.8%
	Whole Building	8.4	2.8	33.7%	25.6%
	Combined Commercial Total	**24.1**	**4.0**	**16.6%**	**21.3%**
	Industrial	4.6	1.4	31.0%	NA
	Combined C&I Total	**28.6**	**4.3**	**15.1%**	**NA**

Table 19: Summer Peak Demand Reduction

Similar to the energy findings, the participant group was more efficient than the non-participant group in terms of coincident peak demand reduction. However the participants are doing much better than the non-participants in comparison to the energy findings presented earlier. Figure 10 shows the summer peak demand reduction of both program participants and non-participants expressed as a percentage of each group's whole building baseline demand. As Figure 10 shows, the participants were about 21% better than baseline on average, while the non-participant comparison group was about 3% better than baseline. Figure 10 also shows these results by end-use. For these results we have included the Whole Building projects with the Systems Approach projects by disaggregating the end-uses into the categories presented below. The participants are more efficient than the non-participants in all end-use categories in terms of coincident peak demand reduction.

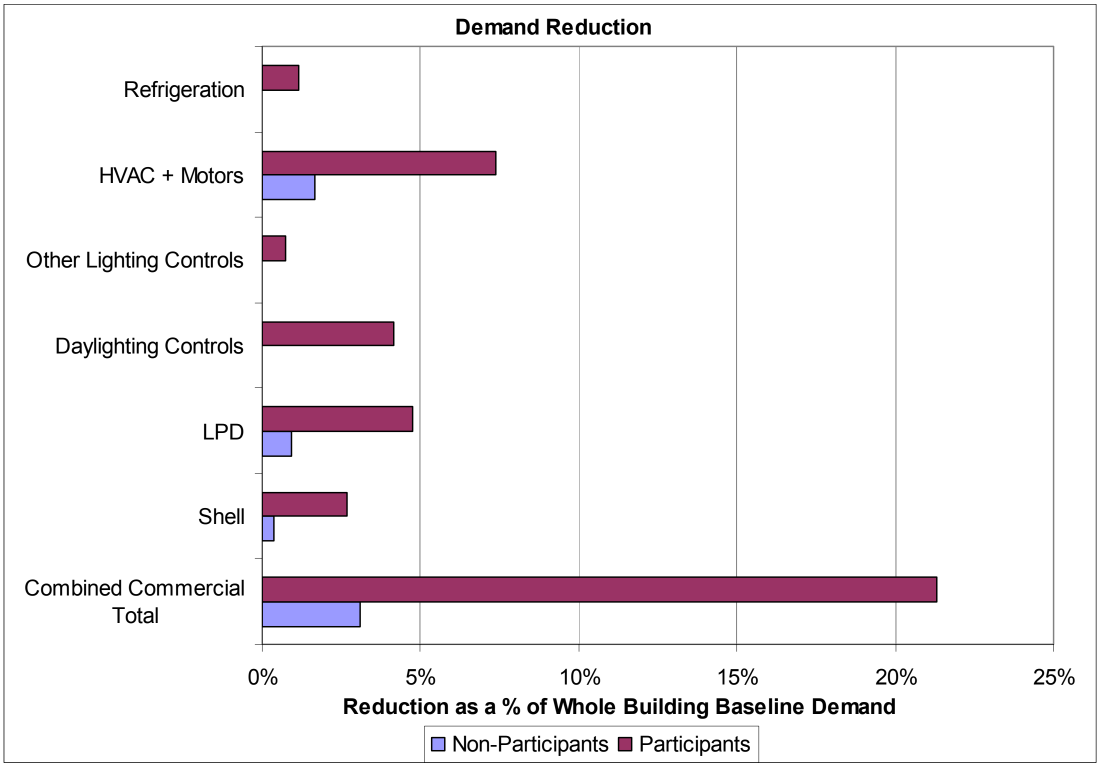


Figure 10: Participant and Non-participant Demand Reduction as a Percentage of Baseline Demand

Incented Measures

Table 20 summarizes the gross summer peak demand reduction due to incented measures relative to the summer peak demand reduction from the program tracking databases. For all program participants, the combined total gross summer peak demand reduction due to incented measures was estimated to be 23.1 MW, representing a gross realization rate of 86.7%. The demand measures only realization rate is nearly identical to the energy savings measures only realization rate, which was shown to be 87.3% in Table 20.

Program Tracking Demand Reduction (MW)	Sampled Demand Reduction (MW)	% Demand Reduction Sampled	Estimated Demand Reduction (MW)	Measures Only Realization Rate
26.6	10.1	38.0%	23.1	86.7%

Table 20: Summer Peak Demand Reduction – Incented Measures Only

Table 21 shows the estimated gross summer peak demand reduction and gross realization rates for incented measures only. About 36% of the reduction due to incented measures is accounted for by Whole Building projects. Daylighting and LPD measures account for approximately 26% of the demand reduction occurring from incented measures with each accounting for about 3 MW of demand reduction. HVAC + Motors also account for about 3 MW of demand reduction.

Table 21 also shows that the Whole Building Approach yields the largest program demand reduction as a percentage of the end use baseline demand, producing approximately 26% savings above the whole building baseline demand. Shell, refrigeration, and industrial are the only measures with gross realization rates of 100% or greater. HVAC + Motors and daylighting control measures are experiencing the lowest gross realization rates. Similar to the energy findings, HVAC + Motors demand savings are producing the lowest realization rates (69%), further substantiating the need for the utilities to review the energy and demand savings claims being made for these measures.

	Measure Category	Demand Reduction (MW)	Error Bound	Relative Precision	Reduction as % of End Use Baseline	Program Tracking Demand Reduction (MW)	Gross Realization Rate
Systems Approach	Shell	0.3	0.3	124.4%	-	0.1	394.3%
	LPD	3.4	1.1	33.5%	24.0%	3.9	87.8%
	Daylighting Controls	2.5	1.2	48.6%	23.5%	3.4	72.7%
	Other Lighting Controls	-	-	0.0%	0.0%	-	-
	HVAC + Motors	3.2	1.3	40.2%	9.2%	4.6	69.0%
	Refrigeration	0.8	0.9	103.3%	13.9%	0.5	178.5%
	Whole Building	8.4	2.8	33.7%	25.6%	10.2	82.2%
	Combined Commercial Total	**18.5**	**3.6**	**19.6%**	**16.0%**	**22.6**	**82.0%**
	Industrial	4.6	1.4	31.0%	-	4.0	113.8%
	Combined C&I Total	**23.1**	**3.9**	**16.9%**	**-**	**26.6**	**86.7%**

Table 21: Summer Peak Demand Reduction and Realization Rates by Measure Category – Incented Measures Only

Figure 11 shows the composition of the total estimated gross summer peak demand reduction for incented measures only. Whole Building and industrial measures continue to represent the lion's share of demand savings, producing more than half of the total incented measures only demand savings for the program.

The previous discussion in the energy section pertaining to 'other lighting controls' also applies here. Thus, demand reductions resulting from 'other lighting controls' may be included in this section. This would add 0.7 MW of demand savings to the measure only totals.

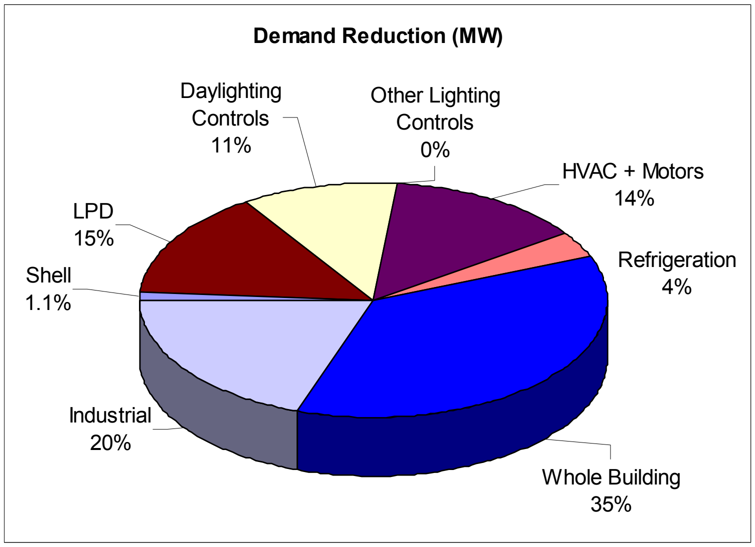


Figure 11: Composition of Summer Peak Demand Reduction – Incented Measures Only

Figure 12 graphically illustrates the efficiency of the incented measures expressed as a percentage of each end-use's baseline demand[12]. As Figure 12 shows, Whole Building, LPD, and daylighting measures were more efficient relative to baseline than were other measures. The summer peak gross demand reduction for these measures was about 25%. The summer peak gross demand reduction from incented refrigeration measures was about 14% of the whole building baseline demand.

HVAC+ Motors had the lowest summer peak gross demand reduction relative to whole building baseline demand at about 9%. Recall 2001 code changes strengthened Title 24 requirements for HVAC, so perhaps this end-use is saving less than the others due to the increased difficulty of exceeding code.

[12] For each measure category, the reduction as a percentage of baseline demand is expressed relative to the end-use baseline demand for the sites that had the measure type installed.

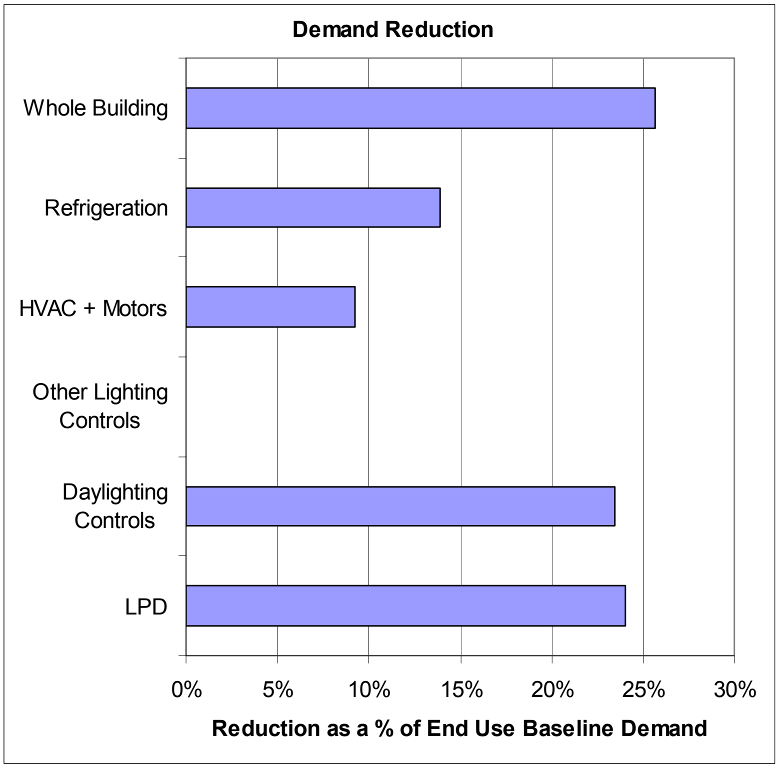


Figure 12: Demand Reductions as Percentages of Whole Building Baseline – Incented Measures Only

Systems Projects vs. Whole Building Projects

The Savings By Design program emphasizes the value of whole building design, or the integrated design philosophy. To evaluate and validate the effectiveness of integrated design we have performed an analysis of Systems Approach (prescriptive) vs. Whole Building Approach (performance) projects on a "per unit" basis. Two comparisons are made at the statewide level in this section.

The first comparison uses total building savings (incented and non-incented measures) to contrast the two approaches to program participation. The second and more informative comparison is the measures only savings for Systems Approach participants vs. Whole Building Approach participants. This analysis is more informative because the SBD program savings estimates for Systems projects are based entirely on the calculated savings at the measure level, whereas in the first comparison, Systems projects are also credited for non-incented measures, or total building savings. For this analysis we have excluded a few Whole Building projects that also included industrial measures, in addition we have excluded systems type industrial projects. We have done so because square footage data was either not available or was not relevant to the analysis.

Statewide Systems vs. Whole-Building

Table 22 compares the energy savings of Systems projects to Whole Building projects. As shown in the table for the statewide program, Whole Building projects save more energy per square foot than Systems projects. The gross realization rate of the Systems and Whole

Building approaches are both 108%. Note that the Systems Approach in this analysis includes other efficient systems and interactions not incented by the SBD program.

	kWh / SQFT	Gross Realization Rate
Systems Approach	2.14	107.5%
Whole Building Approach	4.67	107.8%

Table 22: Systems vs. Whole Building Projects – Annual Energy

Table 23 compares the demand reduction of systems projects to whole-building projects. As Table 23 clearly shows, whole-building projects experience a higher demand reduction per square foot, with nearly a three to one ratio. The table also shows that Whole Building projects experience a lower gross realization rate when compared to the Systems projects. Similar to the energy results, the Systems Approach in this analysis includes other efficient systems and interactions not incented by the SBD program, thus inflating the gross realization rate for this approach. It is also important to recall that the demand savings are calculated based on the utility coincident peak, while the program calculates demand savings based on building peak demand. Depending upon the timing of the building peak, the difference between the two methods can be large.

	W / SQFT	Gross Realization Rate
Systems Approach	0.51	126.4%
Whole Building Approach	1.33	82.2%

Table 23: Systems vs. Whole Building Projects – Summer Peak Demand

Systems Measures Only vs. Whole-Building

Table 24 compares the savings of Whole Building projects to system projects for incented measures only. As shown in the table, Whole Building projects save roughly three times more energy per square foot than do systems projects, and they also produce a higher gross realization rate than systems projects. These results clearly illustrate the benefits of the Whole Building Approach.

	kWh / SQFT	Gross Realization Rate
Systems Approach	1.45	72.7%
Whole Building Approach	4.67	107.8%

Table 24: Systems vs. Whole Building Projects – Incented Measures Only – Annual Energy

Table 25 compares the summer peak demand reduction of Whole Building projects to System projects for incented measures only. As shown in the table, Whole Building projects reduce demand by nearly three times as much as systems projects, while there appears to be no difference in the realization rate between the two approaches. These demand savings performance indicators further reinforce the value of Whole Building design over Systems Approach projects.

	W / SQFT	Gross Realization Rate
Systems Approach	0.33	81.7%
Whole Building Approach	1.33	82.2%

Table 25: Systems vs. Whole Building Projects – Incented Measures Only – Summer Peak Demand

When comparing Systems Approach savings in Table 22 and Table 24 it becomes evident that 35% of the evaluated savings are due to non-incented measures. Under the evaluation methodology employed in the previous 8 years of NRNC evaluation experience, the utilities are credited for these savings because they are considered to be program induced. Perhaps the realization rates for Whole Building projects, which do not benefit from non-incented measures, produce realization rates that are less than 100% because the utility tracking estimates of energy savings were obtained using standard Title-24 operating schedules, while the evaluation relies on “as-surveyed” operating schedules.

At any rate, the data presented in these tables clearly illustrate the value of the Whole Building Approach. In turn, we also recognize that not all projects are good candidates for the Systems Approach; therefore the program has an obvious need to continue offering both participation approaches.

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 building type, end-use, and system vs. whole building projects. Assessments of free-ridership by measure category and assessments of spillover by end-use are shown, where possible.

Energy Findings

Free-ridership and Spillover Net Savings Results

To calculate free-ridership and spillover, RLW surveyed decision makers on their efficiency choices for incented measures and measures more efficient than baseline, for participants and non-participants respectively. 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 then analyzed to obtain the net savings for participants and spillover savings for non-participants.

Table 26 shows the total net program impacts taking into account both participant free-ridership and non-participant spillover. Using this methodology, the net participant savings are 79,296 MWh, which corresponds to a net realization rate of 62.8% and a net-to-gross ratio of 60%. Spillover savings in the non-participant population are 6,401 MWh. These two results together suggest a total net program impact of 82,697 MWh, yielding a net realization rate of 68.0% and a net-to-gross ratio of 65.0%.

	Program Energy Impacts (MWh)	Calculation
Program Tracking Savings	121,531	A
Gross Savings	127,216	B
Gross Realization Rate	104.7%	(B / A)
Net Participant Savings	76,296	C
Participant Net-to-Gross Ratio	60.0%	(C / B)
NP Spillover Savings	6,401	D
Total Net Savings	82,697	C + D
Net Realization Rate	68.0%	(C + D)/A
Net-to-Gross Ratio	65.0%	(C + D)/B

Table 26: Total Net Energy Program Impacts

Table 27 displays the estimated spillover savings in the non-participant population by end-use. The refrigeration end-use accounts for more than 70% of the spillover energy savings that are occurring in the non-participant population. Much of the refrigeration savings can be attributed to a large grocery store chain that reported significant interaction in the design of their prototype (or master spec) construction plan. The remaining spillover is mostly occurring in the LPD end-use. There is no spillover occurring in the lighting control or shell measure categories.

End Use	Non-Participant Spillover Energy Savings (MWh)
Shell	(3)
LPD	1,575
Daylighting Controls	-
Other Lighting Controls	(1)
HVAC + Motors	79
Refrigeration	4,751
Combined Total	6,401

Table 27: Non-participant Spillover Energy Savings

Table 28 shows the total net program impacts by measure type, taking into account both participant free-ridership and non-participant spillover. For this analysis we have disaggregated the measure categories by measure type in order to present a comparison between participants and non-participants. Not surprisingly, the LPD measure shows non-participants have been influenced by the program, nearly 1,600 MWh of spillover energy savings were reported. However the net–to-gross ratio is below 70% because a number of program participants reported the program not influencing their decision to install an energy efficiency lighting system. The refrigeration measure category produced a net-to-gross ratio of 150%, primarily a result of the significant non-participant spillover discussed previously.

The industrial end-use has the worst net-to-gross ratio, 35.2%, which is having a significant negative affect on the overall net-to-gross ratio for the program because the industrial end-use comprises 26% of the total gross savings. Also, the methodology used to determine spillover savings for commercial projects is not applicable to industrial measures; therefore industrial projects and measures do not benefit from spillover, as do commercial measures.

Considering only the commercial end-uses, the program is producing a healthy net-to-gross ratio of 75.3%. Just over 5% (6,401 MWh) of the 75% is a result of spillover savings. Without the spillover impact, the program would have experienced approximately 30% free-ridership. For comparison sake, the previous BEA study found the participant net-to-gross ratio to be 59% for commercial buildings, excluding spillover savings[13]. This finding indicates that in terms of the commercial program, free-ridership has been reduced by approximately 10% when compared to the previous two years of evaluation.

[13] There were no industrial projects in the previous BEA study to compare these results to. The “participant net to gross” only accounts for free-ridership, it does not include spillover savings.

	Net Participant Savings (MWh)	Relative Precision of Net Participant Savings	NP Spillover Savings (MWh)	Total Net Savings (MWh)	Gross Savings (MWh)	Net-to-Gross Ratio
Shell	4,778	45.8%	-3	4,774	5,466	87.4%
LPD	16,607	28.0%	1,575	18,182	26,649	68.2%
Daylighting Controls	8,820	46.5%	0	8,820	15,537	56.8%
Other Lighting Controls	3,126	34.4%	-1	3,125	3,989	78.4%
HVAC + Motors	21,916	30.4%	79	21,995	33,401	65.9%
Refrigeration	9,577	65.9%	4,751	14,328	9,566	149.8%
Combined Commercial Total	**64,824**	**17.5%**	**6,401**	**71,225**	**94,607**	**75.3%**
Industrial	11,472	44.3%	NA	11,472	32,610	35.2%
Combined C&I Total	**76,296**	**16.3%**	**6,401**	**82,697**	**127,216**	**65.0%**

Table 28: Total Net Energy Program Impacts by Measure Type

In order to draw any conclusions between the net savings findings presented in the 99-01 BEA Study and the 2002 study it is necessary to consider the impact industrial projects made on the overall 2002 participant net-to-gross ratio. Table 29 differentiates the results of the net savings analysis by sector (industrial and commercial). For example, the first row contains the participant net-to-gross ratios for commercial projects that were studied in 1999-2001. The second row presents the same information for commercial projects that were studied in this evaluation. For commercial buildings, the results show that in 2002 the Savings By Design program greatly reduced free-ridership, by roughly 15%. Next in the table are the results for industrial projects that participated in the 2002 program. The data shows that a significant amount of free-ridership is occurring in the industrial sector. Because the industrial net-to-gross is 35%, the overall combined C&I net-to-gross is reduced to 60%.

In the previous 99-01 BEA study there were no industrial projects, whereas in the 2002 study the emergence of energy savings due to industrial measures was great. In total, industrial projects represented one-quarter of the overall energy savings evaluated in the 2002 BEA Study. Since these projects represent such a large share of the overall energy and demand savings, they contribute greatly to the overall net-to-gross of the program.

Industrial measures are new to the SBD evaluation, in comparison to the commercial measures. Within the industrial projects we evaluated there tended to be a greater rate of free-ridership in the very large energy savings projects, and less so in the smaller energy savings projects. Key factors that contributed to high industrial free-ridership were a combination of the following:

- Decisions to install energy efficient equipment were made before initial contact with SBD representative,
- Energy savings for one, very large, project were disallowed because the evaluators did not find the project compliant with the Energy Efficiency Policy Manual's Chapter 2: Program Design Requirements and Eligibility Guidelines, and
- Participation in the program only partially influenced the measure or measures.

Sector	Net-to-gross Method	NTGR
Commercial	99-01 Participant Net-to-gross	59%
Commercial	2002 Participant Net-to-gross	75%
Industrial	2002 Participant Net-to-gross	35%
C&I	2002 Participant Net-to-gross	60%

Table 29: Comparison of Net-to-Gross Ratios to 99-01 BEA Study Findings Free-ridership by Measure Category – Incented Measures Only

Table 30 shows the free-ridership rate by measure category for incented measures only. The following tables cannot be produced for the "all measures" parametrics since there is not tracking savings available at this level. The most significant amount of free-ridership is occurring in the shell category, which is primarily composed of high performance glazing measures. Approximately 75% of participants with building shell measures report they would have installed building shell measures with the same efficiency absent the program and its incentives. Although this area of the program does prove to have the highest rate of free-ridership, readers should also consider the low penetration this measure has in the program. Recall from the earlier section, shell measures account for only 2% of the program's energy savings.

The area of the Savings By Design program with the next highest rate of free-ridership is the industrial measure grouping. Industrial measures were diverse and 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, since these measures were typically so important to the customer's process, were large in terms of energy consumption, and expensive to procure, decision makers most often were easily able to recall and discuss the decision making process that led them to install the equipment incented by Savings By Design. The results of these efforts showed the majority of industrial measure savings to be free-ridership, as indicated by the 65% free-ridership rate. Further information on these findings can be obtained by reviewing the industrial site write-ups that discuss the individual measures at the various industrial projects that were included in the evaluation sample.

The area of the program claiming the third highest amount of free-ridership is the LPD measure. This area of the program also had an extremely high rate of free-ridership in the previous evaluation. Like last year, the evaluation has also found that non-participants are designing lighting systems with LPD's that are slightly lower than the participants (see Figure 3). Although those findings in particular have been somewhat surprising, the fact is they do support the net savings results for the LPD end-use.

Of interesting note is that Whole Building Approach projects are producing a 70% net-to-gross ratio, the second best of any other measure (second to refrigeration measures). As discussed earlier, these projects account for a significant portion of the program's total energy savings, they save the most energy on a savings per square foot basis, and they a relatively good measure of net savings, all-in-all adding up to what appears to be the most cost effective type of project for the Savings By Design program.

	Measure Category	Participant Net Energy Savings (MWh)	Relative Precision of Participant Net Savings	Measures Only Gross Savings (MWh)	Net-to-Gross Ratio	Free-Ridership Rate	Program Tracking Energy Savings (MWh)	Net Realization Rate
Systems Approach	Shell	80	98.6%	338	23.6%	76.4%	224	35.6%
	LPD	8,054	33.9%	17,253	46.7%	53.3%	20,446	39.4%
	Daylighting Controls	4,769	61.9%	8,037	59.3%	40.7%	11,412	41.8%
	Other Lighting Controls	-	-	-	-	-	-	-
	HVAC + Motors	6,453	40.8%	12,840	50.3%	49.7%	24,452	26.4%
	Refrigeration	5,652	85.2%	5,652	100.0%	0.0%	4,145	136.4%
	Whole Building	20,571	35.7%	29,404	70.0%	30.0%	27,289	75.4%
	Combined Commercial Total	**45,578**	**22.0%**	**73,524**	**62.0%**	**38.0%**	**87,967**	**51.8%**
	Industrial	11,472	44.3%	32,610	35.2%	64.8%	33,564	34.2%
	Combined C&I Total	**57,050**	**19.7%**	**106,133**	**53.8%**	**46.2%**	**121,531**	**46.9%**

Table 30: Participant Free-Ridership and Net Realization Rates by Measure Category – Incented Measures Only

Summer Peak Demand Findings

Free-ridership and Spillover Net Savings Results

Table 31 shows the total net program impacts for summer peak demand reduction, taking into account both participant free-ridership and non-participant spillover. The net participant savings are 17.7 MW, which corresponds to a net realization rate of 66.5% and a net-to-gross ratio of 61.7%. Spillover savings in the non-participant population are 0.9 MW. These two results together suggest a total net program impact of 18.5 MW, yielding a net realization rate of 69.6% and a net-to-gross ratio of 64.7%.

	Program Demand Impacts (MW)	Calculation
Program Tracking Reduction	26.6	A
Gross Reduction	28.6	B
Gross Realization Rate	107.5%	(B / A)
Net Participant Reduction	17.7	C
Participant Net-to-Gross Ratio	61.8%	(C / B)
NP Spillover Reduction	0.9	D
Total Net Reduction	18.5	C + D
Net Realization Rate	69.6%	(C + D)/A
Net-to-Gross Ratio	64.8%	(C + D)/B

Table 31: Total Net Demand Program Impacts

Table 32 displays the estimated spillover demand reduction in the non-participant population by measure category. The refrigeration end use accounts for approximately 67% of the spillover demand reduction that is occurring in the non-participant population. The remaining spillover is occurring in LPD and HVAC + Motor measures.

End Use	Non-Participant Spillover Demand Reduction (MW)
Shell	0.0
LPD	0.2
Daylighting Controls	-
Other Lighting Controls	(0.0)
HVAC + Motors	0.1
Refrigeration	0.6
Combined Total	0.9

Table 32: Non-participant Spillover Demand Reduction

Table 33 shows the total net program demand reduction by measure type, taking into account both participant free-ridership and non-participant spillover. Using this methodology, the refrigeration measure has a net-to-gross ratio exceeding 100%. All other commercial measures have a net-to-gross ratio ranging between 50% and 75%. The industrial measure has a net-to-gross ratio of 33.3%, which is similar to energy findings.

	Net Participant Reduction (MW)	Relative Precision of Net Participant Reduction	NP Spillover Reduction (MW)	Total Net Reduction (MW)	Gross Reduction (MW)	Net-to-Gross Ratio
Shell	2.3	45.7%	0.0	2.3	3.1	73.4%
LPD	3.4	27.1%	0.2	3.6	5.5	65.7%
Daylighting Controls	2.7	46.8%	0.0	2.7	4.8	55.8%
Other Lighting Controls	0.6	34.8%	0.0	0.6	0.9	69.8%
HVAC + Motors	5.8	29.3%	0.1	5.9	8.6	68.5%
Refrigeration	1.4	72.4%	0.6	2.0	1.3	144.9%
Combined Commercial Total	**16.2**	**16.9%**	**0.9**	**17.0**	**24.1**	**70.6%**
Industrial	1.5	47.3%	NA	1.5	4.6	33.3%
Combined C&I Total	**17.7**	**16.0%**	**0.9**	**18.5**	**28.6**	**64.8%**

Table 33: Total Net Demand Program Reduction by Measure Type-Self Report Methodology

Free-ridership by Measure Category – Incented Measures Only

Table 34 shows the free-ridership rate for summer peak demand reduction by measure category for incented measures only. According to the decision-makers, the program appears to be experiencing a relatively high rate of free-ridership for most measures. The table shows that the greatest amount of free-ridership is occurring for the industrial and shell measures at 66.7% and 83.9%, respectively. LPD and HVAC + Motors measures also have free-ridership rates exceeding 50%. The exception to the relatively high free-ridership is the Whole Building and refrigeration measures, which have free-ridership rates less than 25%.

Table 34 also shows net realization rates by measure category for incented measures only. Shell, refrigeration, and whole building measures are the only measures having a net realization rate greater than 50%. LPD and daylighting controls each have net realization rates between 35% - 45%, HVAC + Motors has a net realization rate just under 30%.

	Measure Category	Measures Only Net Demand Reduction (MW)	Relative Precision of Participant Net Reduction	Measures Only Gross Demand Reduction (MW)	Net-to-Gross Ratio	Free-Ridership Rate	Program Tracking Demand Reduction (MW)	Net Realization Rate
Systems Approach	Shell	0.0	108.0%	0.3	16.1%	83.9%	0.1	63.3%
	LPD	1.4	38.1%	3.4	41.9%	58.1%	3.9	36.7%
	Daylighting Controls	1.5	62.6%	2.5	59.9%	40.1%	3.4	43.5%
	Other Lighting Controls	-	-	-	-	-	-	-
	HVAC + Motors	1.3	43.5%	3.2	39.4%	60.6%	4.6	27.2%
	Refrigeration	0.9	97.0%	0.8	103.4%	-3.4%	0.5	184.5%
	Whole Building	6.3	36.3%	8.4	75.2%	24.8%	10.2	61.8%
	Combined Commercial Total	**11.4**	**23.9%**	**18.5**	**61.3%**	**38.7%**	**22.6**	**50.3%**
	Industrial	1.5	47.3%	4.6	33.3%	66.7%	4.0	37.9%
	Combined C&I Total	**12.9**	**21.8%**	**23.1**	**55.8%**	**44.2%**	**26.6**	**48.4%**

Table 34: Participant Free-Ridership and Net Realization Rates by Measure Category – Incented Measures Only

Decision-maker (DM) surveys were designed to obtain data to assist RLW in determining 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.

Decision-maker (DM) surveys were designed to obtain data to assist RLW in determining 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.

The following sections of this chapter correlate directly with the flow of the decision-maker survey. Wherever possible, the participant and non-participant responses are analyzed and presented together. The responses are presented in a format that facilitates comparison of Non-participants to participants.

This section is further divided into the following categories:

- Building Descriptive Statistics,
- Construction and Commissioning Practices,
- Energy Efficiency Attitudes,
- Building Energy Performance,
- Savings By Design Program Attitudes and Awareness, and
- Prototype Projects

A total of 132 owner surveys were completed. Of the 132 surveys, 68 were with participant owners and 64 were with non-participant owners. The industrial participants were not administered the standard decision maker survey due to issues of applicability; therefore their responses are not included in this section. All of the decision-maker responses have been weighted to the population using the case weights that were developed for the gross savings analysis.

Due to skip patterns in the surveys, not all respondents answered all the questions. The variation in sample size for the various questions requires a test of significance for these results. For example: a difference of 15% would be significant in a sample size of 100 respondents, but would not be statistically significant for a sample population of 5. All statistical significance tests were conducted at the 90% level of confidence. Statistically significant differences between participant and non-participant responses are shaded in gray.

Building Descriptive Statistics

Table 35 shows the building ownership type by program participation status. While the vast majority of projects are privately owned for both types of respondents, the percentage of non-participant private projects (76.7%) is slightly lower than that of participants (81.0%). The low percentage of publicly owned buildings in the participant population may indicate that the utilities are avoiding program free-ridership that would result from mandated efficiency requirements in the public sector, as recommended in previous evaluations.

	% of Respondents	
	Participants	Non-Participants
Private	81.0%	76.7%
Public	19.0%	21.1%
Don't Know	-	2.3%

Table 35: Building Ownership[14]

Table 36 shows the building occupancy intent during construction by program participation status. Research has shown that owner-occupied buildings are designed more efficiently. [15] The pattern of ownership is similar between the two groups.

	% of Respondents	
	Participants	Non-Participants
Owner-Occupied	73.2%	67.1%
Lease All Spaces	20.9%	29.3%
Both	6.0%	3.6%
Don't Know	-	

Table 36: Occupancy Intent During Construction

Table 37 presents the most important financial criteria used to make energy efficient investments during construction by program participation status. Both participants and non-participants consider "return on investment" the most important financial criteria. A slightly higher percentage of participants (25.3%) supported this criterion than did non-participants (22.1%).

The percentage of participants (22.3%) who responded "simple payback" was significantly higher than that of non-participants (5.6%).

The only criterion where the percentage of non-participant responses (3.0%) was significantly higher than that of participants (19.1%) was "lowest first cost." Participants appear to be more concerned with life cycle costs than are the non-participants. The participants are much more likely to implement more comprehensive methods (i.e., lifetime cost, ROI, simple payback) in making energy efficiency purchasing decisions, as compared to the non-participants who are more likely to make decisions based on lowest first cost.

Responses from participants of "other" included:

"Company policy"

"Always use premium efficiency items when possible"

"Capital cost"

---

[14] Shading indicates a statically significant difference between participant and non-participant.

[15] 2000 Non-residential New Construction Baseline Study

	% of Respondents	
	Participants	Non-Participants
Return on Investment	25.3%	22.1%
Lowest Lifecycle Cost	22.2%	13.9%
Simple Payback	22.3%	5.6%
Multiple	10.1%	11.5%
Lowest First Cost	3.0%	19.1%
Net Present Value	1.2%	4.7%
Other	10.1%	-
None	3.3%	15.1%
Don't Know	2.6%	8.0%

Table 37: Most Important Financial Criteria

Table 38 displays the percentage of participants and non-participants who asked their design team to consider energy efficiency above Title 24 requirements. As the table shows, a large majority of participants (66.8%) did so while only 24% of non-participants made this request for greater efficiency to their design team. Some of the verbatim explanations of why they asked their design team to consider energy efficiency are:

> *"We always explore new ways to drive down energy cost, we asked that they consider all potential energy efficient equipment."*
>
> *"Wanted to market the building, thus made improvements to make it more attractive for lease."*
>
> *"We made revisions to qualify for the incentive program."*
>
> *"We design to the highest ROIC (return on investment capital), we incorporate efficiency if the incremental cost pays for themselves."*
>
> *"We wanted to get the LEED rating which required us to far exceed Title-24."*

	% of Respondents	
	Participants	Non-Participants
Yes	66.8%	40.4%
No	24.2%	46.5%
Don't Know	9.0%	13.1%

Table 38: Ask Design Team to Increase Energy Efficiency

Respondents were asked whether the architect or designer of the project followed an integrated design approach. A greater percentage of participant respondents (43%) answered "yes" than non-participants (27%). However, about 45.5% of participants and about 48% of non-participants did not ask their team to follow an integrated design.

	% of Respondents	
	Participants	Non-Participants
Yes	43.4%	27.2%
No	45.5%	48.0%
Don't Know	11.1%	24.8%

Table 39: Architect/Designer Follow Integrated Design Approach

Commissioning and Construction Practices

Table 40 presents the percentage of participants and non-participants that included commissioning, a process that insures systems are designed, installed, functionally tested, and capable of being operated and maintained to perform in conformity with the design intent. About half the respondents (the same percentage of participants and non-participants) used commissioning in their projects

	% of Respondents	
	Participants	Non-Participants
Yes	48.5%	48.8%
No	43.6%	50.3%
Don't Know	7.8%	0.9%

Table 40: Projects that Included Commissioning

Of those who did include commissioning, the majority of the respondents stated that a third-party agent, mechanical contractor or construction manager conducted the commissioning. About 27% of the participants stated that a mechanical contractor conducted the commissioning process whereas only 16.3% of non-participants utilized that person for commissioning. About 38.8% of non-participants stated that a third-party agent conducted the commissioning.

	% of Respondents	
	Participants	Non-Participants
Mechanical Contractor	27.0%	16.3%
Construction Manager	20.9%	29.1%
Third Party Agent	18.1%	38.8%
Electrical Contractor	8.7%	-
Engineering Contractor	5.8%	5.9%
Architect	-	1.8%
Other	18.4%	2.7%
Don't Know	1.2%	5.3%

Table 41: Person who Conducted Commissioning

Energy Efficiency Attitudes

The following tables show the vast majority of respondents place some level of importance on energy efficiency during design and construction. The percentage of participants and non-participants considering energy efficiency during design and construction to be "very important" was 50.9% and 43.6% respectively, as shown in Table 42. Combining the "important" responses ("somewhat" and "very"), 92.6% of participants and 79.4% of non-participants considered energy efficiency during design and construction to be important. Note that there were no participants or non-participants that responded with "very unimportant", even though it was a response option. These results help to explain the high spillover rates documented in the previous sections.

	% of Respondents	
	Participants	Non-Participants
Very Important	50.9%	43.6%
Somewhat Important	41.7%	35.8%
Neither Important nor Unimportant	7.5%	10.3%
Somewhat Unimportant	-	5.8%
Very Unimportant	-	-
Don't Know	-	4.5%

Table 42: Importance of Energy Efficiency of Building

Table 43 shows the percentage of participants and non-participants who were involved in the decision-making process for Title 24 compliance. A significantly higher percentage of participants (66.9%) were involved in the process than were non-participants (44.3%).

	% of Respondents	
	Participants	Non-Participants
Yes	66.9%	44.3%
No	13.5%	24.9%
Somewhat	19.6%	27.4%
Can't Remember	-	0.9%
Don't Know	-	2.6%

Table 43: Involvement in Decision-Making Process for T24 Compliance

Building Energy Performance

All participants and non-participants were asked to compare the efficiency of their building relative to California's energy code (Title 24). Table 44 presents the distribution of responses for both groups. About 44% of participants believe their buildings are better than code, where as only 13.5% of the non-participants thought so, which is a statistically significant difference. Participants and non-participants were equally as likely to believe their buildings were slightly better than required by code. Participants and non-participants were equally as likely to believe their building was just efficient enough to comply with Title 24.

	% of Respondents	
	Participants	Non-Participants
Much Better than Required by Title 24 Energy Code	43.9%	13.5%
Little better than Required by Title 24 Energy Code	36.8%	43.1%
Just Efficient Enough to Comply with Title 24 Energy Code	16.7%	23.7%
Don't Know	2.6%	19.7%

Table 44: Level of Compliance with T24 Energy Code

Table 45 summarizes the responses given when owners were asked to describe the energy performance of their building. Three-fourths of the participants believed their building to be either "an example of energy efficiency" or "as efficient as can be." About 19.1% of the participants stated that their buildings were an example of energy efficiency for others to follow, where as a significantly lower percentage (1.3%) of non-participants felt the same way about their building. However, roughly the same percentage of participants and non-participants stated that their buildings could be much more efficient, somewhat more efficient or about as efficient.

	% of Respondents	
	Participants	Non-Participants
Could be Much More Efficient	4.7%	12.6%
Could be Somewhat More Efficient	32.2%	49.4%
About as Efficient as Can Be	38.1%	25.6%
An Example of Energy Efficiency for Others to Follow	19.1%	1.3%
Don't Know	5.9%	11.1%

Table 45: Energy Performance of Building

Savings by Design Program Attitudes and Awareness

Participants

All SBD program participants were asked how they first became aware of the SBD program, services, and owner incentives that were available. As shown in Table 46, about 71% of participants heard of the program through utility representatives or previous utility program participation. The large proportion of participants that previously participated in NRNC programs (45.5%) 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. This approach would likely lead to lower free-ridership and a potential increase in non-participant spillover.

	% of Participants
Previous Utility Program Participation	45.5%
Utility Representative	26.1%
Other	9.2%
Architect	5.7%
Engineer	5.0%
Construction Manager	4.2%
Marketing Material	4.0%
Web Site	-
Manufacturer Representative	-
Energy Manager	-
PreviousTenant	-
Don't Know	-

Table 46: Source of Awareness of Savings By Design

Table 47 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. About half of the participant owners say they, the owners, were the biggest advocates for SBD participation. This supports the finding of the NRNC baseline study[16] that architects and engineers feel that the owners are the key decision-makers. Surprisingly, energy manager, facility manager and construction manager were cited much more often than designers as being the biggest advocate for participation. Those that are considered a part of the ‘Other’ category were often serving as director of facilities/operations and engineers.

	% of Participants
Owner/Developer	53.8%
Other	17.2%
Energy Manager	10.8%
Architect	7.7%
Construction Manager	4.2%
Lighting Designer/Electrical Engineer	3.4%
Mechanical Engineer	2.9%
Manufacturer Representative	-

Table 47: Biggest Advocate for Participating in SBD

All SBD participants were asked to rate the level of importance of the dollar incentive paid to the owner in motivating their organization to participate. As shown in Table 48, over half of owners felt the incentive was very important. The percentage considering the incentive unimportant was about 5%.

	% of Participants
Very Important	53.4%
Somewhat Important	32.9%
Neither Important nor unimportant	9.3%
Somewhat unimportant	4.4%
Very unimportant	-
Don't Know	-
Refused	-

Table 48: Importance of Owner Incentive in Participation

As shown in Table 49, 60% of participants stated SBD participation influenced them to change their standard building practices to lead to more efficient buildings. The message from the 38% answering “No” is less clear. If their “standard building practice” is an equivalent level of energy efficiency, then they are program free riders. If their standard practice is less than SBD requirements, then they would be expected to revert to less efficient practices in the absence of the program incentives, disregarding the benefits of building life cycle cost analysis. The following comments by participants suggest that both characterizations apply.

---

[16] The 1999 Baseline Study was conducted under the direction of the California Board for Energy Efficiency (CBEE) for buildings constructed between 1994 and 1998. It is important to note that the study included only four predominant market segments: schools, offices, retail, and public assembly. The study also evaluated the buildings against the applicable code at that time which was 1995 Title-24.

"We need to be energy efficient regardless of the program because we're concerned with operating costs."

"Only if an incentive is involved, otherwise we are only concerned with lowest first cost."

"We were already concerned with efficiency prior to participation."

"We have a central design philosophy that goes hand in hand with the SBD approach. We know what works and we employ this in our buildings."

	% of Participants
Yes	59.7%
No	37.5%
Don't Know	2.8%

Table 49: Owner Incentive and NC Rep. Influence on Design of Building

All participant owners were asked whether they used the Systems Approach or the Whole Building Approach and 39.3% stated that they used the Whole Building Approach, as shown in Table 50. About one-third of the participants used the Systems Approach and over a fourth of the participants did not know.

	% of Participant
The Systems Approach	34.2%
Whole Building Approach	39.3%
Don't Know	26.5%

Table 50: Method of Program Delivery

All participants were asked to rate the level of influence of various SBD components on the design of the participant building. Respondents used a three-point scale to specify their rating with 1 indicating "definitely influenced", 2 indicating "possibly influenced", and 3 indicating "did not influence". Table 51 shows the responses in regards to each of those components. On average, the incentive was rated slightly higher in value than design assistance and analysis.

	Average
Incentive	2.27
Design Assistance/Analysis	2.23

Table 51: Level of Value of Components of Program

All participants were asked to provide recommendations for change to the SBD program in order to improve its delivery to customers. These answers were unprompted, but have been categorized based on common responses. Table 52 shows that a third of the participants felt that no changes are needed. The most frequent recommendation was to increase incentive amount.

	% of Participants
No Changes Needed	33.5%
Increased Incentive	27.5%
More Marketing to Increase Awareness of Program	13.6%
More Interaction with Design Team	4.6%
Less Paperwork and Red Tape	3.7%
Increase Post Project Feedback, Better "Closure"	2.4%
Utiltities Should Try to Get Involved Earlier in Projects	1.7%
Utility Reps Needed to Present Benefits More Clearly	1.2%
Review & Response from Utility Needs to be More Timely	0.6%
Other	11.3%

Table 52: Recommended Changes to Savings By Design

Non-participants

All non-participants were asked if they were aware of the Savings By Design New Construction energy efficiency program before they began construction. Table 53 shows about 54% of non-participants were aware of the program before they began construction. These findings do suggest that the SBD program is reaching over half of the non-participants, but that they are choosing not to participate.

	% of Non-Participants
Yes	53.8%
No	46.2%
Don't Know	-

Table 53: Awareness of SBD Before Construction Began

The 54% of non-participants who were aware of SBD before construction began were asked to state the reason why they did not participate in the program. Below are some of the responses that were provided.

> *"We thought there was no more funding available."*
>
> *"SDG&E indicated there won't be incentives available for us."*
>
> *"The incentive was not significant enough for the amount of effort required."*
>
> *"It was not going to be worth the effort for the amount of the incentive."*
>
> *"It was likely a combination of the timing on the project (fast track) or the utilities may have run out of funding."*

These respondents (the 54% answering "yes" in Table 53) were asked if they had any interaction with their utility's new construction program representative or SBD program material regarding the design and equipment specification of their project. The results are displayed in Table 54. A large percentage of the respondents (89%) did not have any interaction with SBD staff or program material regarding design and equipment specifications.

	% of Non-Participants
Yes	11.0%
No	89.0%
Don't Know	-

Table 54: Interaction with SBD Staff or Program Material Regarding Design and Equipment Specifications

All non-participants who were aware of SBD were asked if they were aware of the incentive and if it would have motivated them to design their building to perform better than Title-24. The results are provided in Table 55. About 60% of non-participants who were not aware of the incentive when construction began stated that they would have been very or somewhat likely to design their building to perform better than Title-24 if they had known of the incentive. These findings correspond with the findings in Table 48 that indicate the cash incentive was the original basis for program participation of roughly 50% of program participants.

	% of Non-Participants
Very Unlikely	11.2%
Somewhat Unlikely	4.9%
Neither Likely Nor Unikely	21.7%
Somewhat Likely	17.9%
Very Likely	41.7%
Don't Know	2.6%

Table 55: Likelihood of Designing Building to Perform Better than Title-24 if Aware of Financial Incentives

Prototype Projects

An addition to the 2002 BEA study is a portion of the decision-maker survey that probed the participants about the use of prototype plans. 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. In the 99-01 BEA study it was determined that these types of projects should be uniquely studied due to the various nuances related to prototype development, construction, and program participation. The questions in this section were developed in order to provide program planners with some basic program planning information regarding prototype projects.

Approximately 31% of the projects sampled used a set of prototype plans for their Savings by Design participation. Of those who used a set of prototype plans, about 40% received design assistance through Savings by Design to enhance the energy efficiency of these prototype plans, as shown in Table 56. However, about half of these participants did not. Greater penetration of design assistance to participants may increase the degree of energy efficiency in these buildings.

	% of Participants
Yes	40.3%
No	49.9%
Don't Know	9.8%

Table 56: Received Design Assistance through SBD

Table 57 presents the results for eight participant respondents who used a set of prototype plans and did not receive design assistance. They were asked whether they would have built to the same level of efficiency without the incentives, and 80.5% of these stated that they would do so. None of the eight said no, and about 20% did not know.

	% of Participants
Yes	80.5%
No	-
Don't Know	19.5%

Table 57: Would have built with Same Efficiency without Incentive

Of those who utilized a set of prototype plans, over 71% used the plan for more than 10 buildings, as shown in Table 58. Clearly, the utilities can have a greater impact by recruiting decision makers that use prototype plans, and by spending extra time and resources with design assistance with this subset of the population.

	% of Participants
One building	-
2-5 buildings	9.6%
5-10 buildings	19.0%
More than 10 buildings	71.4%
Don't Know	-

Table 58: Number of Buildings in Prototype

The Program's rules for prototypes has evolved since 1999, and led to a "proto-type 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 limited it to one building within each prototype plan.

RLW asked participants with prototype plans what percentage of their projects qualified for an incentive and on average, 77.5% of their projects qualified. About one-fifth of the participants did not know. However, 76% of the participants with prototype plans stated that they would have participated and built efficiently if they only received a financial incentive for one building only.

	% of Participants
Yes	76.3%
No	23.7%
Don't Know	-

Table 59: Would have Participated if IOUs Limited Incentive to One Building only

A few of the verbatim responses given by the participants who **would** have participated anyway if the IOUs limited them to one incentive per prototype building are as follows:

> *"Yes, we would still have participated with the one building as long as it was cost effective."*
>
> *"The emphasis wasn't on the incentive, it was on saving energy. The incentives help us to recover a quicker payback."*
>
> *"We might have done the one building and used a more generic and less efficient prototype that is applied nationwide; probably about 70% of the measures would have been installed."*
>
> A couple of the reasons given by the participants who **would not** have participated if the IOUs limited them to one incentive per prototype building were:
>
> *"We might have done one building then stuck to a rough baseline that was more generic for our stores nationwide."*
>
> *"The time and effort involved in modeling the prototype would have increased the total project cost and substantially reduced the return on investment without the incentive."*

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.

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 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 future evaluations so as to enhance future evaluation findings that would go toward answering 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.

To begin, 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 year (2002), which means we are evaluating projects that initially signed onto the program as early as 1999, or as late as 2002. CPUC approved programs implemented prior to 2004 were implemented on single year funding cycles. Due to the short (one year) implementation period and 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 2002.

The 2003 SBD evaluation will be no different than the 2002 evaluation, so testing for cost effectiveness will not likely be an option. The utilities and the CPUC should consider this when writing the RFP for the 2004-05 evaluation, acknowledging the fact that it may be years after 2005 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.

We believe 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 by the 2004-05 evaluation these inputs would also require thorough review. For this particular program, a significant investment would likely be necessary if the evaluation were to undertake review and evaluation of all cost-effectiveness inputs, most notably Gross IMC.

Cost effectiveness aside, it seems 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 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. (Although it does appear as though the utilities should strongly consider dropping low LPD as a systems measure due to high free-ridership rate trends for this measure.) The incentives continue to be the clear motivator for participation, proving that the program continues to overcome cost barriers. 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 will 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. Furthermore, the last three years of this evaluation have identified significant spillover savings in the non-participant population, substantiating positive market effects outside of the participant pool. Moreover, a significant proportion of the non-participants reported that they would have participated in the program and designed their building differently had they known of the programs availability at the time of design and construction, further implying a need for this particular program serving the NRNC market.

Projects that Consider Future Savings

One of the projects sampled by the evaluation was dropped because the rules of evaluation are not clear. The project in question is not all that uncommon and we believe projects similar to the following example require a policy decision by the CPUC.

The example identified by the 2002 evaluation is a new central plant project that included incentives for energy savings that are expected to increase over the course of several years while the campus is being built-out. More specifically, the central plant is currently only partially loaded, although it is planned that over the next 5-10 years the chiller will be fully loaded when more buildings are completed and become tied into the central plant. The program provided incentives based on a fully loaded high efficiency chiller, but since the chiller will not be fully loaded for several years the energy savings claims are currently overstated.

Unfortunately the utilities have no other means to claim energy savings for projects like this, so the alternative is to either put it into the program as is, or conversely, not allow the project into the program. Of course the latter is not an acceptable alternative if the goal of the SBD program is to produce more energy efficient buildings and construction practice. Therefore we feel it is important that the utilities have a mechanism for including projects like this in the program, while at the same time having the ability to accurately claim energy savings. We believe there are likely several solutions to this issue, however we do not feel the evaluator is the entity most qualified to recommend how this tracking problem should be addressed. Instead we raise the point as an issue and suggest that the utilities and the CPUC agree upon protocols for managing projects that are expected to meet their energy savings potential well after the year in which they receive the incentive.

Net Savings Analysis for Prototype Projects

During the course of evaluating net energy savings it was determined that there were some inequities in the way spillover and free-ridership are being evaluated. The specific issue pertaining to this discussion arises when a participant receives incentives for a project (or projects) that were built using a prototype plan in which the utility influenced the design and efficiency. We found at least one case where a participant built a second building (Building B) that utilized a prototype that was heavily influenced by the utility. The participant reported that they would have built the exact same building even if an incentive had not been provided. However they also acknowledge that without the design analysis that was provided on the original prototype plan (Building A) they likely would not have built either building (Building A or B) to the same level of efficiency.

Our original protocols would have considered Building B to be a full free-rider, based on the responses of the decision maker survey and scoring methodology. Now consider a similar situation, a non-participant that built a building using a prototype that was influenced by the utility reports that some, or all of the energy efficiency savings are due to the program's design assistance in which an energy efficient prototype was the result of their prior interaction. Here lies the inequity in the process. In both cases it seems as though the program is responsible for creating the energy savings, yet current methodology only gives credit to the non-participant (i.e., some spillover) and no credit is given to the participant (i.e., all free-ridership).

As a result of this finding we have implemented a shift in methodology regarding prototype projects. Using the example above, we in fact do believe that the program should receive credit for influencing the design of Building B, but we need direction from the CPUC on how much credit should be given. For this particular situation we applied the participant net to gross ratio from the 2000-2001 BEA study (0.58).

In the upcoming 2003 study RLW will identify this as an issue that will need to be resolved. To aid in the resolution, RLW will interview the Program Managers to better understand how SBD projects resulting in prototype or "master spec" building plans are managed by each of the utilities. RLW will review the survey instruments and recommend a methodology for estimating the net energy savings once we understand the utility processes and all the nuances of prototype projects. We will also add a non-participant prototype module to the existing non-participant survey guide (a participant prototype module already exists and was in use for the 2002 evaluation). In turn this process will provide the utility Program Managers with a clear understanding of how prototype projects will be evaluated in the future, addressing their need to minimize program free-ridership.

Non-participant Survey Methodology

In this year's evaluation of the program we continued to encounter difficulties when discussing end-use level decision making with program <u>non</u>-participants. The ability of these decision makers to recall end-use level decision-making is nowhere near as strong as it is for participants. We believe this is true because of the in-depth interactions participants often have when deciding between energy efficient and baseline equipment, and the qualification criteria for the SBD program. Non-participants obviously do not go through the participant process, and do not benefit from an in-depth interaction with measure level decision-making with regard to remembering their decision making process. Non-participant questions at the measure level have been used in the previous three years of evaluation to estimate spillover at the measure level. For the 2003 evaluation we propose generalizing the questions to assess spillover at the building level, rather than the end-use level. In doing so the evaluation will continue to provide measure level spillover findings by applying spillover ratios to the DOE-2 end-use parametrics. We believe the result of these changes will not result in the loss of EM&V information, instead there will be less subjectivity introduced into the end-use level information provided for non-participant spillover.

Tracking of Energy Savings for Motor Measures

SDG&E and PG&E track motor measure savings as an independent measure, while SCE tracks motor measure savings within the HVAC end-use savings. We recommend that SCE begin tracking data like PG&E and SDG&E. Doing so will result in more consistent data tracking, and will also allow evaluators the ability to report more detailed findings. For this report we were forced to combine motor and HVAC into a single end-use. If SCE tracks savings data separately for motor measures the evaluation will be able to provide detailed evaluation data on both motor and HVAC measures independent of one another.

The Whole Building Approach

The Whole Building Approach to program participation continues to be the most effective approach to energy efficient design in non-residential new construction projects. While we do not think this is a surprise, the details lie in the data presented in the report. For example, whole building projects save on average three times the energy and demand when compared to their counterpart Systems Approach projects, and the calculated net-to-gross ratios for Whole Building projects are much better than most of the Systems measure groupings. These findings indicate that the utilities should encourage projects to participate through the whole building approach as much as possible.

Industrial Projects

Industrial new construction measures were added to this year's evaluation for the first time. Although new to the evaluation, industrial measures accounted for a significant amount of the 2002 program energy savings, claiming one quarter of the overall energy savings paid in 2002. What was most illuminating in terms of EM&V findings for this new aspect of the BEA evaluation is the disparity in net-to-gross findings between commercial and industrial projects. Findings for the industrial projects result in a net-to-gross ratio of 35%, or 65% free-ridership, whereas the commercial projects showed only about 30% free-ridership. Considering the large share of savings these projects have in terms of overall program impacts we suggest the utilities pay particular attention to industrial projects that participate in future program years. Most important are the extremely large, or high-energy saving industrial projects and measures, which more or less are driving the overall findings for industrial measures.

We found that many of the industrial participants responding to questions regarding energy efficiency decision making had a clear recollection and preconceived dispositions as to what they would have done absent the program, regardless of the incentives. 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.

In general, many of the industrial measures we evaluated appeared to be well developed before any interaction with Savings By Design representatives and consultants, rather than being a result of interaction with Savings By Design. The primary exception being refrigerated warehouses, a long time component of Savings By Design, where the influence and expertise of SBD representatives and consultants was considerable in the design and development of these projects. A more favorable net to gross ratio may be achieved by taking a more active approach to the industrial sector, as has been done with refrigerated warehouses.

Although the commercial aspects of the program proved to have a relatively good overall net-to-gross ratio of 75%, the industrial part of the program, with its 35% net-to-gross ratio, adversely impacted the program's overall net-to-gross, resulting in a net-to-gross ratio of 65%. By paying more attention to the net savings aspects for industrial participants the utilities can improve the overall net savings impacts. In producing CPUC workbooks for program cost-effectiveness the utilities may also consider using different net-to-gross indicators for commercial and industrial measures.

Evaluation of Temperature Dependent Measures

In some instances in this report we note low realization rates for both energy and demand related to heating, ventilation and air-conditioning (HVAC/motors) measures. For the upcoming evaluation it would be useful to test the assumptions and methods of the implementer's energy savings calculations against those used by this evaluation. Doing so will lead to an improved understanding of why the two sets of independently produced results have so much variation. The result of such an analysis should lead to improved program implementation and evaluation.

Interviews with Utility Consultants

Interviews with utility consultants should be considered for the 2004-05 program evaluation. For some of the more complex projects, industrial and commercial, it is not uncommon for the utilities to hire a special project consultant to provide design analysis on behalf of the program. RLW believes the evaluation would benefit from interviewing these consultants. Sampled projects that included a utility consultant would provide further insight into project specific findings. Interviews with these individuals will assist evaluators in the development of the baselines required for determining net savings impacts and understanding methods and reasoning for gross savings calculations. This specific insight and project information may otherwise be missed by the evaluation.

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
- The 2001-2002 F. W. Dodge New Construction Database
- Engineering and manufacturers' reference material
- 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 F.W. Dodge database provided the basis of the non-participant sample frame. 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. The program files and the F. W. Dodge database identified these individuals.

Sampling Plan

The selection of the participant sites was guided by a model-based statistical sampling plan as in the 1994-96 evaluation studies and the 1998 baseline study. A second sampling plan was used to guide the selection of the non-participant sample.

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 BEA study.

This study used a matched sample of participants and non-participants. Once the program tracking data became 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 participant sample design. We used a participant sample that is efficiently stratified by the tracking estimate of annual energy savings, with proportional representation of utilities in the combined participant population.

The non-participant sample was matched site-by-site to the participant sample based on square footage, climate zone, building type, and construction start quarter. In other words, the non-participant sample was selected from those Dodge projects that have the same building type, construction start quarter, climate zone, and approximately the same square footage as the participant.

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 use of the project. The primary stratification variable, the estimated energy savings of the project, will be 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:

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

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 zero expected value, and β, σ_0, and γ (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 μ_k and standard deviation σ_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 a (usually) <u>heteroscedastic</u> regression model with zero intercept.

One of the key parameters of the ratio model is the <u>error ratio</u>, 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 13 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 13 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.

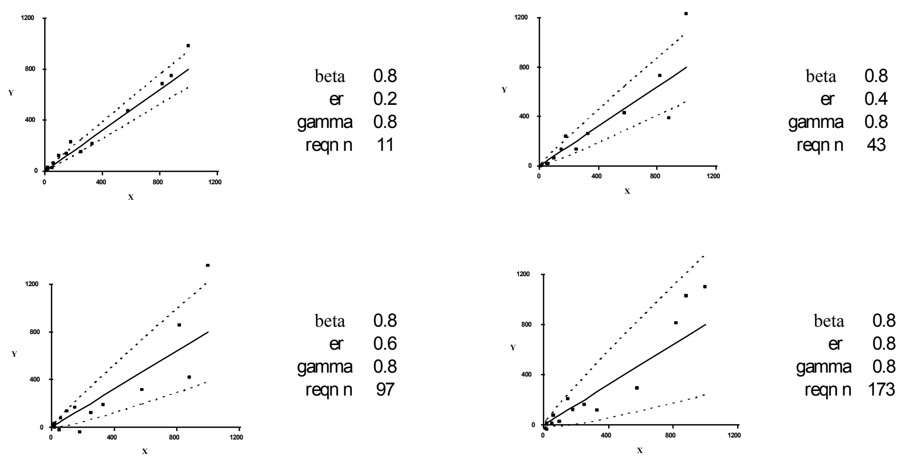


Figure 13: Examples of MBSS Ratio Models

The model parameters -- β, γ, and the error ratio -- were calculated from the 1999-2001 BEA study. The model parameters are shown in Table 60. Based on the 2001 BEA sample projects that have been completed so far, the error ratio is 0.86. *Using this value, our analysis indicated that a sample of 78 2002 BEA program participants would provide a relative precision of about ±13% at the 90% level of confidence*.[17]

Parameter	Value
β	1.06
γ	0.71
Error ratio	0.86

Table 60: Sample Design Model Parameters

In order to inform future sample designs, we have calculated the model parameters, β, γ, and the error ratio, using the actual participant population and sample.

[17] We assumed an error ratio of 0.86, a true gamma of 0.71 and a set gamma of 0.50.

Parameter	Value
β	1.096
γ	0.86
Error ratio	0.54

Table 61: Actual Model Parameters

Participant Sample Design

For the purposes of this study, a participant building was defined to be a building that received an incentive through the Savings By Design program for installing energy efficient equipment during 2002. At the sample design stage, we found that there were 430 projects paid in 2002, combining for a total tracking savings of 121,791 MWh. Considering all 430 projects, the average savings was 283 MWh per project.

Table 62 shows the sample design for the participants. 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 62 shows that for PG&E, there were 65 projects with annual savings of 36 MWh or less, and a total tracking savings of 900 MWh. The maximum kWh in each stratum is called the stratum cut point. These 65 projects were 49% of all PG&E projects, but they represented only 5% of all savings. By contrast, the eight strata 5 projects for PG&E represent only about 6% of all PG&E projects, but yielded 43% of the total tracking savings. Because the population distribution of savings is very 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	Max MWh Savings	Savings per Project (MWh)	Total MWh	Number of Projects	Sample Size	Fraction
PG&E	1	36	14	900	65	3	0.05
	2	84	58	1,752	30	4	0.13
	3	236	150	2,691	18	3	0.17
	4	515	363	4,352	12	3	0.25
	5	2,312	898	7,182	8	4	0.50
	PGE Subtotal		127	16,877	133	17	0.13
SCE	6	146	41	4,242	104	8	0.08
	7	401	239	9,564	40	9	0.23
	8	723	538	13,987	26	9	0.35
	9	1,263	906	17,217	19	8	0.42
	10	4,674	2,517	32,717	13	9	0.69
	SCE Subtotal		385	77,728	202	43	0.21
SDG&E	11	82	30	1,432	47	4	0.09
	12	242	147	2,938	20	4	0.20
	13	526	383	4,592	12	3	0.25
	14	897	700	6,303	9	3	0.33
	15	4,677	1,703	11,922	7	4	0.57
	SDGE Subtotal		286	27,187	95	18	0.19
	Total		**283**	**121,791**	**430**	**78**	**0.18**

Table 62: Participant Sample Design

We applied the sample design to the projects that were paid in 2002. The sample was selected in three steps:

1. Classify each of the projects into one of the fifteen 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 62.
3. Randomly select the specified number of projects.

Final Statewide Participant Sample Design

The participant case weights were calculated using balanced post-stratification[18]. In this approach, the sample sites are sorted by the stratification variables, utility and tracking kWh, and then divided equally among the strata. Then the first stratum cutpoint is determined midway between the values of the stratification variable for the last sample case in the first stratum and the first sample case in the second stratum. The remaining strata cutpoints are determined in a similar fashion. Then the population sizes are tabulated within each stratum. Finally the case weights are calculated in the usual way. The industrial sites were grouped in with the commercial sites in calculating the case weights because we were only able to identify mixed

[18] For a thorough discussion of balanced post-stratification, refer to the Case Weights Section within the "Gross Savings Methodology" chapter.

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 63 shows the final participant sample design that was used to calculate the participant case weights. In this case, a sample of 79 participant sites has been divided among 15 strata. Within each utility, the sample has been equally divided among the 5 strata. Then the stratum cutpoints shown in column three were calculated from the tracking estimates of kWh for the sample sites. Next the population sizes shown in column four were calculated from the stratum cutpoints. The final step was to calculate the case weights shown in the last column. For example, the case weight for the 4 sites in the first stratum is 68 / 4 = 17.

Utility	Stratum	Max MWh Savings	Number of Projects	Total MWh	Sample Size	Fraction	Weight
PG&E	1	38	68	1,011	4	0.06	17.00
	2	127	35	2,533	4	0.11	8.75
	3	331	16	3,519	3	0.19	5.33
	4	539	7	3,157	3	0.43	2.33
	5	2,312	7	6,656	3	0.43	2.33
	PGE Subtotal		133	16,877	17	0.13	
SCE	6	164	106	4,996	9	0.08	11.78
	7	431	41	11,428	9	0.22	4.56
	8	742	23	14,054	9	0.39	2.56
	9	1,386	18	18,231	8	0.44	2.25
	10	4,674	10	28,759	8	0.80	1.25
	SCE Subtotal		198	77,467	43	0.22	
SDG&E	11	74	44	1,194	4	0.09	11.00
	12	242	22	2,934	4	0.18	5.50
	13	641	15	6,027	4	0.27	3.75
	14	947	9	6,959	4	0.44	2.25
	15	4,677	5	10,073	3	0.60	1.67
	SDGE Subtotal		95	27,187	19	0.20	
Total			**426**	**121,531**	**79**	**0.19**	

Table 63: Final Participant Sample Design[19]

Table 64 presents the actual 2002 SBD population and sample by utility and the kWh savings associated with these projects. In general, the larger projects in the program were SCE and SDG&E projects. The PG&E projects tended to be smaller projects. Since the smaller projects have lower sampling fractions, PG&E had smaller sample sizes than SCE and SDG&E.

2002	PG&E		SCE		SDG&E		Statewide	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample
Number of Projects	133	17	198	43	95	19	426	79
MWh Savings	16,877	4,567	77,467	37,195	27,187	12,966	121,531	54,728
Savings per Project (MWh)	127	269	391	865	286	682	285	693

[19] There are 4 fewer sites in the population than in the original sample design due to 4 sites being excluded that were not part of the program.

Table 64: Actual 2002 SBD Participation and Sample by Utility – kWh 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 62 shows, the sample design was based on a stratified sampling plan that over-sampled projects with greater kWh tracking savings, and under-sampled sites with fewer kWh tracking 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 kWh tracking 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.

Non-participant Sample Design

For the purposes of this study, a non-participant building is defined to be a building that completed construction during 2000 – 2002 and did not receive any incentives from a utility-sponsored energy efficiency program.

The non-participant sampling frame was the F.W. Dodge database of new construction. Several preliminary steps were required to prepare the Dodge data for use as a non-participant population. They were:

- Filtering for buildings ready to begin construction
- Filtering out “out-of-territory” buildings
- Filtering out “out-of-scope” projects
- Consolidating building types

The Dodge database contains a code indicating the status of each listed project – from initial permitting to ready to begin construction. Only sites with a “stage code = start”, meaning that construction is scheduled to begin within 60 days were kept in the population. Then, all sites that are not in SCE, PG&E or SDG&E’s service territories were eliminated from the database. Finally, out-of-scope projects were eliminated. A project is out-of-scope if construction did not begin during the target quarter or if the building would not have been eligible for the program.

The Dodge database classifies buildings into one of about 50 types. These were consolidated into the 17 standard Title-24 building types. The 17 standard Title-24 building types are provided in the appendix to this report.

The non-participant sample was matched to the participant commercial and the mixed commercial/industrial sample on a site-by-site basis based on building type, Title 24 code used for compliance, construction start quarter, utility service territory, CEC Climate zone, and square footage. This was done to ensure a relevant comparison group for the net-to-gross analysis. The industrial-only participant sample was not matched to non-participants since it would have been nearly impossible to find adequate industrial matches. Therefore, the industrial sites are separated from the commercial and commercial/industrial sites in most tables in this report.

Table 65 and Table 66 present the number of sites and average square footage for the commercial and commercial/industrial participant and non-participant samples for 2002, by building type and utility. Table 65 shows the participant sample and Table 66 details the non-participant sample. The participant buildings are, on average, larger than their non-participant counterpart buildings. The high level of program penetration into the large building segment was one major factor. This and other considerations are discussed in the next section entitled "Non-participant Sampling and Recruiting Difficulties".

Building Type	PG&E		SCE		SDG&E		Statewide	
	# Sites	Ave SQFT	# Sites	Ave SQFT	# Sites	Ave SQFT	# Sites	Ave SQFT
C&I Storage	2	218,647	7	345,354	1	108,584	10	296,336
General C&I Work	3	79,367	2	223,707	3	55,340	8	106,442
Grocery Store	-	-	6	44,698	1	12,160	7	40,050
Hotels/Motels	-	-	1	962,000	1	626,172	2	794,086
Medical/Clinical	-	-	1	53,480	1	86,157	2	69,819
Office	8	121,156	5	203,461	4	101,148	17	140,655
Religious Worship, Auditorium, Convention	-	-	1	59,110	1	4,246	2	31,678
Restaurant	1	2,412	1	2,646	-	-	2	2,529
Retail and Wholesale Store	1	148,128	6	95,194	2	163,661	9	116,290
School	2	91,309	5	41,563	2	43,019	9	52,941
Total	**17**	**116,341**	**35**	**171,617**	**16**	**113,831**	**68**	**144,201**

Table 65: Participant Sample by Building Type and Utility

Building Type	PG&E		SCE		SDG&E		Statewide	
	# Sites	Ave SQFT	# Sites	Ave SQFT	# Sites	Ave SQFT	# Sites	Ave SQFT
C&I Storage	4	342,567	5	223,477	1	147,294	10	263,494
General C&I Work	4	26,849	3	88,452	-	-	7	53,250
Grocery Store	2	58,542	3	54,608	2	56,848	7	56,372
Hotels/Motels	1	171,486	-	-	1	727,900	2	449,693
Medical/Clinical	1	44,029	1	71,641	-	-	2	57,835
Office	7	71,447	9	73,502	1	325,897	17	87,502
Religious Worship, Auditorium, Convention	2	16,582	-	-	-	-	2	16,582
Restaurant	-	-	2	2,912	-	-	2	2,912
Retail and Wholesale Store	1	142,000	8	110,723	-	-	9	114,199
School	4	45,498	5	39,903	-	-	9	42,389
Total	**26**	**102,598**	**36**	**93,635**	**5**	**262,957**	**67**	**109,749**

Table 66: Non-participant Sample by Building Type and Utility

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, daylighting 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.

Baseline A consistent standard of energy efficiency against which all buildings will be measured. This is defined as the output of a DOE-2.1E 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. refrigeration systems), the baseline defined by the program for estimating the program savings will be used.

As Built A DOE-2.1E simulation of a building using all equipment and operating parameters as found by an on-site surveyor.

Whole Building Savings The difference between the whole building energy use under the baseline and as-built simulations. Positive savings indicate that the building was more efficient – used less energy – than its baseline case.

End-Use Savings The difference between the whole building energy use under the baseline and as-built measures associated with a particular end use. For example, the lighting savings are the whole building savings associated with the lighting measures. Both direct and interactive savings are included in the lighting end use savings.

"Better than baseline" The as built simulation showed less energy consumption than the baseline simulation – more efficient than the base case. Positive savings.

"Worse than baseline" The as built simulation showed more energy consumption than the baseline simulation – less efficient than the base case. Negative savings.

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[20].

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

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 program estimated savings

x is the average program estimated 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 will describe in more detail the methods used to extrapolate the results to the target population. Three topics will be described:

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

Case Weights

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:

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

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.

Participant Case Weights

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

Non-participant Case Weights

The non-participant case weights for the gross savings expansions were also calculated using balanced post-stratification. The stratification variables used to project the non-participants to the participant population are building type and square footage. For each building type in the non-participant sample, the strata cutpoints for the square footage variable are different. Since there are 12 different building types in the sample and, therefore, 12 different sets of strata cutpoints for the non-participant sample, we have opted not to show the specifics.

The difficulty with the non-participant weighting was due to the fact that the participant industrial sites did not have non-participant matching sites. Therefore when we projected the non-participants to the participant population for the gross savings expansions, we had to exclude the industrial sites from the participant population. We also opted to exclude the mixed commercial/industrial sites from the participant population since none of the non-participants that we sampled had industrial components. To obtain weights for the non-participants that matched to the mixed commercial/industrial participants, we equally divided the weights from the mixed commercial/industrial participants among the matching non-participants.

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 building in the sample. The sample of baseline, as built, and savings estimates were projected to the population using 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 – Heat recovery, CO sensors, VSD fume hoods

Net Savings and Spillover 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 will 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 about 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 will take 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 are 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 participant savings and the non-participant spillover savings by measure category.

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 and spillover by measure category (end use).

In the 1999-2001 BEA study the RLW Team prepared a decision maker survey that asked measure specific questions of program participants, and end-use specific questions of non-participants (only for measures more efficient than Title-24). 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 parametric models to develop end-use and measure level estimates of participant free-ridership and non-participant spillover.

We believe this technique produces relatively conservative estimates of both free-ridership and spillover. Decision makers will 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 free-ridership conservatively.

Decision-maker surveys were used to determine the measure-specific level of free-ridership and spillover occurring as a result of SBD. Free-ridership and spillover were quantified after the participant measures and non-participant end-uses received a score for free-ridership and spillover. 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 (spillover) at the measure (end use) level. Results are calculated at the measure (end use) level in order to inform the SBD program staff of measures that are experiencing a high level of free-ridership and/or spillover.

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.
Partial participants	Sites that did not receive a program incentives but were at least partly affected by the program.
Non-participants	Sites that were evidently unaffected by the program.
Direct net impact	The savings of the program participants relative to the level of efficiency expected in the absence of the program.
Spillover	The savings among the non-participants relative to the level of efficiency expected in the absence of the program.
Total net savings	The sum of the direct net savings and the spillover 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%.[21]

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.

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. 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 heatpumps,
- 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.

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

Spillover Impact Analysis Methodology

The *spillover* analysis estimates the amount of savings occurring in the NRNC market that is an indirect result of the SBD or other NRNC programs. Similar to the direct net impact analysis, on-site and telephone survey data of non-participants were used to estimate the amount of *spillover* occurring in the NRNC market.

Spillover is the difference in the energy and demand between what the customer actually installed and what they would have installed in absence of any influence. Spillover is calculated as the savings in the non-participant population associated with the baseline and what was actually installed (as-built) as a result of any SBD program influences, minus the savings associated with the baseline and what would have been installed. In other words, spillover is the amount of savings in the non-participant population that is attributable to the program.

Continuing from the example above, assume that a project used a lighting baseline of 2.0 watts/sqft, and this non-participant installed lighting equipment resulting in 1.3 watts/sqft as a result of participating in the SBD program at an earlier time. Assuming the customer had not participated in the earlier program, they claim the lighting most likely would have been installed at the baseline of 2.0 watts/sqft, resulting in a spillover of 100% for the lighting power density. The key to the spillover analysis is whether the customer was previously influenced by the program (spillover) or influenced by other means not related to the program (not spillover).

Interviewing non-participant decision-makers is perhaps the most direct and effective way to obtain data required for a spillover analysis. Again, we generally found that non-participants were able to provide a sufficient level of detail for the analysis, provided that the interview was timely and relevant. Senior level researchers attempted to conduct telephone interviews with the actual owners/developers of the project but often found that only the architect or engineer was willing or able to discuss the project.

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

Case Weights

The self-reported net savings approach uses case weights that are calculated by projecting the participant sample to the participant population and by projecting the non-participant sample to the participant population. This is to ensure that we are comparing two groups of comparable size. For the estimation of non-participant spillover occurring in the non-participant population using the self-report methodology, we sought to develop non-participant sample weights that properly reflect the saturation of the SBD program.

Non-participant Case Weights

In the best of worlds, we would develop case weights by post-stratifying the non-participant sample using a sampling frame comprised of Dodge sites that were not program participants. To do this it would be necessary to match the sites in the program tracking system to actual Dodge sites. In the 1994 DSM evaluation study, we tried to do this, but found it to be practically impossible. There were two basic problems.

First, the 1994 program participants consisted of projects that received incentives during 1994. The incentives were awarded when the construction was complete. By contrast, the Dodge database lists upcoming projects scheduled to begin construction in the next several weeks. Since construction could take anywhere from a few months to several years, we had to search through several years of Dodge data to hope of finding a given program participant.

The second problem was that the Dodge database often included only vague information identifying the project. Often the exact street address or even the city was missing or inaccurate. So it was hard to find a Dodge project that matched a given program participants.

To get around these problems, the following approach was followed.

A. Calculate case weights for the sample of program participants using the program tracking data as the target population.

B. Calculate case weights for the sample of non-participants using an artificial population comprised of the Dodge sites with square footage, less the weighted participant sample sites.

Figure 14 summarizes the approach. In Step A, the set of all program participants is taken as the target population. The sample of participants is post-stratified by building type and the tracking estimate of savings due to the measures funded by the program. The savings-based strata are constructed using balanced post-stratification. Then case weights are calculated as the reciprocal of the sampling fraction in each stratum. The weighted sample of participants can be considered to be a statistical representation of the population of program participants[22].

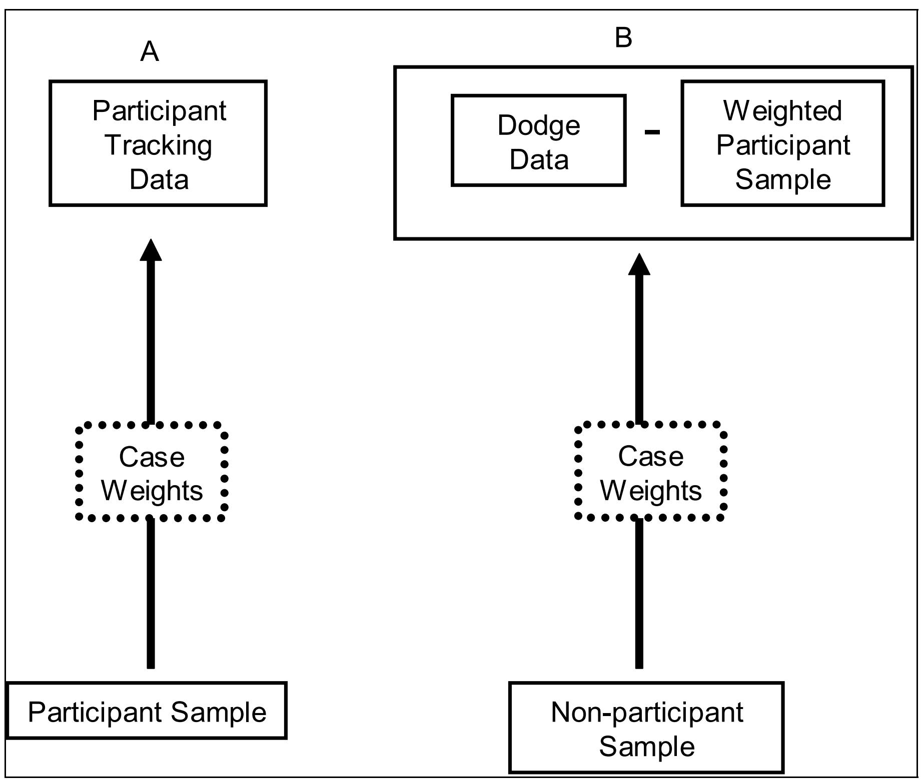

Figure 14: Approach to Non-participant Case Weights

[22] The participant case weights used in this procedure are the same participant case weights discussed throughout this report.

In step B, weights are calculated for the non-participant sample. To do this we obtain a representation of the population of all non-participants by combining the Dodge data with the weighted participant sample from the preceding step. The Dodge data is taken to be a representation of all construction, both participants and non-participants. This database is reduced by the representation of the program participants obtained from Step A.

The underlying principle is the simple equation: The number of non-participants in the population is equal to the number of sites in the entire population minus the number of participants in the population. Now suppose weighted sample are used to represent the entire population and the population of participants. Then the number of non-participants in the population can be estimated as the sum of the weights for the sites representing the entire population minus the sum of the weights for the sites representing the participants in the population. Of course this principle applies to each stratum.

Motivated by this idea, we simply combine the two sets of sites and multiply the case weight by –1 for each site in the participant sample. Then using balanced stratification, the non-participant sample is post-stratified by building type and square footage and the corresponding weights are calculated. In each stratum, the resulting weight is the ratio between the estimated population size and the sample size. The estimated population size is the sum of the positive weights associated the sites representing the entire population and the negative weights associated the sites representing the participants in the population. These weights are attached to the non-participant sample sites.

Technical Description

We let the population be represented by *K* sites, labeled 1 to *K*. Each site *k* has a case weight w_k. Ideally the case weight should be equal to the reciprocal of the probability that site *k* is included in the sample. In practice, the case weight is usually calculated for each site in any stratum *S* as the reciprocal of the sampling fraction:

$$w_k = \frac{N_S}{n_S}.$$

Here N_S is the number of population units in the stratum and n_S is the number of sample units in the stratum. In this case, if we let $\sum_{k \in S}$ denote the sum over all <u>sample</u> units in stratum *S,* then

$$\sum_{k \in S} w_k = \sum_{k \in S} \left(\frac{N_S}{n_S} \right) = N_S.$$

Now suppose the population is divided into participants, denoted *P,* and non-participants, denoted *NP*. Suppose, moreover, that we have three samples. The first sample represents the entire population. The second sample represents the participants in the population. The third sample represents the non-participants in the population. The first two of these samples have case weights. We want to calculate case weights for the third sample, i.e., the sample of non-participants.

Consider any stratum. Let N_S denote the number of population units in the stratum. We can estimate N_S as $\sum_{k \in S} w_k$. Here *S* denotes the set of all sites falling in the stratum from the first sample, i.e., the one representing the entire population.

Let N_S^P denote the number of participant population units in the stratum. We can estimate N_S^P as $\sum_{k \in S_P} w_k$. Here S_P denotes the set of all sites falling in the stratum from the second sample representing the participants.

Finally, let N_S^{NP} denote the number of non-participant population units in the stratum. Then $N_S^{NP} = N_S - N_S^P$. Therefore we define $\hat{N}_S^{NP} = \sum_{k \in S} w_k - \sum_{k \in S_P} w_k$ where $\hat{N}_S^{NP}$ is an estimate of N_S^{NP}

Now we define $S^* = S \cup S_P$, i.e., S^* is the set of all sample sites in the stratum from the first and second samples taken together. Finally we define $w_k^* = w_k$ if $k \in S$, and $w_k^* = -1 \times w_k$ if $k \in S_P$,

Then

$$\hat{N}_S^{NP} = \sum_{k \in S} w_k - \sum_{k \in S_P} w_k = \sum_{k \in S^*} w_k^*$$

Finally we calculate a case weight in the third sample to be $\frac{\hat{N}_S^{NP}}{n_S^{NP}}$. Here n_S^{NP} denotes the number of sites in the stratum from the third sample. We apply this case weight to all sites falling in this stratum from the third sample. Now we can combine the second and third samples to represent the entire population.

Engineering Models

Overall Modeling Approach

The data requirements of the evaluation include kW and kWh 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-2.1E 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. DOE-2.1E Release 119 is 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. Automated data validation of model outputs and energy savings projections.
6. Computerized tools to automatically perform the required parametric runs and store the results in an electronic database.

The models are responsive to both the measures installed under the program and the building attributes covered under Title-24. High-quality DOE-2 models are 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 practice were followed by the surveyors.

Occupancy, lighting, and equipment schedules. Each day of the week was assigned to a 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.

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.

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.

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 setpoints for heating and cooling, and the setback temperatures and times were defined according to the responses. The return from setback and go to setback time was modified on a monthly basis in the same manner as the fan-operating schedule.

Exterior lighting schedule. The exterior lighting schedule was developed from the responses to the on-site survey. If the exterior lighting was controlled by a time clock, the schedule was used as entered by the surveyor. If the exterior lighting was controlled by a photocell, a schedule, which follows the annual variation in 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 observed make and model number. A database of equipment efficiency and capacity data was developed from an electronic version of the ARI rating catalog. Additional data were obtained directly from manufacturers' catalogs, or the on-line catalog available on the ARI website (www.ari.org). Manufacturers' data on packaged system efficiency is a net efficiency, which considers both fan and compressor energy. DOE-2 requires a specification of packaged system efficiency that considers the compressor and fan power separately. Thus, the manufacturers' data were adjusted to prevent "double-accounting" of fan energy, according to the procedures described in the 1998 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 1998 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 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 30 year typical meteorological year (TMY) weather data. 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 is repeated until the model runs successfully and a results page is generated.

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/SF-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. Non-participant sites showing large variations relative to Title-24 performance were also investigated. For participants, 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 67. 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 -	area weighted average, includes air film

	0.033	
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 67: 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 the table shown on the following page.

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 68: 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 and non-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 and non-participants. The 1998 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
- 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 both participants and non-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 zone 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. In addition to the baseline assumptions for the energy efficiency measures targeted by the program, the baseline included the following mandatory measures.

- Space heat reclaim for the store from the refrigeration systems,
- Antisweat heater controls, and
- Multiplexed compressors.

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. *This run is equivalent to the full as-built run.* Note: refrigeration parameters in buildings not eligible for the grocery store refrigeration programs remained at the as-built level for all parametric runs.

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 would be added to the refrigeration parametric.

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

- Structured surveys with new-construction decision-makers
- On-site surveys of new non-residential buildings and industrial projects completed in 2002. The on-site surveys are comprised of SBD participants and non-participants. Data collected on-site are 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 work with the secondary sources of information – the program files, Title-24 documentation, and Dodge data – to develop a complete picture of the Statewide SBD non-residential new construction program. The on-site surveys provide 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 provide data for the net savings and spillover analysis. Additionally, these surveys collect research information from the building owners and the design teams, questions address the following general areas:

- Building classification
- Design and construction practices
- Energy attitudes
- Energy performance
- SBD program participation (participants only)

These data are reported in three statewide reports for the Non-Residential New Construction (NRNC) program area. The reports contain summary information for both SBD participants and non-participants.

The key feature in the process here is that the building models are constructed and reviewed by the surveyor within days of the on-site visit. This process dramatically improves the team's ability to produce models that accurately reflect the building as it is actually operated. It also allows for quick 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. In the case of non-participants, the decision-maker questions affecting the spillover analysis are conducted after the on-site and modeling is completed.
2. The surveyor reviews program records (for participants) 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 a 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 revisited and checked for reasonableness.
7. In the case of non-participants, the building owner and design team members are re-contacted after the model is complete and the decision-maker survey is completed.
8. 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 will review these reports within a few days of the audit, resulting in rapid feedback and data validation. These reports are provided to the H-M-G project manager on a quarterly basis as needed to provide an additional feedback loop.
9. One final simulation of the modified as-built is model is required to produce net savings and spillover 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. In addition, the utilities were able to alert RLW of any participants that were pulled from Dodge and appear in the non-participant call list. These lists were and continue to be distributed one week in advance of recruiting.

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

- 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 methodology was proven to be effective in the prior NRNC studies conducted by the RLW Team in collecting complete data from the correct decision-makers. As stated earlier, decision-maker questions affecting the non-participant sample were conducted post on-site survey and modeling. This slightly different methodology enabled the surveyor to learn more about the efficiency of the end-uses installed to facilitate a more informed non-participant end-use specific decision-maker survey.

The recruiters used contact information found in the tracking database and the project file for program participants and contact information from the Dodge database for non-participants. 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.

Decision-maker Data

The primary use of the decision-maker (DM) data was to conduct the net savings and spillover analysis. The data must be able to explain the energy choices made by the DMs of each building in order to determine the net-to-gross ratio, spillover, and free-ridership. The decision-maker instrument used for this study required some modification based upon lessons learned in the 1994, 1996, and 1998 NRNC Evaluations. The information collected in the decision-maker survey falls into one of four categories:

1. Building characteristics
2. Interaction with utility
3. DM attitude/behavior
4. Energy efficient design practices

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 and non-participant decision-makers were surveyed to gather a global understanding of what influences and market forces contribute to and guide the building design process. DMs 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

RLW 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 and integrated design practices hold during project planning, bidding and design stages.

The survey questions target the owner's interest in retaining design teams qualified in energy efficient design practices. More specifically, the questions address the owner's practice of attracting designers that possess energy efficiency or integrated design qualifications. Moreover, design team members were surveyed in regard to energy efficient design practices. These questions address the awareness of integrated design and whether it is a concept that is used in the marketing of services.

Scoring the Surveys

The decision-maker 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 and spillover can be found in the "Net Savings and Spillover" 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 were conducting the on-site surveys. The on-site visits required from 3 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 20 minute interview with the site contact to gather basic information about the building – operating schedules, number of occupants, Title-24 compliance method, 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. For participants, the presence of 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 Matt Brost and Pete Jacobs from RLW Analytics and AEC respectively, conducted the training for the audit phase of the project. The surveyors were technical personnel experienced as surveyors and building simulation practitioners, or in most cases, both. 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 BEA study, 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 are:

- Identification of project and non project areas within a single building,
- Details of reading SBD program project documentation,
- Importance of communication between the surveyors and senior technical staff, and
- Keys to gathering valid decision-maker data.

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

Engineering File Reviews

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

- Installed measures,
- Location of measures, and

- Any special circumstances.

For the non-participants, the surveyor reviewed data extracted from the Dodge database describing the site location, building type, and any other valuable information available to the surveyor.

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 BEA study. Some minor changes were made to reflect lessons learned in the 1994 and 1996 evaluation. 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 BEA study.