Final Report

2003 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

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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 2003. 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 2003 Building Efficiency Assessment Study does not include Southern California Gas Company program participants. [1]

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 process findings of the SBD program from the perspective of the program participants.

The inclusion of industrial projects and measures are relatively new to the Building Efficiency Assessment studies. 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 measure category has been added to the study to accommodate reporting of industrial measures. The industrial results have been reported separately due to the unique considerations of these process specific measures.

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

The 2003 BEA Study is an evaluation of Savings By Design projects that were paid incentives in calendar year 2003. Though this study is restricted to projects paid in 2003, the evaluated projects initially signed onto the program as early as 1999, or as late as 2003. 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 and/or designers regarding the energy design choices made for these buildings. The results of the decision maker data not only produce process findings, they are also used to adjust the engineering models for estimating the program's net energy impacts.

[1] Due to budgetary limitations and the complexity and cost of integrating gas measure savings into the BEA methodology, SoCalGas participants and gas measures from the other utilities are not included in this analysis.

The following sections of the Executive Summary describe the high-level findings identified by the evaluators in the course of the 2003 BEA Study. Results are presented at the "statewide" level (i.e. in aggregate for all utilities) because the sample sizes were not large enough to support a presentation of results at the utility level (i.e. 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 exceeded by the gross energy and demand savings estimates developed from our evaluation methodology, resulting in a 110% and 121% gross realization rate respectively for energy and demand, as shown in Table 1. These findings are based on sample sizes that comprise 42% of the program's tracked energy savings and approximately 39% of the program's tracked demand savings.

	Program Estimated Energy Savings	Sampled Energy Savings	% Energy Savings Sampled	Estimated Gross Savings	Gross Realization Rate	Measures Only Savings	Measures Only Realization Rate
Energy (MWh)	129,428	54,734	42.3%	143,055	110.5%	127,280	98.3%
Demand (MW)	26.7	10.5	39.4%	32.4	121.1%	27.0	100.9%

Table 1: Estimated 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, 98% of energy and 101% of demand tracking savings are being realized for all measures incented through the SBD program. These results indicate that 11% of the gross energy savings are due to participant spillover. [2]

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 104% and 126% respectively for energy and demand. The results also show that approximately 14% and 19% of gross energy and demand savings for the commercial estimated gross savings are due to participant spillover, respectively. The industrial projects are not evaluated for project spillover because the investigation is confined to a specific industrial process.

[2] (estimated gross savings – measure only savings) / (estimated gross savings)

		Program Tracking Savings	Estimated Gross Savings	Gross Realization Rate	Measures Only Savings	Measures Only Realization Rate
Commercial	**Energy (MWh)**	99,317	111,748	113%	95,973	97%
	Demand (MW)	24.9	28.5	114%	23.1	93%
Industrial	**Energy (MWh)**	30,111	31,307	104%	31,307	104%
	Demand (MW)	3.1	3.9	126%	3.9	126%

Table 2: Evaluated Gross Energy and Demand Impacts – Commercial and Industrial[3]

Net Impact Findings

The net impact findings for the 2003 program year are presented in Table 3 below including both commercial and industrial projects. The results indicate a net-to-gross ratio of 76% for commercial energy savings and 73% net-to-gross for commercial demand savings. The industrial net-to-gross ratio is 59% and 55% for energy and demand savings respectively. While lower than the commercial net-to-gross, these industrial results are significantly improved over the 2002 results (35% energy N-T-G and 33.3% demand N-T-G).

		Net Participant Savings	NP Spillover Savings	Total Net Savings	Gross Savings	Net-to-Gross
Commercial	**Energy (MWh)**	85,023	97	85,119	111,748	76.2%
	Demand (MW)	20.7	0.03	20.8	28.5	72.9%
Industrial	**Energy (MWh)**	18,474	NA	18,474	31,307	59.0%
	Demand (MW)	2.1	NA	2.1	3.9	54.6%

Table 3: Total Net Demand Reduction

Table 4 presents program net savings using a decision maker self-reported methodology. Decision makers were surveyed on their efficiency choices for incented measures (participants) and measures 10% more efficient than baseline (non-participants) to determine free-ridership and spillover. 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 4 presents the commercial and industrial findings of this analysis, presenting two separate indicators of net program impacts, the participant net-to-gross ratio and the comprehensive net-to-gross ratio. The terms in the table are defined below:

[3] The commercial results includes participant and non-participant spillover. The industrial results do not include spillover as explained in the paragraph preceding Table 2.

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.

The participant net-to-gross is an estimate of program-induced savings, less what the participants would have done absent the program (i.e., free-ridership), as a percentage of participant gross savings. The participant net-to-gross ratio is most closely comparable to net-to-gross ratios calculated for past NRNC program evaluations conducted in California. Referring to Table 4, the participant net-to-gross ratio is 76.1%, which represents the percentage of the energy savings that are a direct result of the SBD program (inclusive of participant spillover), while the remainder (23.9%) is considered program free-ridership.

	Commercial Energy Impacts (MWh)	Industrial Energy Impacts (MWh)	Calculation
Program Tracking Savings	99,317	30,111	A
Gross Savings	111,748	31,307	B
Gross Realization Rate	112.5%	104.0%	(B / A)
Net Participant Savings	85,023	18,474	C
Participant Net Realization Rate	85.6%	61.4%	(C / A)
Participant Net-to-Gross Ratio	76.1%	59.0%	(C / B)
NP Spillover Savings	97	NA	D
Total Net Savings	85,119	18,474	C + D
Comprehensive Net Realization Rate	85.7%	61.4%	(C + D) / A
Comprehensive Net-to-Gross Ratio	76.2%	59.0%	(C + D) / B

Table 4: Program Net Savings

Table 5 reports the net-to-gross ratios from the past three NRNC evaluation studies, and provides results with and without non-participant spillover. The net-to-gross ratio of 76% for the 2003 BEA compares favorably with past results, particularly for the results excluding NP spillover. As was reported in the final report for the 99-01 BEA study, the events that took place in the energy industry between 1999 and 2001 played a significant role 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 SCE/PG&E rate increases. It is reasonable to conclude that this uncertainty encouraged building designers and owners to pursue energy efficiency design in non-residential new construction, and this contributed to the high free-ridership (low net-to-gross ratio) for the 99-01program year, as well as the 2002 program year.

Sector	Program Year	Net-to-gross Ratio	
		Including NP Spillover	Excluding NP Spillover
Commercial	99-01 Participant Net-to-gross	82%	59%
Commercial	2002 Participant Net-to-gross	75%	69%
Commercial	2003 Participant Net-to-gross	76%	76%
Industrial	2002 Participant Net-to-gross	na	35%
Industrial	2003 Participant Net-to-gross	na	59%

Table 5: Historic Net to Gross Ratios for NRNC Studies

Table 6 shows the total net program impacts by measure type, taking into account both participant free-ridership and non-participant spillover. The Refrigeration and Shell end uses have the best net-to-gross ratios with each showing a net-to-gross ratio of approximately 95%. The daylighting controls end-use has the lowet net-to-gross ratio, 39%, which is having a sizable negative effect on the overall net-to-gross ratio for the commercial end uses because the daylighting controls end-use comprises 16% of the total commercial gross savings.[4]

	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	8,708	30.0%	0.4	8,709	9,232	94.3%
LPD	20,286	40.3%	96.5	20,383	27,778	73.4%
Daylighting Controls	6,947	37.5%	0.0	6,947	17,648	39.4%
Other Lighting Controls	3,270	46.5%	0.0	3,270	4,373	74.8%
HVAC + Motors	30,473	30.9%	-0.2	30,473	36,835	82.7%
Refrigeration	15,337	34.6%	0.0	15,337	15,883	96.6%
Combined Commercial Total	**85,023**	**12.7%**	**97**	**85,119**	**111,748**	**76.2%**
Industrial	18,474	38.4%	NA	18,474	31,307	59.0%

Table 6: Total Net Energy Program Impacts by Measure Type

[4] Daylight Controls are predominately skylighting controls.

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 estimate of program-induced savings in the non-participant population[5]. These non-participant spillover savings are added to the net participant savings and are used to calculate the comprehensive net-to-gross ratio. Table 4 reports the non-participant spillover was 96MWh. This is much lower than the 6,401 MWh reported in the 2002 program year.

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.
- **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 continued to decrease from the 99-01 BEA study findings (40%). In 2002 this figure dropped to 21%. Current evaluation findings report 16.5% of SBD participants intend to lease their buildings. This finding suggests that the market may be continuing to experience a decline in speculative building construction.

Findings from previous BEA studies have shown that owner occupied buildings are more likely to make construction decisions using more sophisticated investment decision making procedures, such as return on investment (ROI) or lowest lifecycle cost, whereas speculative building decision makers more frequently used lowest first cost decision making. The improvement in commercial net-to-gross results (Table 5) is notable given the dominance of owner occupied projects of the participants in the 2003 program. One could argue that these decision makers are more self-motivated to exceed baseline efficiency levels, yet the vast majority of participants credited the program for influencing their decisions to install efficiency measures.

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

Design Team Requests

Seventy percent of participant owners asked the members of their design team to consider energy efficiency above and beyond Title 24 requirements. This is consistent with the 1999-2001 and 2002 results (70% and 67%). The participant results 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. This is consistent with past findings that participant owners have a greater interest in selecting design teams with experience and qualifications in energy efficient design.

Only 24% of non-participants made this request to their design team, down from 40% in 2002 and 34% in 1999-2001. This result is particularly surprising given the high percentage of schools in the non-participant sample considering the CHPS school construction initiative.[6]

It is not clear why there is a downward trend in non-participants requesting energy efficiency. It may simply be a function of a smaller sample size, it may be that energy efficiency is less important than it was during the height of the energy crisis, or it may be that more A&E firms offer energy efficiency as standard business practice, negating the need for the owner to request such services. These are merely conjecture, more data would need to be collected in order to understand this finding. Regardless of the reasons, this outcome does underscore the impact SBD is having on motivating owners to build more energy efficient buildings.

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. Ninety-nine percent of participants responded that energy efficiency is very important or somewhat important. This is an increase over 2002 (92%) and 1999-2001 (89%). The non-participants have a similar attitude, 85% considered energy efficiency very or somewhat important in 2003, up from 79% in 2002 and 76% in 1999-2001. Virtually no respondents (0.5%), participants or non-participants, considered energy efficiency somewhat unimportant or very unimportant in 2003.

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. As with the 2002 study few non-participants, 18% 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 (38%), while non-participants were significantly less likely to believe their buildings were much better than code (8%).

Savings By Design Program Questions

Previous participation in the Savings By Design, or NRNC programs was the number one source of program awareness for program participants (41%). However 35.5% were first introduced to the program by utility representatives, up from 26% in 2002. The high percentage of return participants suggests satisfaction with the program’s services and offerings. The increase in utility representative introductions of the program implies improved success in this aspect of the

[6] Collaborative for High Performance Schools (CHPS). The Collaborative's goal is to “facilitate the design of high performance schools: environments that are not only energy efficient, but also healthy, comfortable, well lit, and containing the amenities needed for a quality education.”

program marketing efforts. The results indicates a more deliberate attempt to bring new participants into the program, an approach that, intuitively, would have a positive impact on the program's net savings impacts.

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:

- Seventy nine percent 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, up from a respectable 60% in 2002. Although this response was not used to calculate free-ridership, it reinforces the participant commercial net-to-gross ratio of 76% (see Table 4).
- More than 55% 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 acknowledged the influence of each program component. On a scale of 1 (very important) to 5 (not at all valuable), 69% rated the incentive a "1" or "2", 64% rated design assistance similarly, and 75% also rated design analysis a "1" or "2". These results indicate that the other areas of the program are as important as incentives.[7]
- Forty-six percent 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 a decreased awareness of the Savings By Design program among non-participants. Thirty-nine percent of the non-participants were aware of SBD before construction began. This is down from nearly 55% in the 2002. The 2003 results are similar to the 99-01 study which reported that 37% of non-participants were aware of SBD before construction began.

Time investment and incentive amounts present SBD with participation barriers. The 39% of non-participants who were aware of the program before design and construction began were asked why they did not participate in the program. Detailed responses indicate that there are two primary reasons for not participating: 1) Customers declined due to time constraints, and 2) Customers stated that the amount of the incentive was not worth their time for participating. Availability of funding was not an issue, a change over 2002. Apparently this problem was addressed by adopting a two-year program funding cycle. 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.

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

RLW Analytics, Inc. (RLW) has conducted an evaluation of the 2003 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 SBD program; however their projects are not included in this study.[8]

This document is the final report for the Building Efficiency Assessment (BEA) study for the statewide Non-Residential New Construction (NRNC) program area, covering calendar year 2003. This report contains summary results for program participants over multiple years that received their incentive payments in 2003, and NRNC building owners/operators who permitted their projects in 2002 and completed them in 2003 but did not participate in the SBD program[9].

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 on-going process findings 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, assisted 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, 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 and 2002 BEA studies. Moreover, the same approach was also applied to the last four years of program activities, including 1999 through 2002. Findings from these studies are presented in the previous three Building Efficiency Assessment Study reports. This is the fourth in a series of BEA study reports. The participant population for this study consisted of 456 sites paid in the statewide SBD program during 2003.

The BEA Study defines participants by the year in which they were paid their incentive. Alternatively, the utilities define program participation year based upon the year the participant signed a contract to receive program incentives. Therefore the 2003 BEA study is not a true study

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[8] Due to budgetary limitations and the complexity and cost of integrating gas measure savings into the BEA methodology, SoCalGas participants and gas measures from the other utilities are not included in this analysis.

[9] 2002-2003 F. W. Dodge New Construction Database

of PY 2003 program activities. However, because BEA is an on-going evaluation of SBD, a complete picture of SBD and corresponding non-participant projects is evolving over time.

The selection of the participant sites was guided by a model-based statistical sampling plan as in each of the last studies dating back to the 1994 NRNC evaluation. We used a participant sample that was efficiently stratified by utility and the tracking estimate of annual energy savings, with proportional representation of building types and climate zones in the combined participant population. The final participant sample size was 87 sites.

This study and the two previous studies are different from prior NRNC program and BEA evaluations in that they included 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 did not use a matched sample of participants and non-participants. The 2002-2003 F.W. Dodge New Construction Database was used to obtain the non-participant population. The non-participant sample was selected to represent the total population of 2003 NRNC projects as documented in the 2002-2003 F.W. Dodge New Construction Database. The final non-participant sample size was 36 sites. The relationship between the participant and non-participant populations is explored in greater detail within the Process Findings section of this report.

The gross savings evaluation is based on DOE-2 engineering models and engineering calculations that are informed by detailed on-site surveys statistically projected to the program population. Title 24 is the baseline used by the Model-IT software for generating gross savings estimates for the whole building and at the measure level. 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. 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 and non-participants. Results are used to assess the attitudes, decision-making processes and beliefs of NRNC market actors for use in improving program delivery of the Savings By Design program.

Savings By Design Program Description

The Savings By Design program offered by California's Investor Owned Utilities includes design assistance and financial incentives to improve the energy efficiency of commercial new construction and industrial projects. The incentive program has two participation paths, the

Systems approach and the Whole Building approach. Within the Systems approach, there are commercial and industrial projects. The incentive structure targets both the building owner and the building design team.

Systems Approach

Commercial Projects

The Systems Approach used until June 2001, utilized 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”, before June 2001, was a set of prototype models developed for SBD that produced pre-calculated energy savings values based on a set of inputs common to the building systems being evaluated. After June 2001, an expanded and more advanced version of CaNCCalc has been used that applies DOE-2 modeling using the front-end of eQUEST and provides interactive results for custom inputs.

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[10]

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.

Industrial Process or Other Systems

The Other Systems or Processes portion of Savings By Design offers financial incentives to facility owners for energy efficient measures utilized in a wide range of unique industrial applications. These projects utilize the Systems Approach and rely on calculations outside of CaNCCalc provided by utility engineers or consultants. In most cases, the industrial measures are completely isolated from a commercial building. However, some incented industrial 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. The modeling results for these sites were disaggregated into commercial and industrial measures for the analysis, and the resulting industrial findings are included within the industrial results tables.

The incented industrial measures include, but are not limited to:

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

[10] 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.

Whole Building Approach

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

Design Assistance

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

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

Owner Incentives

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

Under the Whole Building Approach, the overall efficiency of the building is evaluated using a computer simulation program. If the building is at least 10% better than baseline, incentives are available. The incentives range from $0.06/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 and may not exceed 50% of the incremental cost.

Under the Systems Approach, energy savings and incentives are calculated system-by-system, based on the quantities and efficiencies of qualifying components. Owner incentives are calculated at a rate of $0.04/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 and may not exceed 50% of the incremental cost.

Design Team Incentives

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

Incentives range from $0.03/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 receives.

This section provides an overview of the statewide Savings By Design (SBD) program for projects paid in 2003. Only projects that were paid incentives within the evaluation year (2003) were considered though the evaluated projects initially signed onto the program as early as 1999, or as late as 2003. 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 7 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 51% of the energy savings, even though they only account for approximately 42% of the projects, suggesting that the SCE projects tend to save more energy per project than those from the other utilities.

Utility	# Projects	Total MWh	Average MWh	kWh/ SQFT
PG&E	165	47,158	285.81	3.50
SCE	198	65,855	332.60	4.03
SDG&E	104	16,414	157.83	2.38
Statewide	467	129,428	277.15	3.52

Table 7: Savings By Design Program Tracking Savings

Table 8 presents participation rates for the Savings By Design program, and previous NRNC programs, by year and by utility. In 2003, the SBD program completed 467 projects – a number that is similar to the number of participants in previous years.

Utility	2003		2002		Q4 1999-2001	
	# Projects	Total MWh	# Projects	Total MWh	# Projects	Total MWh
PG&E	165	47,158	133	16,877	127	19,418
SCE	198	65,855	198	77,467	169	53,835
SDG&E	104	16,414	95	27,187	190	17,034
Statewide	467	129,428	426	121,531	486	90,287

Table 8: Savings By Design Participation Rates and Energy Savings

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 9 shows the number of projects, the associated energy savings and savings per square foot by participation approach. During 2003, Savings By Design had a total of 107 Whole Building projects, or 23% of the total. SCE had the most Whole Building Approach projects of any utility, with 48, and also the largest amount of energy savings. SCE also 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 PG&E and SDG&E, but not SCE which had a very high savings ratio for system projects of 4.05 kWh/SQFT. On average, the SBD program-tracking database estimates 3.52 kWh savings per square foot for all participants.

	PG&E			SCE			SDG&E			Statewide		
Approach	**# Projects**	**MWh Savings**	**kWh/ SQFT**	**# Projects**	**MWh Savings**	**kWh/ SQFT**	**# Projects**	**MWh Savings**	**kWh/ SQFT**	**# Projects**	**MWh Savings**	**kWh/ SQFT**
Systems Approach	133	31,652	3.35	150	43,648	4.05	77	10,206	1.95	360	85,506	3.36
Whole Building Approach	32	15,506	3.83	48	22,208	3.97	27	6,208	3.72	107	43,922	3.88
Overall	**165**	**47,158**	**3.50**	**198**	**65,855**	**4.02**	**104**	**16,414**	**2.38**	**467**	**129,428**	**3.52**

Table 9: Savings By Design Participation Approach: System vs. Whole Building

Program Participation & BEA Sample Size

Table 10 shows the Savings By Design program installations and evaluation sample sizes by utility. Notice that SDG&E had the lowest MWh savings per project at 158 MWh. Also note that the large projects were over-sampled for each utility, which resulted in a higher than average sampled MWh savings per project.

2003	PG&E		SCE		SDG&E		Statewide	
	Population	**Sample**	**Population**	**Sample**	**Population**	**Sample**	**Population**	**Sample**
Number of Projects	165	31	198	40	104	16	467	87
MWh Savings	47,158	20,547	65,855	28,122	16,414	6,065	129,428	54,734
Savings per Project (MWh)	286	663	333	703	158	379	277	629

Table 10: Savings By Design Program Participation by Utility

Table 11 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 Stratum 5 is for large sites. For a complete description of the stratum definitions, the Participant Sample Design (Page 72) 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	89	6	102	8	47	3	238	17
2	31	6	37	8	24	3	92	17
3	20	6	28	8	15	3	63	17
4	15	6	19	8	10	3	44	17
5	10	7	12	8	8	4	30	19
Overall	**165**	**31**	**198**	**40**	**104**	**16**	**467**	**87**

Table 11: Savings By Design Program Participation by Stratum and Utility

Table 12 presents the number of sites and average square footage for the participant sample for 2003, 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	1	12,000	6	269,627			7	232,823
Fire/Police/Jails			3	245,833	1	4,815	4	185,579
General C&I Work	8	103,100	7	93,026			15	98,399
Grocery Store	6	58,623	2	57,170	1	55,000	9	57,898
Hotels/Motels	1	391,524					1	391,524
Medical/Clinical	1	57,750	3	119,216			4	103,849
Office	6	61,575	4	40,087	2	59,148	12	54,008
Other					2	273,033	2	273,033
Religious Worship, Auditorium, Convention	2	254,633	1	70,610	1	38,799	4	154,669
Retail and Wholesale Store	5	123,634	11	65,584	1	133,906	17	86,676
School	1	87,076	2	33,000	8	111,473	11	94,987
Theater			1	6,031			1	6,031
Total	**31**	**103,928**	**40**	**103,630**	**16**	**111,792**	**87**	**105,237**

Table 12: Participant Sample by Building Type and Utility

Participant and Non-participant Sample Description

Table 13 provides information on the samples drawn to represent the participant and non-participant populations[11]. Table 14 presents the characteristics of the sample when extrapolated to the respective populations. There is a substantial difference between the participant and non-participant samples with regards to average areas of the buildings surveyed and the building types that populate the sample. These differences are noteworthy with regard to the interpretation of the comparative results presented in the Gross Results and Process Findings sections. For example: Table 14 reports that the weighted average building area is 72,683 sqft for participants and 19,068 sqft for non-participants. Schools represent nearly 40% of the non-participant population and only 16% of the participant population.

[11] Note: The participant sample does not include sites containing only industrial measures.

Unweighted	Participants					Non Participants				
	Sites	Percent of Sites	Average Area	Total Area	Percent of Total Area	Sites	Percent of Sites	Average Area	Total Area	Percent of Total Area
C&I Storage	7	8%	232,823	1,629,760	16%	4	11%	159,641	638,562	23%
General C&I Work	11	13%	134,180	1,475,982	14%	3	8%	40,077	120,230	4%
Community Center	0	0%	0	0	0%	1	3%	22,500	22,500	1%
Fire/Police/Jails	4	5%	185,579	742,315	7%	1	3%	185,793	185,793	7%
Gymnasium	0	0%	0	0	0%	3	8%	40,271	120,812	4%
Hotels/Motels	1	1%	391,524	391,524	4%	2	6%	202,717	405,434	15%
Medical/Clinical	4	5%	103,849	415,397	4%	3	8%	73,279	219,838	8%
Office	12	14%	54,008	648,091	6%	2	6%	22,000	44,000	2%
Other	2	2%	273,033	546,065	5%	2	6%	54,127	108,254	4%
Religious Worship, Auditorium, Convention	4	5%	154,669	618,674	6%	3	8%	16,572	49,715	2%
Restaurant	0	0%	0	0	0%	2	6%	2,499	4,997	0%
Retail and Wholesale Store	17	20%	134,194	2,281,305	22%	2	6%	78,483	156,965	6%
School	11	13%	94,987	1,044,861	10%	8	22%	88,429	707,428	25%
Grocery Store	9	11%	57,898	521,079	5%	0	0%	0	0	0%
Theater	1	1%	6,031	6,031	0%	0	0%	0	0	0%
Totals	83	100%	124,350	10,321,084	100%	36	100%	77,348	2,784,528	100%

Table 13: Participant and Non-participant Samples

Weighted	Participants					Non Participants				
	Sites	Percent of Sites	Average Area	Total Area	Percent of Total Area	Sites	Percent of Sites	Average Area	Total Area	Percent of Total Area
C&I Storage	28	6%	109,395	3,012,920	9%	76	3%	53,692	4,075,851	8%
General C&I Work	51	11%	82,434	4,189,889	13%	167	6%	18,560	3,101,832	6%
Community Center	0	0%	0	0	0%	52	2%	22,500	1,178,980	2%
Fire/Police/Jails	22	5%	74,106	1,642,685	5%	2	0%	185,793	404,635	1%
Gymnasium	0	0%	0	0	0%	282	10%	16,585	4,682,727	9%
Hotels/Motels	3	1%	391,524	1,305,080	4%	19	1%	69,748	1,357,226	3%
Medical/Clinical	33	7%	72,610	2,374,943	7%	169	6%	27,813	4,700,435	9%
Office	101	22%	40,220	4,065,557	12%	243	9%	6,558	1,594,806	3%
Other	10	2%	129,709	1,297,090	4%	56	2%	21,304	1,202,654	2%
Religious Worship, Auditorium, Convention	26	6%	78,804	2,030,142	6%	443	16%	16,572	7,341,412	14%
Restaurant	0	0%	0	0	0%	452	16%	2,499	1,128,778	2%
Retail and Wholesale Store	59	13%	106,894	6,278,112	19%	150	5%	20,239	3,032,727	6%
School	83	18%	63,278	5,246,800	16%	679	24%	28,610	19,438,326	37%
Grocery Store	28	6%	58,011	1,646,048	5%	0	0%	0	0	0%
Theater	13	3%	6,031	77,649	0%	0	0%	0	0	0%
Totals	456	100%	72,683	33,166,916	100%	2792	100%	19,068	53,240,386	100%

Table 14: Samples Extrapolated to Population

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 T24 baseline and as-built simulations. The results were determined for each sample site both on a whole building basis as well as within each end use. Positive savings indicate that the building was more efficient – used less energy or demanded less – than its baseline case. As in the 2002 Building Efficiency Assessment, we have reported industrial measures in a separate category named “Industrial” due to the unique nature of industrial measures such as those installed in waste water facilities and dairies. Some commercial projects included industrial measures, labs with fume hoods for example. As mentioned in the previous section, the modeling results for these sites were disaggregated into commercial and industrial measures for the analysis, and the resulting industrial findings are included within the industrial results tables.

Statewide Energy Findings

All Measures

We begin the energy impacts section by reporting findings for all measures. Table 15 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 143,055 MWh, representing a gross realization rate of 110.5%.

Program Estimated Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Evaluated Energy Savings (MWh)	Realization Rate
129,428	54,734	42.3%	143,055	110.5%

Table 15: Combined Total Annual Gross Energy Savings

Figure 1 shows the composition of annual gross energy savings by measure type. Whole Building Approach projects comprise nearly 40% of the annual energy savings among program participants. This is a significant increase over the 2002 findings (23%)[12] and 2001 (20%)[13]. The Industrial measures account for over 20% of the annual energy savings. Lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls) and HVAC + Motors

[12] 2002 Building Efficiency Assessment, An Evaluation of the Savings By Design Program, RLW Analytics, Inc., July 2004, page 19.

[13] 1999-2001 Building Efficiency Assessment, An Evaluation of the Savings By Design Program, RLW Analytics, Inc., April 2003, page 20.

measures each comprise just over 15% of the savings. Shell measures, such as fenestration, and refrigeration measures have the smallest share of annual gross energy savings.

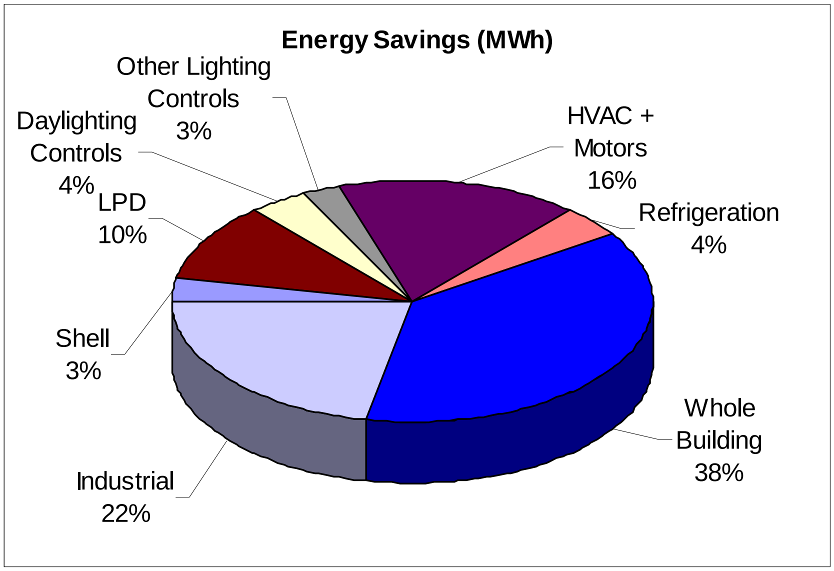


Figure 1: Composition of Annual Gross Energy Savings as % of the Combined Total

Table 16 shows the estimated energy savings and error bound by measure type as well as for the combined commercial total. The combined commercial total energy savings were 111,748 MWh, with an error bound of 12,252 MWh, yielding a 90% confidence interval of 99,496, 124,000 MWh. Industrial measures achieved gross energy savings of 31,307 MWh, with an error bound of 9,398 MWh, yielding a 90% confidence interval of 21,909, 40,705 MWh.

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

	Measure Category	Energy Savings (MWh)	Error Bound	Relative Precision	Savings as % of End Use Baseline
Systems Approach	Shell	4,548	1,847	40.6%	NA
	LPD	14,740	7,288	49.4%	13.0%
	Daylighting Controls	5,827	2,439	41.9%	5.1%
	Other Lighting Controls	3,592	1,607	44.7%	3.2%
	HVAC + Motors	23,514	8,784	37.4%	14.6%
	Refrigeration	5,951	3,850	64.7%	26.0%
	Whole Building	53,577	11,756	21.9%	21.3%
	Combined Commercial Total	**111,748**	**12,252**	**11.0%**	**18.7%**
	Industrial	31,307	9,398	30.0%	NA

Table 16: Annual Gross Energy Savings

Statewide Energy Savings as a Percentage of Baseline

This section provides the participant and non-participant savings for commercial buildings, industrial projects and measures are not included. The results for participants and non-participants are presented together allowing easy comparison. However, due to the limited non-participant sample size, and differences in the populations (see Table 13), these comparisons should be made with caution. There were no buildings in the non-participant sample with a substantial amount of daylighting controls or refrigeration measures; therefore there are no non-participant savings for these measure categories.

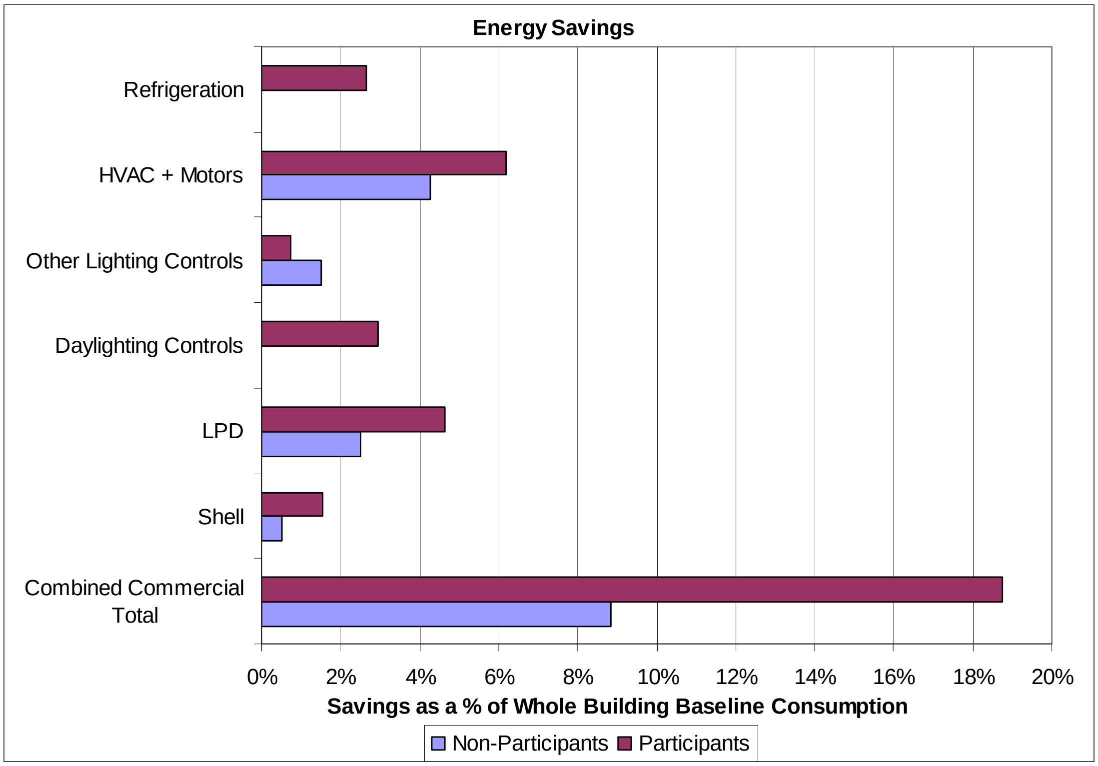


Figure 2: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption – Commercial Sites Only

Table 17 shows participant and non-participant savings as a percentage of baseline consumption by end use as well as the corresponding error bounds; in other words, Table 17 presents the data shown graphically in Figure 2 along with the error bounds at the 90% confidence level. In general, the non-participant error bounds are quite large relative to the estimates, which is a direct consequence of the small non-participant sample size. Therefore, when interpreting these results, one must use caution, particularly when making comparisons between the participants and the non-participants. There are, however, some statistically significant differences between the participants and the non-participants[14]. Participants are significantly more efficient than non-participants at the building level and in the daylighting controls measure category. Refrigeration end uses were not captured in the non-participant sample. For all other end uses (i.e. Shell, LPD, Other Lighting Controls, and HVAC + Motors), the differences shown are not statistically significant.

[14] Statistical significance tests were conducted at the 90% level of confidence.

End Use	Participants		Non-Participants	
	Savings as a % of Building Baseline	Error Bound	Savings as a % of Building Baseline	Error Bound
Shell	1.5%	0.5%	0.5%	0.4%
LPD	4.7%	1.6%	2.5%	2.6%
Daylighting Controls	3.0%	0.9%	0.0%	0.0%
Other Lighting Controls	0.7%	0.3%	1.5%	1.0%
HVAC + Motors	6.2%	1.9%	4.3%	4.9%
Refrigeration	2.7%	1.0%	-	-
Combined Commercial Total	**18.7%**	**3.5%**	**8.8%**	**3.9%**

Table 17: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption with Error Bounds – Commercial Sites Only

Figure 3 shows participant and non-participant energy savings as a percentage of baseline consumption by Title 24 energy code year (1998 or 2001). 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 date were subject to the 2001 Title 24 code requirements[15]. Unlike all other results presented throughout this report, the results in these charts are unweighted. In order to properly weight these results, it would be necessary to know which Title 24 energy code type was utilized for each site in the non-participant population. This information is not available.

The results of this analysis, although unweighted, reveal very interesting comparisons. Non-participant efficiency as a percentage of whole building energy consumption is nearly equal to participants when compared to the 1998 code. However, when making the same comparison to 2001 code, non-participant efficiency decreased drastically, perhaps maintaining nearly the same overall level of efficiency as the pre-2001 Title 24 non-participants. These findings illustrate the role SBD has played in pushing the efficiency levels for projects complying to 2001 standards, a comparison that yields a near 20% gap between participants and non-participants.

[15] 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.

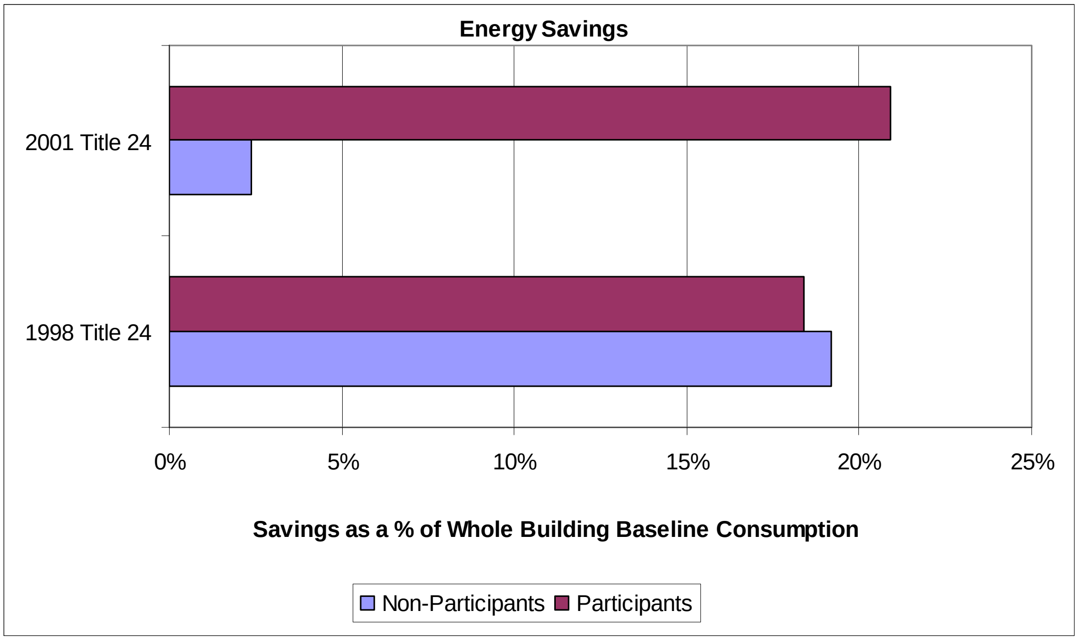


Figure 3: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption – 2001 Title 24 versus 1998 Title 24, Commercial Sites Only (Unweighted)[16]

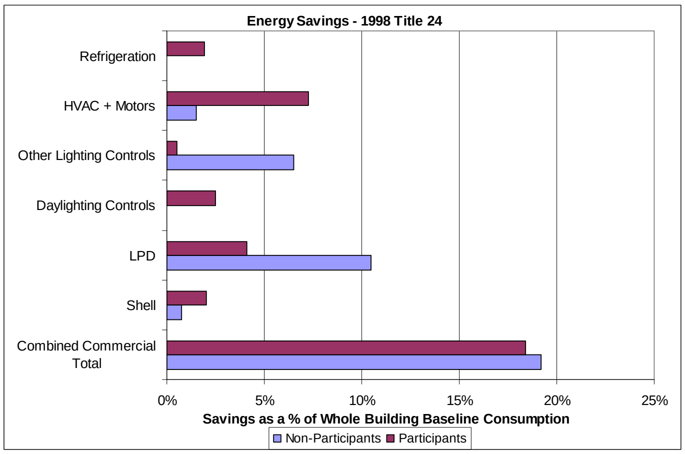
Table 18 numerically shows the same results displayed graphically in Figure 3 along with the corresponding error bounds. The non-participant error bounds are quite large relative to the estimates of savings as a percentage of baseline consumption. In fact, the non-participant error bounds exceed the estimates. Thus, the results shown in Figure 3 and Table 18 must be interpreted with caution.

Title 24 Code Year	Participants		Non-Participants	
	Savings as a % of Building Baseline	Error Bound	Savings as a % of Building Baseline	Error Bound
1998 Title 24	18.4%	9.5%	19.2%	24.1%
2001 Title 24	20.9%	7.5%	2.4%	7.9%

Table 18: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption with Error Bounds – 2001 Title 24 versus 1998 Title 24, Commercial Sites Only (Unweighted)

[16] Note: the 1998 code non participant sample size is 6 sites, resulting in a large error bound on the finding.

Figure 4 presents the 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. The participant and non-participants results are presented side-by-side for ease of comparison. However, the large error bound associated with the small non-participant sample size suggest caution is warranted when comparing these results, particularly when considering individual measure findings.



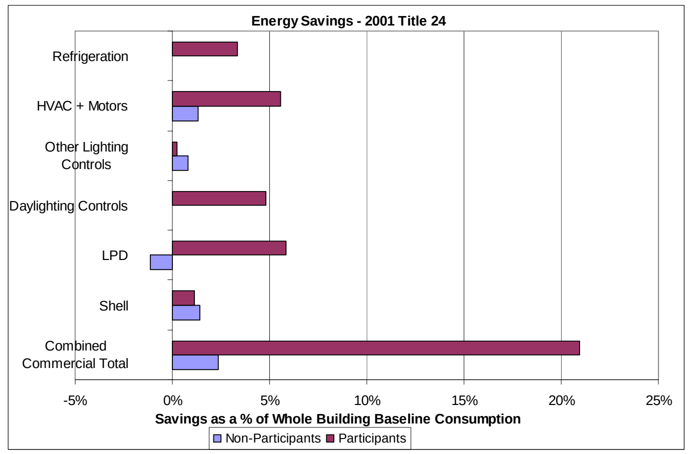


Figure 4: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption – 1998 and 2001 Title 24 Commercial Sites Only (Unweighted)

Incented Measures

Incented measures refer only to the measures explicitly receiving an incentive within a specified end-use. Table 19 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 127,280 MWh, representing a gross realization rate of 98.3%.

Program Estimated Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Evaluated Energy Savings (MWh)	Realization Rate
129,428	54,734	42.3%	127,280	98.3%

Table 19: Annual Gross Energy Savings – Incented Measures Only

Table 20 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 approximately two-thirds of the measures only gross savings produced by the program. The lighting power density + other lighting controls and daylighting controls measures comprise nearly an additional 20% of the savings due to incented measures with each accounting for over 18,000 MWh and 5,000 MWh of savings, respectively. Table 20 also displays lighting power density + other lighting controls achieving the highest savings relative to baseline, producing nearly 30% savings above the lighting baseline consumption. Whole Building projects follow lighting power density + other lighting 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 20 shows that Whole Building is the only commercial measure category with a gross realization rate exceeding 100%. HVAC + Motors and Refrigeration measures are experiencing the lowest gross realization rates at 57%. The realization rate for HVAC + Motors was affected by inaccurate assumptions for VFD savings on large central plant chillers (two prisons and a medical center). The Refrigeration realization rate was affected by lower as-built operating hours than projected. This would suggest that a review of the energy savings assumptions used for these types of measures would be beneficial. All other measure categories are within a reasonable Realization Rate range.

	Measure Category	Energy Savings (MWh)	Error Bound	Relative Precision	Savings as % of End Use Baseline	Program Estimated Energy Savings (MWh)	Gross Realization Rate
Systems Approach	Shell	497	636	127.9%	NA	567	88%
	LPD + Other Lighting Controls	18,576	5,152	27.7%	29.9%	20,219	92%
	Daylighting Controls	5,870	2,482	42.3%	9.5%	6,182	95%
	HVAC + Motors	13,995	3,583	25.6%	9.3%	24,446	57%
	Refrigeration	3,458	2,256	65.2%	15.6%	6,026	57%
	Whole Building	53,577	11,756	21.9%	21.3%	41,877	128%
	Combined Commercial Total	**95,973**	**10,793**	**11.2%**	**16.1%**	**99,317**	**97%**
	Industrial	31,307	9,398	30.0%	NA	30,111	104%

Table 20: Annual Gross Energy Savings and Realization Rates by Measure Category – Incented Measures Only[17]

Figure 5 shows the composition of the total estimated annual gross energy savings for incented measures only. Over 65% of the energy savings, considering only incented measures, is resulting from Industrial and Whole Building Approach measures and projects. Lighting measures account for 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. Since they are not shown as measures in the utility tracking system, the evaluation team has combined them with LPD measures during the analysis.

[17] 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. LPD is combined with Other Lighting Controls to match the IOU reporting methodology in order to calculate the Gross Realization Rate.

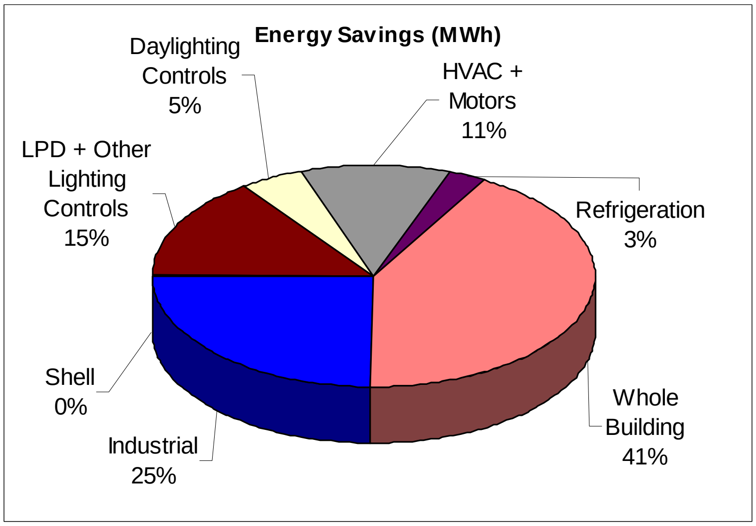


Figure 5: Composition of Estimated Annual Energy Savings – Incented Measures Only

Figure 6 shows the annual gross savings for incented measures expressed as a percentage of each end-use baseline usage. LPD + other lighting controls were more efficient relative to baseline consumption than were other measures. For the Whole Building measure, the annual gross savings relative to baseline consumption were approximately 21%, refrigeration measures savings were about 15% relative to baseline, and HVAC and daylighting controls measures were also roughly equal, saving nearly 10% more energy than baseline.

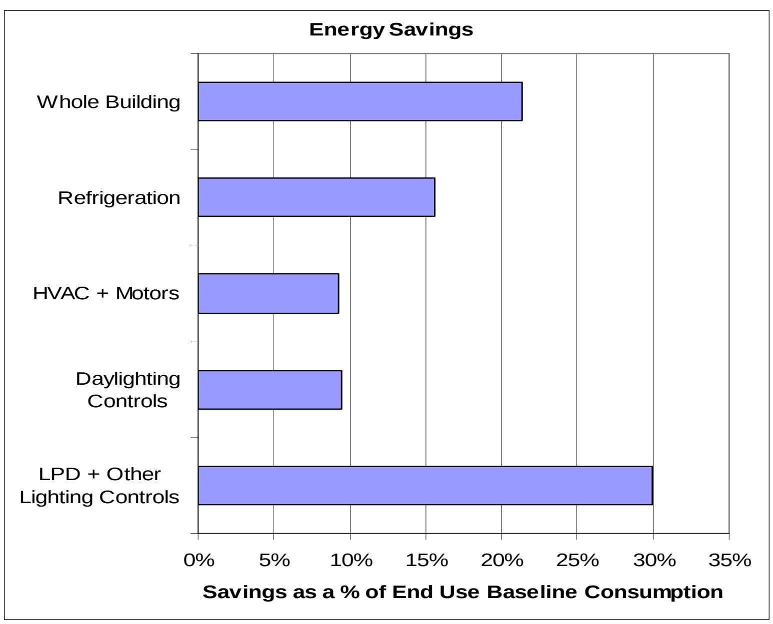


Figure 6: Energy Savings as Percentages of End-Use Baseline – Incented Measures Only

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 HVAC + Motors have the greatest impact on the summer peak demand reduction among program participants and refrigeration accounts for the least of demand reduction.

All Measures

Table 21 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 32.4 MW, representing a gross realization rate of 121.1%. This is 13% greater than the evaluated demand reduction documented for the 2002 program (28.6 MW).

Program Estimated Demand Reduction (MW)	Sampled Demand Reduction (MW)	% Demand Reduction Sampled	Evaluated Demand Reduction (MW)	Realization Rate
26.7	10.5	39.4%	32.4	121.1%

Table 21: Combined Total Summer Peak Demand Reduction

It is important to point out that for this study the demand savings is calculated based on the utility coincident peak, while the program calculates demand savings based on building peak demand. While the demand realization results are less applicable to program evaluation, this approach has been taken for these reports to provide information in support of the resource acquisition process. The coincident peak hour of 2pm, July 18th was used for this study. The relationship between building peak demand and system peak demand is provided in Table 22 below.

	Measure Category	Coincident Peak Demand Reduction (MW)	Building Peak Demand Reduction (MW)	% Difference
Systems Approach	Shell	0.5	0.4	-22%
Systems Approach	LPD + Other Lighting Controls	3.5	4.6	33%
Systems Approach	Daylighting Controls	1.4	2.2	55%
Systems Approach	HVAC + Motors	4.1	6.5	56%
Systems Approach	Refrigeration	0.4	0.3	-22%
	Whole Building	13.1	13.7	5%
	Combined Commercial Total	**23.1**	**27.8**	**20%**

Table 22: System Coincident Peak vs. Building Peak

Figure 7 shows the breakdown of summer peak demand reduction by measure category. As with the energy savings results, Whole Building Approach projects account for about 40% of the summer peak demand reduction among program participants. Over 15% of the reduction is due to lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls), while HVAC + Motors measures comprise an additional 20% of the reduction.

The comparison of Figure 1 and Figure 7 reveals that the demand and energy savings contribution by end use is similar for Whole Building, Daylighting Controls, Other Lighting Controls, and LPD. The Industrial measure category is experiencing the largest differential between the demand and energy savings percentage at 12% and 22%, respectively. This is due in large part to the impact of a large dairy barn industrial lighting measure that does not create peak demand savings.

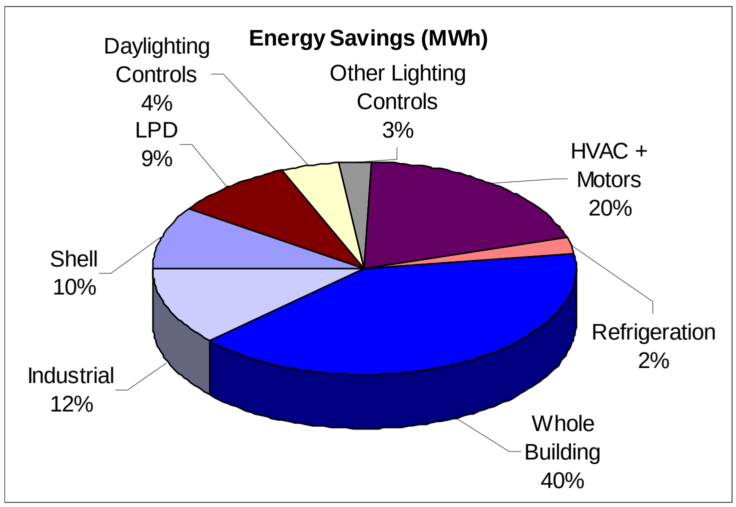


Figure 7: Composition of Summer Peak Demand Reduction

Table 23 shows the estimated gross summer peak demand reduction and error bound by measure type, as well as for combined commercial total. The combined commercial total gross summer peak demand reduction was 28.5 MW, with an error bound of 4.2 MW, yielding a 90% confidence interval of 24.3, 32.7MW. Industrial measures achieved summer peak demand reduction of 3.9 MW, with an error bound of 1.2 MW, yielding a 90% confidence interval of 2.7, 5.1MW.

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 (645 MW). Whole Building projects are producing nearly one-half of the demand savings for all commercial measures, which account for 13.1 MW out of a total 28.5 MW.

	Measure Category	Demand Reduction (MW)	Error Bound	Relative Precision	Savings as % of End Use Baseline
Systems Approach	Shell	3.1	1.5	49.1%	NA
	LPD	2.9	1.4	47.8%	14.6%
	Daylighting Controls	1.5	0.7	47.1%	7.3%
	Other Lighting Controls	0.8	0.5	60.8%	4.2%
	HVAC + Motors	6.4	1.8	28.0%	12.1%
	Refrigeration	0.8	0.5	64.6%	25.0%
	Whole Building	13.1	2.9	22.0%	24.8%
	Combined Commercial Total	**28.5**	**4.2**	**14.6%**	**20.7%**
	Industrial	3.9	1.2	31.1%	NA

Table 23: Summer Peak Demand Reduction

Figure 8 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. The participants were approximately 21% better than baseline on average, while the non-participant comparison group was approximately 7% better than baseline. Figure 8 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 small sample sizes for these subgroups suggest caution in the interpretation of the results.

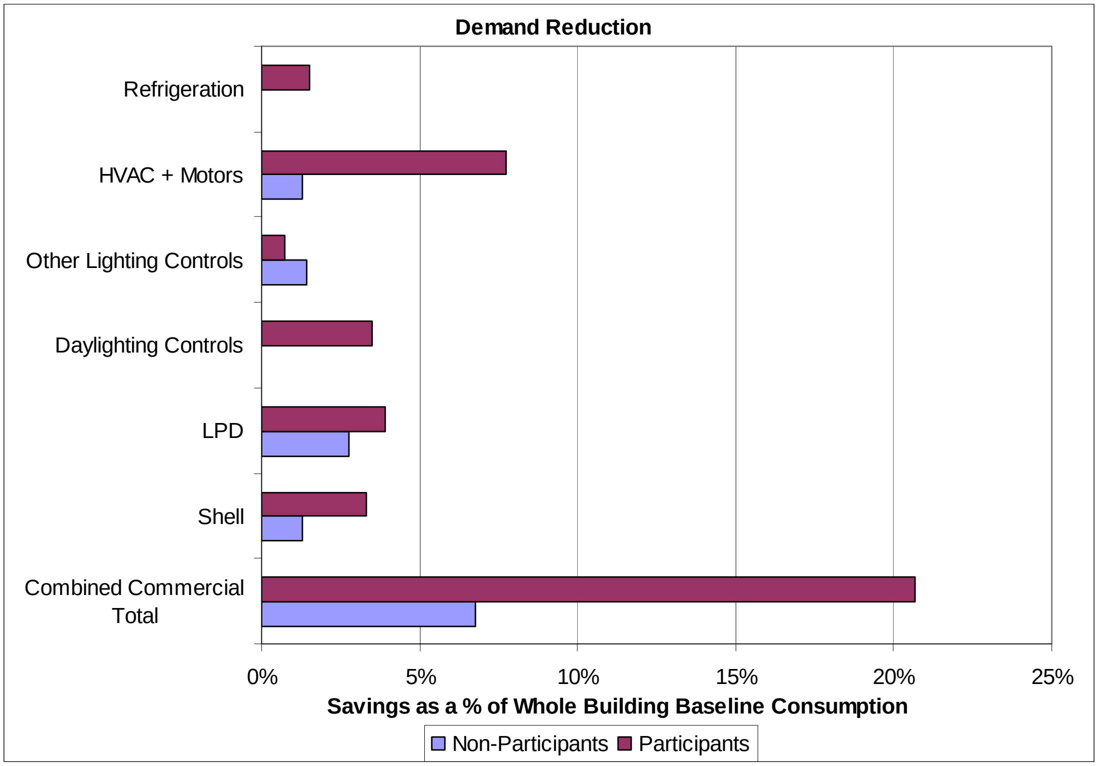


Figure 8: Participant and Non-participant Demand Reduction as a Percentage of Baseline Demand

Table 24 shows participant and non-participant savings as a percentage of baseline consumption by end use as well as the corresponding error bounds; in other words, Table 24 presents the data shown graphically in Figure 8 along with the error bounds at the 90% confidence level. In general, the non-participant error bounds are quite large relative to the estimates, which is a direct consequence of the small non-participant sample size. Therefore, when interpreting these results, one must use caution, particularly when making comparisons between the participants and the non-participants. There are, however, some statistically significant differences between the participants and the non-participants[18]. Participants are significantly more efficient than non-participants at the building level and in the HVAC + Motors and daylighting controls. Refrigeration end uses are not represented in the non-participant sample. For all other end uses (i.e. Shell, LPD, Other Lighting Controls, and HVAC + Motors), the differences shown are not statistically significant.

[18] Statistical significance tests were conducted at the 90% level of confidence.

End Use	Participants		Non-Participants	
	Savings as a % of Building Baseline	Error Bound	Savings as a % of Building Baseline	Error Bound
Shell	3.3%	1.2%	1.3%	0.9%
LPD	3.9%	1.3%	2.8%	3.0%
Daylighting Controls	3.5%	1.1%	0.0%	0.0%
Other Lighting Controls	0.7%	0.4%	1.4%	1.1%
HVAC + Motors	7.7%	1.9%	1.3%	1.8%
Refrigeration	1.5%	0.6%	-	-
Combined Commercial Total	**20.7%**	**4.3%**	**6.8%**	**4.1%**

Table 24: Participant and Non-participant Demand Reduction as a Percentage of Baseline Consumption with Error Bounds – Commercial Sites Only

Incented Measures

Table 25 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 27.0 MW, representing a gross realization rate of 100.9%.

Program Estimated Demand Reduction (MW)	Sampled Demand Reduction (MW)	% Demand Reduction Sampled	Evaluated Demand Reduction (MW)	Realization Rate
26.7	10.5	39.4%	27.0	100.9%

Table 25: Summer Peak Demand Reduction – Incented Measures Only

Table 26 shows the estimated gross summer peak demand reduction and gross realization rates for incented measures only. Nearly 50% of the reduction due to incented measures is accounted for by Whole Building projects (Figure 9). Lighting measures account for nearly 20% of the demand reduction occurring from incented measures with lighting measures accounting for about 5 MW of demand reduction. HVAC + Motors account for about another 4 MW of demand reduction.

Table 26 also shows that the Whole Building Approach as well as LPD + Other Lighting Controls yield the largest program demand reduction as a percentage of the end use baseline demands, with each producing over 25% savings above their baseline demands. Shell, whole building, and industrial are the only measures with gross realization rates of 100% or greater. Refrigeration measures are experiencing the lowest gross realization rate. Similar to the energy findings, Refrigeration demand savings are producing the lowest realization rates (65%), 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 Estimated Demand Reduction (MW)	Gross Realization Rate
Systems Approach	Shell	0.5	0.8	143.1%	NA	0.3	185%
	LPD + Other Lighting Controls	3.5	1.3	37.0%	29.6%	4.9	71%
	Daylighting Controls	1.4	0.7	47.3%	12.3%	1.9	78%
	HVAC + Motors	4.1	1.2	28.4%	9.2%	4.4	94%
	Refrigeration	0.4	0.3	68.3%	14.2%	0.6	65%
	Whole Building	13.1	2.9	22.0%	24.8%	12.8	102%
	Combined Commercial Total	**23.1**	**3.2**	**13.8%**	**16.7%**	**24.9**	**93%**
	Industrial	3.9	1.2	31.1%	NA	3.1	126%

Table 26: Summer Peak Demand Reduction and Realization Rates by Measure Category – Incented Measures Only

Figure 9 shows the composition of the total estimated gross summer peak demand reduction for incented measures only. Whole Building measures continue to represent the greatest portion of demand savings, producing nearly half of the total incented measures only demand savings for the program.

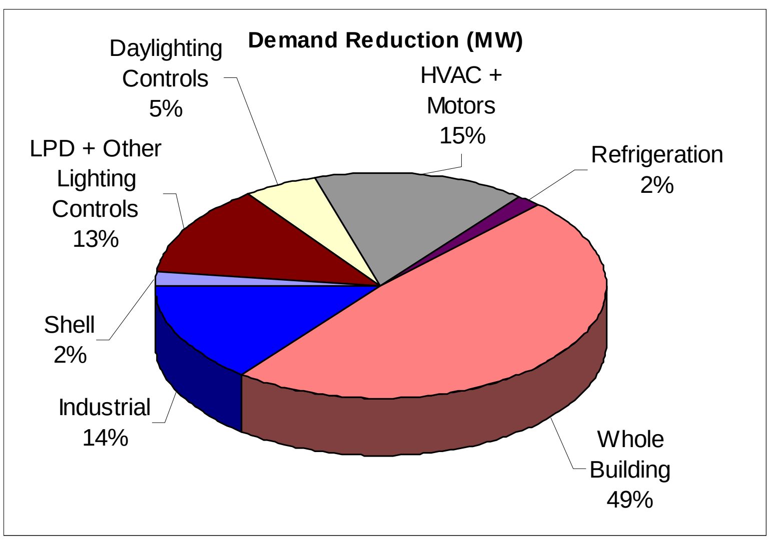


Figure 9: Composition of Summer Peak Demand Reduction – Incented Measures Only

Figure 10 graphically illustrates the efficiency of the incented measures expressed as a percentage of each end-use's baseline demand[19]. As Figure 10 shows, Whole Building and LPD + Other Lighting Controls measures were more efficient relative to end use 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 HVAC + Motors measures was less than 10% of the end use baseline demand. 2001 code changes strengthened Title 24 requirements for HVAC, so perhaps this end-use is saving less (as a percentage of end-use consumption) than the other measures due to the increased difficulty of exceeding code requirements for HVAC. This challenge will intensify for small HVAC units (65,000 BTUh and smaller) when the Federal standard of SEER 13 becomes effective in January 2006.

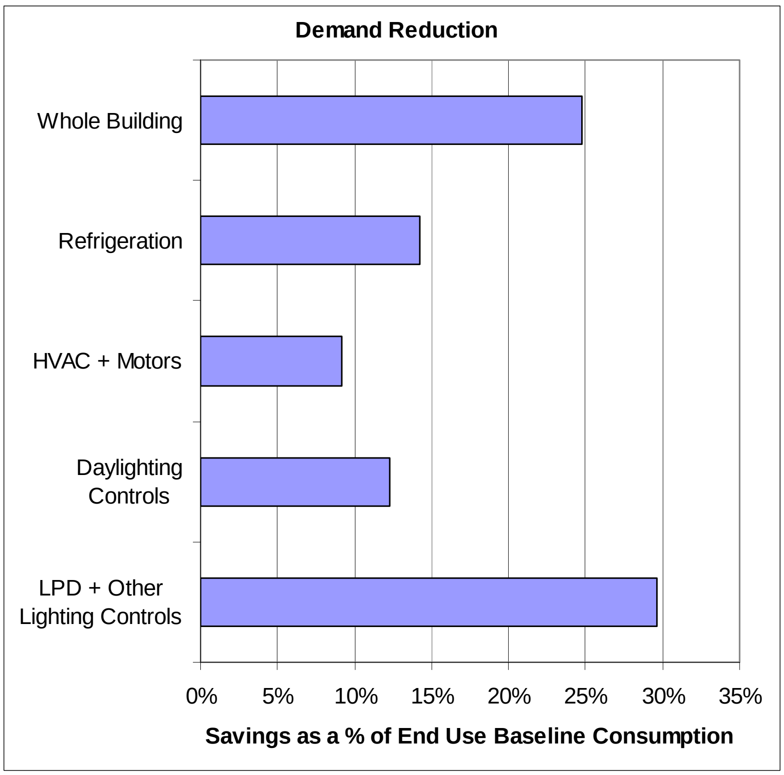


Figure 10: Demand Reductions as Percentages of End Use Baseline – Incented Measures Only

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 vs. Whole Building Approach projects on a "per unit" basis. Two comparisons are made at the statewide level in this section.

[19] 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.

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 (total building savings). For this analysis we have excluded industrial projects because square footage data was either not available or was not relevant to the analysis.

Statewide Systems vs. Whole-Building

Table 27 compares the energy savings of Systems projects to Whole Building projects. As shown in the table, Whole Building projects save significantly more (nearly two times) energy per square foot than Systems projects. The gross realization rate of the Systems and Whole Building approaches both exceed 100%, with systems projects achieving a gross realization rate of 101% and whole building projects experiencing a gross realization rate of 128%. Note that the Systems Approach in this analysis includes other efficient systems and interactions not incented by the SBD program. The whole building analysis is a comprehensive integrated design approach which, by its comprehensive nature, includes savings for all measures employed in the building design.

	kWh / SQFT	Gross Realization Rate
Systems Approach	2.72	101.3%
Whole Building Approach	5.27	127.9%

Table 27: Systems vs. Whole Building Projects – Annual Energy Savings

Table 28 compares the demand reduction of systems projects to whole-building projects. Whole-building projects experience a higher demand reduction per square foot, with nearly a two to one ratio, similar to the energy savings results in Table 27. The table also shows that Whole Building projects experience a gross realization rate closer to 100% than 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 consider that the demand savings are calculated differently between the BEA study and the program. The BEA evaluation is based on the utility coincident peak, while the program calculates demand savings based on building peak. Depending upon the timing of the building peak, the difference between the two methods can be significant (Table 22).

	W / SQFT	Gross Realization Rate
Systems Approach	0.72	127.2%
Whole Building Approach	1.29	102.4%

Table 28: Systems vs. Whole Building Projects – Summer Peak Demand Reduction

Systems Measures Only vs. Whole-Building

Table 29 compares the savings of Whole Building projects to System projects for incented measures only. As shown in the table, Whole Building projects save over twice as much 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	1.98	73.8%
Whole Building Approach	5.27	127.9%

Table 29: Systems vs. Whole Building Projects – Incented Measures Only – Annual Energy Savings

Table 30 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. These results are similar to 2002 findings (Systems = 0.33 w/sqft, Whole Building Approach=1.33 w/sqft)[20]. The demand savings performance indicators further reinforce the value of Whole Building design over Systems Approach projects.

	W / SQFT	Gross Realization Rate
Systems Approach	0.47	82.6%
Whole Building Approach	1.29	102.4%

Table 30: Systems vs. Whole Building Projects – Incented Measures Only – Summer Peak Demand Reduction

When comparing Systems Approach savings in Table 27 and Table 29 it becomes evident that 27% 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. 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 Whole Building Approach; therefore the program has an obvious need to continue offering both participation options.

[20] 2002 Building Efficiency Assessment, An Evaluation of the Savings By Design Program, RLW Analytics, Inc., July 2004, page 35.

Net savings results for both annual energy savings and summer peak demand reduction are presented in this chapter. Furthermore, results are shown by end-use and System vs. Whole Building projects. Assessments of free-ridership by measure category 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 (participants) and measures more efficient than baseline (non participants). Based on the survey responses the engineering simulation models were adjusted to reflect these efficiency choices absent the Savings By Design program. The engineering models were then re-simulated. The results of these simulations were analyzed to obtain the net savings for participants and spillover savings for non-participants.

Table 31 shows the total net program impacts taking into account both participant free-ridership and non-participant spillover. Using this methodology, the commercial net participant savings are 85,023 MWh, which corresponds to a participant net realization rate of 86% and a participant net-to-gross ratio of 76%. Spillover savings in the non-participant population are 97 MWh. These two results together suggest a commercial total net program impact of 85,119 MWh, yielding a net realization rate of 86% and a net-to-gross ratio of 76%. Industrial measures achieved net savings 18,474 MWh, corresponding to a net realization rate of 61% and a net-to-gross ratio of 59%.

	Commercial Energy Impacts (MWh)	Industrial Energy Impacts (MWh)	Calculation
Program Tracking Savings	99,317	30,111	A
Gross Savings	111,748	31,307	B
Gross Realization Rate	112.5%	104.0%	(B / A)
Net Participant Savings	85,023	18,474	C
Participant Net Realization Rate	85.6%	61.4%	(C / A)
Participant Net-to-Gross Ratio	76.1%	59.0%	(C / B)
NP Spillover Savings	97	NA	D
Total Net Savings	85,119	18,474	C + D
Comprehensive Net Realization Rate	85.7%	61.4%	(C + D) / A
Comprehensive Net-to-Gross Ratio	76.2%	59.0%	(C + D) / B

Table 31: Total Net Energy Program Impacts

Table 32 displays the estimated spillover savings in the non-participant population by end-use. The LPD end-use accounts for more than 99% of the spillover energy savings that are occurring in the non-participant population. Only one non-participant site was found to be experiencing any spillover energy savings. The spillover experienced was in the LPD end use; the remaining spillover shown in Table 32 is due to interactive effects.

End Use	Non-Participant Spillover Energy Savings (MWh)
Shell	0.4
LPD	96.5
Daylighting Controls	0.0
Other Lighting Controls	0.0
HVAC + Motors	-0.2
Refrigeration	0.0
Combined Total	**96.7**

Table 32: Non-participant Spillover Energy Savings

Table 33 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. The Refrigeration and Shell end uses have the best net-to-gross ratios with each showing a net-to-gross ratio of approximately 95%. The daylighting controls end-use has the worst net-to-gross ratio, 39%, which is having a sizable negative effect on the overall net-to-gross ratio for the commercial end uses because the daylighting controls end-use comprises 16% of the total commercial gross 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	8,708	30.0%	0.4	8,709	9,232	94.3%
LPD	20,286	40.3%	96.5	20,383	27,778	73.4%
Daylighting Controls	6,947	37.5%	0.0	6,947	17,648	39.4%
Other Lighting Controls	3,270	46.5%	0.0	3,270	4,373	74.8%
HVAC + Motors	30,473	30.9%	-0.2	30,473	36,835	82.7%
Refrigeration	15,337	34.6%	0.0	15,337	15,883	96.6%
Combined Commercial Total	**85,023**	**12.7%**	**97**	**85,119**	**111,748**	**76.2%**
Industrial	18,474	38.4%	NA	18,474	31,307	59.0%

Table 33: Total Net Energy Program Impacts by Measure Type

Considering only the commercial end-uses, the program is producing a net-to-gross ratio of 76.2%. Less than 1% (97 MWh) of the 76% is a result of spillover savings. The spillover impact is negligible. The program experienced approximately 25% free-ridership. For comparison sake, the previous BEA study (program year 2002) found the free-ridership to be 31% for commercial buildings, excluding spillover savings (Table 34). This finding indicates that in terms of the commercial program, free-ridership has been reduced by approximately 7% when compared to the previous year's evaluation. For industrial projects, previous BEA study found the participant free-ridership to be 65% for industrial measures, indicating free-ridership has been reduced by approximately 24% in the 2003 program.

Sector	Program Year	Net-to-gross Ratio	
		Including NP Spillover	Excluding NP Spillover
Commercial	99-01 Participant Net-to-gross	82%	59%
Commercial	2002 Participant Net-to-gross	75%	69%
Commercial	2003 Participant Net-to-gross	76%	76%
Industrial	2002 Participant Net-to-gross	na	35%
Industrial	2003 Participant Net-to-gross	na	59%

Table 34: Net-to-Gross Ratio Results– Incented Measures Only

In 99-01 BEA study, there were no industrial projects, whereas in the 2002 and 2003 studies the energy savings due to industrial measures were considerable. In total, industrial projects represented 22% in 2003, down from 25% of the overall energy savings evaluated in the 2002 BEA Study.

Industrial measures were diverse and the net savings analysis often called for in-depth qualitative questioning that went beyond the scope of the original survey questionnaire. Many of the industrial measures were extremely large in terms of energy savings; therefore it was extremely important to have comprehensive discussions regarding the decision making that occurred at the time of the measure installation. However, these measures were typically important to the customer's process, large in terms of energy consumption, and expensive to procure. Therefore decision makers were easily able to recall and discuss the decision making process that led them to install the equipment incented by Savings By Design. These issues also contributed to the relatively high free-ridership of 41%.

Some specific findings that contributed to the low NTG included:

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

The final net to gross ratio of 59% represents an improvement over 2002. However, it is important to note that the low net-to-gross for 2002 (35%) was, in large part, because the energy savings for one very large project were disallowed. Further information on each industrial site evaluated is available in the industrial site write-ups provided in the Appendix.

Table 35 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 are not tracking savings available at this level.

The areas of the Savings By Design program with the next highest rate of free-ridership are the LPD + Other Lighting Controls and the HVAC + Motors measure categories, with each showing approximately 35% free-ridership. Like last year, the evaluation has found that about half of non-participant energy savings are attributable to LPD and Other Lighting Controls with a free-ridership of 53%.

Whole Building Approach projects are producing a 74% net-to-gross ratio. 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 have a relatively good measure of net savings. These considerations indicate that the Whole Building Approach is the most cost effective method of project qualification 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 Estimated Energy Savings (MWh)	Net Realization Rate
Systems Approach	Shell	495	128.4%	497	99.5%	0.5%	567	87.2%
	LPD + Other Lighting Controls	11,831	30.5%	18,576	63.7%	36.3%	20,219	58.5%
	Daylighting Controls	4,602	50.5%	5,870	78.4%	21.6%	6,182	74.4%
	HVAC + Motors	9,162	29.6%	13,995	65.5%	34.5%	24,446	37.5%
	Refrigeration	3,135	66.0%	3,458	90.7%	9.3%	6,026	52.0%
	Whole Building	39,866	24.0%	53,577	74.4%	25.6%	41,877	95.2%
	Combined Commercial Total	**69,090**	**13.2%**	**95,973**	**72.0%**	**28.0%**	**99,317**	**69.6%**
	Industrial	18,474	38.4%	31,307	59.0%	41.0%	30,111	61.4%

Table 35: 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 36 shows the total net program impacts for summer peak demand reduction, taking into account both participant free-ridership and non-participant spillover. The commercial net participant reduction is 20.7 MW, which corresponds to a participant net realization rate of 83% and a participant net-to-gross ratio of 73%. Spillover savings in the non-participant population are small, 0.03 MW. These two results together indicate a commercial total net program impact of 20.8 MW, yielding a net realization rate of 84% and a net-to-gross ratio of 73%. Industrial measures achieved a net reduction of 2.1 MW, corresponding to a net realization rate of 69% and a net-to-gross ratio of 55%.

	Commercial Demand Impacts (MW)	Industrial Demand Impacts (MW)	Calculation
Program Tracking Savings	24.9	3.1	A
Gross Savings	28.5	3.9	B
Gross Realization Rate	114.5%	125.9%	(B / A)
Net Participant Savings	20.7	2.1	C
Participant Net Realization Rate	83.3%	68.7%	(C / A)
Participant Net-to-Gross Ratio	72.8%	54.6%	(C / B)
NP Spillover Savings	0.03	NA	D
Total Net Savings	20.8	2.1	C + D
Comprehensive Net Realization Rate	83.5%	68.7%	(C + D) / A
Comprehensive Net-to-Gross Ratio	72.9%	54.6%	(C + D) / B

Table 36: Total Net Demand Program Impacts

Table 37 displays the estimated spillover demand reduction in the non-participant population by measure category. Only one non-participant site was found to have spillover, as noted earlier in the energy savings section.

End Use	Non-Participant Spillover Demand Reduction (MW)
Shell	0.00
LPD	0.03
Daylighting Controls	-
Other Lighting Controls	-
HVAC + Motors	(0.00)
Refrigeration	-
Combined Total	**0.03**

Table 37: Non-participant Spillover Demand Reduction

Table 38 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 shell and refrigeration measure categories each have a net-to-gross ratio exceeding 95%. Daylighting controls show a net-to-gross ratio of 38%. 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 55%, 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	4.4	34.7%	0.00	4.4	4.5	97.1%
LPD	3.8	36.8%	0.03	3.9	5.4	72.0%
Daylighting Controls	1.8	42.7%	-	1.8	4.8	38.1%
Other Lighting Controls	0.8	64.5%	-	0.8	1.0	74.0%
HVAC + Motors	7.9	20.2%	(0.00)	7.9	10.7	73.9%
Refrigeration	2.0	36.1%	-	2.0	2.1	96.6%
Combined Commercial Total	**20.7**	**15.5%**	**0.03**	**20.8**	**28.5**	**72.9%**
Industrial	2.1	37.5%	NA	2.1	3.9	54.6%

Table 38: Total Net Demand Program Reduction by Measure Type

Free-ridership by Measure Category – Incented Measures Only

Table 39 shows the free-ridership rate for summer peak demand reduction by measure category for incented measures only. The table shows that the greatest amount of free-ridership is occurring in the HVAC + Motors and Industrial measure categories, with the free-ridership rate in each category exceeding 45%. The measure category with the next highest level of free-ridership is LPD + Other Lighting Controls, which has a free-ridership rate of 41%. Whole Building measures have a free-ridership rate of 31%, and daylighting controls show approximately 22% free-ridership. The exceptions to the relatively high free-ridership are the refrigeration and shell measures, which have free-ridership rates less than 10%.

Table 39 also shows net realization rates by measure category for incented measures only. All measures with the exception of LPD + Other Lighting Controls have a net realization rate greater than 50%. Shell measures have a net realization rate exceeding 100%. Whole building and Industrial measures each have a net realization rate of approximately 70%. Daylighting controls and refrigeration measures each have net realization rates of approximately 60%, and HVAC + Motors achieves a net realization rate of 50%. The category with the lowest net realization rate is LPD + Other Lighting Controls, which has a net realization rate of 42%.

	Measure Category	Participant Net Demand Reduction (MW)	Relative Precision of Participant Net Reduction	Measures Only Gross Reduction (MW)	Net-to-Gross Ratio	Free-Ridership Rate	Program Estimated Demand Reduction (MW)	Net Realization Rate
Systems Approach	Shell	0.5	143.4%	0.5	99.8%	0.2%	0.3	184.6%
Systems Approach	LPD + Other Lighting Controls	2.1	42.0%	3.5	59.1%	40.9%	4.9	41.8%
Systems Approach	Daylighting Controls	1.1	61.4%	1.4	77.3%	22.7%	1.9	60.4%
Systems Approach	HVAC + Motors	2.2	27.4%	4.1	53.6%	46.4%	4.4	50.2%
Systems Approach	Refrigeration	0.4	71.3%	0.4	90.9%	9.1%	0.6	59.5%
	Whole Building	9.0	24.0%	13.1	69.0%	31.0%	12.8	70.7%
	Combined Commercial Total	**15.3**	**15.0%**	**23.1**	**66.4%**	**33.6%**	**24.9**	**61.6%**
	Industrial	2.1	37.5%	3.9	54.6%	45.4%	3.1	68.7%

Table 39: 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 and correlate directly with the flow of the decision-maker survey. Wherever possible, the participant and non-participant responses are analyzed and presented together to facilitate comparison.

This section addresses the following areas of interest:

- Building descriptive statistics,
- Construction practices,
- Energy efficiency attitudes,
- Building energy performance,
- Savings By Design program attitudes and awareness, and
- Prototype projects

Survey Respondents

A total of 110 surveys were completed; 74 with program participants, and 36 with non-participants. 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.

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

Many of the SBD program participants were responsible for multiple buildings within our sample, especially where a set of prototype plans were used. In some cases, several surveys were conducted with a single person responsible for the energy efficient design decisions for all of the sampled projects under their control, and questions were asked multiple times to get the project specific information. For example, design decisions may be different for similar buildings built in different climates due to HVAC considerations.

Methodology

Comparing Participants with Non-Participants

Wherever possible, the participant and non-participant responses are analyzed and presented together, to facilitate comparison. As described in the Program Activity and Sample Summary section, comparisons between participants and non-participants should consider the different characteristics of each sample as described in Table 13.

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, and assume an absence of bias. Statistically significant differences between participant and non-participant responses are shaded in gray. A sample set of results is shown in Table 40.

	% of Respondents	
	Participants	Non-Participants
Yes	72.2%	46.0%
No	13.6%	28.9%
Somewhat	14.3%	23.2%
Don't Know	-	1.9%
Sample Size	73	33

Table 40: Sample Table of Responses (q16)

The table title includes a reference to the actual question number (q16) in the surveys, found in the appendix. In this example, q16 is question #16 in both the participant and non-participant surveys.

Weighted Responses

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

Results are reported by “% of respondents,” calculated by:

(weighted number of respondents) / (total weighted sample).

Percentage of respondents

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

Sample Size

“Sample size”, as shown in Table 40, represents the actual un-weighted number of respondents who answered the question, and is reported separately for each question. This is necessary since not every question was answered by every person, due to refusal or inapplicability

Don’t Know

These answers are included in the sample size for each question and are considered a legitimate category of response.

Refusals/No Answer

Not every question was answered in every interview, due to refusal to answer, non applicable, or other reasons. For each question, non-responses (missing values) have been eliminated and the sample size for that question appropriately reduced.

Qualitative Responses

For non quantitative results, verbatim responses are provided throughout this report. Some questions list all responses, while other questions provide only a sampling of responses. In this case, sample responses were selected for their content and may not be representative of all the responses for that question. A complete list of responses for each question is included in the Appendices.

Survey Results

Comparison of Participants with Non-Participants

Table 41 shows the building ownership type by program participation status. While the majority of projects are privately owned for both types of respondents, the percentage of non-participant private projects (70.4%) is higher than that of participants (57.0%).

	% of Respondents	
	Participants	Non-Participants
Private	57.0%	70.4%
Public	43.0%	29.6%
Sample Size	74	36

Table 41: Building Ownership (q10)

Table 42 shows the building occupancy intent during construction by program participation status. We found the pattern of owner-occupation to be similar between the two groups. Findings from previous BEA studies have shown that owner occupied buildings are more likely to make construction decisions using more sophisticated investment decision making procedures, such as return on investment (ROI) or lowest lifecycle cost, whereas speculative building decision makers more frequently used lowest first cost decision making.

	% of Respondents	
	Participants	Non-Participants
Built to be owner occupied	83.5%	88.7%
Built with intent to lease space	16.5%	3.1%
Mixed owner occupy and lease	0.0%	8.2%
Sample Size	74	36

Table 42: Occupancy Intent During Construction (q11)

Energy Efficiency Attitudes

All interviewees were asked how they would describe the level of importance of energy efficiency. The responses, in Table 43, show that there is a significant difference between participants and non-participants, however virtually all respondents ranked efficiency as either "very important" or "somewhat important", 99% and 85% respectively. Note that essentially no one responded with "very or somewhat unimportant".

	% of Respondents	
	Participants	**Non-Participants**
Very Important	61.1%	28.4%
Somewhat Important	37.8%	56.2%
Neither Important nor Unimportant	0.8%	13.5%
Somewhat Unimportant	0.4%	0.0%
Very Unimportant	0.0%	0.1%
Don't Know	0.0%	1.9%
Sample Size	74	36

Table 43: Importance of Energy Efficiency (q12)

Table 44 presents the most important financial criteria used to make energy efficient investments during construction by program participation status. The most frequent answer for participants was "lowest lifecycle cost" (31%) while 17.8% of non-participants provided this response. The most frequent response for non-participants was "lowest first cost" (48.3%), a substantial increase over the 2002 findings (19.1%).

The cost-over-time responses (lowest lifecycle cost, simple payback, ROI, and net present value) were indicated by 53% of participants, but only 43% of non-participants. These responses are higher than the 2002 findings (46% and 23% respectfully).

	% of Respondents	
	Participants	**Non-Participants**
Lowest first cost	18.4%	48.3%
Lowest lifecycle cost	30.8%	17.8%
Simple payback	17.6%	2.0%
Return on investment	5.0%	17.2%
Net present value	0.0%	6.5%
None	14.9%	0.0%
Multiple	12.2%	0.0%
Don't Know	1.2%	8.1%
Sample Size	74	36

Table 44: Most Important Financial Criteria (q13)

Design and Construction Practices

Table 45 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 majority of participants did so (70%), while only 24% of non-participants made this request to their design teams.

	% of Respondents	
	Participants	**Non-Participants**
Yes	70.2%	23.7%
No	24.5%	73.8%
Don't Know	5.3%	2.5%
Sample Size	74	33

Table 45: Asked Design Team to Increase Energy Efficiency (q14)

Some of the verbatim explanations of why they asked their design team to consider energy efficiency are listed below:

<u>*Select Participants*</u>

Yes, we did go beyond Title-24 by incorporating premium efficient motors with VFDs, lighting controls, and reflective roofs. This is one of the most energy efficient buildings in our history.

Yes, there was some analysis and modest changes only on the rebated measures: lighting and HVAC.

With energy rates so high in California, we knew it was important to design an efficient building. SCE helped us achieve that by improving our HVAC & lighting.

We were trying to achieve 25% better than Title 24; the systems we worked on to achieve this were lighting, glazing and HVAC.

We went to PG&E so that we could meet the minimum requirements to qualify for the SBD program. After we found out what those requirements were, we told the design team to incorporate them.

We wanted dimmable ballasts on our lights to capture natural daylight, high efficiency refrigeration compressors, and improved HVAC system.

We told them to incorporate energy efficient features that were effective in saving energy but not too costly. These discussions on energy efficiency came after our meetings with PG&E.

Energy efficiency was the subject of many meetings with the design team not sure of the specifics.

To look at the most cost effective measures, things that we would consider included windows, insulation, lighting and the mechanical system.

<u>*Select Non-participants*</u>

The HVAC system is always specified for high efficiency. We also requested motion sensors and EMS to control the HVAC units.

Requested daylighting to reduce light load.

Our team attended a seminar at the PEC and came to us with 3-4 methods to design an efficient building.

Longevity of equipment and being better than Title-24 within our limited budget.

Asked for the best they [our client] could afford.

Asked for daylighting and the natural air flow (circulation).

Typically HVAC exceeds [T24 requirements]--it is standard operating procedure.

Table 46 displays the percentage of participants and non-participants who said they downgraded energy efficiency features through value engineering. A significantly smaller percentage of participants made downgrades over non-participants.

	% of Respondents	
	Participants	**Non-Participants**
Yes	5.0%	21.6%
No	91.2%	76.0%
Other	1.4%	0.0%
Don't Know	2.4%	2.5%
Sample Size	74	35

Table 46: Energy Efficiency Features Downgraded through Value Engineering (q15)

Respondents who said energy efficiency features were downgraded were asked to elaborate.

Select Participants

Our lumen monitoring system was disabled and down-graded.

We modeled our building after another building using KALWALL--but it got voted out and we used another design.

Select Non-participants

The PV had to be eliminated, but we got the windows and airflow.

The contractor didn't deliver on the skylights.

Refrigerator's compressor motors.

Probably yes, the project was on a tight budget I suspect the mechanical system was value engineered.

Don't know that energy efficiency was compromised but there was some value engineering on the AC system.

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 47 presents the distribution of responses for both groups, and shows a significant difference in participants versus non-participants. Non-participants are significantly more likely to design projects just to code. This is a significant increase over the 2002 responses (23.7%).

	% of Respondents	
	Participants	Non-Participants
Much better	38.0%	7.6%
A little better	47.0%	46.3%
Just to code	11.6%	28.2%
Don't Know	3.4%	17.9%
Sample Size	73	33

Table 47: Estimate of Energy Efficiency to Title 24 (q17)

Table 48 summarizes the responses given when owners were asked to describe the energy performance of their building. While there are significant differences in how the two groups responded, there is no consistent trend. Perhaps the most surprising category was “the building is about as efficient as it can be”, selected by 34.5% of non-participants, but only 18.1% of participants. Only 30.2% of non-participants responded that their buildings “could be much more efficient”.

	% of Respondents	
	Participants	Non-Participants
Is an example of energy efficiency	14.3%	9.6%
Is about as efficient as it can be	18.1%	34.5%
Could be somewhat more efficient	46.2%	14.8%
Could be much more efficient	15.0%	30.2%
Don't Know	6.5%	10.9%
Sample Size	73	35

Table 48: Energy Performance of Building (q18)

Participant Responses

Savings by Design Program Attitudes and Awareness

All SBD program participants were asked how they first became aware of the SBD program, services, and owner incentives that were available. As shown in Table 49, about 76% of participants heard of the program through utility representatives or previous utility program participation. The large proportion of participants that previously participated in utility programs (41%) suggests that the program may need to change its marketing strategy to attract a broader audience and get more customers that have not previously participated. However, the number learning from utility representatives (35.5%) is significantly higher than the 2002 results (26.1%). The lack of responses indicating web sites or marketing material is noteworthy.

	% of Participants
Previous utility program participation	40.6%
Utility representative	35.5%
Architect	5.2%
Utility seminar PEC or SCE	4.8%
Engineer	4.6%
Other	3.6%
Energy manager	2.7%
Don't Know	2.6%
Previous tenant	0.4%
Marketing material	0.0%
Web site	0.0%
Manufacturer representative	0.0%
Construction manager	0.0%
Sample Size	74

Table 49: Source of Awareness of Savings By Design (q21)

All SBD participants were asked at what stage of the design and construction process they became actively involved with the SBD representative. Interviewees were read the list of options in Table 50. The results indicate that over half became involved with the program early in the design process (32% during project conception, 19% during project development, and 10% during the design development phase). SBD involvement began during the construction documents phase for 21% of respondents. However, 7.2% involved SBD representatives late in the process, 3.7% during construction, and 3.5% following completion of construction, suggesting that design and equipment decisions were made prior to SBD involvement. Barring other countervailing considerations, these participants would be considered freeriders.

	% of Participants
Project conception	31.5%
Project development phase	19.0%
Schematic design phase	8.7%
Design development phase	9.8%
Construction documents phase	20.9%
During construction	3.7%
Following completion of construction	3.5%
Following facility occupancy	0.0%
Don't Know	3.0%
Sample Size	68

Table 50: When became involved with SBD representative (q23)

Table 51 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 were the biggest advocates for SBD participation. This supports the finding of the NRNC baseline study[21] that architects and engineers feel that the owners are the key decision-makers. Other notable advocates were architects and mechanical engineers.

	% of Participants
Owner/Developer	60.4%
Architect	14.9%
Mechanical Engineer	11.5%
Energy Manager	7.1%
Contstruction Manager	4.2%
Other	1.2%
Electrical Engineer	0.7%
Sample Size	74

Table 51: Biggest Advocate for Participating in SBD (q24)

All SBD participants were asked to rate the level of importance of the incentives paid to the owner in motivating their organization to participate. As shown in Table 52, approximately 85% said the incentive was either “very important” or “somewhat important”, while 9% rated the incentive very unimportant or somewhat unimportant. This suggests that incentives are a critical tool for engaging program participation of building owners.

	% of Participants
Very important	54.6%
Somewhat important	30.3%
Neither important nor unimportant	6.2%
Somewhat unimportant	5.2%
Very unimportant	3.7%
Sample Size	74

Table 52: Importance of Owner Incentive in Participation (q25)

All SBD participants were asked to rate the level of importance of the design assistance provided by SBD in motivating their participation in the program. Table 53 shows that 72% rated the assistance as very or somewhat important, while 20% rated the assistance as very or somewhat unimportant.

[21] 1999 Non-Residential New Construction Baseline Study.

	% of Participants
Very important	32.0%
Somewhat important	39.5%
Neither important nor unimportant	8.3%
Somewhat unimportant	9.8%
Very unimportant	10.4%
Sample Size	74

Table 53: Importance of Design Assistance for Participation (q26)

As shown in Table 54, 79% of participants stated SBD participation influenced them to change their standard building practices to lead to more efficient buildings in the future; while 18% answered it did not influence changes in standard practice.

	% of Participants
Yes	79.0%
No	18.3%
Don't Know	2.7%
Sample Size	74

Table 54: Changed Standard Practice to Higher Energy Efficiency due to SBD Participation (q27)

Participants who responded that SBD will not influence standard practice on future buildings were asked why. All responses are listed below.

<u>All Participant Responses</u>

> *We had already specified energy-efficiency components in our prototype design absent of the program. When a representative contacted us about the program they determined that our specifications were better than code and qualified for incentives.*
>
> *The … standards influence our design standards, these buildings don't have to meet Title 24. This was a unique project, so we would not be designing something like this usually.*
>
> *They [our client] already had energy-efficient guidelines.*
>
> *We already had energy efficiency in our design. It is part of our standard practice.*
>
> *We think our design team is cutting-edge and they build the most efficient buildings possible.*
>
> *Couldn't justify the cost of EMS without incentive.*

Participants who answered "Yes, SBD will influence standard practice on future buildings", were asked what specific changes they are making or will make to their standard practice to increase future building energy efficiency. Select responses are below.

Select Participant Responses

We've changed our lighting fixtures by improving the luminaire and the ballast factor by reducing it to 0.78 from 0.88 BF. We also improved the HVAC packaged rooftop units to a higher EER and included economizers where applicable.

Changes we'll make are to go with a more efficient lighting system. Better insulation and incorporating energy management systems.

We try to exceed Title 24 by 20% we achieve this by installing increased insulation, glazing and higher efficiency HVAC system.

More use of natural lighting, energy efficient lighting fixtures, and different types of material on insulation.

They have influenced us to include VFD the other measures are pretty much standard practice.

On future projects, we would install high performance lighting and HVAC systems.

Incentives helped us to practice more energy efficient designs. It is our goal (design team) to beat Title 24 on every project.

We always incorporate energy efficiency into our design for various reasons, including return on investment and business objectives. We know that daylight harvesting improves test scores in schools.

Using energy efficient lighting wasn't something we had done in the past. We are not only putting in efficient lighting in new construction but also renovating existing buildings. Air handlers for HVAC we make sure are always high performance with VFD.

If we were to develop another building we would get involved with SBD earlier, during project conception, and we would reduce the quantity of lighting fixtures.

Participants were asked to rate the value of SBD Incentives, Design Assistance, and Design Analysis. The results, shown in Table 55, indicate high satisfaction with all three components. A significant majority of respondents gave a rating of 1 or 2, where a rating of one is “very valuable”. The ratings are highest for Design Analysis where 75% rated this service a 1 or 2, as compared to 64% for Design Assistance. Only 30 of the 72 participants were able to respond to Design Analysis questions since this participation path is not always utilized by program participants, unlike the other two program offerings (incentives and design assistance), which are always utilized. Design Analysis typically requires very early engagement of SBD in the building design process and also requires willingness of the owner and A&E team to pursue advanced methods of project design and integration of energy efficiency. The results of this question highlights the value of the advanced services Design Analysis accomplishes with participants that elect to participate in this program offering.

% of Participants 1="Very Valuable" 5="Not at all Valuable"	Incentives	Design Assistance	Design Analysis
1	33.2%	13.3%	18.7%
2	35.8%	50.5%	56.3%
3	13.2%	14.5%	3.3%
4	13.5%	12.9%	3.2%
5	4.2%	8.8%	4.5%
Don't Know	0.0%	0.0%	14.0%
Sample Size	74	74	30
Average score	**2.19**	**2.53**	**2.05**
Sample deviation	0.20	0.32	0.51

Table 55: Value of Incentives, Design Assistance, and Design Analysis (q29)

All participants were asked to provide recommendations for changes to the SBD program in order to improve its delivery to customers. These answers were unprompted, and multiple responses were accepted. The answers have been categorized based on common responses. Percentages reported were calculated by (weighted number of respondents with a particular answer) / (total weighted number of respondents who answered the question). Table 56 shows that 41% of the participants felt that no changes are needed. Other suggestions received support in the range of 10% - 20%. Interestingly, one of the least mentioned responses was to increase incentives (2.9%). This is a significant change from the 2002 results where 27.5% of respondents recommended increased incentives.

Multiple answers were accepted on this question. (Therefore percantages do not add to 100%)	% of Participants
No changes needed	41.4%
Utility should try to get involved earlier in the projects	19.5%
Review and response from utility needs to be more timely	13.8%
More interaction with design team	13.6%
Less paperwork and red tape	11.9%
More marketing to increase awareness of program	10.0%
Utility reps need to present benefits more clearly	3.4%
Increase incentives	2.9%
Increase post project feedback, better "closure"	2.2%
Other	20.2%
Sample Size	50

Table 56: Recommended Changes to Savings By Design (Non prototype, q35)

Other recommendations are listed below.

When power is established at the site they should update people on this program.

We felt that some of their suggestions and their thresholds were unreasonable without a cost-benefit analysis (systems approach). From our assessment the (AC units) were too expensive to justify the increased cost relative to the savings.

Simplify application so owners can fill it out. We had a difficult time understanding the terms, owners need to be able to fill this out and we are not engineers.

On a previous project the design team received a larger incentive than we did which we don't think is right. Some questions we have are, as an end user, how we get the most out of the program. We also wanted to know what we missed. There is no design check list.

More market research on new technologies.

Methodology needs to be explained better for some of the measures as to why they are a good practice. The utility reps also need to present benefits more uniformly… we get a lot of different information depending on who we talk to.

Lower the standards for qualifying design teams.

A lot of our clients are hesitant to participate in the program because it takes too long to get the check and they (utilities) are too picky when they verify measures.

Non-Participants

Savings by Design Program Attitudes and Awareness

All Non-Participants were asked if they were aware of the Savings By Design New Construction energy efficiency program before they began construction. Table 57 shows almost 40% of non-participants indicated they were aware of the program before they began construction, but they did not participate.

	% of Non-Participants
Yes	39.0%
No	55.8%
Don't Know	5.3%
Sample Size	36

Table 57: Awareness of SBD Before Construction Began (npq19)

Non-participants 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 58. A large percentage of the respondents (72%) did not have any interaction with SBD staff or program material regarding design and equipment specifications.

	% of Non-Participants
Yes	16.1%
No	72.0%
Don't Know	11.9%
Sample Size	36

Table 58: Interaction with SBD Staff or Program Material Regarding Design and Equipment Specifications (npq21)

Reasons for Not Participating in SBD Program

Those who were aware of SBD before construction began (the 39% answering “yes" in Table 57) were asked why they did not participate in the program. A sample of verbatim responses is below. The vast majority of responses focus on time constraints or the size of incentives.

Select Non-Participants

Time constraints were the biggest reasons. We needed to proceed as quickly as possible and we would have had to back into it; we just needed to proceed.

This was a fast track project and we were not thoroughly aware of the entire process we suspected including them would slow down the development.

This project was expected to be a SBD recipient but the utilities changed their requirements so it no longer qualified. Our managers didn't alter the design but we have pursued SBD for other projects since this one.

They’ve [our client] got a formula that has worked for them in the past.

The architects have to stick to the plan that comes from the architectural team. They are all cookie cutter.

It was mentioned at the pre-design conference. It was not pursued because of cost. The value in the payback wasn't there because of the amount of time we would have had to spend.

It was considered but the effort to submit the plans and go through the process would have cost more than we would have received from the incentive. Incentive was not significant enough to pursue.

(Electrical Engineer) We made it clear to the client that the building would comply with the program and they could pursue the incentives. But, they showed no interest and there was no budget for us to assist in pursuing the incentives.

(Architect) There was no compensation to pursue the programs and the follow through with SBD suggestions. Construction schedule was tight. And schools look for a short payback for their investments which wouldn't have been possible.

Possible Effect of Incentives

All non-participants were asked if they had been aware of the availability of cash incentives, how likely they would have been to improve their building design to perform better than Title-24, to get the incentives. The results are provided in Table 59. Seventy-six percent of non-participants stated 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. This result is somewhat contradictory since in

Table 57 almost half (39%) said they were aware of the program. It seems unlikely that many non-participants could have been aware of the program, but not aware of incentives.

	% of Non-Participants
Very likely	46.0%
Somewhat likely	30.4%
Neither likely or unlikely	8.2%
Somewhat unlikely	13.4%
Very unlikely	2.0%
Sample Size	35

Table 59: Likelihood of Designing Building to Perform Better than Title-24 if Aware of Financial Incentives (npq22)

Prototype Projects

Comparison of Participants & Non-Participants

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

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

Both participants and non-participants were asked if they used a set of prototype plans or master specifications in the design and construction of their building. There is a significant difference in how the two groups responded, with participants being less likely to use prototype plans than non-participants, although both groups use prototype plans with significant frequency.

	% of Respondents	
	Participants	Non-Participants
Yes	24.8%	53.1%
No	75.2%	41.5%
Don't Know	0.0%	5.4%
Sample Size	74	36

Table 60: Used a set of Prototype Plans (q30 & npq23)

Both participants and non-participants who used a set of prototype plans were asked if at any time SBD was actively involved with design assistance or design analysis in the development, refinement and/or enhancement of the prototype plans. Not surprisingly, many more participants (83%) answered yes, as compared to non-participants, as shown in Table 61. There was one project which received assistance. This site represented 15.2% of the non-participants and is responsible for the non-participant spillover reported in the Net Savings Results section.

	% of Respondents	
	Participants	Non-Participants
Yes	83.3%	15.2%
No	14.8%	74.8%
Don't Know	1.9%	10.0%
Sample Size	25	10

Table 61: Received Design Assistance or Analysis through SBD (q37 and npq29)

Participants – Incentives, Energy Improvements & Recommendations

Of participants who utilized a set of prototype plans, over 43% used the plan for more than 10 buildings, as shown in Table 62. 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
Built 1	0.0%
Built 2-5	22.9%
Built 6-10	33.9%
More than 10	43.3%
Sample Size	25

Table 62: Number of Buildings in Prototype (q43)

Participants using prototype plans were asked if future SBD incentives were an important consideration in the development/modification of their prototype plans. Seventy-six percent of the respondents indicated it was an important consideration. One possible interpretation of this result is that changes to prototype plans were viewed as an “investment” in future incentives.

	% of Participants
Yes	75.8%
No	24.2%
Sample Size	25

Table 63: Future Incentives Important Consideration in Modifying Prototype Plans (q38)

Participants were asked if they would have participated in SBD if they were limited to receive an incentive for only one building using the prototype plans. Most respondents indicate that incenting only one building of a prototype series is sufficient for participation. However, 33% indicate that their participation was dependent on incentive payments on more than one building. This apparent contradiction to Table 63 indicates a high level of complexity associated in the prototype decision process and the difficulty in isolating the impact of one element, such as the influence of incentives.

	% of Participants
Yes	66.9%
No	33.2%
Sample Size	25

Table 64: Would have Participated (past) if IOUs Limited Incentive to One Building Only (q45)

Those who answered "no" above were asked why not. There were some common responses.

<u>Select Participant Responses</u>

We probably would not have produced as many buildings using this prototype with only one incentive.

We need the incentive on each project to pay for the high performance measures.

We need the incentive for each project to install most of the measures. We wouldn't achieve our payback without the incentive, especially on lighting.

There is a lot of extra work to coordinate SBD requirements if we could not get incentives for all the projects we wouldn't participate.

With a lack of incentives it's too time consuming. Construction is an evolving process with input from SBD. We look at this as a process, not just a project, which is also evolving our prototype design.

Participants with prototype plans were asked if they would participate in the SBD program in the future to further improve the efficiency of their prototype plans <u>if only one</u> prototype project would be eligible for an incentive. Fifty-nine percent said yes, and 28% indicated maybe, suggesting a confirmation of the results presented in Table 64.

	% of Participants
Yes	58.7%
No	11.9%
Maybe	27.5%
Don't Know	1.9%
Sample Size	25

Table 65: Would Participate in Future if Limited Incentive to <u>One Building Only</u> (q47)

Participants who responded "no" or "maybe" (above) were asked why they would not participate for only one incentive. Common answers were:

Select Participant Responses

With the amount of time spent developing the prototype the projects would not be financially feasible without the incentives.

We would implement the energy efficient measure on the prototype project. But we would not do this on the other projects if they didn't receive an incentive because they would not meet to the 2 yr payback criterion.

The energy rates are so high in CA this becomes a motivating factor. We would probably participate but we might not install all of the measures -- mainly skylights.

Payback wouldn't be achieved. We would consider the benefits of the lighting but not the other measures.

Participants with prototype plans were asked if they would participate in the SBD program in the future to further improve the efficiency of their prototype plans if all buildings constructed using the prototype would be eligible for incentives -- 93% said yes. There is a high degree of certainty in future participation if incentives are available for each project constructed using the prototype plan and master specifications.

	% of Participants
Yes	93.3%
No	-
Maybe	6.7%
Sample Size	22

Table 66: Would Participate in Future if Incentive applied to All Buildings (q48)

Participants were asked if they could recall what energy efficiency improvements were made to the prototype based on their involvement in SBD.

Select Participant Responses

The only real change was including VFD to the motors.

In addition to lighting we discussed the benefits of including shade trees around the outside of the building; we looked at construction elevation and slanting the roof to reflect heat and adjusted, tilted the overhangs by about 6'.

Higher efficient HVAC equipment.

Glazing, insulation factors, green building stuff, thermal mass - masonry block walls in gymnasium.

Participants with prototype plans were asked to rate their overall satisfaction with the assistance they received in the development of their prototype plans. Eighty-nine percent said they were very satisfied, while 9% indicated dissatisfied.

	% of Participants
Very satisfied	89.0%
Satisfied	-
Nuetral	2.4%
Dissatisfied	8.7%
Very dissatisfied	-
Sample Size	25

Table 67: Participant Satisfaction with Assistance Developing Prototype Plans (q51)

The reasons given for dissatisfaction were all related to slow response time.

Participant Responses

> *We would like to see the response time to be timelier and incentive information to be more uniform.*
>
> *The reps don't present benefits uniformly and by the time we finally get back their input on design modifications it's typically too late to make significant changes.*
>
> *The process was rather slow.*

Prototype participants were asked for their recommendations to change the SBD program to improve its delivery. Responses were unprompted and multiple responses were accepted. Similar answers were grouped into the categories in Table 68. Twenty-five percent stated that no changes are needed.

The following response represents roughly 20% of the total.

> *"Lift the cap on incentives per customer, per year. Go back to the original payment method where the rep gets the check, indicates to the owner he has it, and sends them all at once."*

This statement was given by a single person responsible for multiple projects that were included in our sample. Therefore his response represents a large percentage of the participant responses when expanded to the participant population Table 68.

Multiple answers were accepted on this question. (Therefore percantages do not add to 100%)	% of Participants
Utility should try to get involved earlier in the projects	39.4%
No changes needed	25.0%
Lift cap on incentives. Go back to original payment method…	19.4%
More marketing to increase awareness of program	14.8%
Increase incentives	11.7%
Review and response from utility needs to be more timely	11.0%
More interaction with design team	10.5%
Utility reps need to present benefits more clearly	8.7%
Increase post project feedback, better "closure"	8.7%
Other	6.9%
Sample Size	25

Table 68: Recommendations to improve SBD program delivery (q52)

Increasing incentives was not a frequent response at 12%, down from 27.5% in 2002. It was mentioned more frequently than by the non-prototype respondents (3%).

Other recommendations and comments included:

<u>*All Participants*</u>

> *Third party verifications are too time-consuming.*
>
> *The utility is very strict on the measures they will provide as incentives. We think they should expand this list because some of the ideas we proposed that saved electricity they would not rebate.*
>
> *PG&E doesn't seem as proactive as SCE in promoting the program and encouraging our involvement.*

Non-Participants – Incentives & SBD Past Influence

Non-participants were asked if any of their recent projects using the same prototype plans received incentives through SBD. Not surprisingly, most (75%) had not. However, 15% had received past SBD incentives on 2-4 buildings.

	% of Non-Participants
None	74.7%
1 or 2	0.2%
2 to 4	15.2%
Don't Know	10.0%
Sample Size	10

Table 69: Number of recent projects using same prototype plans that have received SBD incentives (npq27)

Those who had received incentives on recent projects using the same prototype plans were asked if they knew why this project didn't receive SBD incentives. Reasons given were:

<u>*All Non-Participants Responses*</u>

> *The project probably didn't qualify; maybe as a result of the existing single pane windows were not efficient enough.*
>
> *The lighting.*

In Table 70 non-participants were asked if they could recall having any interaction with SBD, on any prior projects, that may have influenced the design and energy efficiency of this prototype plan -- 25% said yes, indicating some potential spillover.

	% of Non-Participants
Yes	24.9%
No	75.1%
Sample Size	11

Table 70: Past SBD Prototype Design Influence (npq32)

Conclusions

Overall program participants were satisfied with the program, indicated by "no changes needed" responses, and positive scores on the value of incentives, design assistance and analysis (Table 55 and Table 56). The most consistent request for change came in the area of making the program easier and faster to use.

The issue of incentives came up directly and indirectly in many questions. While it is reasonable to conclude that everyone values financial incentives, the degree to which those incentives are influencing measure implementation is not clear. In other words, while the incentives may be necessary for enlisting program participation, they may not be required for encouraging measure implementation beyond code requirements. This may explain situations where a respondent expresses the importance of incentives while stating that their measure choices were standard practice.

Many of the responses reported in this section indicate a general trend toward market transformation. A high value is placed on energy efficiency in both the participant and non-participant populations (Table 43). Also, decision makers expressed an increased emphasis on cost-over-time analysis by both participants and non-participants as compared to the 2002 program results (Table 44). Finally, Table 45 reports that 70% of participants instructed their design teams to consider energy efficiency above Title 24 requirements. These results, along with low net to gross results for LPD and HVAC measures (Table 35), suggests that more aggressive targets may be required in the future.

Finally we encountered several instances where non-participants indicated to the interviewer that they would like to learn more about the SBD program for possible future participation, indicating an opportunity for SBD program marketing. This corresponds to the narrow range of responses about the source of awareness of Savings By Design (Table 49), and the lack of mention of marketing material and web sites by respondents. These results indicate that a broader marketing program would be beneficial.

Program Observations and Recommendations

This chapter presents observations made about SBD through the course of conducting this project. Recommendations to improve SBD are also presented. Furthermore, some of the recommendations in this section are similar, if not the same as those reported in the 2002 SBD EM&V report. RLW has chosen to include previous recommendations either because they continued to arise in the 2003 evaluation, or because the issue is important and on-going, and should be a consideration for future program planning.

Judging Continuing Need for the Savings By Design Program

Judging continuing need for the Savings By Design program cannot easily be summed up given the lack of information regarding program cost effectiveness. Many of the metrics used to measure the cost effectiveness and the continuing need for the SBD program are not easily obtainable given the timing of the evaluation and the duration of NRNC cycles. In this section we discuss these issues and possible ways to modify 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.

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 (2003), which means we are evaluating projects that initially signed onto the program as early as 1999, or as late as 2003. Due to the long NRNC construction cycles that characterize this program, it becomes extremely difficult to account for the costs that would be associated with only the projects that were paid in 2003.

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

Testing cost effectiveness of the program would require significant revision to the evaluation design. As reported last year, 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. Due to the timing of the evaluation RFP process and the defined scope of work, this recommendation could not be incorporated into the 2003 study, but we recommend that it be considered for the next round.

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

Cost effectiveness aside, it is clear through these evaluation activities that the Savings By Design program is delivering energy efficiency and long-term energy savings to the non-residential new construction 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 continued high free-ridership rate trends for this measure.) The incentives continue to be the clear motivator for program participation, and participant projects are much more energy efficient than non-participant projects, especially considering those that complied to 2001 Title 24. The dominant role of the incentives in motivating the implementation of measures is less certain. An emerging finding is that market actors participating in the program are reporting near equal satisfaction with other aspects of the SBD program that are designed to increase energy savings at the project level and lead to market transformation, such as the design analysis offerings.

Participating building designers and owners are gaining valuable building science expertise through the program's design assistance and design analysis components, which 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 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

The issue of partially built out projects with central plants continues to be an unresolved evaluation issue which will require a policy decision by the CPUC.

The common example is a new central plant project that includes incentives for energy savings that are expected to increase over the course of several years while the project, typically a multi building campus is being built-out. At the time of the evaluation, the campus is only partially built out and therefore the central plant is only partially loaded. The plan is that the chiller will be fully loaded when more buildings are completed over the next 5-10 years and are 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 overstated, per our current methodology.

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

During the course of the evaluation the net to gross analysis approach developed by RLW, which was a refinement of the 2002 BEA net savings approach, was questioned. Several project reviewers and advisors had reservations regarding the self-report approach and analysis methodology. After peer review RLW's approach was ultimately approved with only minor modifications. However, the controversy caused by this process lead NRNC stakeholders to reconsider the approach currently used to address program net savings, past approaches, and possible new approaches that might provide more accurate estimates of the program's net effects. Dr. Roger Wright wrote a white paper on RLW's past and current net savings methods, introducing many of the issues that tend to complicate and cloud the various approaches (e.g., econometric, difference of differences, self-reported) that have been taken over the years. This white paper is included in the appendix of this document and is necessary reading for understanding all of the nuances and complexities this evaluation has been confronted with over the years[22].

Master Design Guidelines

A similar situation exists with the use of master guidelines within large institutions such as the University of California, the California K-12 schools (CHPS) and large corporations. SBD Program influence in the development of these master guidelines or standards has been clearly documented. This influence is typically applied at the upper echelons of the corporate or institutional government structure beyond the awareness of the decision maker contacted by our team to gauge SBD influence on individual projects. When queried about design decisions, the respondent may answer "standard practice" which will result in a 100% free rider designation for the project. A clear example is a university building which is designed under the UC master design guidelines. Savings By Design played an important role in the development and adoption of the guidelines but would not receive any credit for buildings which made design decisions based on the guidelines rather than direct SBD influence. While credit is due to the SBD program for these high level influence initiatives, the methodology inherent in the BEA study is poorly suited to determining such influence on individual projects. A policy determination is required to define the method for evaluating and assigning appropriate credit for these situations.

Evaluation of Complex Building Models

The BEA sample will frequently capture state-of-the-art buildings which have been designed based on complex building energy modeling. The resources which were invested in this modeling far exceed the level of investment available to BEA for the evaluation model. Study resources would be more effectively utilized by accepting the design team model rather than creating a competing energy model. The UCSD Natural Sciences building is an excellent example where BEA modeling resources would have been better spent verifying inputs and assumptions of the design team energy model.

[22] This topic has also been addressed in a related paper, *White Paper on Methods for Estimating Net-to-Gross Ratio for Non-Residential New Construction*, by Chappell, Mahone, Megdal and Keating, prepared for Marian Brown, Southern California Edison, June, 2005.

Industrial Projects

As with last year's results, 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.

Evaluation of Temperature Dependent Measures

Low realization rates continue to be an issue for both energy and demand related to heating, ventilation and air-conditioning (HVAC/motors) measures. As mentioned in last year's report, 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 may 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.

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, the 1998 baseline study, and the 1991-2001 and 2002 BEA studies. 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, and 2002 BEA studies.

One major difference in this study is the fact that a non-matched sample of participants and non-participants were used. Once the program tracking data were available, model-based methods were used to combine the tracking data with the findings from prior studies about the sample design parameters – the error ratio and gamma parameter. Using these data, we determined the statistical precision to be expected on gross annual energy savings from the planned sample size for the participant sample.

Once the sample size had been determined, we developed the 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 selected in a similar manner using model-based methods to determine the statistical precision to be expected on gross annual energy savings from the planned sample size for the non-participant sample. The sample was stratified by square footage and was designed to be representative of statewide new construction that was permitted in 2002, and likely built by 2003.

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:

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

Here $x_k > 0$ is known throughout the population. *k* denotes the sampling unit, i.e., the project. $\{\varepsilon_1, \ldots, \varepsilon_N\}$ are independent random variables with 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) heteroscedastic regression model with zero intercept.

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

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

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

Figure 11 gives some typical examples of ratio models with different error ratios. An error ratio of 0.2 represents a very strong association between *y* and *x*, whereas an error ratio of 0.8

represents a weak association. Loosely speaking, an error ratio of .75 implies that the measured savings is typically within ±75% of the tracking estimate of savings adjusted for the realization rate. The smaller the error ratio, the stronger the association between tracking and measured savings, and the smaller the sample size needed to estimate the program realization rate with a fixed precision.

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

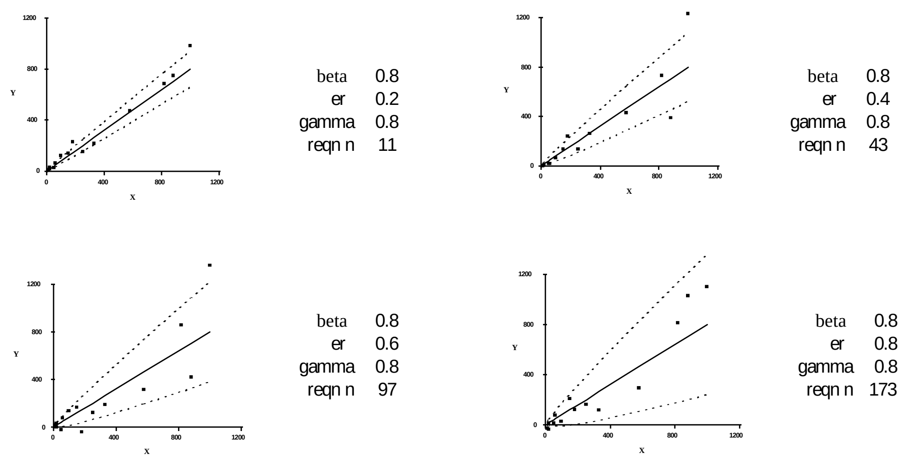


Figure 11: Examples of MBSS Ratio Models

The model parameters -- β, γ, and the error ratio -- were calculated from the 2002 BEA study. The model parameters are shown in Table 71. Based on the 2003 BEA sample projects that have been completed so far, the error ratio is 0.70. *Using this value, our analysis indicated that a sample of 87 2003 BEA program participants would provide a relative precision of about ±10.6% at the 90% level of confidence*.[23]

Parameter	Value
β	1.096
γ	0.86
Error ratio	0.70

Table 71: 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.

Parameter	Value
β	1.129

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

γ	0.78
Error ratio	0.59

Table 72: 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 2003. At the sample design stage, we found that there were 468[24] projects paid in 2003, combining for a total tracking savings of 129,517 MWh. Considering all 468 projects, the average savings was 277 MWh per project.

Table 73 shows the original 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 73 shows that for PG&E, there were 89 projects with annual savings of 85 MWh or less, and a total tracking savings of 2,343 MWh. The maximum kWh in each stratum is called the stratum cut point. These 89 projects were 54% of all PG&E projects, but they represented only 5% of all savings. By contrast, the ten strata 10 projects for PG&E represent only about 6% of all PG&E projects, but yielded 45% 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
SDGE	1	50	22	1,052	47	3	0.06
	2	133	77	1,848	24	3	0.13
	3	318	202	3,027	15	3	0.20
	4	419	363	3,632	10	3	0.30
	5	1,807	857	6,856	8	4	0.50
	SDGE Subtotal		158	16,414	104	16	0.15
PGE	6	86	26	2,343	89	6	0.07
	7	263	165	5,109	31	6	0.19
	8	535	400	7,995	20	6	0.30
	9	911	712	10,684	15	6	0.40
	10	6,327	2,103	21,029	10	7	0.70
	PGE Subtotal		286	47,158	165	31	0.19
SCE	11	100	32	3,336	102	8	0.08
	12	317	218	8,084	37	8	0.22
	13	502	371	10,399	28	8	0.29
	14	1,127	758	14,405	19	8	0.42
	15	8,658	2,477	29,721	12	8	0.67
	SCE Subtotal		333	65,945	198	40	0.20
Total			**277**	**129,517**	**468**	**87**	**0.19**

[24] During the recruitment stage of the study, SCE determined that one sites was not a SBD project and it was dropped from the evaluation.

Table 73: Participant Sample Design

We applied the sample design to the projects that were paid in 2003. 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 73.
3. Randomly select the specified number of projects.

Final Statewide Participant Sample Design

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

Table 74 shows the final participant sample design that was used to calculate the participant case weights. In this case, the sum of the population residual standard deviations has been divided equally among 15 strata. Within each utility, the sum of the residual standard deviations 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 population. Next, within each utility the sample was allocated equally to each stratum. The population sizes shown in column four were calculated from the stratum cutpoints. The final step was to calculate the case weights shown in the last column. For example, the case weight for the 6 sites in the first stratum is 89 / 6 = 14.833.

Utility	Stratum	Max MWh Savings	Number of Projects	Total MWh	Sample Size	Fraction	Weight
PG&E	1	86	89	2,343	6	0.07	14.833
	2	263	31	5,109	6	0.19	5.167
	3	535	20	7,995	6	0.30	3.333
	4	911	15	10,684	6	0.40	2.500
	5	8,000	10	21,029	7	0.70	1.429
	PG&E Subtotal		165	47,158	31	0.19	
SCE	6	107	103	3,353	8	0.08	12.875
	7	317	36	7,978	8	0.22	4.500
	8	502	28	10,399	8	0.29	3.500
	9	1,127	19	14,405	8	0.42	2.375
	10	20,000	12	29,721	8	0.67	1.500
	SCE Subtotal	0	198	65,855	40	0.20	
SDG&E	11	50	47	1,052	3	0.06	15.667
	12	133	24	1,848	3	0.13	8.000
	13	318	15	3,027	3	0.20	5.000
	14	419	10	3,632	3	0.30	3.333
	15	3,000	8	6,856	4	0.50	2.000
	SDG&E Subtotal		104	16,414	16	0.15	
Total			**467**	**129,428**	**87**	**0.19**	

Table 74: Final Participant Sample Design

Table 75 presents the actual 2003 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 PG&E projects. The SDG&E projects tended to be smaller projects. Since the smaller projects have lower sampling fractions, SDG&E had smaller sample sizes than SCE and PG&E.

2003	PG&E		SCE		SDG&E		Statewide	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample
Number of Projects	165	31	198	40	104	16	467	87
MWh Savings	47,158	20,547	65,855	28,122	16,414	6,065	129,428	54,734
Savings per Project (MWh)	286	663	333	703	158	379	277	629

Table 75: Actual 2003 SBD Participation and Sample by Utility – MWh 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 73 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 began construction during 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 year 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.

Unlike the prior BEA studies, the non-participant sample in this study was not matched to the participant sample. Rather, the non-participant sample was selected in a manner similar to that of the participants. Specifically, we used model-based statistical sampling methods to guide the sample design and to determine the expected statistical precision for gross annual energy savings for the planned size of the non-participant sample. The 2002-2003 F.W. Dodge New Construction Database was used to obtain the non-participant population. The sample was selected by stratifying the non-participant population by square footage and was designed to be representative of statewide new construction that was permitted in 2002, and likely built by 2003, and did not participate in SBD. The final non-participant sample size was 36 sites.

Table 76, Table 77 and Table 78 present the number of sites and average square footage for the commercial and commercial/industrial participant and non-participant samples and population for 2003, by building type and utility. Table 76 shows the participant sample and Table 78 details the non-participant sample. The participant buildings are, on average, larger than their non-participant counterpart buildings.

Building Type	PG&E		SCE		SDG&E		Statewide	
	# Sites	Ave SQFT	# Sites	Ave SQFT	# Sites	Ave SQFT	# Sites	Ave SQFT
C&I Storage	1	12,000	6	269,627			7	232,823
Fire/Police/Jails			3	245,833	1	4,815	4	185,579
General C&I Work	8	103,100	7	93,026			15	98,399
Grocery Store	6	58,623	2	57,170	1	55,000	9	57,898
Hotels/Motels	1	391,524					1	391,524
Medical/Clinical	1	57,750	3	119,216			4	103,849
Office	6	61,575	4	40,087	2	59,148	12	54,008
Other					2	273,033	2	273,033
Religious Worship, Auditorium, Convention	2	254,633	1	70,610	1	38,799	4	154,669
Retail and Wholesale Store	5	123,634	11	65,584	1	133,906	17	86,676
School	1	87,076	2	33,000	8	111,473	11	94,987
Theater			1	6,031			1	6,031
Total	**31**	**103,928**	**40**	**103,630**	**16**	**111,792**	**87**	**105,237**

Table 76: 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	66	46,545	95	57,193	14	36,786	175	51,545
Community Center	54	26,812	39	14,705	21	9,095	114	19,407
Fire/Police/Jails	23	12,435	20	118,800	4	48,500	47	60,766
General C&I Work	73	22,405	54	17,519	8	14,375	135	19,975
Grocery Store	23	39,174	24	34,243	2	32,000	49	36,466
Gymnasium	25	20,858	11	22,727	6	39,333	42	23,987
Hotels/Motels	9	45,667	5	42,600	2	268,292	16	72,537
Libraries	19	26,474	4	29,250	4	16,500	27	25,407
Medical/Clinical	64	32,938	35	46,857	16	86,875	115	44,679
Office	165	20,059	146	31,336	92	42,152	403	29,188
Other	27	44,296	11	85,727	2	9,000	40	53,925
Religious Worship, Auditorium,	29	16,730	30	14,063	4	15,750	63	15,398
Restaurant	41	9,171	81	9,840	22	5,500	144	8,986
Retail and Wholesale Store	92	32,424	86	35,977	48	23,083	226	31,792
School	143	27,003	105	42,617	51	29,284	299	32,875
Theater	5	56,200	5	43,200	1	70,000	11	51,545
Total	**858**	**27,247**	**751**	**35,809**	**297**	**33,869**	**1906**	**31,653**

Table 77: Non-participant Population 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			5	101,912			5	101,912
Community Center	2	106,677					2	106,677
General C&I Work			2	60,000			2	60,000
Grocery Store	2	57,000	1	2,000			3	38,667
Gymnasium	2	53,730					2	53,730
Libraries					1	24,000	1	24,000
Medical/Clinical			1	129,000	1	179,000	2	154,000
Office	4	8,750	1	55,000			5	18,000
Other	1	289,000					1	289,000
Religious Worship, Auditorium, Convention			3	23,000			3	23,000
Restaurant			1	2,000			1	2,000
Retail and Wholesale Store	2	97,000	1	95,000			3	96,333
School	2	64,000	3	17,130	1	53,000	6	38,732
Total	**15**	**72,054**	**18**	**57,386**	**3**	**85,333**	**36**	**65,827**

Table 78: 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[25].

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

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

– 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:

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

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

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

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

Participant Case Weights

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

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

Non-participant Case Weights

The non-participant case weights for the gross savings expansions were calculated using balanced post-stratification. In this approach, the sample sites are sorted by the stratification variable, square footage, 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.

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 in scope and 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.

Additionally, the Dodge database contains projects that are out of scope for the SBD program; that is, the Dodge database contains projects that are not qualified to participate in Savings By Design. Out of scope projects include projects that don't consume electricity, projects that are served by a municipal utility such as LADWP or SMUD, and projects consisting of façade renovations to an old building, etc.

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 that are in scope, less the weighted participant sample sites.

Figure 12 summarizes the approach. In Step A, the set of all program participants is taken as the target population. The sample of participants is stratified by utility and the tracking estimate of energy savings due to the measures funded by the program. The savings-based strata were constructed using model based 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[26].

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

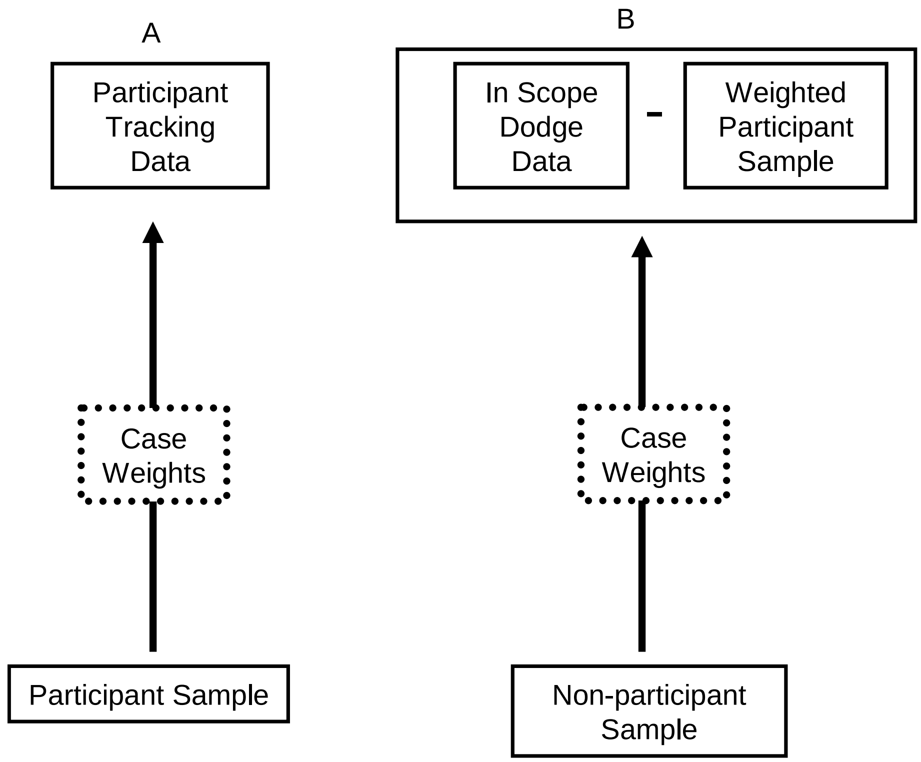


Figure 12: Approach to Non-participant Case Weights

In step B, weights are calculated for the non-participant sample. To do this we obtain a representation of the population of all in scope 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 samples 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 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 of in scope projects 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.

Stratified Ratio Estimation

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

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

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

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

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

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

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

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

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

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

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

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

and the achieved relative precision is calculated as

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

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

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

$$\bar{e}_h \approx 0$$

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

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

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

Gross Savings Expansions

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

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

- Shell – High performance glass
- Lighting Power Density– Lamps and ballasts,
- Daylight Controls-Daylighting controls such as continuous dimming daylight controls and stepped dimming daylight controls.
- Other Lighting Controls- Other lighting controls such as occupancy sensors and lumen maintenance controls.
- Motors – All energy efficient motors, including HVAC fans. Also overall air distribution system design end-uses such as efficient cooling coils and oversized ducts.
- HVAC – Compressor efficiency, VSDs, oversized cooling towers
- Refrigeration – Commercial refrigeration systems (condensers, compressors, cases)
- Industrial – Process pumps, CO sensors, VSD fume hoods

Net Savings Methodology

In this chapter, the methodology used to calculate the net savings results is presented. We have used a customer self-report methodology to calculate the net savings attributable to the SBD program. We 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.

The evolution of the freeridership methodology is explored in greater detail in the attached white paper titled “Measuring the Net Impact of the Savings By Design Program”[27]. This paper also explores options for future “fine-tuning” of the net-to-gross analysis.

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 this 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

[27] Roger L. Wright, PhD, June 30, 2005.

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, and participants for non-incented measures, 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%.[28]

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

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.

Non-participant Spillover

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.

Participant Spillover

Participant Spillover is calculated to be the energy savings of all non-incented measures. For example, if the participant received an incentive for lighting measures, but also installed energy saving HVAC measures (not incented), the savings for these HVAC measures are considered participant spillover. This methodology assumes that program participation encouraged the owner to seek energy efficiency in general, and perhaps provided important supporting information to aid in the implementation of the measure.

The detailed methodology used to conduct the spillover assessment is presented within the appendices of this report.

Case Weights

Similar to the gross savings analysis, 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 in scope non-participant population. This is to ensure that the non-participant sample is representative of statewide new construction that was permitted in 2002, and likely built by 2003, while the participant sample is representative of the 2003 participant population..

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 practices 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 2001 Alternate Compliance Method (ACM) manual.

Pumps and fans. Input power for pumps, fans and other motor-driven equipment was calculated from motor nameplate horsepower data. Motor efficiencies as observed by the surveyors were used to calculate input power. In the absence of motor efficiency observations, standard motor efficiencies were assigned as a function of the motor horsepower. A rated load factor was used to adjust the nameplate input rating to the actual running load. For VAV system fans, custom curves were used to calculate fan power requirements as a function of flow rate in lieu of the standard curves used in DOE-2, as described in the 1998 ACM manual.

Service hot water. Service hot water consumption was calculated based on average daily values from the 2001 ACM for various occupancy types. Equipment capacity and efficiency were assigned based on survey responses.

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

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

Commercial Refrigeration. The algorithms used in the DOE-2.1E release 119 program were used to evaluate the performance of commercial refrigeration systems found in grocery stores, commercial kitchens, schools, and so on. Refrigerated cases, compressor plant, condensers, and control system characteristics were surveyed. The automated modeling software provided DOE-2 models of both the building and the refrigeration systems, providing an accurate representation of the refrigeration system performance, and the interactions between the refrigeration system and the building HVAC system.

Plant

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

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

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

Model Review and Quality Checks

After the DOE-2 model was generated, the model was run using the CEC Climate thermal zone (CTZ) long term average weather data corresponding to the climate zone where the project was located. The model either was run successfully generating a results page, or received errors and/or warnings. When warnings and/or errors were encountered, modifications to the data entry database were performed and another model for the site was created, and run. This process 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 79. Data falling outside of the QC range were validated during the QC process.

Building Parameter	Range	Definition
Cooling Ratio	95 - 200%	capacity from annual run / capacity from sizing run
Cooling EER	8 - 14	capacity weighted cooling efficiency

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

Table 79: 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 80: Survey It™ 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.

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 were added to the refrigeration parametric.

Data Collection

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 2003. 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 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 constant communication between the surveyor and senior engineering staff. Sites with large variances in the savings estimates relative to program expectations are investigated and resolved in a timely manner. Sites that fall out of the standard quality control range are re-evaluated and rechecked for reasonableness.
7. 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 frequently resulted in contacting the mechanical designer in addition to the owner. This methodology was proven to be effective in the prior NRNC studies conducted by 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 after 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 past evaluations 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 during project planning, and design stages.

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 was 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 Sam Pierce 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 and 2002 BEA studies, and upon the considerable building survey experience of the surveyors.

This training team conducted a one-day training session that covered relevant theory and new construction practice as well as the mechanics of completing the on-site forms. Items that received special emphasis based on the results of past evaluations 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 and 2002 BEA studies. 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 and 2002 BEA studies.

ATTACHMENT A: Measuring the Net Impact of the Savings By Design Program

Measuring the Net Impact of the Savings By Design Program

July 2005

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RLW Analytics

Background

The goal of this paper is to discuss limitations in the current methodology for estimating the net impact of the Savings by Design (SBD) nonresidential new construction program in California and to explore possible improvements. The paper describes the program, gives some examples that illustrate certain problems, broadens the conventional definition of net savings, and recommends some specific improvements for consideration.

Description of the Program

Savings By Design[29] [30] is a statewide program for commercial, industrial and agricultural customers that encourages energy-efficient building design and construction. The program is administered by California's four investor-owned utilities under the auspices of the California Public Utilities Commission (CPUC). SBD offers building owners and their design teams a variety of services:

- **Design assistance, analysis and resources to aid building owners and design teams with energy-efficient facility design.**
- **Owner incentives** of up to $150,000 per project to help compensate the investment in energy-efficient building and design.
- **Design team incentives** of up to $50,000 per project to reward designers who meet ambitious energy-efficiency goals.

SBD seeks to improve the energy efficiency of nonresidential new construction in the state by:

- Directly encouraging owners to build buildings that are more energy efficient than the Title 24 energy code in California, by providing direct incentives for measures and for integrated building design.
- Increasing the knowledge and awareness among design professionals, such as architects and engineers, about energy efficient design and measures.
- Helping develop and promote design standards including corporate design standards and standards promulgated by programs such as the California High Performance Schools (CHPS) program,[31] the LEED government building program, [32] and San Francisco's Green Building Ordinance. All of these standards reach beyond Title 24 and often overlap with the standards of SBD itself.
- Helping move Title 24 to new levels by demonstrating that more advanced measures and requirements are effective, affordable, and acceptable in the market place.

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[29] http://www.savingsbydesign.com/

[30] The Savings by Design program replaced the existing non-residential new construction programs of the California investor owned utilities.

[31] http://www.opsc.dgs.ca.gov/School+Energy+Programs/Default.htm

[32] LEED, the green building rating system of the U.S. Green Building Council, stands for Leadership in Energy and Environmental Design. The utilities in California worked on the original development of LEED but that work predated the SBD program.

http://temp.sfgov.org/sfenvironment/facts/resource_bldg.htm

Success Stories

The following examples serve to show how the program works. We will draw on these examples to illustrate the challenge of measuring the net savings of SBD.

The Georgia Blach Intermediate School

The Georgia Blach Intermediate School is a model California High Performance school, featuring daylighting, advanced lighting controls, natural ventilation, and other design features. This is one of several CHPS schools that received support from SBD for in-depth design support and post-construction analysis. [33]

Figure 13: The Georgia Blach School

Sonoma State University

At Sonoma State University, the gutted and remodeled former Salazar Hall is now the most energy-efficient building in the California State University system. The building incorporates a unique system of low-energy cooling, lighting controls, high efficiency windows and a photovoltaic system. The building is expected to use 42 percent less energy than required by Title 24. The school is receiving funds from two different programs within Pacific Gas and Electric Company - Savings By Design and the Self-Generation Incentive Program.

Pacific Gas and Electric Company has been working with the University's design team since the fall of 1999. "The energy partnership between Pacific Gas and Electric Company and Sonoma State University is a long term one and we value the working relationship we have had with the campus," says Beverly Alexander, vice president of energy efficiency programs. Since 1991, the university has received more than $450,000 in energy efficient incentives from Pacific Gas and Electric Company and has another project in the works for an additional $450,000.

The project is so innovative, that engineers from Lawrence Berkeley National Lab will spend a year studying the performance of the building with its mixture of low energy cooling, daylighting schemes and solar panel array.

[33] http://www.pge.com/docs/pdfs/biz/energy_tools_resources/savings_by_design/highlights/blach.pdf

Premier Automotive Group North American Headquarters

This project consolidated the headquarters for all five of Ford Motor Company's "premier" automobile brands. The facility consists of a five-story, 250,000 square foot office tower, a 30,000 square foot design center, and a four-story parking structure. The project has earned a LEED™ 2.0 certification from the U.S. Green Building Council.

Figure 14: The Premier Automotive Group Headquarters

This large-scale project elegantly integrates innovative energy strategies such as daylighting and spectrally selective glazing while fulfilling its strategy of branding high-end automobiles throughout the building design. Having a goal of LEED certification from the outset, this project pushed the envelope of energy efficiency starting with the original design through construction and maintenance.

The Landscape Surrounding SBD

As can be seen by these success stories, SBD does *not* have a monopoly on energy efficiency in non-residential new construction. Many agencies, organizations and private companies are committed to promoting energy efficiency in various sectors. In practice, the goals of SBD are generally compatible with other energy efficiency programs and the relationship is synergistic – increasing the visibility and effectiveness of each program. Consequently, an owner or design team is encouraged to participate in multiple programs as long as their requirements are not in conflict.

California and National Programs

As the preceding examples show, the SBD program works closely with other programs such as CHPS, LEED, the Bright Schools Program, Flex Your Power, Rebuild America, and the Consortium for Energy Efficiency. The following is a partial list.[34]

- **Rebuild America** – DOE supported program to foster energy efficiency and renewable energy in commercial, government and public-housing buildings.
- **LEED** - Leadership in Energy and Environmental Design nationally recognized green building rating system.
- **U.S. Green Building Council** – a national coalition of corporations, builders, universities, government agencies, and non-profit organizations.
- **The Consortium for Energy Efficiency** - a national nonprofit corporation that promotes energy-efficient products and services.
- **Flex Your Power** - California's statewide energy efficiency marketing and outreach campaign.
- **The Division of the State Architect** – schools, community colleges and government buildings.
- **CHPS** - The Collaborative for High Performance Schools.
- **Bright Schools Program** - for schools considering high performance design strategies.

Many of these programs provide design assistance and/or financial incentives that overlap with SBD. For example, California's Office of Public School Construction (OPSC) offers grants for energy efficient schools through its Energy Allowance Grant Program.[35] Prior to applying for a grant from the OPSC, a school district must obtain a verification of compliance with energy efficient standards from the Division of the State Architect.[36] To meet the requirements of the

[34] These programs are described in greater detail in the Appendix to this report.

[35] http://www.dsa.dgs.ca.gov/Sustainability/energy.htm

[36] The Division of the State Architect maintains a comprehensive directory of resources supporting energy efficiency in schools and public buildings. See http://www.theenergyguy.com/SchoolPrograms.html#StateProgramsCalif

grant, new construction must surpass Part 6 of Title 24 with the calculated source of energy at least 15% less than the energy budget.

However, these state and national programs are just one aspect of the energy efficiency landscape surrounding SBD.

Regional Efforts

SBD also works with non-governmental regional efforts. An excellent example of a joint effort has occurred in Silicon Valley. The SBD program is working with the Silicon Valley Manufacturing Group, Sustainable Silicon Valley, and Flex Your Power to reduce energy use in the Valley. Partners in "Flex Your Power Silicon Valley" facilitate energy efficiency improvements and demand reduction commitments to ensure reliable power, protect the environment, and deliver costs savings to Valley businesses. [37]

As another example, SBD personnel at PG&E have worked actively with the City of San Francisco to develop its Green Building Ordinance.[38] This ordinance requires that all new projects, including city-owned facilities and leaseholds, achieve a Leadership in Energy and Environmental Design® (LEED) Silver certification from the U.S. Green Building Council.

San Francisco's Green Building Ordinance will apply to all new city construction projects, renovations, and building additions. San Francisco joins nine other cities that have adopted green building ordinances requiring LEED. "The City's adoption of LEED Silver standards in their ordinance demonstrates San Francisco's exemplary commitment to green building," said USGBC President, CEO & Founding Chair Rick Fedrizzi. "We look forward to more cities following their leadership."

Under this ordinance, municipal buildings will need to follow green building design principles, which will help to create healthy workplaces, increase energy productivity, protect the environment, and save the city millions in funds. "This Green Building Ordinance will translate into millions in savings on future operational costs for new city buildings. The ordinance is good for the city and will help improve the health of our environment and the well-being of the thousands of employees that continue to provide services for this community," explains Jared Blumenfeld, director of the San Francisco Department of the Environment.

Corporate Initiatives

The SBD program also works with specific companies. A good example is Cisco Systems.[39] Partly due to a long-term relationship between Cisco and SBD, Cisco's philosophy for new construction is to "plan it right," which means thinking about energy efficiency during the design phase, before a building is actually constructed. Cisco's approach includes investing in chilled water systems rather than more traditional package unit HVAC (heating, ventilation, and air

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[37] http://www.fypower.org/com/fyp_sv.html

[38] http://www.buildings.com/Articles/detail.asp?ArticleID=2146

[39] http://www.cisco.com/en/US/about/ac227/ac228/ac229/about_cisco_corp_citi_case_study.html

conditioning) systems; using energy-efficient interior lighting and low-pressure sodium exterior lighting instead of mercury vapor or halogen lighting; high-performance glazing that minimizes energy loss and heat gain; integrating computerized building automation which adjusts things such as building temperature more quickly, efficiently and uniformly; and placing motion sensors in conference rooms, bathrooms and offices so that lights turn off automatically when not in use.

Cisco believes that effective planning requires improved collaboration between groups with different expertise. "We used to have discrete facilities and maintenance groups, which is typical in most companies. Now, those groups operate together. We've combined people who specialize in the design side with people who have day-to-day working familiarity with the buildings to leverage each other's knowledge," says Mike Lavazza, Cisco manager for operations and engineering.

Designing and building environmentally sensitive, cost-efficient facilities is only part of the Cisco's conservation equation. For facilities to have a positive environmental and financial impact, constant monitoring and behavioral change is required. "It's essential to communicate and coordinate with employees and business units to show them the value of conservation. We make it clear that conservation should not affect product quality or compromise business interests. Our message to employees is that it is good business to use energy efficiently," says Nayeem Sheikh, facilities engineer.

By reviewing energy use audits constantly, Cisco adapts conservation measures and building control systems to optimize energy use. The Energy Monitoring Committee (EMC) meets regularly to evaluate conservation programs and address energy use across the company—not just at the San Jose headquarters. "Our success has a real grassroots appeal. For example, the EMC and our energy management Web site just emerged organically and are representative of the many little things that accumulate to make a big impact," says Lavazza.

Cisco continues to integrate new technologies into the design and construction of its facilities, as well as keep a close eye on the ongoing changes in the energy marketplace. "There are so many different facets to energy management that it's tough to juggle all the balls at once. We've taken a proactive approach to meeting our goals by using new technologies and making sure that people are empowered to use them effectively," says Lavazza.

Title 24

Another very important element in the landscape surrounding SBD is the Title 24 Energy Efficiency Standards. It is estimated that the standards have saved more than $36 billion in electricity and natural gas costs since 1978 and will save an additional $43 billion by 2013. [40] Title 24 has a very broad scope, including the following:

- Skylights with daylighting controls
- HVAC system efficiency
- Commissioning of lighting and HVAC
- Cool roofs
- Wall, ceiling and duct insulation

[40] http://www.energy.ca.gov/title24/

- Ventilation
- Lighting power limits
- Efficient lighting and controls
- Outdoor lighting and signs

Title 24 is revised and expanded periodically as new conservation measures can be shown to be reliable and cost effective.

The MV&E Challenge

Ideally, SBD is not just one of the many programs promoting energy conservation of non-residential new construction in California, but is leading the charge, as suggested by Figure 15. Through its direct design assistance and financial incentives, SBD seeks to get owners to adopt innovative design approaches and conservation measures that are not widely accepted among architects and engineers. As experience is gained through SBD projects, it is assumed that these measures will diffuse more deeply into the market, first to the early adaptors (CHPS schools, LEED buildings, strongly motivated corporations such as Cisco, etc.) and eventually to Title 24.

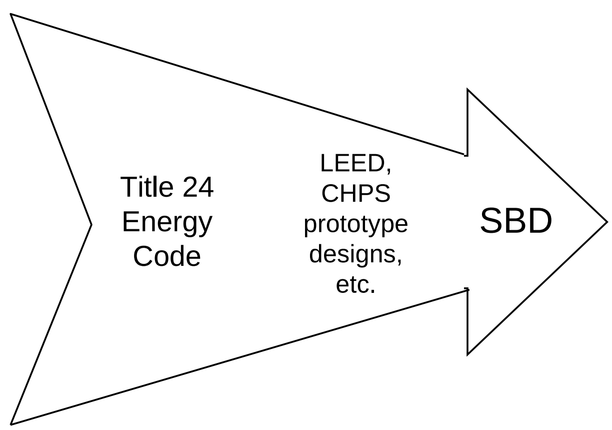

Figure 15: SBD Should Lead the Way

To accomplish this goal, SBD must continue to work at the cutting edge of design practice. It must be continually identifying new approaches and energy conservation measures and demonstrating them in its projects. At the same time, it must be continually encouraging diffusion by working with corporate design standards, CHPS programs, etc.

Figure 15 also attempts to illustrate that, ideally, SBD has a substantial direct impact at the tip of the arrow, but a much greater indirect impact by moving broad design practice throughout the market. The MV&E challenge is to accurately estimate the impact of the innovations directly attributable to SBD, and the indirect effect of its success in moving the market itself. If either the direct impact or indirect impact is inaccurately assessed, then MV&E will be giving distorted signals to the program itself. Conversely, accurately measuring both the direct and indirect effects will help to ensure the continued efficiency of the program itself by encouraging program staff to seek the most effective allocation of their efforts between innovation and diffusion. Moreover accurate assessment will help policy makers and resource planners understand the magnitude of its impact on energy efficiency in the state.

Measuring the Net Impact of SBD

In this section we will review the methodology that has been used to assess the net impact of the non-residential new construction programs conducted by PG&E, SCE and SDG&E from the 1994 program year to the present. We will focus on the various methodologies used by RLW Analytics since we have first-hand experience with these studies.[41]

During this period the nonresidential new construction (NRNC) programs themselves evolved in various ways. At the beginning each of the investor-owned utilities ran their own program, but they worked together to minimize differences between their separate programs. Partway through the period they were redesigned under the common state-wide name, Savings By Design. Many of the new features of SBD were directed to design assistance in order to alter design practices in the general NRNC market among non-participants as well as participants.[42] Just as the NRNC programs evolved in California, the evaluation methodology also evolved.

To set the stage for our review of the changing methodology, we will start by discussing some important terminology.

Terminology

Table 81 and Figure 16 show the energy consumption of a hypothetical building, in this case a program participant, under various assumptions. Row A shows the *Title 24 baseline energy consumption* of the building. This is the energy consumption of the building if it had been designed and built precisely in compliance with the Title 24 requirements. In other words, this is the energy consumption of the building if it had been built with all measures required by Title 24 but no added conservation measures.

Program Participant	Energy Use
A) Title 24 Baseline	1000
B) T24 + Other Influences	900
C) T24 + Other Influences + Prior SBD	800
D) T24 + Other Influences + SBD = As Built	600

Table 81: Energy Use of a Program Participant under Alternative Scenarios

[41] This topic has also been addressed in a related paper, *White Paper on Methods for Estimating Net-to-Gross Ratio for Non-Residential New Construction*, by Chappell, Mahone, Megdal and Keating, prepared for Marian Brown, Southern California Edison, June, 2005.

[42] Similarly, in recent years the evaluation studies have been called the Building Efficiency Assessment (BEA) studies, whereas in the beginning of this period, they were simply known as the non-residential new construction evaluation studies. These distinctions are not germane to our discussion and will be ignored.

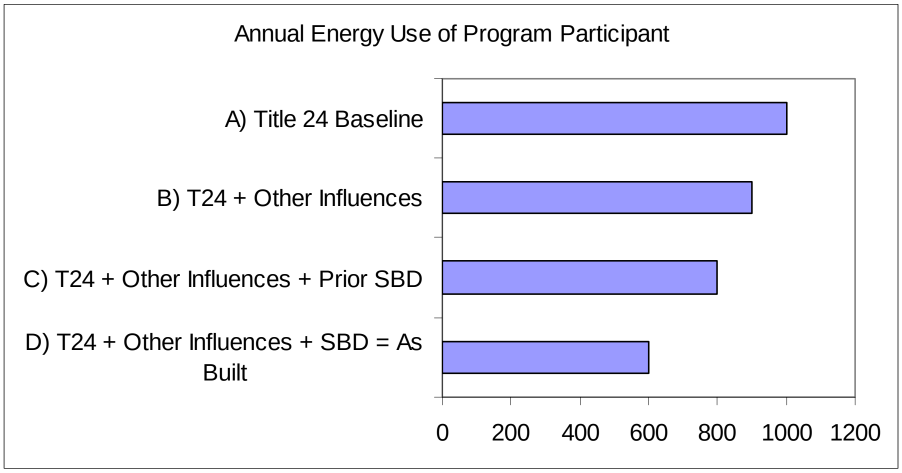

Figure 16: Energy Use of a Program Participant under Alternative Scenarios

Row B of Table 81 and Figure 16 shows the energy consumption of the building in the absence of the SBD program but reflecting Title 24 plus non-SBD factors such as the owner's interest in conservation, the independent influence of the design team, other programs or standards such as CHPS or corporate standards, to the extent that these factors would have existed in the absence of the SBD program. For example, if the building is a CHPS building, B would reflect the influence of the CHPS program in the absence of SBD.

To assess B we would need to understand what the CHPS requirements would have been if SBD had not existed and influenced the CHPS program. In other words, this is the energy consumption of the building if it had been built with all measures required by Title 24 plus certain added conservation measures that would have been installed even if SBD had never existed. These are sometimes called the naturally occurring measures. Of course, this is an abstract concept and is often difficult to assess.

Row C shows the energy consumption of the building reflecting the Title 24 measures, the non-SBD, naturally occurring measures just described, plus the measures attributable to SBD in prior years. For example, if the building is a CHPS building, and the CHPS specifications were influenced by SBD in the past, then C would fully reflect the measures specified by CHPS.

Row D shows the energy consumption of the building reflecting Title 24, all of the non-SBD factors, the SBD in prior years, and the current SBD program. D reflects all of the measures installed in the building regardless of their root cause. D is often called the as-built energy consumption of the building.

Table 82 shows the types of participant savings associated with Table 81. The difference between the Title 24 baseline consumption and the as built consumption of the building, i.e., A – D, is called the *gross savings*. The *naturally occurring savings* are A – B. These are the savings that would have occurred in the absence of the SBD program in the current and past years. These are sometimes called free ridership savings. The *participant spillover* is B – C, i.e., the savings in the current project that are due to the SBD program in prior years. Finally the *direct savings* are the difference between the C and D. They are the savings specifically attributable to the current SBD program, over and above the measures to the SBD program in prior years and other programs. Note that the participant gross savings are equal to the sum of the naturally occurring savings, the participant spillover savings, and the direct savings.

Participant Savings	Energy
Gross Participant Savings = A - D	400
Naturally Occuring Savings = A - B	100
Participant Spillover = B - C	100
Direct Savings = C - D	200

Table 82: Types of Participant Savings

With these definitions, the free ridership rate would be the naturally occurring savings divided by the gross savings. The participant spillover rate would be the participant spillover divided by the gross savings. The direct saving rate would be the direct savings divided by the gross savings. The sum of the free ridership rate, the participant spillover rate and the direct saving rate ratio would be equal to one.

With a minor modification of terminology these concepts also apply to a non-participant building. Table 83 and Table 84 show a hypothetical example. The gross savings of the non-participants is equal to the Title 24 baseline consumption minus the as-built consumption. The difference between A and B is called the naturally occurring savings, just the same as for participants. The difference between B and C is called the non-participant spillover due to prior SBD programs. Finally, the difference between C and D can be called non-participant spillover attributable to the current SBD program. This might be due, for example, to partial participation in the current SBD program.

We will use the term *non-participant spillover* to refer to the sum of the two categories of non-participant spillover associated with prior SBD programs and the current SBD program. In practice, it may not be necessary to differentiate between these two components of non-participant spillover.

Program Non-Participant	Energy Use
A) Title 24 Baseline	1000
B) T24 + Other Influences	900
C) T24 + Other Influences + Prior SBD	800
D) T24 + Other Influences + SBD = As Built	750

Table 83: Energy Use of a Non- Participant under Alternative Scenarios

Non-Participant Savings	Energy
Gross NP Savings = A - D	250
Naturally Occuring Savings = A - B	100
NP Spillover of Prior Program= B - C	100
NP Spillover due to Partial Participation = C - D	50

Table 84: Types of Non-Participant Savings

With these definitions, we regard the *net impact* of the SBD program in a given year to be the sum of the three components - the direct impact, the participant spillover, and the non-participant spillover. We define the *net to gross ratio* of the program in a given year to be the net impact of the program among all participants and non-participants divided by the gross impact of the program among all participants.[43]

In the past, we have not attempted to distinguish between the participant savings attributable to the current SBD program and the participant savings attributable to prior SBD programs. However, we believe these added distinctions are useful and are needed to accurately measure the net impact of the SBD program.

For example consider a new Cisco building that participated in the current SBD program. Cisco has a corporate standard that requires the building to include certain energy conservation measures beyond Title 24. These measures should not count toward the direct savings of the current SBD program since they would have been included in the building even in the absence of the current program. However, these measures may have been included in the corporate standards either partly or fully due to the efforts of SBD in prior years. Therefore part or all of the associated savings should be considered to be spillover from prior SBD programs. If some of these measures would have been required by Cisco even in the absence of the past SBD program, the associated savings should be considered to be naturally occurring.

Similarly if a CHPS school such as the Georgia Blach Intermediate School participates in SBD, then the measures that are included due to CHPS should not be included in the direct savings of the current SBD program, but these savings should be included in the participant spillover savings to the extent that they are attributable to prior SBD programs.

With this background and terminology, we are in a position to review the evolution of the methodology that has been used to measure the net impact of the SBD program in recent years.

1994 - 1998

The 1994, 1996 and 1998 program evaluations used two different methods to asses the net impact of the California NRNC programs that were the pre-cursers to SBD.

Difference of Difference Estimation

The difference-of-differences approach rests the hypothesis that the efficiency of the non-participants is an indicator of what would be expected of the program participants in the absence of the program. The net efficiency of the program participants is taken to be their gross efficiency minus the energy efficiency of a matched sample of non-participants. For example, assume that the participant projects are 25% more efficient than baseline and that the matched non-participating projects are 10% more efficient than baseline. Then it is assumed that among the participants, the naturally occurring savings are 10% of the baseline and that the program is responsible for the remaining 15% savings relative to the baseline.

The analysis was carried out in the following steps:

1. Define the gross energy efficiency of the participating projects to be their total gross savings as a percentage the total baseline energy consumption of the participating projects. The total gross savings of the participating projects is the difference between the total baseline energy consumption and total as-built energy consumption of the participating projects.

[43] In the past, participant and non-participant spillover has been neglected or assumed to be zero, and the net to gross ratio has been taken to be one minus the free ridership rate.

2. Select a stratified sample of projects, use onsite audits and DOE-2 simulation to estimate both the as-built and baseline energy consumption of each project, and then use stratified ratio estimation to estimate the gross energy efficiency of the participating projects. In this instance, the sample participants are weighted to reflect the population of participating projects.
3. Select a stratified sample of non-participating projects matched to the preceding sample of program participants, use onsite audits and DOE-2 simulation to estimate both the as-built and baseline energy consumption of each non-participating project, and then use stratified ratio estimation to extrapolate the energy efficiency observed in the non-participant sample to the population of participating projects. In this instance, the sample non-participants are weighted to reflect the population of participating projects.
4. Estimate the net energy efficiency of the program participants as the difference in the gross energy efficiency of the participating projects and the average energy efficiency of the non-participating projects, and
5. Estimate the net kWh and kW energy savings of the program participants by multiplying the net energy efficiency of the program participants by the estimated total baseline energy consumption of all program participants.

The validity of the approach depends on the following assumption:

> *The efficiency choices of the non-participants reveal what the efficiency choices of the participants would have been in the absence of the SBD program*.

This is generally *not* the case under either of the following conditions:

1. The program participants have a higher level of interest in and commitment to energy conservation than the non-participants (called self-selection bias).
2. The program has had an influence on the efficiency choices of the non-participants (called non-participant spillover).

Using non-participant behavior as the measurement of what participants would have done without the program has the long standing problem of self-selection bias for any program that allows anyone to participate. If there is self selection bias, the efficiency of the non-participants will tend to *underestimate* what the efficiency choice of the participants would have been in the absence of the SBD program. So, the risk of self-selection bias is a serious flaw in the difference-of-differences approach.

Spillover is also a serious problem for the methodology. Like other non-residential new construction programs, the SBD program has been explicitly designed to move general design standards and equipment specifications toward increased energy efficiency. Under the difference of difference methodology, the *greater* the spillover, the *smaller* the net savings attributable to the program. Therefore this methodology would tend to encourage the program to minimize spillover, rather than to optimize diffusion. This provides a seriously distorted incentive to the program.

In short, if there is self selection bias, the efficiency of the non-participants will tend to *underestimate* what the efficiency choice of the participants would have been in the absence of the SBD program. If there is non-participant spillover, the efficiency of the non-participants will tend to *overestimate* what the efficiency choice of the participants would have been in the absence of the SBD program. If both conditions hold, the one error will offset the other error to a greater or lesser extent. But there is no *a priori* reason to expect the two errors to be of similar magnitude.

Thus, while the method appears to be simple and easily understood, it was difficult to know whether or not it yielded a valid estimate of the net impact of the SBD program. The California Evaluation Framework discusses the principles of identifying what the participant would have done in the absence of the program and recommends that a simple comparison between participant and non-participants is not acceptable given the self-selection and spillover issues.

Econometric Modeling

The second approach to estimating the net impact of SBD was econometric. The goal was to model the level of efficiency of a sample of program participant and non-participant sites in order to estimate the net participant savings after adjusting for free ridership and self selection, and to estimate non-participant spillover.

As explained above, onsite audits and DOE-2 modeling were used to estimate the energy efficiency of each project in the samples of participating and non-participating projects. The efficiency of each sample project was defined to be the gross savings as a percentage of the total baseline energy consumption of the project. The gross savings of the project was calculated as the difference between the total baseline energy consumption and total as-built energy consumption of the project determined from the simulation.

In addition, a survey was conducted with the owner of the project (or the most qualified spokesperson) to collect information about his interest in and commitment to energy conservation, the degree of interaction between the owner and design team with SBD staff and materials, and the influence of the SBD program on their efficiency choices in the project.

These data were used to estimate a regression model relating the observed level of efficiency of each site against decision-maker information about the interest in energy conservation, involvement with SBD, and the influence of the program. To the extent that a statistically significant correlation was found among these variables, the resulting statistical model could be used to estimate the naturally occurring savings among the participants and the spillover savings among the non-participants.

This approach depended on self-reported information about the degree of involvement and influence of the program as well as large samples to ferret out a statistically significant association. The program-influence information was not collected for specific measures or end uses. As in most exercises in econometric modeling, the results were conditional on the validity of the assumed regression model. In particular, it was usually assumed that the effect of the various variables was properly represented in the model, that no significant variables were omitted from the model and that the errors in the model were statistically independent.[44]

In practice, the results were rather sensitive to the specification of the econometric model (choice of variables) as well as the weight given to each observation especially the most influential observations. In addition the results for free-ridership and spill over were not traceable to

[44] A technique called the Mills ratio or double-mills ratio has sometimes been used to correct for residual self selection not controlled by the model.

specific buildings, measures or respondents. Because of these limitations, the results were difficult to defend.

1999 - 2001

The difference-of-differences approach was attempted for the Building Efficiency Assessment study, the statewide study evaluating the Savings By Design program in the 1999-2001 program years. The problems associated with the difference-of-differences approach came to a head because the methodology yielded very implausible results. There were three rounds of analysis in that study. The first round obtained a net-to-gross ratio of 79.7%. This was somewhat higher than found previously but not outside the range of what had been found historically or what was defensible. The second round provided a net-to-gross ratio of *minus* nine percent (-9.0%).[45] This result made no sense. One of the hypotheses for these disparate results was the impact the 2001 California energy crisis had on all new construction decision-making. In addition, the sample sizes available in these studies were too small to support the econometric approach. This motivated the evaluation team to focus on a new methodology.

In the course of the 1999-2001 NRNC program evaluation, a new methodology was developed. Self-report techniques were used for each conservation measure included in the building to identify the efficiency choices of the participant sites traceable to the program. Then DOE-2 modeling was used to estimate the direct impact of these choices for the demand and energy of each participant site. The results were extrapolated from the participant sample to the participant population using the same stratified ratio estimation techniques used for gross savings. Similar non-participant self-report techniques were used to measure spillover effects for the demand and energy savings of specific measures, and these were extrapolated from the non-participant sample to the total non-residential new construction population developed from the Dodge new construction database.

This approach also addressed some of the limitations of the econometric modeling approach. In particular, the net impact results were measured in energy units (kWh and kW), were traceable to specific projects and end uses, and were extrapolated to the population using the same statistical techniques used for gross savings. It was hoped that this methodology would yield statistically reliable results despite the smaller sample sizes.

The study also sought to improve the accuracy of the information by scheduling the data collection much closer to the time that the actual decisions were made about each project. In the prior studies, the evaluators were often talking to decision-makers about projects that were completed several years prior to the survey. Starting with the 1999 program year study completed in 2003, the goal was to schedule the interviews within a few months of the completion of the project. It was hoped that this would make it easier to obtain an interview with the most suitable spokesperson and to gather the most accurate information about the decision making process.[46]

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[45] "Measuring Accomplishments of Energy Efficiency in California's Nonresidential New Construction Market" (2002), pp. 10.41.

[46] In this section and the next, we may refer to the respondent as the 'owner' of the building. This is because the owner is often considered to be the most influential party in the decision-making process. However the interviewers were trained to seek the most suitable spokesperson for the decision-making process, regardless of title. Often this was the project manager or a member of the design team. Frequently, especially for the more complex projects, several people were interviewed in order to put together a complete picture of the process.

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 addressed to each specific energy conservation measure (ECM) or technology identified in the building. Some common ECMs were as follows:

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

The free ridership questions focused on the owner's prior experience with the measure and the direct effect of the dollar incentive paid to the owner on the decision to install each specific ECM included in the project. If the owner had installed the ECM in a prior building with no outside funding or incentive, then the measure was considered an absolute free rider. The measure was also considered an absolute free rider if the owner reported that the SBD incentive paid on the present project did not influence the decision and that the measure would have been installed if the incentive had not been available.

If the owner had not installed the ECM in a prior building or had received some outside funding or incentive for installing the measure previously, then the extent of free ridership was based on the reported degree of influence of the current SBD incentive on the present project, and whether or not the owner indicated that the measure would have been installed if the incentive had not been available. In particular, if the spokesperson reported that the incentive definitely influenced the decision and that the measure would not have been installed in the absence of the incentive then the program was given credit for the measure.

Non-participant spillover was also assessed by asking the spokesperson a series of questions about the ECMs identified in the onsite audit. Essentially the questions addressed the influence of interactions with the SBD program representative or program materials on (a) the present building, or (b) prior projects. Interactions on the present building were given a higher weight than interactions on prior projects. For example, in the case of a dichotomous measure that could be either implemented or not, the program was only given credit for the measure if interactions on both the present and prior buildings were reported to have at least a possible influence.[47]

In addition to these decision-maker surveys, the analyst looked for more concrete evidence to help characterize free ridership and spillover. In the case of a program participant, the SBD project files were reviewed in their entirety. For example, if the files referred to a pre-existing corporate design standard or indicated that there was very little interaction between SBD staff and the owner and design team, then this was considered to be evidence of free ridership and considered alongside the decision-maker survey. In the case of a non-participant, there generally was less supporting information. However, if the building was found to be a CHPS school or a LEEDS building, for example, this was considered to be evidence that the project was not influenced by the current SBD program.

In spite of the improvements over the prior econometric approach, this methodology still had limitations. Using the terminology we introduced in the prior section, the focus was on identifying

[47] Appendix H describes the questions and scoring rule more completely.

free ridership and direct program savings. However, participant-spillover due to the prior SBD program was generally interpreted as free ridership. For example, suppose a program participant had installed the measure in a prior building and received an SBD incentive and, due to the experience, adapted the measure into a corporate standard. Then the measure would have been considered an absolute free rider under the scoring rule that was used. Similarly, measures installed in a school to meet CHPS requirements would be interpreted as free riders even if the CHPS program was strongly influenced by prior SBD program activities.

Similarly, the scoring rule tended to recognize non-participant spillover due to partial participation on the current project, but gave relatively little weight to non-participant spillover due to participation with SBD on prior projects. For example, suppose that an owner participated in the SBD program for a prior building and was so impressed with a particular energy conservation measure that she adopted the measure in the current building with no further interaction with SBD staff. Then the program would have been given little or no non-participant spillover credit for the measure since there was no current interaction.

In summary, the methodology seems to have done a reasonably good job of characterizing the direct impact of current SBD incentives and activities on current projects, including both program participants and non-participants, but the methodology seems to have generally given the program little or no credit for participant and non-participant spillover associated with prior SBD activities.

The detailed methodology used to conduct the free-ridership and spillover assessment in these studies is presented in Appendix H of this paper.

2003

In the 2003 program-year studies, the decision-maker questions were closely scrutinized and extensively revised to address many of the limitations of the preceding methodology. The complete participant and non-participant surveys are reproduced in Appendix D.

The following are the most relevant changes and additions to the participant survey.

- The spokesperson was asked specifically about the influence of *design assistance and design analysis* as well as the financial incentive (Question 26, 29).
- Questions explored the influence of the program on the participant's *standard building practice* (Q27, 28).
- The spokesperson was asked whether the building used *prototype plans* (Q30). If so, the owned was asked a battery of questions about the influence of the program on the prototype plans (Q37 - Q50).
- The questions about the influence of the program on specific measures specifically include the influence of *design assistance and design analysis and interactions with SBD representatives and consultants,* as well as the financial incentive (Q31).
- A question asked *how* the program influenced the measure, and provided *pre-coded answers for possible ways*, *including prior SBD projects* (Q32).
- A question asked whether the measure would have been installed if there had been no interaction with SBD regarding this project, and asked for a specific follow up explanation. The pre-coded possible answers included the possibility that the project would have been

installed *as a result of what was learned through previous SBD program participation.* (Q33).

- The surveyor was specifically asked to record any mitigating factors (Q34).[48]

The non-participant survey was very similar to the new participant survey. The following are some of the most noteworthy characteristics of the non-participant survey.

- The survey asks the spokesperson whether the owner or her design team was aware of SBD and had any interaction with the utility's new construction program representative or SBD program materials on the current project. (Q19-21).
- If the answer to the previous question was no awareness nor interaction on the current project, one more question was asked (Q22) and then the survey was terminated. In this case, SBD was given no credit for any influence on the project.
- Otherwise the spokesperson was asked whether the building used *prototype plans or a master spec* (Q23). If so, the spokesperson was asked a battery of questions about the influence of the SBD program on the prototype plans (Q27 – Q34).
- If a prototype was not used, the survey asked the spokesperson about the influence of SBD on each energy conservation measure included in the building. If the response was 'definitively influenced,' for a particular measure, the spokesperson was asked to explain how (Q24).
- The spokesperson was also asked about interaction with SBD on any prior projects. (Q25). If there was prior interaction, the spokesperson was asked whether it influenced the current project and to explain how (Q26).

To summarize, the current instruments attempt to get at the effect on the current project of prior interaction with the SBD program. They also ask whether a prototype design was used in the project and if so, they ask a sequence of questions to quantify the influence of SBD on the prototype design. This has seemed to work fairly well since the owner or design teams are usually knowledgeable about the evolution of a prototype design within their firm.

However, the current methodology does not address the question of assessing the impact due to SBD if the project participates in other programs such as CHPS and LEEDS. The difficulty is that the owner of the building or the design team for a particular project is not in the best position to address this issue. On the contrary, it is fairly common for the owner to indicate that SBD had little or no impact on the building since their primary focus was on CHPS or LEEDS standards. There is no reason to expect them to be aware of how SBD might have influenced these standards.

[48] The pre-coded answers were used to simplify coding but, to avoid response bias, they were not read to or shown to the respondent.

Other Policy Questions

In this section we will address several added questions.

Assessing the effect of SBD on Other Programs

We have pointed out that (a) SBD should get credit for its influence on programs such as CHPS and LEEDS, and (b) the building owner or design team is not in a good position to assess the influence of SBD on programs such as these. We would like to address this gap.

We believe an independent study should be undertaken of the influence of SBD on other major programs to establish the proportion of the savings associated with its efforts in each program. This would be conducted much as a process study. The investigators would review the goals and operation of a particular program, its interaction with SBD, the influence of SBD on the evolution of its standards and requirements, etc. The outcome would be a finding that SBD should be given spillover credit for a specified fraction of the savings associated with the standards and requirements of the program. This finding would be subject to review and feedback both from the leaders of the program (who might be motivated to minimize the influence of SBD so as to credit their program with greater savings) and from SBD staff (who would have the opposite motivation.). The study should be conducted by an impartial expert without a vested interest in the results, and should be repeated periodically if conditions are changing.[49]

The resulting 'deemed values of indirect influence' would be similar to deemed free ridership rates or persistence rates that are often used in other programs. They would be available for use in the SBD impact evaluation and would tend to simplify the evaluation. If it was determined that a project participated in a program such as CHPS or LEEDS, the SBD program would be given spillover savings for a portion of the associated savings, regardless of whether it was a SBD program participant or non-participant. The current self-report methodology would be used to assess the influence of SBD on those measures that were beyond the other program. In particular if the project participated in the SBD program, a particular effort would be made to identify measures that were directly influenced by the incentives and design assistance of the current program so that the associated savings could be reported separately as direct savings.

Double Dipping

Is there a risk of double counting savings if the current SBD program is given credit for the effects of the efforts of the SBD program in prior programs? In other words, is there a risk of double counting with the concept of participant-spillover?

The short answer is this: the savings credited to SBD in a given year are always directly associated with the specific construction projects completed in that same year. Since a single project cannot be completed in two different years, there is little risk of double counting the associated savings.

[49] An alternate approach would be to introduce a full-blown market effects study of the SBD program. This approach is discussed in the paper by Chappell, Mahone, Megdal and Keating, cited earlier. However, it should be recognized that reliable assessment of the gross program savings requires onsite audits and detailed energy simulations. Since this approach involves extensive interaction with the owner, it seems sensible to take the opportunity to learn as much as possible about the direct and indirect effects of the program within this type of study.

A broader question is whether the program should get credit for savings at the time that it interacts with an owner or design team. It is important to recognize that a typical owner usually builds a sequence of buildings over a period of years. Consider two buildings called A and B and assume that they are built in years X and Y respectively. Suppose the owner gets design assistance for building A in program year X and this affects the design of a future building B. So B has real savings due to the efforts of the SBD program in year X.

But the policy has been to *not* credit the year-X program for the future savings of building B since B is not yet built. To do otherwise would require a forecast of the future plans of each program participant. So it seems to be a sound policy to only credit savings when a building is actually built.

Now move forward in time to year Y, the year in which B is actually built. First suppose that B does *not* participate in the SBD program. Then the savings would be considered to be spillover savings in year Y due to the program.

But if B *does* participate in the SBD program, then the program should still be credited with the savings in year Y. In particular, these savings are not double counted since they were not counted in year X.

Therefore we do not believe there is a problem with double counting. We do believe it is important to clearly distinguish participant-spillover savings from the direct impact of the current program. In other words, we feel that it is important to clearly distinguish the direct impact of the current program from the indirect impact of the program in order to accurately assess both innovation and diffusion.

Restriction of Incentives

It has been suggested that SBD would be more cost effective if its incentives were restricted to the most innovative measures and withheld from measures that may only be indirectly attributable to the program. Corporate design standards are an extreme case. If a corporate design standard is in place, should SBD give incentives for the measures that it requires.

To address this issue, let us continue with the prior example. Recall that we assumed that, due to the efforts of SBD, building A was substantially more efficient than it would have been otherwise. Suppose as a result, the owner adopts a design standard for future buildings incorporating these measures. Perhaps the program should deny program participation to building B. If B uses exactly the same design as A this might have some merit since no new innovation is involved.[50].

The key issue is that SBD is designed to encourage the early adoption of increasingly innovative designs. Ideally the program has continued to work with the owner to include in B added design features not included in A. It is likely that the new incentive is needed to get the owner to adapt these new measures. Moreover, one could argue that the program *has* to work with owners like this one that are receptive to the most innovative energy efficiency measures. These are the owners likely to have had a good experience with the program in a prior building.

[50] Of course this would require a drastic change in the rules of the SBD program that might have unintended consequences if they were possible at all.

In summary, we do not believe it is possible or desirable to deny program participation and incentives for projects that meet the requirements of the program, even if they have only been indirectly affected by the current SBD program.

Other Timing Issues

Consider the following example. Suppose a central chiller plant participates in the SBD program and is sized to serve the current building A and a future building B. Assume that the chiller and A are built in year X and building B is to be built in a later year Y. The question is when does the chiller project get the savings associated with B? There seem to be only two choices (1) in year X and (2) in year Y.[51]

Under the present methodology, the chiller is modeled in year X but its full savings are only realized when B is built and the chiller is at full load. This is a little like the case of an office building that is not fully occupied at the time of the onsite audit. In the case of the office building, the standard practice has been to model the office as if it were fully occupied. Perhaps the chiller situation is analogous. But if the chiller is given the credit for B in year X, there should be some basis for projecting the chiller load associated with B such as very specific plans.

If there are no specific plans for B in year X, then the chiller savings in year X would be based on the known load of building A. Assume that B is eventually built in year Y and is in the new M&V sample in that year. It seems awkward to return to the chiller project and give it the added savings associated with B since the focus of the new study will be on B not on the older chiller project.

A better option might be to give the chiller the first-year saving associated with A but force the chiller project into the next persistence study and then reassess its savings. Suppose there is a 3rd year persistence study and that B has been built by that time. Then when the persistence study returns to the chiller project and asks whether any changes have affected its savings, the added savings associated with B could be captured. The added savings would offset any lost savings in other projects and increase the expected lifetime of the savings for the program as a whole. Conversely suppose there had been specific plans for B and the chiller had been given first-year credit for both buildings A and B in year X. Then the persistence study would provide an opportunity to verify that B was actually built and that the savings were fully realized.

There is a potential problem with using the persistence study to true up the chiller savings. In the persistence studies, the policy has been to retain the occupancies and schedules from the first year evaluation. If that policy were strictly applied to the chiller example, it might be considered inappropriate to adjust the chiller savings for building B since this is like a revised occupancy or schedule.

The solution may be to make a distinction between *temporary* changes in occupancy such as changes that are affected by current business conditions, and *permanent* changes in occupancy or schedules. An argument can be made for ignoring temporary changes in a persistency study but including permanent changes in the study. For example if a building is actually demolished, that is like a permanent change in occupancy and we say the savings have died. Similarly if the chiller savings are affected by building B, this would be a permanent change to the load of the chiller and could be reflected in the persistence study.

[51] Strictly speaking, this example raises questions about measuring gross as well as net savings. It is included in this paper because it has been identified by the SBD M&V team as an important unresolved issue.

In summary, if B is not yet built but specific plans are available in year X perhaps the chiller should be given first-year credit for the savings associated with B. If the plans for B are more vague, then credit should not be given. In either case, the chiller project should be designated for certainty inclusion in the persistence studies until the issues become resolved.

This raises the idea of designating a project for future persistence studies if issues such as these cast doubt on future savings. In the preceding example, the chiller project would be so designated because of the uncertainty associated with the future load on the chiller. Similarly, if an auditor saw other things at a site, such as expected changes in space use or permanent occupancy, the project might be designated for inclusion in future persistence studies. In order to avoid biasing the future studies, these designated projects would have to be treated as certainty projects or in their own sampling stratum.

Conclusions and Recommendations

The following is a concise summary of our principle observations and conclusions:

1. SBD is designed to directly promote innovate measures and to indirectly encourage the widespread adoption of these measures.
2. SBD works with and through many other programs that have similar goals and standards, such as CHPS and LEED.
3. MV&E should be designed to assess and report both the *direct and indirect savings* attributable to SBD. The *direct savings* are associated with the innovative measures implemented by program participants due to the direct influence of the current program. The *indirect savings* (often called spillover savings) are associated with its contribution to the diffusion of these measures in new-construction practice.
4. An important measure of the efficiency of SBD is the ratio of the total direct savings to the total gross savings of the program participants.
5. The *indirect savings* should include both participant spillover attributable to prior SBD interactions and efforts, and non-participant spillover attributable to both current and prior SBD interactions and efforts.
6. The net savings of the program should include the sum of the direct savings and all indirect savings. The net to gross ratio should be defined as the ratio between the net savings and the gross savings of the program participants. The net to gross ratio is another important measure of the performance of the program.
7. The MV&E methodology has evolved and improved continuously over the years. The current methodology is sound and addresses many of these goals but continued improvement should be sought.
8. The current methodology is not suitable for assessing SBD's share of the savings associated with programs such as CHPS and LEED. For this, a different approach is required addressed to each individual major program and periodically repeated when conditions change. The resulting values would be used by the SBD evaluators in conjunction with the onsite audits and DOE-2 simulations that have always formed the cornerstone of the SBD evaluations.
9. In limited cases, a project such as a central chiller plant can be credited for savings associated with future buildings or load, provided that specific plans are available. If the plans are vague, the future load should not be considered in the first-year M&V study. But in either case, the project should be designated for special inclusion in future persistence studies until the issues are resolved.