Statewide Market Assessment and Evaluation Non-Residential New Construction Program Area

Building Efficiency Assessment Quarterly Report

4th Quarter 1999 through 3rd Quarter 2000

Prepared for

Southern California Edison

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Executive Summary

Introduction

This document is the first of three statewide reports for the Non-Residential New Construction (NRNC) program area, covering program years 1999-2000. This report contains summary results for both program participants of the Savings By Design (SBD) program and program non-participants. Savings By Design is the statewide NRNC energy efficiency program administered by PG&E, SCE, and SDG&E. Included in the report are buildings that were completed and occupied in the 4th Quarter of 1999 through the 3rd Quarter of 2000.

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 is the lead on the engineering simulation work. Eskinder Berhanu & Associates (EBA), located in Southern California, is assisting RLW 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) programs. Our methodology builds on our prior experience evaluating PG&E and SCE's 1994, 1996, 1998 and 1999 NRNC programs, as well as our work on the CBEE California Statewide Non-residential New Construction Baseline study.

The evaluation is based on DOE2 engineering models that are informed by detailed onsite audits and statistically projected to the program population. RLW Analytics has successfully used this approach across the nation in non-residential evaluation studies.

The key objectives of the study are to:

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

This study has used a refinement of the methods used in most of the prior NRNC impact evaluations. The key innovation is the use of a customer self-report method for determining participant free-ridership and non-participant spillover. Past evaluations relied on the use of econometric modeling and the difference of differences approach to determine the efficiency choices of the program participants. The self-report approach was successfully used in PG&E's 1998 "Paid in 1999" Carryover Evaluation. In this study the self-report approach has been used for a second estimate of program free-ridership, in addition to the difference of differences approach.

Findings

This section presents study findings for both the impact and the process components of the study. The impact findings were developed from the DOE2 modeling process, while the process findings are a result of the surveys with building owners and design teams.

Gross Savings

Gross Energy Savings

Table 1 shows the estimated whole building gross energy savings relative to the energy savings from the SBD program tracking databases. For all program participants, the tracking estimate of savings was 19,222 MWh. We estimated the whole-building gross annual energy savings to be 19,387 MWh. Therefore, the gross realization rate was 100.9%. The estimate is based on a sample of 24 participant buildings with 10,379 MWh of tracking savings, representing 54% of the program savings.

These results indicate that the mechanisms in place for estimating project energy savings are working very well. Since all paid projects in this reporting cycle were incented under the 'Systems' delivery channel, the data suggests "NCCalc", the SBD estimating tool, is providing sound estimates of energy savings.

Program Tracking Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Estimated Energy Savings (MWh)	Realization Rate
19,222	10,379	54.0%	19,387	100.9%

Table 1: Whole Building Annual Gross Energy Savings

Figure 1 shows the composition of annual gross energy savings by measure category. Lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls) account for about 60% of the annual energy savings among program participants. HVAC measures comprise an additional 20% of the savings. Most of the remaining savings are due to motors measures.

Daylighting controls represent a larger fraction of the program savings than what has typically been the case for past efficiency programs. Daylighting controls were typically found in warehouses, which tend to have shorter construction cycles than other buildings. As the project progresses, the SBD participant population will be comprised of more buildings with longer construction cycles. For this reason, we expect that the fraction of savings represented by daylighting controls to decrease as this study progresses.

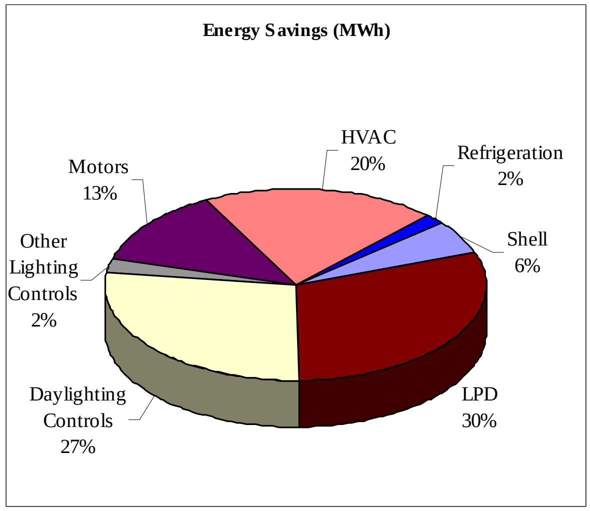

Figure 1: Composition of Annual Gross Energy Savings

The program participants continue to be energy efficiency leaders in the non-residential new construction program area, as they were in past NRNC programs. Figure 2 shows the savings of both program participants and non-participants expressed as a percentage of each group's whole-building baseline usage. As Figure 2 shows, the participants were 19% better than baseline on average, while the non-participant comparison group was about 4% better than baseline. For participants, the level of efficiency relative to baseline is highest for the lighting power density and daylighting controls measures. For non-participants, the level of efficiency relative to baseline is fairly constant for all end uses. In the other lighting controls and refrigeration end uses, however, the non-participants were somewhat more efficient than the participants.

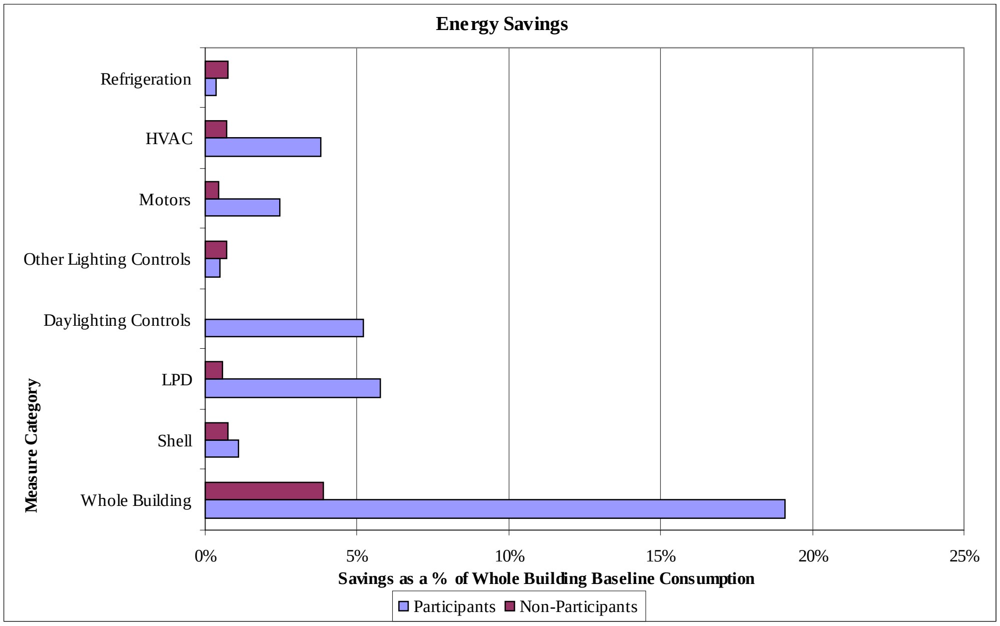

Figure 2: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption

Gross Demand Impacts

With the current energy crisis, there is great interest in demand reduction. Table 2 shows the estimated whole-building gross summer peak demand reduction relative to the summer peak demand reduction from the program tracking databases. For all program participants, the whole building summer peak gross demand reduction are estimated to be 5.0 MW, representing a gross realization rate of 101.8%. The sample consisted of 2.3 MW of savings, nearly 50% of the programs total demand reduction. Again, the results indicate the "NCCalc" tool is providing accurate estimates of demand reduction as well as energy savings.

Program Tracking Demand Savings (MW)	Sampled Demand Savings (MW)	% Demand Savings Sampled	Estimated Demand Savings (MW)	Realization Rate
4.9	2.3	47.7%	5.0	101.8%

Table 2: Whole Building Summer Peak Demand Reduction

Figure 3 shows the breakdown of summer peak demand reduction by measure category. Lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls) account for over 60% of the summer peak demand reduction among program participants. HVAC measures comprise an additional 20% of the savings.

Daylighting controls represent a larger fraction of the program demand reduction than what has typically been the case for past efficiency programs. Daylighting controls were typically found in warehouses, which tend to have shorter construction cycles than other buildings. As the project progresses, the SBD participant population will be comprised of more buildings with longer construction cycles. For this reason, we expect that the fraction of demand reduction represented by daylighting controls to decrease as this study progresses.

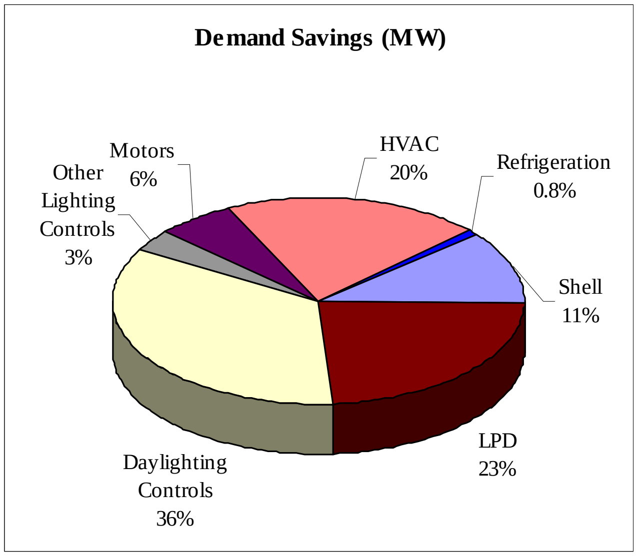

Figure 3: Composition of Summer Peak Gross Demand Reduction

As we would expect, the participant group was more efficient than the non-participant group. Figure 4 shows the summer peak demand reduction of both program participants and non-participants expressed as a percentage of each group's whole-building baseline demand. As Figure 4 shows, the participants were about 22% better than baseline on average, while the non-participant comparison group was about 5% better than baseline. For participants, the level of efficiency relative to baseline is highest for the lighting power density, daylighting controls, and HVAC measure categories. In the lighting controls and refrigeration end uses, however, the non-participants were somewhat more efficient than the participants.

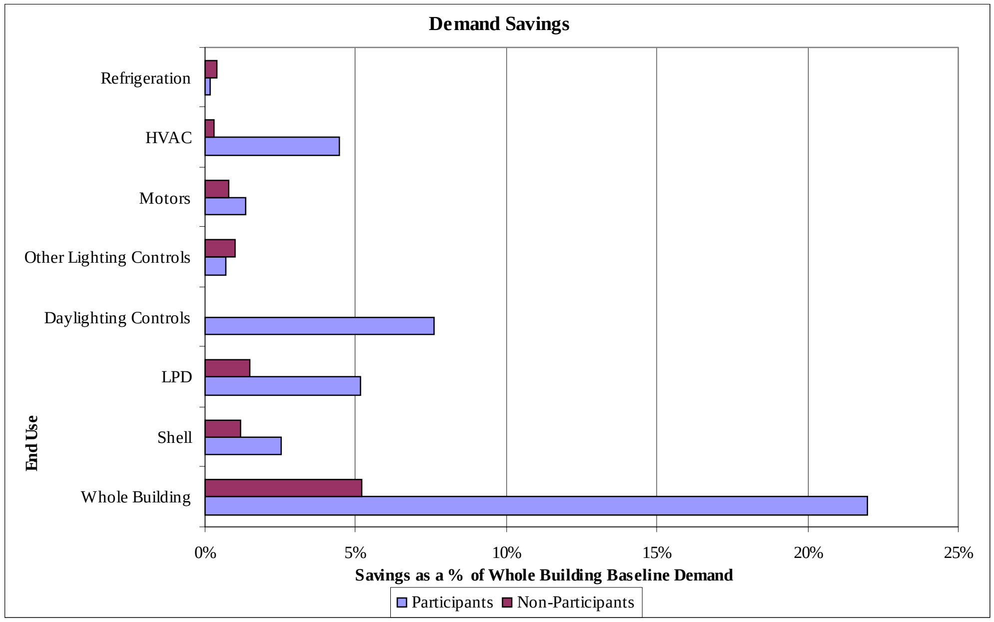

Figure 4: Participant and Non-participant Demand reduction as a Percentage of Baseline Demand

Net Savings

Net Energy Savings

Table 3 presents the difference-of-differences calculations for net annual energy savings. The calculations result in 15,442 MWh of net annual energy savings. These net savings correspond to a net-to-gross ratio of 79.7%.

	Participants	Non-Participants	Participant Net Savings
Baseline (MWh)	101,558	60,028	
As-Built (MWh)	82,171	57,696	
Savings (MWh)	19,387	2,332	15,442
Savings (% of Baseline)	19.1%	3.9%	15.2%
Net-to-Gross Ratio			79.7%

Table 3: Difference of Differences Net Savings Calculation – Annual Energy

Net Demand Impacts

Table 4 presents the difference-of-differences calculations for the net summer peak demand reduction. The calculations result in 3.8 MW of net summer peak demand reduction. This net demand reduction corresponds to a net-to-gross ratio of 76.4%.

	Participants	Non-Participants	Participant Net Savings
Baseline (MWh)	22.7	13.4	
As-Built (MWh)	17.7	12.7	
Savings (MWh)	5.0	0.7	3.8
Savings (% of Baseline)	22.0%	5.2%	16.8%
Net-to-Gross Ratio			76.4%

Table 4: Difference of Differences Net Savings Calculation – Summer Peak Demand

Process Findings

This section presents some of the more important findings from the building owner and design team surveys. The surveys addressed satisfaction with various SBD components on the participant side, and awareness on the non-participant side. Additionally, questions were asked of both non-participants and participants that addressed issues such as financial criteria, design team qualifications, energy efficiency attitudes, and energy performance. Detailed findings from these surveys can be found in the Owner and Design Team Survey section.

All statistically significant differences will be shaded in gray. All statistical significance tests were conducted at the 90% level of confidence.

Owner Surveys

A total of 45 owner surveys were completed. Of the 45 surveys, 23 were with participant owners, with the remaining 22 with non-participant owners.

Financial Criteria

Table 5 shows the most important financial criteria used to make energy efficient investments during construction as reported by program participants and non-participants. Program participants were significantly more likely than non-participants to use the “Lowest Lifetime Cost” and “Simple Payback” criteria than were non-participants. Non-participants were significantly more likely than participants to use “Lowest First Cost” as the most important financial criteria or to not know the criteria used. This may indicate that non-participants are not participating because, while participation does result in a more energy efficient building, the reality is that the up front cost is usually higher. This suggests an emphasis should be placed on educating potential participants on the value of using various economic analyses to evaluate new construction options.

	% of Respondents	
	Participants	**Non-Participants**
Lowest Lifetime Cost	40.7%	10.2%
Simple Payback	30.6%	-
Return on Investment	16.6%	16.8%
Lowest First Cost	5.0%	22.1%
Other	4.0%	23.2%
Don't Know	3.0%	23.2%
Net Present Value	-	-
Refused	-	4.6%

Table 5: Most Important Financial Criteria

Design Team Qualifications

All respondents were asked if, when selecting a design team, they considered qualifications in energy efficiency. Table 6 summarizes the responses. Nearly 40% of participants and about 25% of non-participants state they did consider energy efficiency qualifications. In other words, respondents that participate in the program appear to be more concerned about energy efficiency than non-participants.

	% of Respondents	
	Participants	**Non-Participants**
Yes	39.2%	26.9%
No	47.3%	60.0%
Don't Know	13.5%	13.1%

Table 6: Consideration of Energy Efficiency Qualifications in Design Team Selection

Energy Efficiency Attitudes

All survey respondents were asked to rate the level of importance of energy efficiency when they built their building, on a one-to-five scale, where one meant very unimportant and five meant very important. Table 7 presents the distribution of responses along with the mean rating for both participants and non-participants. Program participants (Mean = 4.22) placed a significantly higher level of importance on energy efficiency than did non-participants (Mean = 3.22). Only 8% of program participants stated that energy efficiency was not important while nearly 35% of non-participants held the same opinion.

	% of Respondents	
	Participants	Non-Participants
Very Important	36.3%	8.3%
Somewhat Important	53.7%	46.7%
Neither Important nor Unimportant	2.0%	10.4%
Somewhat Unimportant	8.1%	28.3%
Very Unimportant	-	6.4%
Mean :	4.18	3.22

Table 7: Importance of Energy Efficiency during Design and Construction

All survey respondents were asked to rate the level of importance of energy efficiency in the daily operations of their building, on a one-to-five scale, where one means very unimportant and five means very important. Table 8 presents the distribution of responses along with the mean rating for both participants and non-participants. There is some indication that program participants (Mean = 3.90) place a higher level of importance on energy efficiency in operations than do non-participants (Mean = 3.74), although the difference is not statistically significant.

Recall in the "Financial Criteria" section, participants were more concerned with Life Cycle and long term costs than were the non-participants. This is reiterated by the non-participants, as show in Table 7, where 35% report energy efficiency is not important at the time of design and construction. Meanwhile, a much higher proportion of non-participants think energy efficiency is important during the daily operations of their building, as indicated in Table 8. The data leads us to believe that while non-participants do think about the energy efficiency implications related to daily operations, they do not connect this to up front costs or life cycle costs. On the other hand, it does appear as the participants do make the connection.

	% of Respondents	
	Participants	Non-Participants
Very Important	35.2%	28.5%
Somewhat Important	39.6%	36.8%
Neither Important nor Unimportant	8.5%	8.0%
Somewhat Unimportant	13.6%	20.3%
Very Unimportant	3.0%	1.6%
Don't Know	-	4.8%
Mean :	3.90	3.74

Table 8: Importance of Energy Efficiency in Daily Operations

Energy Performance

All participants and non-participants were asked to compare the efficiency of their building relative to the energy code. Table 9 presents the distribution of responses for both groups. Participants were significantly more likely to believe their building was much better than required by code, while non-participants were significantly more likely to state their building was just efficient enough to comply with code.

Relative to Code	% of Respondents	
	Participants	Non-Participants
Just Efficient Enough to Comply	13.6%	28.8%
Little Better than Required	46.8%	29.6%
Much Better than Required	31.1%	21.9%
Don't Know	8.5%	19.7%

Table 9: Opinion of Building Efficiency Relative to Code

Savings By Design Program Questions

All SBD program participants were asked how they first became aware of the SBD program, services, and owner incentives that are available. As shown in Table 10, nearly two-thirds of participants heard of the program through a utility representative.

	% of Participants
Utility Representative	63.7%
Previous Utility Program Participation	13.6%
Architect	8.5%
Engineer	6.2%
Current Tenant/Previous Tenant	5.0%
Don't Know	3.0%

Table 10: Source of Awareness of Savings by Design

Table 11 summarizes the responses given when SBD participants were asked which member of their project team was the single biggest advocate for participating in the program. Nearly two-thirds of participant owners say they were the biggest advocates for SBD participation. This supports a finding of our NRNC baseline study that architects and designers feel that the owners are the key decision-makers.

	% of Participants
Owner/Developer	63.3%
Architect	3.0%
Lighting Designer/Electrical Engineer	8.5%
Mechanical Engineer	8.5%
Energy Manager/Facility Manager	5.0%
Construction Manager	8.5%
Other	3.0%

Table 11: Biggest Advocate for Participating in Savings by Design

All SBD participants were asked to rate the level of importance of the dollar incentive paid to the owner in motivating their organization to participate. As shown in Table 12, nearly 25% of owners felt the incentive was very important. Nearly 20% of participant building owners stated they felt the incentive was very unimportant in motivating them to participate. This suggests that these participants find significant value in other aspects of the program, such as design assistance and information.

	% of Participants
Very Important	23.5%
Somewhat Important	45.3%
Neither Important Nor Unimportant	8.5%
Somewhat Unimportant	3.0%
Very Unimportant	19.7%

Table 12: Importance of Owner Incentive in Participation

As shown in Table 13, nearly 40% of participants say SBD participation influenced them to change their standard building practices to lead to more efficient buildings. This may indicate one of two things; a number of the participants may be program free-riders because they are already constructing efficient buildings; or they may go back to a less efficient design in future projects if they are not participating in an incentive program.

	% of Participants
Yes	39.2%
No	60.8%

Table 13: Incidence of SBD Participation Changing Building Practices

All SBD participants who say participation caused them to change their standard building practices to lead to more efficient buildings were asked which component of the program was the most instrumental in causing this design practice change. Table 14 displays the results. Nearly three-quarters of participants say the owner incentive was the most influential, while about one-quarter say the design assistance was the most influential.

It may be difficult to understand why the owner incentive component of the program will lead owners to design more energy efficient buildings in future projects. The responses may be suggesting the cash incentive was the original basis for program participation, and in turn the owners have had a favorable experience with the measures that were installed. Therefor making it likely that they would install similar measures in the future as a result of the experience they have had with SBD. This reiterates the importance of incentive-based programs as a vehicle to transform the NRNC market to a more energy efficient and sustainable market.

	% of Participants
Owner Incentive	73.2%
Design Assistance	26.8%

Table 14: Most Instrumental Component in Causing Change in Building Practices

All participants were asked to provide any recommendations for change to the SBD program in order to improve its delivery to customers. Table 15 shows that over one-quarter of the participants stated that no changes were needed, and one-quarter stated that the review and response from the utility needs to be expedited. The third most common recommendation was to increase the incentives paid for efficient equipment. Some respondents mentioned that the utility representatives need to present the benefits more clearly and more marketing is needed to increase awareness of the program.

	% of Participants
No changes needed	26.5%
Review and response from utility needs to be more rapid	26.5%
Increase Incentives	21.0%
Utility Reps need to present benefits more clearly	10.2%
More marketing to increase awareness of program	9.7%
Increase requirements to increase energy savings	2.4%
Don't Know	3.7%

Table 15: Changes to Savings by Design

Table 16 shows the percentage of non-participants who were aware of Savings By Design before they began construction. About 23% of non-participants were aware of the program.

	% of Non-Participants
Yes	22.9%
No	77.1%

Table 16: Non-Participant Awareness of SBD Before Construction Began

All non-participants were asked, if they were aware that cash incentives were available, how likely it is that they would have pursued these incentives by designing their building to perform better than Title 24 by at least ten percent. Table 17 presents the responses cross-tabulated by whether the respondents was aware of SBD. Over 50% of those respondents who were aware of SBD stated they would have been very unlikely to do so. Nearly 50% of all non-participants state they would have been very likely to do so. Over 85% of non-participants who were unaware of SBD state they would have been at least somewhat likely, if they had been aware of the financial incentives. These results suggest that if a larger marketing campaign was undertaken, it is highly likely that participation would increase.

	% of Non-Participants	
	Aware of SBD	Not Aware of SBD
Very Likely	46.7%	47.9%
Somewhat Likely	-	39.6%
Neither Likely Nor Unlikely	-	6.3%
Somewhat Unlikely	-	
Very Unlikely	53.3%	-
Don't Know	-	6.3%

Table 17: Likelihood of Designing Building to Perform Better than Title 24 If Aware of Financial Incentives

Design Team Surveys

A total of 16 participant and 19 non-participant design team surveys were completed. Over 71% of the 16 design team members who responded to the surveys for the participant projects were architects. The second most common participant survey respondents were engineers, comprising 22% of the respondents. The remaining respondents were either general contractors or construction managers.

The majority of the 19 non-participant design team survey respondents were architects, totaling 61% of respondents. The second most common non-participant respondents were engineers, totaling 18% of respondents. Construction managers and general contractors were the remaining respondents, totaling 15% and 6% of the respondents, respectively.

All survey respondents were asked if their firm advertised energy efficient design practices. Table 18 presents the results by program participation status.

Participants were more likely to advertise energy efficient design practices and non-participants were more likely to not advertise energy efficient design practices. However, in general, advertising energy efficiency does not appear to be seen as a valuable marketing strategy.

	% of Respondents	
	Participants	**Non-Participants**
Yes	17.2%	8.7%
No	66.2%	79.1%
Don't Know	16.6%	12.2%

Table 18: Advertisement of energy efficient design practices

All non-participants were asked if they were familiar with Savings By Design. As shown in Table 19, over two-thirds of the non-participants were familiar with the program. Non-participant design teams were much more likely to be aware of SBD than were non-participant owners. We also found several cases where design teams were involved in projects that were both participants and non-participants.

Some of the design teams that had both participant and non-participant projects reported the non-participant owners simply were not interested in participating. Reasons for not participating included project time delays as a result of participation and the owner simply not being aware of the program. These results underscore the importance of marketing the program to building owners, since they are ultimately responsible for the decision to participate and because at this time the non-participant design teams aware of SBD are not marketing SBD to their customers. This is further supported by the fact that overwhelmingly the owner was the biggest advocate to participate in the program (Table 66, Table 80) according to both building owners and design teams, respectively 63% and 81%.

However, because a large proportion of design teams are either familiar with SBD or are already participating with other clients suggest that a considerable amount of program spillover may be occurring. Of course this assumes the design teams are effectively transferring what they are learning and designing through SBD to other projects not currently participating in the program.

	% of Non-Participants
Yes	67.5%
No	32.5%

Table 19: Familiar with Savings By Design

The non-participants who stated that they were familiar with the program were then asked if they were aware that a Design Team Incentive might have been available to their team. Table 20 shows that among the 67.5% of respondents who were aware of the program, only 40.0% of them were aware that an incentive might have been available. Therefore, approximately 27% of all the non-participants were aware of the Design Team Incentive.

	% of Non-Participants
Yes	40.4%
No	59.6%

Table 20: Awareness of Incentive

All non-participants who were unaware of SBD, plus non-participants who were aware of SBD but unaware of the Design Team Incentive were then asked how likely it is that they would have pursued the incentives by designing their project to perform better than Title 24 by at least 15%. Table 21 presents the percentage breakdown of the responses. Over 30% of the respondents stated that they would have been somewhat likely and 20% would have been very likely to have designed a more efficient project. This is evidence that more communication needs to take place between the design teams and the SBD representatives.

	% of Non-Participants
Very Likely	19.6%
Somewhat Likely	30.9%
Neither Likely Nor Unlikely	8.0%
Somewhat Unlikely	19.6%
Very Unlikely	13.1%
Don't Know	8.7%

Table 21: Likelihood of Pursuing Design Team Incentives if Aware of Incentives

All non-participants who were unaware of SBD, plus non-participants who were aware of SBD but unaware of the Design Team Incentive were then asked how likely it is that they would have pursued the Design Assistance and Design Analysis component of SBD had they been aware of it. Table 22 shows that almost two-thirds of respondents would have been likely to pursue the Design Assistance and Design Analysis component of SBD.

	% of Non-Participants
Very Likely	44.0%
Somewhat Likely	18.9%
Somewhat Unlikely	19.6%
Very Unlikely	13.1%
Don't Know	4.4%

Table 22: Likelihood of Pursuing Design Assistance and Design Analysis if Aware of Design Team Incentives

Introduction and Overview

Introduction

RLW Analytics, Inc. (RLW) is conducting an on-going impact and a process evaluation of Savings By Design (SBD), California's statewide non-residential new construction (NRNC) energy efficiency program, administered by PG&E, SCE, and SDG&E.

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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 is the lead on the engineering simulation work. Eskinder Berhanu & Associates (EBA), located in Southern California, is assisting RLW in the data collection and engineering modeling.

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The evaluation is based on DOE2 engineering models that are informed by detailed onsite audits and statistically projected to the program population.

The difference-of-differences approach is used to calculate the overall net savings. Basically, this approach compares the overall energy savings (demand reduction) of the participants as a fraction of their baseline energy usage (demand) to the overall savings of the non-participants as a fraction of their baseline usage. The difference between the two groups is used to calculate the overall net savings.

This study has also used a refinement of the methods used in most of the prior NRNC impact evaluations. The key innovation is the use of a customer self-report method for determining participant free-ridership and non-participant spillover. Past evaluations relied on the use of econometric modeling and the difference of differences approach to determine the efficiency choices of the program participants. The self-report approach was successfully used in PG&E's 1998 "Paid in 1999" Carryover Evaluation. In this study the self-report approach has been used for a second estimate of program free-ridership, in addition to the difference of differences approach.

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. The incentive program has two principal components:

1. Systems Approach
2. Whole-Building Approach

Systems Approach

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

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
- Lumen maintenance 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
- HVAC controls to regulate system operation
- Low solar heat gain coefficient (SHGC) glazing[1]

Refrigeration Systems

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

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

Whole Building Approach

The Whole Building Approach offers a comprehensive package of services designed to analyze energy-efficient, cost-effective design alternatives. The Whole-Building Approach is not limited to particular measures, but provides incentives based on reduced energy consumption relative to Title 24. This program component provides design assistance and building energy simulation modeling to help provide an optimized "whole-building" design. In addition to informing the design process, the simulation models are used to calculate the estimated total annual energy savings for the building compared to the Title 24 minimum requirements. The analysis can be prepared by the design team, or by an energy consultant provided by the utility, using an approved hourly

[1] 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.

simulation computer tool. DOE-2, eQUEST, EnergyPro, Carrier HAP and Trane Trace are examples of computer tools approved for use by the program.

Other Systems

Additional projects not covered specifically under the Systems or Whole Building Approaches may also qualify for participation in SBD. Projects are reviewed by a program energy analyst, and energy-efficiency improvement recommendations are made. Savings are estimated based on the adoption of the recommended energy efficiency improvements. Examples of "other systems" projects covered under Savings by Design include industrial refrigerated warehouse projects and ice skating rinks.

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, as the savings relative to Title 24 increases. The maximum incentive is $250,000 per freestanding building or individual meter.

Under the systems approach, energy savings and incentives are calculated system-by-system, based on the quantities and efficiencies of qualifying components. Owner incentives are calculated at a rate of $0.06/annualized kWh savings, with a maximum incentive of $100,000 per freestanding building or individual meter.

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.

Data Sources and Sampling Plan

Data Sources

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

- Statewide SBD program databases and files
- The 1999-2001 F. W. Dodge New Construction Database (Shared with MCPAT Study)
- Engineering and manufacturer's reference material
- Title 24 compliance certificates
- California Energy Commission weather data

California's Investor Owned Utilities (IOU) databases and program files are used to identify participating buildings, estimated savings, and rebated measures. The F.W. Dodge database forms the basis of the non-participant sample frame. The other secondary sources are used to support the modeling and calibration effort.

Primary data sources include:

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

Data are obtained from the primary sources through quantitative interviews and surveys. Buildings will be 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 identify these individuals.

Sampling Plan

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

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

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

Once the sample size had been determined, we developed the participant sample design. We expect to use a participant sample that is efficiently stratified by the tracking estimate of annual energy savings, with proportional representation of utilities, building types and climate zones in the combined participant population.

Then the sample design for the non-participants was developed. In prior studies, the participant sample has been stratified by building type and square footage. Then the F. W. Dodge New Construction database has been stratified to match the participant population. Finally the actual non-participant sample has been selected from the Dodge database. However, the very small quarterly samples of non-participants make it impractical to carry out this much stratification. Instead, the non-participant sample was matched site-by-site to the participant sample based on square footage, climate zone, and building type. In other words, the non-participant sample was selected from those Dodge projects that have the same building type, climate zone, and approximately the same square footage as the participant.

Theoretical Foundation

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

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

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

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 5 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.

As Figure 5 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.

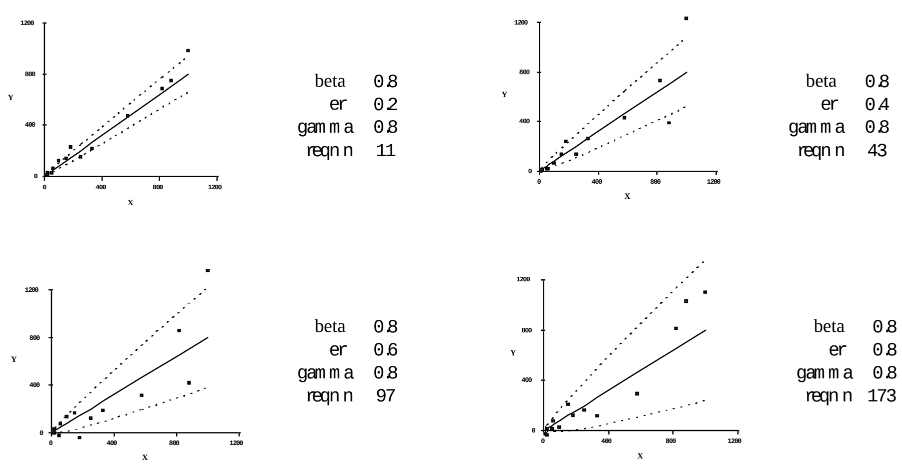

Figure 5: Examples of MBSS Ratio Models

The model parameters -- β, γ, and the error ratio -- were calculated from the 1994 PG&E Non-Residential New Construction study. The model parameters are shown in Table 23.

Parameter	Value
β	1.00
γ	0.50

Error ratio	1.00

Table 23: Study Model Parameters

Participant Sample Design

In order to plan the participant sample design, we asked the utilities to prepare a projection of the number of projects and expected savings for each quarter of this study. Table 24 shows the results. The projections shown in Table 24 include both commercial and industrial projects. The actual number of commercial projects and savings for the fourth quarter of 1999 through the third quarter of 2000 are presented later in this section.

		SCE		SDG&E		PG&E		Total	
Year	**Quarter**	**Projects**	**kWh**	**Projects**	**kWh**	**Projects**	**kWh**	**Projects**	**kWh**
1999	4th	7	2,859,010	1	58,786	-	-	8	2,917,796
2000	1st	8	3,062,760	4	452,494	3	220,383	15	3,735,637
2000	2nd	13	5,951,747	7	879,315	5	1,064,641	25	7,895,703
2000	3rd	20	7,735,839	11	1,142,897	6	1,198,417	37	10,077,153
2000	4th	39	13,234,645	21	1,955,294	38	3,772,334	98	18,962,273
2001	1st	14	6,009,588	8	1,332,442	12	2,418,688	34	9,760,718
2001	2nd	18	13,807,222	13	2,589,284	20	3,930,368	51	20,326,874
2001	3rd	26	14,028,414	20	3,365,447	23	4,535,040	69	21,928,901
2001	4th	47	18,320,464	37	5,757,681	96	19,349,504	180	43,427,649
	Total	**192**	**85,009,689**	**122**	**17,533,640**	**202**	**36,489,375**	**516**	**139,032,704**

Table 24: Projections of SBD Participation

We combined these projections with the tracking savings of the individual 1996 PG&E and SCE projects to create a proxy population. In 1996 the two utilities had a total of 538 projects with a total savings of 119,157,163 kWh. To make the 1996 population match the combined projected population, we gave each of the 1996 projects a weight of 0.958 and we multiplied the savings of each project by 1.2177. This gave us a proxy population with the same number of projects and total savings as the combined projected population shown in Table 24.

Next we used MBSS methodology to develop an optimal sample design. The results indicated that we would need a sample of 143 project to provide ±10% precision at the 90% level of confidence, assuming an error ratio of 1 and a gamma of 0.5. The planned sample size of 136 projects can be expected to yield a precision of ±11% at the 90% level of confidence.

Finally we used the proxy population to develop the optimal stratification for a sample of 136 projects over the life of the study. Table 25 shows the results. The sample design consists of five conventional strata plus a certainty stratum. Stratum one, for example, consists of all projects with savings up to 82,431 kWh. In our proxy population, there were 250 such projects. In our optimal sample design we would select 26 of these projects, i.e., 10.4% of all projects in the population. In stratum six, the certainty stratum, we select all projects with savings greater than 2,009,305 kWh.

Stratum	Max kWh	Number	Total kWh	Sample	Fraction
1	82,431	250	7,261,997	26	0.104
2	214,106	107	14,080,652	26	0.243
3	477,253	66	22,706,862	26	0.394
4	767,499	50	29,786,264	26	0.520
5	2,009,305	36	42,790,310	26	0.722
6	7,000,000	6	22,406,619	6	1.000
Total		515	139,032,704	136	0.264

Table 25: Participant Sample Design

The final step is to apply the sample design to the projects that are paid in each quarter. The sample will be selected in three steps:

1. Classify each of the projects into one of the six strata according to the size of the savings.
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 25.
3. Randomly select the specified number of projects.

The combined quarterly samples will consist of a total of 136 commercial projects. The sample size for each quarter will be allocated based on the amount of activity in each quarter. Specifically, the number of projects and the associated kWh savings in each quarter will determine the quarterly sample sizes. This design allows for examining and studying the quarters relative to their amount of activity.

Table 26 and Table 27 present the actual quarterly SBD participation and sample by utility for the fourth quarter of 1999 through the third quarter of 2000. Table 26 shows the number of commercial projects participating and Table 27 shows the kWh savings associated with these projects. In general, the larger projects in the population were SCE projects. The PG&E and SDG&E projects tended to be smaller projects that were in the smaller strata. Since the smaller strata have lower sampling fractions, PG&E and SDG&E had smaller sample sizes than SCE.

	4th Quarter 1999		**1st Quarter 2000**		**2nd Quarter 2000**		**3rd Quarter 2000**	
	#Paid	**Sample Size**	**#Paid**	**Sample Size**	**#Paid**	**Sample Size**	**#Paid**	**Sample Size**
PG&E	-	-	-	-	5	1	7	1
SCE	8	5	6	1	10	5	14	5
SDG&E	4	1	5	1	8	-	22	4
TOTAL	**12**	**6**	**11**	**2**	**23**	**6**	**43**	**10**

Table 26: Actual Quarterly SBD Participation and Sample by Utility – Number of Projects

	4th Quarter 1999		1st Quarter 2000		2nd Quarter 2000		3rd Quarter 2000	
	kWh Paid	Sample kWh	kWh Paid	Sample kWh	kWh Paid	Sample kWh	kWh Paid	Sample kWh
PG&E	-	-	-	-	231,572	105,744	1,403,775	716,940
SCE	4,122,361	3,958,216	2,172,918	283,460	3,270,350	2,241,292	4,556,045	2,435,870
SDG&E	1,086,632	106,675	86,698	20,680	117,894	-	2,173,620	510,347
TOTAL	**5,208,993**	**4,064,891**	**2,259,616**	**304,140**	**3,619,816**	**2,347,036**	**8,133,440**	**3,663,157**

Table 27: Actual Quarterly SBD Participation and Sample by Utility – kWh Savings

Table 28 displays the quarterly population and sample sizes and quarterly population and sample kWh savings by stratum for the fourth quarter of 1999 through the third quarter of 2000. For each quarter, with the exception of the first quarter of 2000, the percentage of kWh savings exceeds the percentage of sites sampled.

Quarter	Stratum	Population Size	Sample Size	% Sampled	Population kWh	Sample kWh	% kWh Sampled
Q4 - '99	1	5	1	20.0%	157,090	57,995	36.9%
	2	2	1	50.0%	258,872	106,675	41.2%
	3	1	1	100.0%	290,309	290,309	100.0%
	4	1	1	100.0%	506,688	506,688	100.0%
	5	3	2	66.7%	3,996,034	3,103,224	77.7%
	TOTAL	**12**	**6**	**50.0%**	**5,208,993**	**4,064,891**	**78.0%**
Q1 - '00	1	9	1	11.1%	235,434	20,680	8.8%
	2	1	1	100.0%	283,460	283,460	100.0%
	3	1	0	0.0%	1,740,722	-	0.0%
	TOTAL	**11**	**2**	**18.2%**	**2,259,616**	**304,140**	**13.5%**
Q2 - '00	1	14	1	7.1%	297,305	5,950	2.0%
	2	3	1	33.3%	398,064	105,744	26.6%
	3	3	1	33.3%	930,438	241,333	25.9%
	4	3	3	100.0%	1,994,009	1,994,009	100.0%
	TOTAL	**23**	**6**	**26.1%**	**3,619,816**	**2,347,036**	**64.8%**
Q3 - '00	1	20	2	10.0%	694,896	29,503	4.2%
	2	13	3	23.1%	1,788,416	447,974	25.0%
	3	5	3	60.0%	1,521,288	1,002,782	65.9%
	4	4	1	25.0%	2,662,882	716,940	26.9%
	5	1	1	100.0%	1,465,958	1,465,958	100.0%
	TOTAL	**43**	**10**	**23.3%**	**8,133,440**	**3,663,157**	**45.0%**

Table 28: Quarterly Population and Sample Sizes and kWh by Stratum

Non-Participant Sample Design

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 are:

- Filtering for buildings ready to begin construction

- Filtering out-of-territory buildings
- Filtering out-of-scope projects
- Consolidating building types

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

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

The non-participant sample will be matched to the participant sample on a site-by-site basis based on building type, region, and square footage. This was done to ensure a relevant comparison group for the net-to-gross analysis.

Table 29 and Table 30 present the number of sites and square footage for the participant and non-participant samples for 4th quarter 1999 – 3rd quarter 2000, by building type and utility. Table 29 shows the participant sample and Table 30 details the non-participant sample. Currently, the two samples are slightly out of balance from one another in terms of the number of sampled sites by building type. We will balance the two samples in future quarters.

	PG&E		SCE		SDG&E		Statewide	
Building Type	**# Sites**	**SQFT**	**# Sites**	**SQFT**	**# Sites**	**SQFT**	**# Sites**	**SQFT**
C&I Storage	-	-	7	3,310,904	-	-	7	3,310,904
General C&I Work	-	-	5	477,852	3	224,930	8	702,782
Grocery Store	1	106,000	-	-	-	-	1	106,000
Office	1	73,254	2	161,499	3	120,235	6	354,988
Restaurant	-	-	1	3,567	-	-	1	3,567
School	-	-	1	33,400			1	33,400
Total	2	179,254	16	3,987,222	6	345,165	24	4,511,641

Table 29: Participant Sample by Building Type and Utility

	PG&E		SCE		SDG&E		Statewide	
Building Type	**# Sites**	**SQFT**	**# Sites**	**SQFT**	**# Sites**	**SQFT**	**# Sites**	**SQFT**
C&I Storage	-	-	7	1,679,269	1	59,920	8	1,739,189
General C&I Work	-	-	6	259,642	1	120,000	7	379,642
Grocery Store	1	54,000	-	-	-	-	1	54,000
Office	1	61,000	2	121,147	3	107,428	6	289,575
Restaurant	-	-	1	3,513	-	-	1	3,513
School	-	-	1	51,390			1	51,390
Total	2	115,000	17	2,114,961	5	287,348	24	2,517,309

Table 30: Non-Participant Sample by Building Type and Utility

Data Collection

There are two 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 completed in 4th quarter 1999 – 4th quarter 2001. 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.

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

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

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

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

1. The site is recruited and the recruiter asks basic decision-maker questions of the building owner and designers as appropriate. In the case of non-participants, the decision-maker questions affecting the spillover analysis are conducted after the on-site and modeling is completed.
2. The surveyor reviews program records (for participants) prior to the site visit.
3. The surveyor responsible for the model collects the on-site data.

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

Recruiting & Decision-Maker Surveys

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

The utilities received a list of the primary and backup sample sites from RLW before each quarter of data collection. The list allowed the utility account representatives the chance to alert RLW of any potentially sensitive customers. In addition, the utilities were able to alert RLW of any participants that were pulled from Dodge and appear in the non-participant call list. These lists were and continue to be distributed one week in advance of recruiting.

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

- Validated the site for inclusion in the study,
- Confirmed the location,

- Collected SBD process information to inform program managers, and
- Collected decision-maker survey data for the net savings and spillover analysis.

Once a site was recruited, the recruiter administered the decision-maker survey. If a respondent could not answer specific questions in the survey, the recruiter obtained contact information for other individuals who were able to provide the requested information. This methodology was proven to be effective in the prior NRNC studies conducted by the RLW Team in collecting complete data from the correct decision-makers. As stated earlier, decision-maker questions affecting the non-participant sample were conducted post on-site survey and modeling. This slightly different methodology enabled the surveyor to learn more about the efficiency of the end-uses installed to facilitate a more informed non-participant end-use specific decision-maker survey.

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

Decision-maker Data

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

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

Building characteristics

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

Interaction with utility

In the 1996 study, the 1994 binary variables were replaced with scaled variables to more accurately capture interaction with utility staff. This methodology was retained for the 1998 evaluations. However, since this study requires 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.

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.

DM Attitude/Behavior

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

Energy Efficient Design Practices

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

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

Scoring the Surveys

The decision-maker surveys were scored at the measure and end-use level based upon completed survey data. A senior level analyst was responsible for reviewing each survey response and making a final determination for each score using a predetermined scoring method. These scores were then be 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' chapter 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. The database will become a project deliverable at the end of the study. Random data entry checks serve as a quality control mechanism for maintaining consistent error free data entry. Moreover, where applicable, data entry forms will be designed such that only valid parameters can be entered into the database in an effort to eliminate data entry error.

On-Site Surveys

On-site surveys are being conducted on a quarterly basis, guided by the sample design. Experienced surveyors/DOE-2 modelers from RLW, AEC, and EBA are conducting the on-site audits. The on-site visits require from 3 hours to a full day, by one or more surveyors, depending on the size and complexity of the building.

The on-site audits begin 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. Then the surveyor walks through the building to examine the energy-using systems (e.g. lighting, HVAC, energy management systems, etc.) System types and sizes are cataloged, along with information about the condition of the equipment. For participants, the presence of measures is verified. If plans are available, the surveyor uses 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 do not open equipment to collect nameplate data on inaccessible parts.

Training of On-Site Survey Staff

The process of gathering accurate, timely field data is the foundation upon which the project's analysis ultimately rests. Training surveyors to collect the proper field information is the first step in the building this foundation. Lead surveyors/engineers Matt Brost and Pete Jacobs from RLW Analytics and AEC respectively, conducted the training for the audit phase of the project. The surveyors consist of technical personnel experienced as surveyors, 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 and the 1998 CBEE NRNC baseline study, and upon the considerable building survey experience that the surveyors already have.

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.

As required, 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

Two data collection instruments were used for the on-site data collection portion of this study. They were:

- the On-site survey form, and
- the Refrigerated warehouse on-site survey form.

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

The refrigerated warehouse survey form is essentially the same as the one used in the 1998 evaluation.

Engineering Models

Overall Modeling Approach

The data requirements of the evaluation include kW and kWh savings for program and non-program measures during specific costing periods, including end-use interactions. Based on the California protocols and the prior NRNC evaluations, the gross impact analysis is conducted using the DOE-2.1E building energy simulation program. The DOE-2 program is well suited to analyzing the impacts of most measures included in the SBD new construction program. DOE-2 is a very flexible modeling tool, allowing the calculation of energy savings and demand reduction for lighting, lighting controls, shell measures, HVAC efficiency improvements and many HVAC control measures. DOE-2.1E Release 119 is used to take advantage of its abilities to model commercial refrigeration.

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

1. Collection of appropriate building information during the on-site survey. This relies on competent, well-trained surveyors focused on collecting key building data. The team places the responsibility for creating and controlling for quality of the DOE-2 models in the hands of the surveyors responsible for data collection, i.e., the person most familiar with each site.
2. Quality control over the on-site data collection and data entry, including range, internal consistency, and reasonableness checks. These are incorporated into the data-entry software provided to the surveyors.
3. Computerized tools to calculate model input parameters from the on-site survey databases and automatically generate as-built and Title-24 DOE-2 input files.
4. A second level of model review and quality control by an experienced DOE-2 engineer. Senior engineering staff review and check the models after surveyor has constructed and checked the models for quality and validity.
5. 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 will be 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 will be 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 is an accurate representation of the diversity of heating and cooling loads within the building. The subdivision of spaces will also take 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 will be associated with the applicable space. When the HVAC systems serving a particular space are different, the spaces will be sub-divided. Reasonable HVAC system zoning practice will be followed.

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 contains 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 load portion of DOE-2. Since the interior walls of the zones were not surveyed, it was not possible to use the standard DOE-2 algorithms for simulating the daylighting illuminance in the space. A daylight factor, defined as the ratio of the interior illuminance at the daylighting control point to the global horizontal illuminance was estimated for each zone subject to daylighting control. Typical values for sidelighting applications were used as default values. The daylight factor was entered into the function portion of the DOE-2 input file. Standard DOE-2 inputs for daylighting control specifications were used to simulate the impacts of daylighting controls on lighting schedules. The default daylight factors were adjusted during model calibration.

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

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

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

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

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

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

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

Systems

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

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

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

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

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

- Packaged single zone (PSZ)
- Packaged VAV (PVAVS)
- Central constant volume system (RHFS)
- Central VAV system (VAVS)
- Central VAV with fan-powered terminal boxes (PIU)
- Four-pipe fan coil (FPFC)

Packaged HVAC system efficiency. Manufacturers' data were gathered for the equipment surveyed based on the observed make and model number. A database of equipment efficiency and capacity data was developed from an electronic version of the ARI rating catalog. Additional data were obtained directly from manufacturers' catalogs, or the on-line catalog available on the ARI website (www.ari.org). Manufacturers' data on packaged system efficiency is a net efficiency, which considers both fan and compressor energy. DOE-2 requires a specification of packaged system efficiency that considers the compressor and fan power separately. Thus, the manufacturers' data were adjusted to prevent "double-accounting" of fan energy, according to the procedures described in the 1998 Alternate Compliance Method (ACM) manual.

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

Service hot water. Service hot water consumption was calculated based on average daily values from the 1998 ACM for various occupancy types. Equipment capacity and efficiency were assigned based on survey responses.

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

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

Commercial Refrigeration. The algorithms used in release 119 of the DOE-2.1E program will be used to evaluate the performance of commercial refrigeration systems found in grocery stores, commercial kitchens, schools, and so on. The algorithms used in release 119 were extensively validated during the 1996 NRNC evaluation project, and were found to be responsive to the refrigeration measures supported by the Savings by Design program. Refrigerated cases, compressor plant, condensers, and control system characteristics will be surveyed. The automated modeling software will provide DOE-2 models of building and the refrigeration systems, providing an accurate representation of the refrigeration system performance, and the interactions between the refrigeration system and the building HVAC system.

Plant

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

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

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

Model Review and Quality Checks

After the DOE-2 model was generated, the model was run using 30 year typical meteorological year (TMY) weather data. The model either was run successfully generating a results page, or received errors and/or warnings. When warnings and/or errors were encountered, modifications to the data entry database were performed and another model for the site was created, and run. This process is repeated until the model runs successfully and a results page is generated.

The on-site survey data entry program contained numerous quality control (QC) checks designed to identify invalid building characteristics data during data entry. Once the models were run successfully, the surveyor/modeler and senior engineering staff reviewed the results. A building characteristics and model results summary report was created for each site. The overall quality assurance process is outlined as follows:

A list of key physical attributes of the buildings will be summarized and checked for reasonableness, such as:

- 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.

An example of some of the QC criteria that were utilized is shown below in Table 31. Data falling outside of the QC range were validated during the QC process.

Building Parameter	Range	Definition
Lighting Power Density	0.9 - 1.9	building wide average
Equipment Power Density	0.1 - 5	building wide average
Cooling Ratio	95 - 200%	capacity from annual run / capacity from sizing run
Cooling EER	8 - 14	capacity weighted cooling efficiency
Wall U-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 31: Model Quality Control Criteria

Parametric Runs

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

As-Built Parametric Run

Once the models are completed and QC checked, the as-built parametric run was done. Monthly schedule variations resulting from partial occupancy and building startup were eliminated, and the models were run using long-term average weather data from the 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
- 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.

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 (except for hospitals) were simulated with economizers in the baseline run. All VAV fan systems larger than 50 hp were simulated with inlet vane control. All variable-volume pumps were simulated with throttling valve control.

HVAC System Sizing

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

Lighting

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

Grocery Store Refrigeration Systems

Since there are no energy standards for grocery store refrigeration systems, the Savings by Design program baseline equipment specifications served as the baseline or reference point for the gross impact calculations. In addition to the baseline assumptions for the energy efficiency measures targeted by the program, the baseline included the following mandatory measures.

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

Other Systems.

In cases where Title 24 does not address the systems analyzed under the "other systems" option, the Savings by Design program baseline equipment specifications served as the baseline or reference point for the gross impact calculations. Gross savings for each participant were calculated from the difference in the energy consumption between the project as modeled with the baseline specifications and the project modeled with the as-built efficiency specifications. In most cases, the baseline is likely to be a customer self-reported baseline, representing the efficiency levels incorporated into the project design at the time of entry into the program.

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 will remain at the as-built level for all parametric runs.

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

Note: The parametric runs defined above are based on those used in the NRNC Baseline Study. These parametric categories do not map directly into the measure groupings used in the Systems Approach. For example, improved glazing is a component of both the Daylighting and HVAC Systems components.

On a quarterly basis a database of simulation results will be prepared and delivered to SCE. This database will contain the results of each of the sixteen model runs for each sampled building. These data will be extrapolated to the population of program participants using the standard MBSS methodology used in prior studies for SCE.

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.

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 of a building using 1998 Title 24 required equipment efficiencies (where applicable) run 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.

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.[2]

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

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

$$Y = y/x\ X$$

Where

Y is the population total measured savings

y is the average measured savings in the sample

X is the population total program estimated savings

x is the average program estimated savings in the sample

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

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

Case Weights

Theoretical Foundation

Given observations of a variable *y* in a stratified sample, estimate the population total *Y*.

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

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

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

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 $w_k = \dfrac{N_h}{n_h}$. 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

Table 32 shows an example, using the actual population and sample sizes for this study. In this example, the population of SBD program participants has been stratified into five strata based on the annual savings of each project shown in the tracking system. For example, the first stratum consists of all projects with annual savings less than 82,431 kWh. The maximum kWh in each stratum is called the stratum cut point. There are 48 projects in this stratum and they have a total tracking savings of 1,384,725 kWh. The estimate of gross impact was obtained from the measured savings found in a total sample of 24 projects.

Column 5 of Table 32 shows that the sample contains 5 projects from the first stratum. Each of these 5 projects can be given a case weight of 48/5 = 9.60.

Stratum	Max kWh	Population Size	Total KWh	Sample Size	Case Weight
1	82,431	48	1,384,725	5	9.60
2	214,106	19	2,728,812	6	3.17
3	477,253	10	4,482,757	5	2.00
4	767,499	8	5,163,579	5	1.60
5	2,009,305	4	5,461,992	3	1.33
Total		**89**	**19,221,865**	**24**	

Table 32: Participant Case Weights

Non-participant Case Weights

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

We will use the following example problem shown in Table 33 to develop the idea of case weights[3]. In this case, a sample of 85 sites has been equally divided among five strata, so there are 17 sites per stratum. Then the stratum cutpoints shown in column two were calculated from the tracking estimates of kWh for the sample sites. Next the population sizes shown in column three were calculated from the stratum cutpoints. The final step was to calculate the case weights shown in the last column. For example, the case weight for the 17 sites in the first stratum is 136 / 17 = 8.

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

[3] The complexity of the calculation of the non-participant case weights makes it difficult to concisely present the calculation. For this reason, this example is provided only to demonstrate the statistical concepts used in the study. The numbers presented have no relevance to the current findings.

Total		**469**	**62,709,678**	**85**	

Table 33: Balanced Stratification Example

Stratified Ratio Estimation

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

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

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

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

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

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

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

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

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

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

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

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

and the achieved relative precision is calculated as

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

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

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

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

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

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

Gross Savings Expansions

Baseline, as-built, and savings estimates were developed for each building in the sample. The sample of baseline, as built, and savings estimates was projected to the 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. Seven 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)

Gross Savings Results

This section presents the gross energy savings and demand reduction results. 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 this chapter.

The combined total energy savings and demand reduction are defined to be the difference between the energy use or demand for the entire building under the baseline and as-built simulations[4]. 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.

Energy Findings

All Measures

Table 34 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 19,387 MWh, representing a gross realization rate of 100.9%.

Program Tracking Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Estimated Energy Savings (MWh)	Realization Rate
19,222	10,379	54.0%	19,387	100.9%

Table 34: Whole Building Annual Gross Energy Savings

Figure 6 shows the composition of annual gross energy savings by measure category. Lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls) account for about 60% of the annual energy savings among program participants. HVAC measures comprise an additional 20% of the savings.

Daylighting controls represent a larger fraction of the program savings than what has typically been the case for past efficiency programs. Daylighting controls were typically found in warehouses, which tend to have shorter construction cycles than other buildings. As the project progresses, the SBD participant population will be comprised of more buildings with longer construction cycles. For this reason, we expect that the fraction of savings represented by daylighting controls to decrease as the project progresses.

[4] Throughout this report, combined total savings refers to the difference between the energy use (demand) under the baseline and as-built simulations.

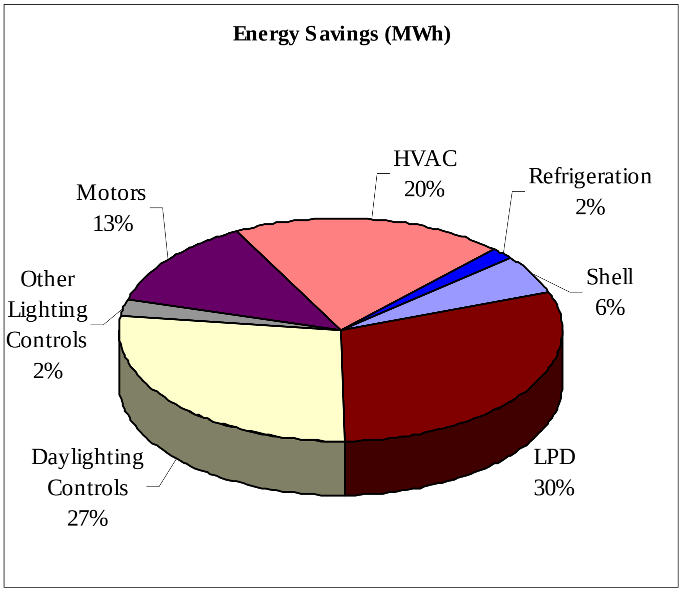

Figure 6: Composition of Annual Gross Energy Savings

Table 35 shows the estimated energy savings and error bound by measure type as well as for the combined total. The combined total energy savings were 19,387 MWh, with an error bound of 5,127 MWh, yielding a 90% confidence interval of (14,260, 24,514) MWh.

	Measure Category	Energy Savings (MWh)	Error Bound	Relative Precision
Systems Approach	Shell	1,099	1,112	101.1%
	LPD	5,848	2,586	44.2%
	Daylighting Controls	5,267	1,813	34.4%
	Other Lighting Controls	477	595	124.8%
	Motors	2,500	1,710	68.4%
	HVAC	3,858	1,969	51.0%
	Refrigeration	338	372	110.1%
	Whole Building	-	-	-
	Combined Total	19,387	5,127	26.4%

Table 35: Annual Gross Energy Savings

As expected, the participant group was more energy efficient than the non-participant group. Figure 7 shows the savings of both program participants and non-participants expressed as a percentage of each group's entire building baseline usage. As Figure 7 shows, the Participants were 19% better than baseline on average, while the non-participant comparison group was about 4% better than baseline. For participants, the level of efficiency relative to baseline is highest for the lighting power density and daylighting controls measures. For non-participants, the level of efficiency relative to baseline is fairly constant for all end uses. The end uses where the non-participants are more efficient than the participants are other lighting controls and refrigeration.[5]

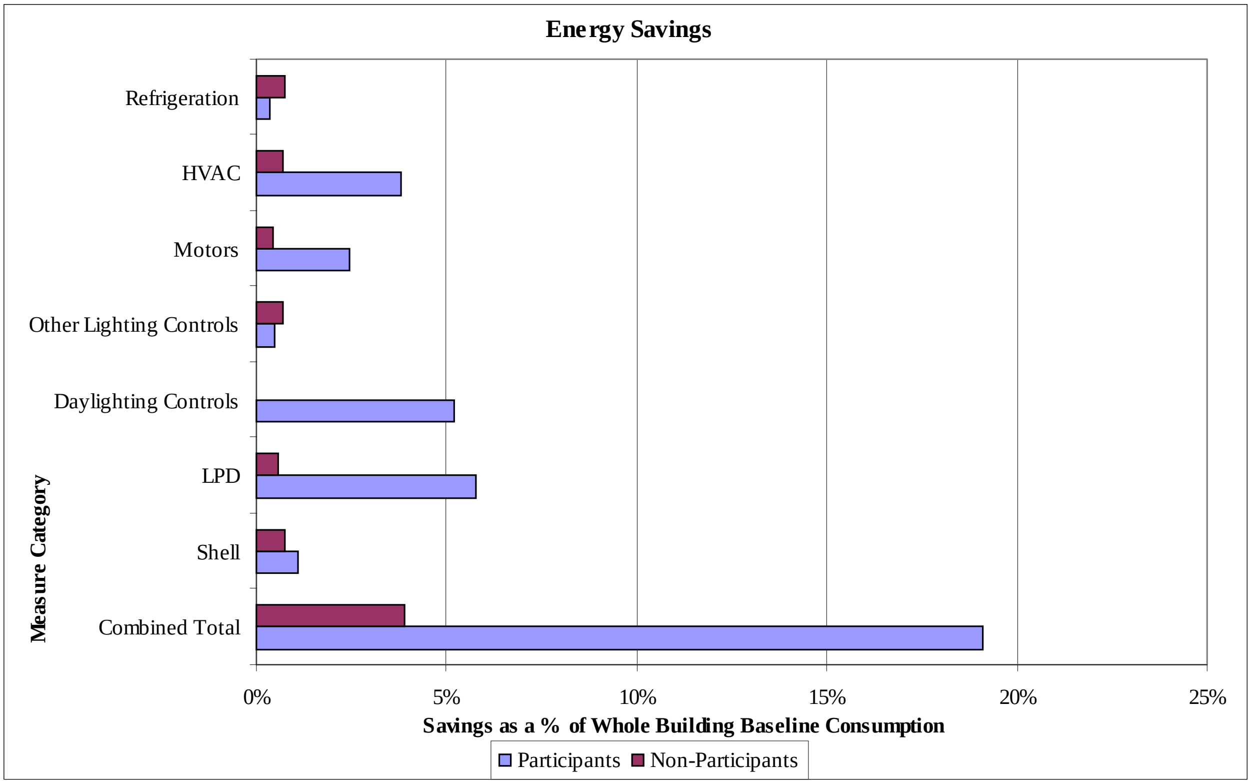

Figure 7: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption

Incented Measures

Table 36 and Figure 8 show the estimated annual gross energy savings for incented measures only. The lighting power density and daylighting controls measures account for over 75% of the savings due to incented measures with each accounting for over 5,000 MWh of savings.

Daylighting controls represent a larger fraction of the program savings than what has typically been the case for past efficiency programs. Daylighting controls were typically found in warehouses, which tend to have shorter construction cycles than other buildings. As the project progresses, the SBD participant population will be comprised of more buildings with longer construction cycles. For this reason, we expect that the fraction of savings represented by daylighting controls to decrease as the project progresses.

[5] The refrigeration results are based on a sample of one participant and one non-participant.

	Measure Category	Energy Savings (MWh)	Error Bound	Relative Precision	Savings as % of End Use Baseline
Systems Approach	Shell	-	-	-	-
	LPD	5,501	2,203	40.1%	32.4%
	Daylighting Controls	5,234	1,810	34.6%	26.1%
	Other Lighting Controls	-	-	-	-
	Motors	1,270	1,054	83.0%	20.4%
	HVAC	2,128	1,108	52.0%	8.1%
	Refrigeration	225	247	110.1%	17.4%
	Whole Building	-	-	-	-

Table 36: Annual Gross Energy Savings by Measure Category – Incented Measures Only[6]

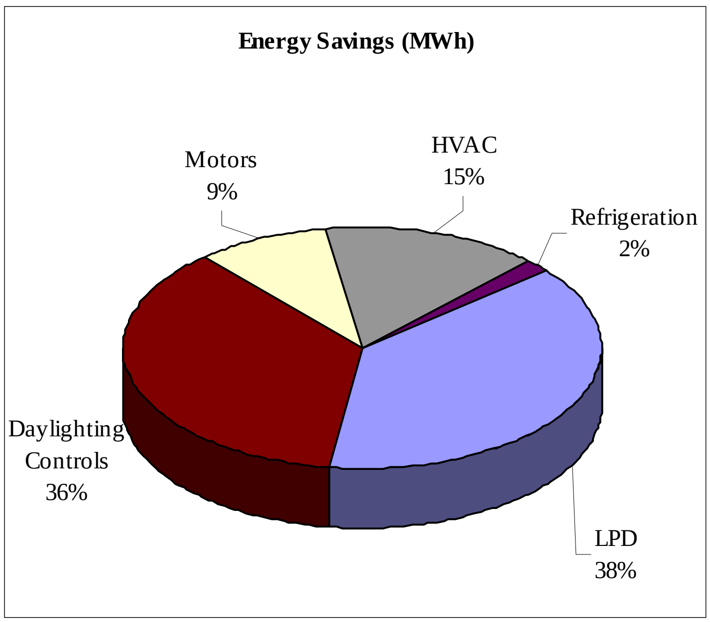

Figure 8: Composition of Annual Energy Savings – Incented Measures Only

Figure 9 shows the annual gross savings for incented measures expressed as a percentage of each end use's baseline usage. As Figure 9 shows, lighting measures were more efficient relative to baseline than were other measures. The annual gross energy savings resulting from lighting power density (LPD) and daylighting control measures were both more than 25% of the lighting baseline useage.

[6] For lighting measures, the savings as a percentage of baseline consumption is expressed relative to the lighting baseline consumption.

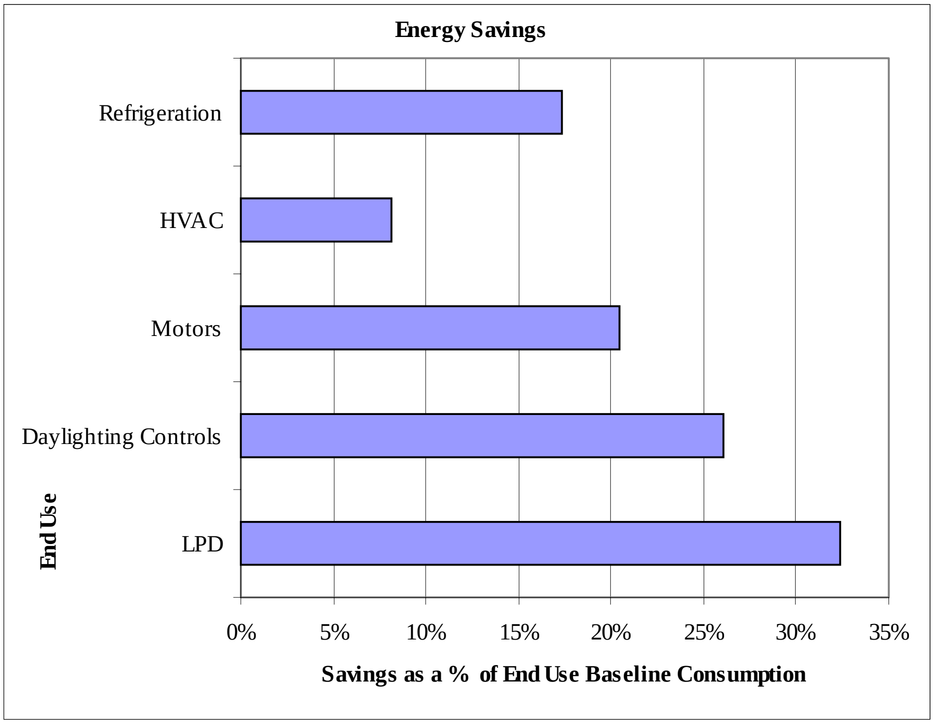

Figure 9: Energy Savings as Percentages of End Use Baselines – Incented Measures Only

Demand Reduction Results

All Measures

Table 37 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 5.0 MW, representing a gross realization rate of 101.8%.

Program Tracking Demand Savings (MW)	Sampled Demand Savings (MW)	% Demand Savings Sampled	Estimated Demand Savings (MW)	Realization Rate
4.9	2.3	47.7%	5.0	101.8%

Table 37: Combined Total Summer Peak Demand Reduction

Figure 10 shows the breakdown of summer peak demand reduction by measure category. As with the energy savings results, lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls) account for over 60% of the summer peak demand reduction among program participants. HVAC measures comprise an additional 20% of the savings.

Daylighting controls represent a larger fraction of the program savings than what has typically been the case for past efficiency programs. Daylighting controls were typically found in warehouses, which tend to have shorter construction cycles than other buildings. As the project progresses, the SBD participant population will be comprised of more buildings with longer construction cycles. For this reason, we expect that the fraction of savings represented by daylighting controls to decrease as the project progresses.

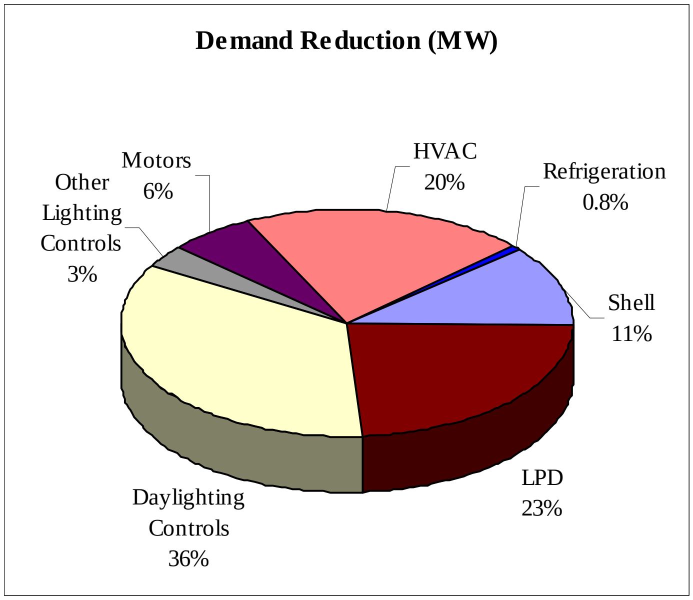

Figure 10: Composition of Summer Peak Demand Reduction

Table 38 shows the estimated gross summer peak demand reduction and error bound by measure type, as well as for whole building. The whole building gross summer peak demand reduction were 5.0 MW, with an error bound of 1.4 MW, yielding a 90% confidence interval of (3.6, 6.4) MW.

	Measure Category	Demand Reduction (MW)	Error Bound	Relative Precision
Systems Approach	Shell	0.6	0.6	110.5%
	LPD	1.2	0.6	47.8%
	Daylighting Controls	1.7	0.6	35.8%
	Other Lighting Controls	0.2	0.2	125.3%
	Motors	0.3	0.2	65.7%
	HVAC	1.0	0.5	50.5%
	Refrigeration	0.04	0.05	110.1%
	Whole Building	-	-	-
	Combined Total	5.0	1.4	28.1%

Table 38: Summer Peak Demand Reduction

As we would expect, the participant group was more efficient than the non-participant group. Figure 11 shows the summer peak demand reduction of both program participants and non-participants expressed as a percentage of each group's whole-building baseline demand. As Figure 11 shows, the participants were about 22% better than baseline on average, while the non-participant comparison group was about 5% better than baseline. For participants, the level of efficiency relative to baseline is highest for the lighting power density, daylighting controls, and HVAC measure categories. The end uses where the non-participants are more efficient are other lighting controls and refrigeration.[7] These results arae similar to the energy savings results.

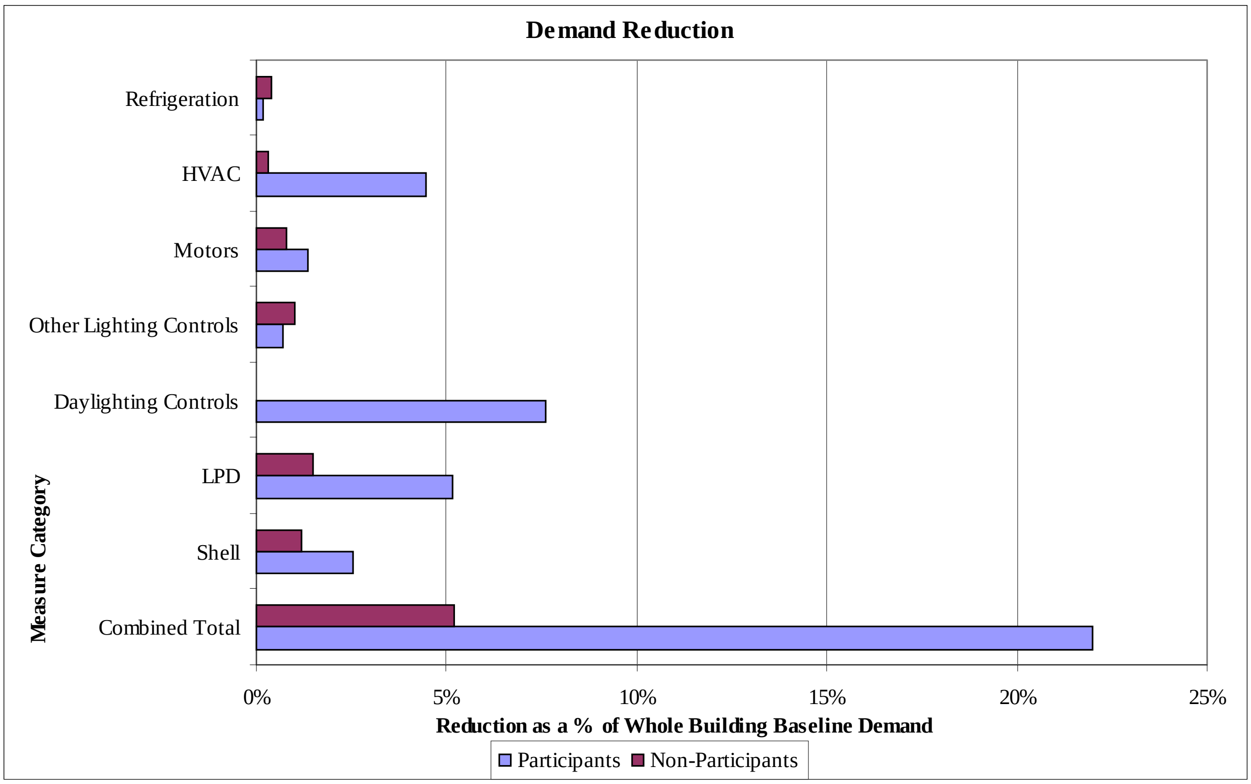

Figure 11: Participant and Non-participant Demand Reduction as a Percentage of Baseline Demand

Incented Measures

Table 39 and Figure 12 show the estimated gross summer peak demand reduction for incented measures only. The lighting measures (lighting power density and daylighting controls) account for nearly three-quarters of the savings, with each accounting for over 1.0 MW of savings.

Daylighting controls represent a larger fraction of the program savings than what has typically been the case for past efficiency programs. Daylighting controls were typically found in warehouses, which tend to have shorter construction

[7] The refrigeration results are based on a sample of one participant and one non-participant.

cycles than other buildings. As the project progresses, the SBD participant population will be comprised of more buildings with longer construction cycles. For this reason, we expect that the fraction of savings represented by daylighting controls to decrease as the project progresses.

	Measure Category	Demand Reduction (MW)	Error Bound	Relative Precision	Savings as % of End Use Baseline
Systems Approach	Shell	-	-	-	-
	LPD	1.1	0.4	40.7%	31.9%
	Daylighting Controls	1.7	0.6	36.0%	44.8%
	Other Lighting Controls	-	-	-	-
	Motors	0.14	0.12	82.0%	17.2%
	HVAC	0.9	0.5	50.6%	12.0%
	Refrigeration	0.03	0.03	110.1%	16.7%
	Whole Building	-	-	-	-

Table 39: Demand Reduction by Measure Category – Incented Measures Only

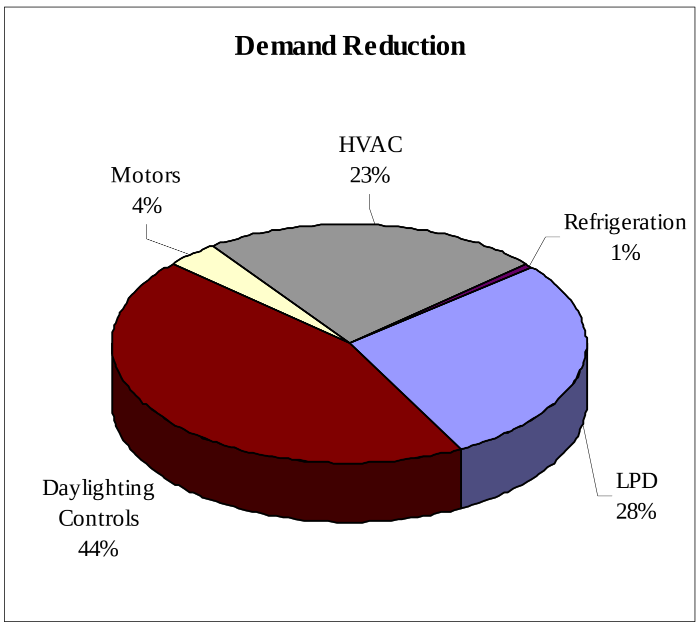

Figure 12: Composition of Summer Peak Demand Reduction – Incented Measures Only

Figure 13 shows the efficiency of the incented measures expressed as a percentage of each end use's baseline demand[8]. As Figure 13 shows, Daylighting controls and LPD measures were significantly more efficient relative to baseline than were other measures. For daylighting controls, the

[8] For lighting measures, the savings as a percentage of baseline consumption is expressed relative to the lighting baseline consumption.

demand reduction was about 45% of the lighting baseline demand. The demand reduction resulting from lighting power density (LPD) were more than 30% of the lighting baseline demand.

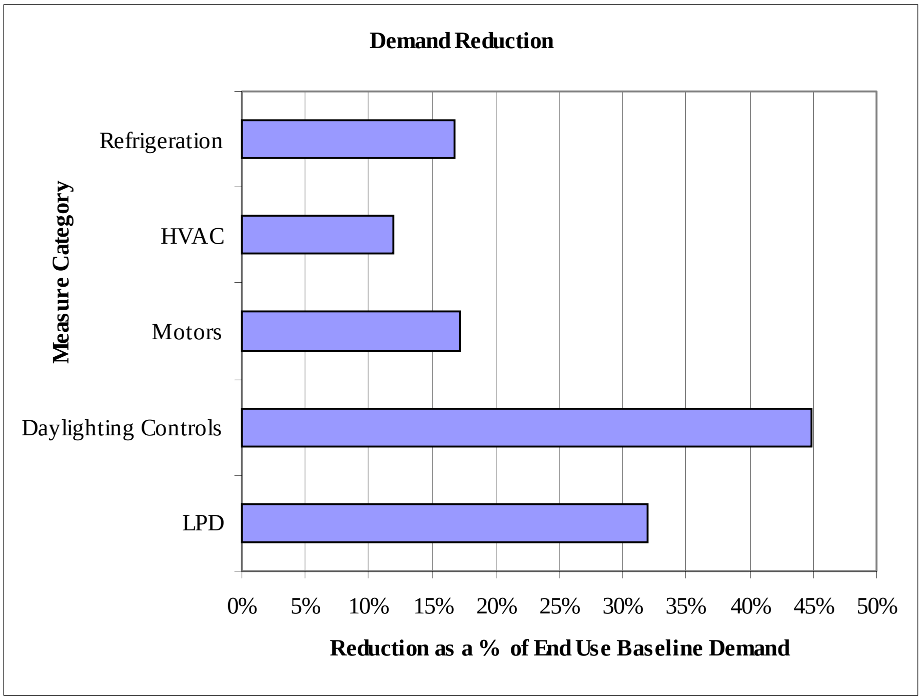

Figure 13: Demand Reductions as Percentages of End Use Baselines – Incented Measures Only

Direct Net Savings and Spillover Methodology

In this chapter, the methodology for the net savings analysis is presented. First, the difference-of-differences methodology is shown. The difference-of-differences approach is the approach that was used to calculate the net savings results. We also present 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) that are presented in the "Owner and Design Team Surveys" chapter.

Differences of Differences Methodology

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

Table 40 summarizes the derivation of the net-to-gross ratio for annual energy using the difference-of-differences approach. The analysis begins with the baseline and as-built energy consumption of the participants and non-participants. All of these results are reported in MWh and were obtained by statistically expanding the sample data to the population of program participants in 4th quarter 1999 through 3rd quarter 2000. For example, the table shows that we would estimate that all program participants would have an aggregate annual consumption of 82,171 MWh, based on the as-built simulation runs developed for the sites in the participant sample. By contrast, if we expand the as-built simulation runs of the non-participants to the same participant population, we would expect an aggregate annual consumption of 57,696 MWh.

	Participants	Non-Participants	Participant Net Savings
Baseline (MWh)	101,558	60,028	
As-Built (MWh)	82,171	57,696	
Savings (MWh)	19,387	2,332	15,442
Savings (% of Baseline)	19.1%	3.9%	15.2%
Net-to-Gross Ratio			79.7%

Table 40: Difference of Differences Net Savings Calculation – Annual Energy

After expanding both samples to the population of program participants, the preceding table shows that the resulting savings are 19,387 MWh using the participant sample and 2,332 MWh using the non-participant sample. Thus, considering only the savings results, the participants appear to have nearly ten times as much savings as the non-participants.

However, this fails to control for differences between the two samples. The preceding table shows that the baseline results were 101,558 MWh using the participant sample and 60,028 MWh using the non-participant sample. Both samples were designed to be representative of the population of 4th quarter 1999 through 3rd quarter 2000 program participants. However we would expect differences in the baseline results from the two samples due to normal sampling variability. Moreover, difficulty in obtaining large non-participant sample sites to match the large participants in the program may have led to some systematic difference between the participant and non-participant samples.

For a more meaningful comparison, the as-built energy use should be considered relative to the baseline. In proportion to the respective baseline energy use of each sample, the gross savings were 19.1% for the participant sample and 3.9% for the non-participant sample.

In the difference-of-differences approach, the net savings can be estimated as the difference between the percentage savings of the participants and non-participants. In this case the net savings is 15.2% of baseline use. Multiplying 101,525 MWh by 15.2%, the net savings of the population of 4th quarter 1999 through 3rd quarter 2000 can be estimated to be 15,442 MWh.

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

$$\left(\frac{57{,}696}{60{,}028}\right)\cdot 101{,}558-82{,}171=15{,}442$$

Here the first factor is the as-built energy use relative to the baseline energy use using the non-participants. This is used to adjust the baseline energy use of the participants. Then the net savings is calculated by subtracting the as-built energy use of the participants. Finally, the net savings is found to be 15.2% of the baseline energy use of the participants. The two approaches for calculating net savings are mathematically equivalent.

The net-to-gross ratio can also be calculated two equivalent ways. One is to divide the participants' net savings (15,442 MWh) by their gross savings (19,387 MWh). The other is to divide the participants' net percent savings (15.2%) by their gross percent savings (19.1%). Either approach gives the difference of differences estimate of 79.7% for the net-to-gross ratio for annual energy.

Self-Report Methodology

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 effects for demand and energy savings resulting from program free-ridership. 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. In the present study, results are summarized cumulatively for each quarter of the year, using a planned sample of approximately 30 sites for each quarter. Because of the need for periodic results and the relatively small sample that will be summarized in the first few reports, the econometric approach can not be expected to be effective.

On the other hand, 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 quarter.

To reflect these differences, the RLW team used a different approach to estimating net participant savings and spillover effects. Self-report techniques at the end use level were used to identify the efficiency choices of the participant sites traceable to the program, and DOE-2 modeling was used to estimate their direct net impacts for demand and energy. Similar non-participant self-report techniques were used to measure spillover effects for demand and energy savings.

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

Free-ridership Analysis Methodology

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

Free-ridership is calculated as the difference between the baseline and what would have been installed absent the program, divided by the difference between baseline and what actually was installed. For example, assume a project used a lighting baseline of 2.0 watts/sqft, and the participant received incentives for and installed lighting equipment resulting in 1.3 watts/sqft. If the participant would have installed lighting at 2.0 watts/sqft in the absence of the program, then the baseline is accurate and free-ridership would be zero. If lighting equipment equaling 1.3 watts/sqft would have 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 25%.[9]

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

[9] $$\frac{1.8\ \mathrm{W/SF} - 1.3\ \mathrm{W/SF}}{2.0\ \mathrm{W/SF}} = 0.25$$

- 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 o this report.

Spillover Impact Analysis Methodology

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

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

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

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

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

Net Savings Results

This chapter presents the net savings results calculated using the difference-of-differences methodology. Results for both annual energy savings and summer peak demand reduction are shown. Assessments of free-ridership by measure category and assessments of spillover by end use are shown in the Process Findings chapter.

Energy Findings

Table 41 presents the difference-of-differences calculations for net annual energy savings. The calculations result in 15,442 MWh of net annual energy savings. These net savings correspond to a net-to-gross ratio of 79.7%.

	Participants	Non-Participants	Participant Net Savings
Baseline (MWh)	101,558	60,028	
As-Built (MWh)	82,171	57,696	
Savings (MWh)	19,387	2,332	15,442
Savings (% of Baseline)	19.1%	3.9%	15.2%
Net-to-Gross Ratio			79.7%

Table 41: Difference of Differences Net Savings Calculation – Annual Energy

Demand Findings

Table 42 presents the difference-of-differences calculations for the net summer peak demand reduction. The calculations result in 3.8 MW of net summer peak demand reduction. This net demand reduction corresponds to a net-to-gross ratio of 76.4%.

	Participants	Non-Participants	Participant Net Savings
Baseline (MWh)	22.7	13.4	
As-Built (MWh)	17.7	12.7	
Savings (MWh)	5.0	0.7	3.8
Savings (% of Baseline)	22.0%	5.2%	16.8%
Net-to-Gross Ratio			76.4%

Table 42: Difference of Differences Net Savings Calculation – Summer Peak Demand

Process Findings

Decision-maker (DM) surveys were designed to obtain data to assist RLW in determining the net savings attributable to the program. In addition to these questions, RLW also asked both building owners and design teams a set of process evaluation questions. In general 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, first for the owners and next for the building design teams.

Free-ridership and Spillover Results

The approved methodology for calculating program level net energy savings and demand reduction is the difference-of-differences approach. One shortcoming of the difference-of-differences approach is that it does not provide measure specific estimates of free-ridership and spillover. In order to provide additional insight to SBD program representatives, separate estimates of free-ridership and spillover by measure category were requested as a part of this study. For this reason a self-report methodology relying on decision-maker survey data was utilized to provide these estimates. The results presented below were calculated using the self-report methodology and should only be used to understand which measures are experiencing the most free-ridership and spillover.

Decision-maker surveys were used to determine the 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 at the measure level. The net-to-gross ratios are estimated at the measure level in order to inform the SBD program staff of measures that are experiencing a high level of free-ridership.

Energy Savings Free-Ridership and Spillover

Free-ridership by Measure Category

Table 43 shows the free-ridership rate by measure category. The table shows that the greatest amount of free-ridership is occurring in the motors measures[10] and the least is occurring in the refrigeration and daylighting controls measures. According to the decision-makers, the program appears to be experiencing a relatively high rate of free-ridership for several measures.

[10] The current sample only contains 3 sites that were rebated for motor measures. Of these 3 sites, the gross savings for one is about 12 times greater than the other two added together. This one site was a total free-rider (100% free-ridership rate) and is a highly influential site on the net savings estimate.

	Measure Category	Participant Net Energy Savings (MWh)	Gross Savings	Net-to-Gross Ratio	Free-Ridership Rate
Systems Approach	Shell	-	-	-	-
	LPD	3,211	5,501	58.4%	41.6%
	Daylighting Controls	4,236	5,234	80.9%	19.1%
	Other Lighting Controls	-	-	-	-
	Motors	67	1,270	5.3%	94.7%
	HVAC	1,368	2,128	64.3%	35.7%
	Refrigeration	224	225	99.5%	0.5%
	Whole Building	-	-	-	-

Table 43: Participant Free-Ridership by Measure Category

Spillover by Measure Category

Table 44 presents the non-participant spillover energy savings by measure category. In the non-participant population, program influences were responsible for 1,462 MWh of annual energy savings. The majority of spillover is occurring in the LPD measure category.

Measure Category	Non-Participant Spillover Energy Savings (MWh)
Shell	13
LPD	1,480
Daylighting Controls	-
Other Lighting Controls	-
Motors	-
HVAC	-31
Refrigeration	-

Table 44: Non-participant Spillover Energy Savings by Measure Category

Demand Reduction Free-Ridership and Spillover

Free-ridership by Measure Category

Table 45 shows the free-ridership rate by measure category. The table shows that the greatest amount of free-ridership is occurring in motors[11], while the least free-ridership is occurring in the refrigeration and daylighting controls measures.

[11] The current sample only contains 3 sites that were rebated for motor measures. Of these 3 sites, the gross savings for one is about 12 times greater than the other two added together. This one site was a total free-rider (100% free-ridership rate) and is a highly influential site on the net savings estimate.

	Measure Category	Participant Net Demand Reduction (MW)	Gross Savings	Net-to-Gross Ratio	Free-Ridership Rate
Systems Approach	Shell	-	-	-	-
	LPD	0.6	1.1	57.7%	42.3%
	Daylighting Controls	1.4	1.7	79.8%	20.2%
	Other Lighting Controls	-	-	-	-
	Motors	0.01	0.14	5.8%	94.2%
	HVAC	0.5	0.9	60.2%	39.8%
	Refrigeration	0.03	0.03	99.7%	0.3%
	Whole Building	-	-	-	-

Table 45: Participant Free-Ridership by Measure Category

Spillover by Measure Category

Table 46 presents the non-participant spillover energy savings by measure category. In the non-participant population, program influences were responsible for approximately 4.0 MW of summer peak demand reduction.

Measure Category	Non-Participant Spillover Demand Reduction (MW)
Shell	-0.0003
LPD	0.4
Daylighting Controls	-
Other Lighting Controls	-
Motors	-
HVAC	0.001
Refrigeration	-

Table 46: Non-participant Spillover Demand Reduction by Measure Category

Owner Surveys

The following sections of this chapter correlate directly with the flow of the decision-maker survey. Wherever possible, the participant and non-participant responses are analyzed and presented together.

This section is further divided into the following categories:

- Financial Criteria – General building information such as ownership type and financial criteria used in energy efficient investments;
- Design Team Qualifications – The criteria used in the selection of the design team and use of an integrated design approach;

- Energy Efficiency Attitudes – The importance of energy efficiency to the company and any policies used to encourage efficiency;
- Energy Performance – Decision-maker perceptions of energy efficiency of their building;
- Savings By Design Program Questions -Awareness of program, motivations to participate, and barriers to participation.

A total of 45 owner surveys were completed. Of the 45 surveys, 23 were with participant owners, with the remaining 22 with non-participant owners. All of the decision-maker responses have been weighted to the population using the case weights that were developed for the gross savings analysis.

All statistically significant differences are shaded in gray. All statistical significance tests were conducted at the 90% level of confidence.

Building Characteristics

Table 47 shows the building ownership type by program participation status. All sampled program participants were privately owned. About 6% of non-participants were publicly owned.

	% of Respondents	
	Participants	**Non-Participants**
Private	100.0%	88.8%
Public	-	5.6%
Don't Know	-	5.6%

Table 47: Building Ownership

Table 48 shows the building occupancy intent during construction by program participation status. Approximately 50% of both participants and non-participants constructed the building to be occupied by the owner.

	% of Respondents	
	Participants	**Non-Participants**
Owner-Occupied	54.3%	46.3%
Developed with Intent to Lease All Space	45.7%	45.3%
Developer - Occupied with Intent to Lease Remaining Space	-	8.4%

Table 48: Occupancy Intent during Construction

Table 49 presents the most important financial criteria used to make energy efficient investments during construction by program participation status. Program participants were significantly more likely to use the “Lowest Lifetime Cost” and “Simple Payback” criteria than were non-participants. Non-Participants were significantly more likely to use “Lowest First Cost” as the most important financial criteria or to not know the criteria used than were participants. This may indicate that non-participants are not participating because, while participation does result in a more energy efficient building, the reality is that the up front cost is usually higher. Therefore, an emphasis should be placed on educating potential participants on the value of using various economic analysis to evaluate new construction options.

	% of Respondents	
	Participants	Non-Participants
Lowest Lifetime Cost	40.7%	10.2%
Simple Payback	30.6%	-
Return on Investment	16.6%	16.8%
Lowest First Cost	5.0%	22.1%
Other	4.0%	23.2%
Don't Know	3.0%	23.2%
Net Present Value	-	-
Refused	-	4.6%

Table 49: Most Important Financial Criteria

Table 50 displays the percentage of participants and non-participants that used a set of stock plans in the design of the building. Approximately one quarter of each group used stock plans. If 21% of participants are using stock plans <u>without</u> any modifications, the results suggest that 21% of participants are program free-riders.

	% of Respondents	
	Participants	Non-Participants
Yes	21.0%	25.9%
No	77.0%	69.3%
Don't Know	2.0%	4.9%

Table 50: Use of Prototype plans

Design Team Selection and Construction Practices

Table 51 presents the percentage of participants and non-participants that used an independent architect or designer (i.e. one not employed by the construction firm or general contractor). Virtually all respondents from both groups say they used an independent architect or designer.

	% of Respondents	
	Participants	Non-Participants
Yes	98.0%	100.0%
No	2.0%	-

Table 51: Use of Independent Architect / Designer

Table 52 shows the percentage of respondents that considered qualifications in energy efficiency in selecting the design team. Nearly 40% of participants and about 25% of non-participants state they did so.

	% of Respondents	
	Participants	**Non-Participants**
Yes	39.2%	26.9%
No	47.3%	60.0%
Don't Know	13.5%	13.1%

Table 52: Consideration of Energy Efficiency Qualifications in Design Team Selection

The respondents who did consider qualifications in energy efficiency were then asked to explain their answer. Below are some verbatim explanations that were given as a response to the question.

Participants

> *"In selecting the refrigeration design team, we chose a firm with experience in energy efficiency."*
>
> *"Energy management requirements of building are high so we looked for EMS qualifications."*

Non-Participants

> *"Look at prior history or call and inquire."*
>
> *"We have history with them. Energy Efficiency has always been a consideration."*
>
> *"Although it was a consideration, it was the lowest priority of our considerations."*

Table 53 shows the percentage of participants and non-participants who asked the members of the design team to consider energy efficiency beyond Title 24 requirements. Participants were significantly more likely to make this request (62%) than were non-participants (24%).

	% of Respondents	
	Participants	**Non-Participants**
Yes	61.7%	23.7%
No	30.2%	62.4%
Don't Know	8.1%	13.9%

Table 53: Consideration of Energy Efficiency Beyond Title 24 Requirements

The respondents that stated they asked the members of their design team to consider energy efficiency beyond Title 24 requirements were asked to elaborate on their answer. The participants provided more complete answers than the non-participants. Below are some verbatim responses:

Participants

> *"We knew about the rebate program so we asked people to design with that in mind, which probably required design beyond T24."*
>
> *"We looked at and installed an EMS, which included variable frequency drives on cooling towers."*
>
> *"We talked about utilizing efficient options because we are in it for long term operation. That was part of the criteria in the contract."*
>
> *"Efficiency goes beyond T24 always."*
>
> *"We asked the team to weigh the cost of equipment against what more expensive energy efficient equipment could save us in energy costs."*
>
> *"We're always trying to achieve better efficiency with HVAC, lighting, glazing, etc. We asked for options on how to exceed T24 - specifically glazing."*

Non-Participants

> *"We always ask for energy efficiency beyond T24."*
>
> *"We asked for lighting controls."*
>
> *"Requested insulation in an unconditioned warehouse roof."*
>
> *"Not familiar with T24, but considered efficiency of building.*

All survey respondents were asked if they were familiar with the practice of designing new buildings using an Integrated Design approach. Responses of "Don't Know" were reclassified as "No". Table 54 presents the results by program participation status. Participants were significantly more likely to be familiar with the Integrated Design approach.

	% of Respondents	
	Participants	**Non-Participants**
Yes	50.8%	27.2%
No	49.2%	72.8%

Table 54: Familiarity with Integrated Design Approach

All survey respondents who were familiar with the practice of designing new buildings using an Integrated Design approach were asked to explain what it was. Below are some of the responses that were given.

Participants

> *"We understood the initial investment for our equipment would provide our tenants with lower operating costs."*
>
> *"Heard about it subsequently through SDG&E rep."*

"Familiar with load circulation because of complex manufacturing."

"During design, all aspects are considered (not just independently) of architect, mechanical & electrical design."

"Consider all components (HVAC, lighting, envelope) to achieve low EUI."

"High performance glazing is used to reduce cooling capacities."

"Systems work together - loads calculated for sizing air conditioning system."

"Accounting for building heat load for HVAC design."

Non-Participants

"I've heard of it."

"EMS systems to monitor building functions."

"Very tight time frame, systems & design of building (insulation levels) come into play together."

It is not clear from these responses that any of the non-participants know what integrated design means. Conversely, it appears that the participants really do understand what integrated design is and can define it. This indicates that the SBD program is impacting participants by providing education on the value of designing and constructing buildings using an approach that considers the interaction of all building systems.

All respondents who stated they were familiar with the practice of designing new buildings using an Integrated Design Approach were asked if they asked the architect or designer to follow an Integrated Design approach. Table 55 summarizes the responses. Participants who were familiar with the approach were significantly more likely to ask the architect/designer to follow the Integrated Design approach. Not one non-participant asked their design team to use an Integrated Design approach.

	% of Respondents	
	Participants	**Non-Participants**
Yes	79.3%	-
No	20.7%	100.0%

Table 55: Occurrence of Requesting Integrated Design Approach Among Those Familiar With the Approach

The survey respondents who asked the architect or designer to follow an Integrated Design approach were then asked to explain the approach that was used. Below are some of the responses that were given.

Participants

"We specifically asked for the equipment that we wanted."

"Lighting / AC levels taken into consideration during design."

"Glazing & HVAC systems were considered / analyzed as requested by owners."

Respondent expected that all the architects did some sort of 'integrated design'. He did not know what integrated design was, but knew the description.

"Size system to load and not size of building."

Interestingly here, it is not as apparent that the participants know what integrated design means. Some provide a useful description, however in no cases do we hear anything about computerized modeling. The data does indicate that a certain percentage of the respondents that think they know what integrated design is, really do not completely grasp the concept.

All survey respondents were asked if they solicited competitive bids for construction of the building. As Table 56 shows, approximately four-fifths of both program participants and non-participants solicited competitive bids.

	% of Respondents	
	Participants	**Non-Participants**
Yes	81.4%	83.5%
No	16.6%	16.5%
Don't Know	2.0%	-

Table 56: Solicitation of Competitive Bids

Table 57 shows the percentage of participants and non-participants who state that initial energy efficiency features were changed to less efficient features through value engineering, substitutions, or competitive bidding. Approximately one-fifth of both groups says such changes took place.

	% of Respondents	
	Participants	**Non-Participants**
Yes	22.1%	16.4%
No	63.3%	73.9%
Don't Know	14.6%	9.7%

Table 57: Occurrence of Changed Energy Efficiency Features

The 22% of participants and 16% of non-participants that stated energy efficiency features were changed through value engineering, substitutions or competitive bidding were asked to explain their response. Below are some verbatim answers that were received from the respondents.

Participants

"Time limitations caused more changes."

"EMS systems down-graded."

Non-Participants

> *"Equipment probably changed through value engineering, but can't remember which; most are still in place from original plans."*
>
> *"Value engineering changed some equipment - not sure which."*
>
> *"Mechanical 'manufacturers' changed [system] through value engineering."*

Table 58 shows the percentage of respondents who claim they hired an independent construction manager or commissioning agent to help insure the final building was in-line with the original design intent. Participants (21%) were significantly less likely to claim they used such an agent than were non-participants (43%). These are difficult responses to explain, since we know very few new construction project utilize commissioning agents, we must assume that the majority of the responses are referring to construction managers. However, there still seems to be an overly high proportion of respondents with <u>independent</u> construction managers. At least two possibilities could explain these odd results; 1) the surveyor did not adequately emphasize independent or 2) many of the respondents do not know what a commissioning agent or a construction manager is. Most likely a combination of these two possibilities led to the responses.

	% of Respondents	
	Participants	**Non-Participants**
Yes	20.6%	42.7%
No	79.4%	40.8%
Don't Know	-	16.5%

Table 58: Use of Independent Construction Manager or Commissioning Agent

Energy Efficiency Attitudes

All survey respondents were asked to rate the level of importance of energy efficiency when they built their building, on a one-to-five scale, where one means very unimportant and five means very important. Table 59 presents the distribution of responses along with the mean rating for both participants and non-participants. Program participants (Mean = 4.22) place a significantly higher level of importance on energy efficiency than do non-participants (Mean = 3.22). Only 8% of program participants stated that energy efficiency was not important while nearly 35% of non-participants held the same opinion.

	% of Respondents	
	Participants	Non-Participants
Very Important	36.3%	8.3%
Somewhat Important	53.7%	46.7%
Neither Important nor Unimportant	2.0%	10.4%
Somewhat Unimportant	8.1%	28.3%
Very Unimportant	-	6.4%
Mean :	4.18	3.22

Table 59: Importance of Energy Efficiency during Design and Construction

All survey respondents were asked to rate the level of importance of energy efficiency in the daily operations of their building, on a one-to-five scale, where one means very unimportant and five means very important. Table 60 presents the distribution of responses along with the mean rating for both participants and non-participants. There is a slight indication that program participants (Mean = 3.90) place a higher level of importance on energy efficiency than do non-participants (Mean = 3.74), although the difference is not statistically significant. It is interesting that non-participants find energy efficiency less important at the time of construction as they do during operation of the building. This reiterates the importance of educating customers on the value of using some form of economic analysis, as opposed to lowest first cost decision making.

Recall in the “Financial Criteria” section, participants were more concerned with Life Cycle and long term costs than were the non-participants. This is reiterated by the non-participants, as show in Table 60, where 35% report energy efficiency is not important at the time of design and construction. Meanwhile, a much higher proportion of non-participants think energy efficiency is important during the daily operations of their building, as indicated in Table 61. The data leads us to believe that while non-participants do think about the energy efficiency implications related to daily operations, they do not connect this to up front costs or life cycle costs. On the other hand, it does appear as the participants do make the connection.

	% of Respondents	
	Participants	Non-Participants
Very Important	35.2%	28.5%
Somewhat Important	39.6%	36.8%
Neither Important nor Unimportant	8.5%	8.0%
Somewhat Unimportant	13.6%	20.3%
Very Unimportant	3.0%	1.6%
Don't Know	-	4.8%
Mean :	3.90	3.74

Table 60: Importance of Energy Efficiency in Daily Operations

Table 61 presents the percentage of participants and non-participants whose companies have a policy on energy management. As one might expect, participants were significantly more likely to have such a policy (39%) than were non-participants (12%).

	% of Respondents	
	Participants	**Non-Participants**
Yes	39.2%	11.7%
No	43.8%	75.5%
Don't Know	17.1%	12.8%

Table 61: Existence of Energy Management Policy

The respondents that stated their company had an energy management policy were then asked to state their company's policy. Below are some examples of the policies:

Participants

"Basically a book describing energy use during off hours - use of motion sensors, etc."

"It is not as formal as it could be; just try to conserve."

"We weigh the cost of equipment vs. more expensive energy efficient equipment and what could be saved in energy costs."

"To cut costs and save energy."

"Try to use best available technologies - especially in motor design."

Non-Participants

"We ask for monitoring and for offices to use the minimum amount of electricity."

"All systems used only as necessary."

Energy Performance

All survey respondents were asked if the company's energy performance was used in the review of anyone's performance or compensation. Table 62 summarizes the responses among both program participants and non-participants. Approximately 16% of participants and 6% of non-participants state that the company's energy performance is used to review employee performance or compensation.

	% of Respondents	
	Participants	**Non-Participants**
Yes	15.5%	6.4%
No	59.3%	76.0%
Don't Know	25.2%	17.6%

Table 62: Use of Company Energy Performance to Review Employee Performance/Compensation

All participants and non-participants were asked to compare the efficiency of their building relative to the energy code. Table 63 presents the distribution of responses for both groups. Participants were significantly more likely to believe their building was much better than required by code, while non-participants were significantly more likely to state their building was just efficient enough to comply with code.

Relative to Code	% of Respondents	
	Participants	**Non-Participants**
Just Efficient Enough to Comply	13.6%	28.8%
Little Better than Required	46.8%	29.6%
Much Better than Required	31.1%	21.9%
Don't Know	8.5%	19.7%

Table 63: Opinion of Building Efficiency Relative to Code

Table 64 summarizes the responses given when owners were asked to describe the energy performance of their building. As might be expected, participants were significantly more likely to believe their building is about as efficient as it could be. Surprisingly, non-participants were significantly more likely to believe their building is an example of energy efficiency for others to follow.

	% of Respondents	
	Participants	**Non-Participants**
Could be Much More Efficient	-	5.6%
Could be Somewhat More Efficient	55.3%	62.7%
About as Efficient as Can Be	34.1%	14.4%
An Example of Energy Efficiency for Others to Follow	2.0%	8.3%
Don't Know	8.5%	9.1%

Table 64: Opinion of Building's Energy Performance

Savings By Design Program Questions

Participants

All SBD program participants were asked how they first became aware of the SBD program, services, and owner incentives that were available. As shown in Table 65, nearly two-thirds of participants heard of the program through a utility representative.

	% of Participants
Utility Representative	63.7%
Previous Utility Program Participation	13.6%
Architect	8.5%
Engineer	6.2%
Current Tenant/Previous Tenant	5.0%
Don't Know	3.0%

Table 65: Source of Awareness of Savings by Design

Table 66 summarizes the responses given when SBD participants were asked which member of their project team was the single biggest advocate for participating in the program. Nearly two-thirds of participant owners say they were the biggest advocate for SBD participation.

	% of Participants
Owner/Developer	63.3%
Architect	3.0%
Lighting Designer/Electrical Engineer	8.5%
Mechanical Engineer	8.5%
Energy Manager/Facility Manager	5.0%
Construction Manager	8.5%
Other	3.0%

Table 66: Biggest Advocate for Participating in SBD – Owners

All SBD participants were asked to rate the level of importance of the dollar incentive paid to the owner in motivating their organization to participate. As shown in Table 67, nearly 25% of owners felt the incentive was very important. Nearly 20% of participant building owners stated they felt the incentive was very unimportant in motivating them to participate.

	% of Participants
Very Important	23.5%
Somewhat Important	45.3%
Neither Important Nor Unimportant	8.5%
Somewhat Unimportant	3.0%
Very Unimportant	19.7%

Table 67: Importance of Owner Incentive in Participation

As shown in Table 68, nearly 40% of participants say SBD participation influenced them to change their standard building practices to lead to more efficient buildings. This indicates one of two things; a number (61%) of the participants are program free-riders because they are already constructing efficient buildings; or participants will go back to a less efficient design in future projects if they are not compensated for energy efficient choices in an incentive based program.

	% of Participants
Yes	39.2%
No	60.8%

Table 68: Influence of SBD Participation on Changing Future Building Practices - Owners

The participants who stated that SBD had not influenced them to change their standard building practice were asked why it had not influenced them. Below are some verbatim responses.

> *"The decision was driven by tenant's desire to save money in the long run."*
>
> *"The incentives were too low to influence practices; looking to build efficient buildings."*
>
> *"We were going to do it with or without program - operating cost savings."*
>
> *"No, energy conservation is driving force."*
>
> *"We would follow the same process to achieve energy savings and reduce costs."*
>
> *"We feel we're ahead of the curve because we already design better than T24."*
>
> *"The money convinced management; however they look at the ability of technology to be economically justifiable."*
>
> *"Payback from lighting controls is too long without rebate. If tenant requested it, we would do it."*

All SBD participants who say participation caused them to change their standard building practices to lead to more efficient buildings were asked which component of the program was the most instrumental in causing this design practice change. Table 69 shows that nearly three-quarters of participants say the owner incentive was the most influential, while about one-quarter say the design assistance was the most influential.

It may be difficult to understand why the owner incentive component of the program will lead owners to design more energy efficient buildings in future projects. The responses may be suggesting the cash incentive was the original basis for program participation, and in turn the owners have had a favorable experience with the measures that were installed, making it likely that they would install similar measures in the future as a result of the experience they have had with SBD. This reiterates the importance of incentive-based programs as a vehicle to transform the NRNC market to a more energy efficient and sustainable market.

	% of Participants
Owner Incentive	73.2%
Design Assistance	26.8%

Table 69: Most Instrumental Component in Changing Building Practices

All participants were asked to rate the level of influence of various SBD components on the design of the building, using a scale of one to five where one means very un-influential and five means very influential. Table 70 shows the results. More than 40% of participants found the new construction rep. recommendations to be un-influential on the design of their building.

	% of Participants	
	Owner Incentive	NC Rep. Recommendations
Very Un-influential	11.6%	20.0%
Somewhat Un-influential	23.2%	24.3%
Neither Un-influential Nor Influential	28.7%	16.4%
Somewhat Influential	10.5%	17.5%
Very Influential	26.1%	18.2%
Don't Know	-	3.7%

Table 70: Owner Incentive and NC Rep. Recommendations Influence on Design of Building

All participants were asked to provide any recommendations for change to the SBD program in order to improve its delivery to customers. Table 71 shows that over one-quarter of the participants stated that no changes were needed, and one-quarter stated that the review and response from the utility needs to be expedited. The third most commonly mentioned recommendation was to increase the incentives paid for efficient equipment. Some respondents mentioned that the utility representatives need to present the benefits more clearly and more marketing is needed to increase awareness of the program.

	% of Participants
No changes needed	26.5%
Review and response from utility needs to be more rapid	26.5%
Increase Incentives	21.0%
Utility Reps need to present benefits more clearly	10.2%
More marketing to increase awareness of program	9.7%
Increase requirements to increase energy savings	2.4%
Don't Know	3.7%

Table 71: Recommended Changes to Savings by Design

All participant owners were asked if the design team received a Design Team Incentive for the project. This question was intended to be method of checking the building owner’s understanding of the program. Table 72 shows the results. For the fourth quarter of 1999 to the third quarter of 2000, there were no projects that had a Design Team incentive in the SBD population. Only 5% of participant building owners mistakenly believed that the design team received an incentive.

	% of Participants
Yes	4.8%
No	75.2%
Don't Know	20.0%

Table 72: Design Team Incentives

Non-Participants

Table 73 shows the percentage of non-participants who were aware of the Savings By Design New Construction energy efficiency program before they began construction. About 23% of non-participants were aware of the program before they began construction.

	% of Non-Participants
Yes	22.9%
No	77.1%

Table 73: Non-Participant Owner Awareness of SBD Before Construction Began

The 23% of non-participants who were aware of SBD before construction began were asked to state the reason why they did not participate in the SBD program. Below are some of the responses that were provided.

“I don't believe that incentives were available at that time.”

> *"We didn't think the impact was worth the hassle. We were fast tracking the project and when you get these guys involved they are like the government-they slow everything down."*
>
> *"Probably because of the complexity of the refrigeration system. For this store it was more trouble than it was worth to pursue the incentive. For the cooling rebates, the engineering required too much documentation."*
>
> *"Time limitations."*
>
> *"Didn't make economic sense to change the design. The incentives were not enough."*

Table 74 presents the percentage of non-participants who had any interaction with their utility's new construction program representative or SBD program material regarding the design and equipment specification of their project, among non-participants who were aware of the SBD program. Nearly three-quarters of non-participants say they had some interaction.

	% of Non-Participants
Yes	73.3%
No	26.7%

Table 74: Interaction with SBD Staff or Program Material Regarding Design and Equipment Specifications

All non-participants were asked, if they were aware that cash incentives were available, how likely it is that they would have pursued these incentives by designing their building to perform better than Title 24 by at least ten percent. Table 75 presents the responses cross-tabulated by whether the respondents was aware of SBD. Over 50% of those respondents who were aware of SBD stated they would have been very unlikely to do so. Nearly 50% of all non-participants state they would have been very likely to do so. Over 85% of non-participants who were unaware of SBD state they would have been at least somewhat likely, if they had been aware of the financial incentives. These results suggest that if a larger marketing campaign was undertaken, it is highly likely that participation would increase.

	% of Non-Participants	
	Aware of SBD	Not Aware of SBD
Very Likely	46.7%	47.9%
Somewhat Likely	-	39.6%
Neither Likely Nor Unlikely	-	6.3%
Somewhat Unlikely	-	
Very Unlikely	53.3%	-
Don't Know	-	6.3%

Table 75: Likelihood of Designing Building to Perform Better than Title 24 If Aware of Financial Incentives

Design Team Surveys

A survey of the key design team members was conducted for each sampled site. A total of 16 participant and 19 non-participant design team surveys were completed. Of the 16 participant surveys, 8 were with architects, 6 with engineers, 1 with a construction manager, and 1 with a general contractor. Of the 19 non-participant design team surveys, 12 were with architects, 3 with engineers, 3 with a construction manager, and 1 with a general contractor. All of the design team responses have been weighted to the population using the case weights that were developed for the gross savings analysis.

The design team surveys were implemented in order to assess the level of energy efficient design that is being practiced on new construction projects.

Moreover, design team members were surveyed in regard to energy efficient design practices. These questions address the awareness of integrated design practice and whether it is a concept that is used in the marketing of services. The members of the design team that were targeted were either the engineer or the architect, varying by project depending upon their knowledge of the building systems and the decision making regarding the program. Both participants and non-participants were asked some similar basic questions, such as whether they were familiar with SBD, and whether they advertised energy efficient practices or integrated design.

The questions directed exclusively to the participants focused on their motivations to participate in the program, and non-participants were asked the reasons behind their non-participation in SBD. Below is a list of the general questions asked of the participants and non-participants:

Participants

- Importance of incentive in motivation to participate in SBD
- Method of program delivery
- Design Analysis provided and value of service
- Any changes to building after Design Analysis component of SBD
- Importance of SBD components on building design
- Single biggest advocate for participation on the design team
- Influence of SBD on standard design practice

Non-Participants

- Awareness of Incentives
- Reasons for not pursuing incentive
- Design project 15% better than baseline if aware of incentive
- Computer simulation used to optimize and enhance the energy performance of the building

These questions have been analyzed and the results of the analyses are presented in this section of the report. The design team survey responses were not weighted since an appropriate 'design team population' could not be defined for the purposes of this project. The results are presented in three sections, the first contains the questions that were common to both participants and non-participants, the second section contains participant specific questions, and the final section contains the non-participant specific questions.

Participant and Non-participant Questions

All survey respondents were asked if their firm advertised energy efficient design practices. Table 76 presents the results by program participation status. Participants were more likely to advertise energy efficient design practices and non-participants were more likely to not advertise energy efficient design practices. However in general, advertising energy efficiency does not appear to be seen as a valuable marketing strategy at this time.

	% of Respondents	
	Participants	**Non-Participants**
Yes	17.2%	8.7%
No	66.2%	79.1%
Don't Know	16.6%	12.2%

Table 76: Advertisement of Energy Efficient Design Practices

All survey respondents were then asked if their firm advertised Integrated Design. Table 77 presents the results by program participation status. Participants were significantly more likely to advertise Integrated Design than non-participants. None of the non-participants stated they were aware that their firm advertised Integrated Design. This data suggest that the SBD program is educating not only building owners on integrated design, but it is educating and possibly changing design practices of building design teams. These significant differences suggest the program is successful in working with and educating both the owners and the design teams. What makes this interesting is the fact that all of the projects evaluated thus far have been 'systems' projects. We should expect these numbers to increase as more 'whole building' projects are included in the program.

	% of Respondents	
	Participants	**Non-Participants**
Yes	22.3%	0.0%
No	65.5%	91.0%
Don't Know	12.2%	9.0%

Table 77: Advertisement of Integrated Design

Participant Design Teams

All designer participants were asked to recall which method of program delivery was used on their project. The surveyor knew the method of program delivery from reviewing the program file, therefore this question was simply a check to understand how informed the respondent was about the project. All projects during this quarter used the "Systems Approach". Table 78 shows that only 29.5% of the participant respondents answered this question correctly. The other 70.5% of the respondents were unaware of the method of program delivery.

	% of Participants
Systems Approach	29.5%
Don't Know	70.5%

Table 78: Method used for Program Delivery

All designer participants were asked to rate the level of influence of various SBD components on the design of the building, using a scale of one to five where one means very un-influential and five means very influential. Table 79 shows that nearly 70% of the respondents found the owner incentive to be influential on the design of their building, while approximately 15% found the new construction representative recommendations to be influential. An interesting finding surfaces here, in Table 70, 26% of building owners felt the owners incentive was very influential, while in Table 79 nearly 60% of the design team members thought the owner incentive was very influential. Furthermore, the building owners believe the NC Rep. recommendations are much more influential than the design teams believe they are, respectively 18.2% and 4.4% think these recommendations are very influential.

	% of Participants	
	Owner Incentive	NC Rep. Recommendations
Very Influential	58.3%	4.4%
Somewhat Influential	10.0%	10.0%
Neither Un-influential Nor Influential	-	25.1%
Somewhat Un-influential	-	16.6%
Don't Know	31.7%	43.9%

Table 79: Owner Incentive and NC Rep Recommendations Influence on Design of Building – Design Team

All designer participants were asked to state which member of their design team was the biggest advocate for participating in SBD. As shown in Table 80, over 80% of participants stated that the owner/developer was the single biggest advocate for participating in the program. Architects were mentioned second most often, with 12.2% of participants mentioning them, while construction managers and mechanical engineers were seldomly mentioned. Again, comparing these responses to the owner responses in Table 66, we find there to be some significant differences in opinion. The design team members were approximately 20% more likely to think the owner was the biggest advocate than were the owners themselves.

	% of Participants
Owner/Developer	80.6%
Architect	12.2%
Mechanical Engineer	2.8%
Construction Manager	4.4%

Table 80: Biggest Advocate of Savings by Design – Design Team

All participants were asked if any component of the SBD program influenced their standard design practice in a way that led to more energy efficient building designs on a regular basis. Table 81 shows that 38.2% of the participants stated that their standard design practices were influenced by SBD. This is very similar to the 39.2% of participant owners who stated that their standard design practices were influenced by SBD as shown in Table 68.

	% of Participants
Yes	38.2%
No	61.8%

Table 81: Influence of SBD Participation on Changing Future Building Practices – Design Team

The participants who stated that SBD did not influence them to change their standard design practices (61.8%) were then asked why they were not influenced. Below are a few examples of the responses:

> *"Must be a payback. In industrial markets, at least a 2 year payback is needed for the owner. Anything over 2 years, owners don't do it. Industrial measures have longer payback periods."*

> *"Already do anyway – we spec energy efficiency. Ultimately the owner either downgrades or the valve engineering decreases efficiency."*

> *"We are cutting edge in energy efficiency. Many of our standard designs are more efficient than the SBD requirements. The rebate does sell these designs through improved payback periods."*

The participants who stated that SBD influenced them to change their standard design practices (38.2%) were then asked why they changed their standard practice. Below are a few examples of the responses that were given when asked this question:

> *"Payback results through Design Assistance component of participation."*

> *"One day seminars keep us up to speed on energy efficient technologies (Not a SBD component). The program keeps us informed of energy*

efficient technologies. We have also begun using Energy Pro as a result of programs like SBD.

“Life cycle cost - Design Analysis - has brought a lot of conversation in meetings about energy efficiency.”

“Design assistance - mostly daylighting systems have really changed our design practice.”

Non-participant Design Teams

All non-participant design team respondents were asked if they were familiar with Savings By Design. As shown in Table 82, over two-thirds of the non-participants were familiar with the program. Non-participant design teams were much more likely to be aware of SBD than were non-participant owners. We also found several cases where design teams were involved in projects that were both participants and non-participants. In these cases, the design team was classified as a non-participant design team member when working on a non-participating site, and a participant design team member when working on a participating site.

	% of Non-Participants
Yes	67.5%
No	32.5%

Table 82: Familiarity with Savings By Design – NP Design Team

The non-participants who stated that they were familiar with the program were then asked if they were aware that a Design Team Incentive might have been available to their team. Table 83 shows that among the 67.5% of respondents who were aware of the program, only 40% of them were aware that an incentive might have been available. Therefore, approximately 27% of all the non-participants were aware of the Design Team Incentive.

	% of Non-Participants
Yes	40.4%
No	59.6%

Table 83: Awareness of Incentive – NP Design Team

The 27% of non-participants who were aware of the Design Team Incentive were then asked their reasons for not pursuing the incentive. Below are some verbatim responses from non-participants:

“The developer makes the decisions on how the building is designed.”

“We did submit for the incentive but didn't get paid; we are not sure why.”

“Time limitations; project was on a fast track.”

“SCE told us the money wasn't available yet so we couldn't participate.”

All non-participants who were unaware of SBD, plus non-participants who were aware of SBD but unaware of the Design Team Incentive were then asked how likely it is that they would have pursued the incentives by designing their project to perform at least 15% better than Title 24, if they had known about the incentive. Table 84 presents the percentage breakdown of the responses. Over 30% of the respondents stated that they would have been somewhat likely and 20% would have been very likely to have designed a more efficient project. Further evidence that more communication needs to take place between the design teams and the SBD representatives.

	% of Non-Participants
Very Likely	19.6%
Somewhat Likely	30.9%
Neither Likely Nor Unlikely	8.0%
Somewhat Unlikely	19.6%
Very Unlikely	13.1%
Don't Know	8.7%

Table 84: Likelihood of Pursuing Design Team Incentives if Aware of Incentives

The non-respondents who stated it was unlikely that they would have redesigned the project to make it more efficient were then asked why. Below are some verbatim responses from the non-participants:

> *"Owners would not have pursued based on cash issue. Not an owner occupied building."*
>
> *"Restricted by owner specifications; manufacturing equipment had specific requirements."*
>
> *"I think that mechanical engineers and energy consultants would push for higher efficiency, not the architect."*

A common theme is illustrated in these quotes, that the owners guide the decision making process because these decisions impact project budgets. However, with more collaboration between the SBD representatives and the design teams it may be possible for the design team members to sell the owners on more energy efficient design. This would include presentations of economic analysis which we have learned are not used on a large scale by building owners.

All non-participants who were unaware of SBD, plus non-participants who were aware of SBD but unaware of the Design Team Incentive were then asked how likely it is that they would have pursued the Design Assistance and Design Analysis component of SBD had they been aware of it. Table 85 shows that almost two-thirds of respondents would have been likely to pursue the Design Assistance and Design Analysis component of SBD.

	% of Non-Participants
Very Likely	44.0%
Somewhat Likely	18.9%
Somewhat Unlikely	19.6%
Very Unlikely	13.1%
Don't Know	4.4%

Table 85: Likelihood of Pursuing Design Assistance and Design Analysis if Aware of Design Team Incentives

Those respondents who stated it was unlikely they would have pursued the Design Assistance and Design Analysis component of SBD were then asked to explain their reasoning. Below are some of the verbatim responses:

> *"(We're) Currently into latest energy efficiency requirements and building design is a prototype that is used throughout the country."*
>
> *"SCE is slow to respond."*
>
> *"No latitude - specific requirements by owner."*

All designer non-participants were asked if they used a computer simulation model to optimize and enhance the energy performance of the building during the design. As shown in Table 86, almost two-thirds of the non-participants did not utilize a computer simulation model during the design of the building.

	% of Non-Participants
Yes	17.7%
No	65.9%
Don't Know	16.4%

Table 86: Use of Computer Simulation Modeling Design

The 18% of non-participants who stated they did use a computer simulation in the design of the building were then asked if that was standard practice or at the request of the clients. Table 87 shows that almost three-quarters of those non-participants, or 13% of all non-participants, stated that a computer simulation was standard practice.

	% of Non-Participants
Standard Practice	73.1%
Request of Clients	26.9%

Table 87: Computer Simulation as Standard Practice

Those 17.7% of non-participants who stated they did use a computer simulation in the design of the building were then asked when and why they began using energy simulation models to optimize and enhance the energy efficiency of their building's designs. Below are some of the verbatim responses:

> *"When T24 was enacted."*

"To optimize efficiency and for T24 compliance."

"We use Energy Pro to do T24, started last year. Allows for better design and is used in providing payback calculation to clients."

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.

Daylighting Controls

Incented daylighting controls observed while on-site were only functioning in roughly 75% of the buildings. In buildings where the controls were not functioning, we found that participants were commonly overriding the systems because of inadequate system commissioning. Problems included insufficient light levels, unsatisfactory training of building operators, insufficient system documentation, incorrect location of sensors, and general user dissatisfaction with the overall performance of the systems. In cases where the daylighting controls were not working we found the systems in the override position. It is our recommendation that some sort of follow-up by the SBD representative and/or the lighting contractor take place to insure the systems installed function as intended. The program may also consider requiring the commissioning of these systems to insure operational performance meets the design intent. Commissioning of the system should also include staff training and documentation to operate and troubleshoot the systems during periods of sub-optimal performance, which is when system overrides commonly occur.

SBD Project Delays

We heard several times while on-site and during the decision-maker interviews that involvement in the SBD program slowed down project timelines. Participants felt that SBD representatives were difficult to communicate with because they were all too commonly unavailabile and took far too much time processing paperwork. Some smaller project participants reported they would not again participate because the rebate amount did not compensate them adequately for the amount of time program participation incurred. A few non-participants reacted in much the same way, stating past participation in other programs has taught them not to do so anymore because of the “bureaucratic nature” of the utility sponsored programs.

Project Types

Savings By Design provides two separate mechanisms for participating in the program, the systems approach and the whole building approach. In the first four quarters of program operation, completed projects utilized only the ‘systems’ approach of program delivery. This is most likely a result of the size and complexity of the projects that were completed in the first four quarters. Historically, in previous NRNC programs, the larger and more complex projects utilize the ‘whole building’ (or performance) approach. These projects incur a longer construction period, therefore we would expect that, as the program ages, there will be a greater proportion of completed projects using the ‘whole building’ delivery mechanism.

It should also be noted that we did not see any design teams that participated and received design team incentives. This is because design teams only become eligible for an incentive if they use the 'whole building' program delivery mechanism.

Program Marketing

A large proportion of non-participant design teams are aware of the SBD program but are not encouraging their clients to participate. Program representatives should strive to encourage design teams to encourage their clients to participate in the program, in a sense acting as program marketers. Design team members that are successful in encouraging participation should be acknowledged for their efforts in some way, certainly since so few are qualifying for design team incentives.

Appendix

Title 24 Building Types

Table 88 presents the 17 standard Title 24 building types used in this study. These building types were used as one of the criteria to match the participant sample to the non-participant sample.

1	C&I Storage
2	Grocery Store
3	General C&I Work
4	Medical/Clinical
5	Office
6	Other
7	Religious Worship, Auditorium, Convention
8	Restaurant
9	Retail and Wholesale Store
10	School
11	Theater
12	Unknown
13	Hotels/Motels
14	Fire/Police/Jails
15	Community Center
16	Gymnasium
17	Libraries

Table 88: 17 Key Title 24 Building Types

Assessment of Free Ridership

The free-ridership was estimated by reviewing the program files and discussing the decision-making process with the participants. We used all of the available information to assess what the customer would have done in the absence of the program.

The formal free-ridership survey is shown below. The first question identified the importance the incentive had on the customer's participation in the program. (Question FR1 was not used in the free-ridership analysis, although it was used to double-check the results for rationality.) The remaining questions, FR2-FR5, were asked at the measure level. These measure level questions were used to develop a free-ridership scoring methodology to determine what might have happened absent the program and its incentives.

FR 1. How important was dollar incentive paid to you, the owner, in motivating your organization to participate in the SBD program?

01 Very unimportant

02 Somewhat unimportant

03 Neither important nor unimportant
04 Somewhat important
05 Very important
98 Don't know
99 Refused

FR 2. Let's talk about specific energy efficient measures included in your project. Did the SBD incentive play a role in influencing you to install the energy efficient measures contracted under the program? **ASK FOR EACH MEASURE LISTED ON MEASURE SHEET.**

01 Definitely Influenced (0 points)
02 Possibly Influenced (1 points)
03 Did Not Influence (2 points)

FR 3. Which, if any, of these measures would you have installed if the incentives offered through the program were not available? **ASK FOR EACH MEASURE LISTED ON MEASURE SHEET.**

01 Would have installed (4 points)
02 Possibly would have installed (2 points)
03 Would not have installed (0 points)

FR 4. Prior to building this facility, which of these energy efficient measures, if any, have you installed previously? **ASK FOR EACH MEASURE LISTED ON MEASURE SHEET.**

01 Have installed previously
02 Have not installed previously
97 Not Applicable (No Previous Experience)

FR 5. Did you receive any outside funding for these previous energy efficient designs or equipment choices, including other utility program incentives?

01 Yes
02 No
97 Not Applicable
98 Don't Know
99 Refused

Scoring Methodology

The free-ridership scoring methodology is based on the answers to questions FR2, FR3, and if applicable FR4 and FR5. The score for each measure range from 0, which represents a measure that was completely incentive influenced, up to 6, for an absolute free-rider. The measure is assigned up to two points for FR2 and four points for FR3. Question FR3, which asks whether they would have installed the measure in the absence of the incentive, is the essence of free-ridership. It logically follows then that scoring for this question is weighted greater than question FR2. Question FR2, whether the incentive played a role in influencing the measure, is secondary but is given some consideration for insuring that the incentive was implemented even if there was intent to implement without the incentive. In other words, the incentive "locked in" the installation of the measure. If the company has built any previous facilities, and has implemented a similar measure in the absence of any rebate, determined from the answers to FR4 and FR5, the measure is considered an absolute free-rider, and assigned a score of six regardless of the answers to FR2 and FR3. If they have not installed a similar measure or have installed a similar measure with an incentive, the score from questions FR2 and FR3 are the score for the measure.

Energy efficiency measures can be classified into two distinct types, dichotomous measures, those measures that are either implemented or not, such as VFDs and lighting controls, and measures with continuous or incremental efficiency ratings such as motor efficiency and glazing performance.

A copy of the database containing all of the "as surveyed" models was made after finalization of calibration and quality control. This copy was converted into a "modified" or free-ridership database. The free-ridership database consisted of adjustments of efficiency levels and removals of some dichotomous measures from the "as-surveyed" database, according to the free-ridership assessment.

Dichotomous measures were left in the models when measures had scores of three or less. The dichotomous measure was removed from the free-ridership model if the score was four or greater.

For measures with continuous or incremental energy efficiency ratings, a free-ridership energy rating was calculated using the following formula.

$$\frac{[(6-Score)(AsBuiltRating)]+[(Score)(BaselineRating)]}{6} = FreeRidershipRating$$

For an example, the lighting power density (LPD) measure of one site had a free-rider score of 2. When asked FR2, the site contact claimed to have been definitely influenced by the incentive, which counts zero for the free-rider score. When asked question FR3, the same site contact claimed that there was a possibility that an equally low LPD would have been installed without the incentive, counting two points in the free-rider scoring. This site had an as-built

LPD of 0.94 Watts per square foot. The space, which is an office, had a baseline LPD of 1.6 Watts per square foot. These values and the score were plugged into the above equation.

$$\frac{[(6-2)(0.94)]+[(2)(1.6)]}{6}=1.16$$

Therefore the free-ridership LPD for this space was 1.16 Watts per square foot. In the free-rider simulation model, lighting fixtures were added until the LPD was brought up to 1.16 Watts per square foot. For sites with multiple space types, the same adjustment approach was applied to every space type.

A free-ridership rating was calculated for all continuous energy ratings to be modified, including motor efficiency, cooling EER, lighting power density, glazing U-value and shading coefficient. These were calculated on a per item basis and adjusted individually to create the free-ridership models.

For a more complex example, assume the site in the previous LPD example also was incented for VFDs on secondary chilled water pumps. When asked FR2 for the VFDs, the site contact claimed that they were not influenced by the incentive, which counts two points toward the free-rider score. When asked question FR3, the same site contact claimed that the VFDs would have been installed without the incentive, counting four points in the free-rider scoring. Therefore, the free-ridership score for the VFDs would be 6, indicating strong free-ridership. In this case, the VFD controls would be changed to constant volume in the free-ridership model.

Having an analogous free-rider model for every “as-surveyed” model provided a simple approach to the calculation of net program savings. The net savings were calculated using the same methodology as whole building savings for the original “as-surveyed models”. The modified free-rider “as-built” run for both energy and demand was deducted from the baseline run yielding the net savings.

To determine the best estimate of net program savings, the analysis followed the following steps:

1. The *net savings* are determined for each participant at the end-use level.
2. The *program net savings estimate* is calculated by using the same MBSS methods described for the gross savings, but using the net savings estimates for each sampled site.
3. The *free-ridership rate* is calculated as the proportion between the *program gross* savings less the *program net savings* divided by the *program gross savings.* The net-to-gross ratio is simply 1 – *free-ridership rate* or the *program net savings* divided by the *program gross savings*.

Assessment of Spillover

The spillover was estimated by discussing the decision-making process with the non-participants. We used all of the available information to assess what the customer would have done in the absence of any influence from the new construction rep or program material.

The formal spillover survey is shown below. The first question identified the customer's awareness of the program. The second question was used to determine whether the customer had any interaction with the program rep or material on the current project. (Questions SP1, SP2, and SP4 were not used in the spillover analysis, but were used to validate the results of the spillover analysis.) The remaining questions, SP3-SP5, were asked at the measure level. SP3 and SP5 were used to develop a spillover scoring methodology to determine the level of influence the program rep or material had on the customer. Below, the questions are presented as they were during the decision-maker interviews.

SP 1. Were you aware of your *utility's* Savings By Design New Construction energy efficiency program before you began construction?

01 Yes

02 No

98 Don't Know

99 Refused

SP 2. Did you have any interaction with your utilities New Construction program representative or Savings By Design program material regarding the design and equipment specification on this project?

01 Yes

02 No

98 Don't Know

99 Refused

SP 3. Please rate the level of influence the new construction rep or program material had on your design and equipment choices for the following end-use categories.

01 Definitely Influenced (4 points)

02 Possibly Influenced (2 points)

03 Did Not Influence (0 points)

SP 4. Please rate your level of interaction with your *utility's* New Construction efficiency program staff during the design and equipment selection of those projects before this building was designed. (on each end use)

01 Significant Interaction

02 Some Interaction

03 No Interaction

SP 5. Did the prior interaction influence the design and equipment choices of this project? (for each end use)

01 Definitely Influenced (2 points)

02 Possibly Influenced (1 points)

03 Did Not Influence (0 points)

Scoring Methodology

Each of the questions above attempts to investigate the various ways the customer might have been influenced by previous NRNC programs or utility program staff. Similar to the free-rider analysis, the spillover analysis relies on end-use specific customer self-report methods for estimating the amount of spillover. However, unlike the participant sample where measure specific data exists (e.g., tracking data, files), there is very little readily available information on the non-participant buildings.

The difficulty that exists is trying to understand what the non-participant would have done at the end-use level had there been no previous program influences.

Questions SP01-SP05 from above were asked of the non-participant respondent. If the customer responded "no" to most or all questions, then there is no spillover, however if the customer responded "yes, or possibly" then there is most likely some amount of spillover. We then asked end-use level questions to try to determine where the spillover occurred within the building design.

One problem remained however, the interviewer still had no information on whether or not the end-use in discussion was truly energy efficient or whether the customer just believed it to be. Typically the on-site and subsequent DOE2 model are unavailable at the time of the decision-maker surveys and cannot be used to inform us if any of the end-uses are energy efficient, or built more efficient than code. However, it was posed that if the decision-maker interview questions were withheld until the on-site survey and modeling tasks were completed we could use the data to inform the DM survey questions. With this information the interviewer would have more strategic information for directing end-use specific spillover questions to the respondent. This was the approach used for the non-participants. Initial contact was made with the decision-maker to explain the nature of the study and ultimately gain permission to conduct an on-site survey. Once the data collection and simulation model was complete, the decision-maker was re-contacted to complete the end-use level questions.

The spillover scoring methodology is based on the answers to questions SP3 and SP5. The score for each measure range from 0, which represents a measure that was not at all influenced by the program rep or material, up to 6, for absolute spillover. The measure is assigned up to four points for SP3 and two points for SP5. Since SP3, the level of influence the program rep or material had on the design and equipment choices on the current project, is the essence of spillover, it logically follows that scoring for this question is weighted greater than question SP5. Question SP5, whether the customer's prior interaction with the program rep or material played a role in influencing the measure, is secondary but is given some consideration since previous interaction with the program rep or program material may have influenced the design and equipment choices for the current project. The previous interaction may have had a lasting impact on the customer which would influence them to design differently than they would have without the previous interaction.

As stated in the free-ridership assessment, energy efficiency measures can be classified into two distinct types, dichotomous measures, that are either implemented or not, such as VFDs and lighting controls, and measures with continuous or incremental efficiency ratings such as motor efficiency and glazing performance.

A copy of the database containing all of the “as surveyed” non-participant models was made after finalization of calibration and quality control. This copy was converted into a “modified” or spillover database. The spillover database consisted of adjustments of efficiency levels and removals of dichotomous measures from the “as-surveyed” database, according to the spillover assessment.

Dichotomous measures were left in the models when measures had scores of three or less. The dichotomous measure was removed from the spillover model if the score was four or greater.

For measures with continuous or incremental energy efficiency ratings, a spillover energy rating was calculated using the following formula.

$$\frac{[(6-Score)(AsBuiltRating)]+[(Score)(BaselineRating)]}{6} = SpilloverRating$$

For example, the lighting power density (LPD) measure of one site had a spillover score of 3. When asked SP3, the site contact claimed to have been possibly influenced by the program rep or material on the current project, which counts two for the spillover score. When asked question SP5, the same site contact claimed that there was a possibility that *prior* interaction with the program rep or material influenced the current project, counting one points in the spillover scoring. For this site, the as built LPD was 1.0 Watts per square foot. The space, which was an office, had a baseline LPD of 1.6 Watts per square foot. These values and the score were plugged into the above equation.

$$\frac{[(6-3)(1.0)]+[(3)(1.6)]}{6} = 1.3$$

Therefore the spillover LPD for this space was 1.3 Watts per square foot. In the spillover model, lighting fixtures were added until the LPD was brought up to 1.3 Watts per square foot. For sites with multiple space types, the same adjustment approach was applied to every space type.

A spillover rating was calculated for all continuous energy ratings to be modified, including motor efficiency, cooling EER, lighting power density, glazing U-value and shading coefficient. These were calculated on a per item basis and adjusted individually to create the spillover models.

As another example, high performance glazing measure of one site had a spillover score of 5. When asked SP3, the site contact claimed to have been definitely influenced by the construction rep or program material, which counts four for the spillover score. When asked question SP5, the same site contact claimed that the prior interaction with the rep or program information possibly influenced the design and equipment choices of this project, counting 1 towards the spillover score. The total spillover score for the high performance glazing measure for this site would be 5, indicating strong spillover. Therefore, the U-Value and the shading coefficient would be increased.

Having an analogous spillover model for every "as-surveyed" model provided a simple approach to the calculation of spillover. The spillover savings were calculated as the difference between the gross savings and the net savings for the non-participants. The following equation shows the actual calculation that was used to compute the spillover:

$$SpilloverSavings = GrossSavings - NetSavings:$$

$$[Baseline - AsBuilt]_{\substack{As-Surveyed \\ Model}} - [Baseline - AsBuilt]_{\substack{Spillover \\ Model}}$$

Spillover was calculated for each site in the sample. MBSS ratio estimation was be used to estimate the total amount of spillover occurring in the NRNC population. The result is total spillover, and spillover at the end-use level for the population. As shown in the owner survey results chapter, the only spillover in the non-participant population was for the lighting end use.