Final Report

1999-2001 Building Efficiency Assessment (BEA) Study

An Evaluation of the Savings By Design Program

Prepared for California's Investor Owned Utilities:

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL® Company

SDGE
A Sempra Energy utility

PG&E Pacific Gas and Electric Company
WE DELIVER ENERGY.

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Dr. Roger Wright of RLW Analytics directed the evaluation and Matt Brost was acting project manager. RLW would also like to thank our sub-contractors for their excellent field work, Architectural Energy Corporation led the engineering simulation tasks and Eskinder Berhanu and Associates assisted in the field data collection.

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Executive Summary

This document is the final report for the Building Efficiency Assessment (BEA) study for the statewide Non-Residential New Construction (NRNC) program area, covering program years 1999-2001. This report contains summary results for both program participants of Savings By Design (SBD) and program non-participants. Savings By Design is the statewide NRNC energy efficiency program administered by the California investor-owned utilities (IOUs) PG&E, SCE, and SDG&E. Southern California Gas (SCG) also runs the program, but this study does not include SCG participants.

The key objectives of the study are to:

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

The evaluation is based on DOE-2 engineering models that are informed by detailed onsite audits and statistically projected to the program population, as well as by surveys with the building owners and design teams regarding the energy design choices made for these buildings.

Gross Impact Findings

This section presents gross impact findings for the statewide Savings By Design program. The evaluation results show that the utilities are doing well at estimating program impacts, which is supported by a 107% and 103% gross realization rate respectively for energy and demand, as shown in Table 1. These findings are based on sample sizes that comprise approximately 50% of the program's tracked energy and demand savings.

	Program Tracking Savings	Sampled Savings	% Sampled Savings	Estimated Gross Savings	Gross Realization Rate	Measures Only Savings	Measures Only Realization Rate
Energy (MWh)	90,288	46,710	52%	96,244	107%	74,920	83%
Demand (MW)	26.7	11.9	45%	27.4	103%	20.1	75%

Table 1: Evaluated Gross Energy and Demand Impacts

The evaluated gross savings methodology includes participant spillover. Under the BEA gross impact evaluation methodology, the utilities are credited for participant non-incented end-use efficiencies that are more efficient than baseline. Conversely, the utilities are penalized for participant end-use efficiencies that are found less efficient than baseline. The final two columns of Table 1 also show the measure only savings for both energy and demand. The evaluation findings suggest that under the measures only methodology 83% and 75% of energy and demand tracking savings, respectively, are being realized. These results imply that approximately 25% of the gross savings is due to participant spillover.

Net Impact Findings

In the absence of shareholder earnings claims, the utilities saw value in readdressing the method in which net savings are calculated for NRNC evaluation, measurement and verification (EM&V). The past several NRNC evaluations utilized an approach called the "Difference of Differences" to measure net impacts. Unfortunately the difference-of-differences methodology can provide a biased estimate with regard to free-ridership among program participants, and has no ability to report non-participant spillover. [1] The lack of non-participant spillover means that it fails to take into account any program influence in the non-participant population that is attributable to the program. Therefore we felt it was necessary to come up with an alternative to the difference-of-differences methodology that has served well in the past.

With this in mind, we developed the self-reported methodology to better estimate participant free-ridership and spillover savings, or what we refer to as non-participant net savings. We were fully aware that historically California program evaluations avoided using self-reported information, but we were compelled to pursue this methodology in light of the alternative. We feel that the inclusion of both free-ridership and non-participant spillover savings at the measure level in what we call "comprehensive" net savings provides the more accurate measure of actual program savings.

Table 2 presents program net savings using a decision maker self-reported methodology. In short, RLW surveyed decision makers on their efficiency choices for incented measures and measures more efficient than baseline, for participants and non-participants respectively. Based on the survey responses the engineering simulation models were adjusted to reflect these efficiency choices absent Savings By Design. The engineering models were then re-simulated. The results of these simulations were then analyzed to obtain net savings for participants and spillover savings for non-participants. Table 2 presents the findings of this analysis, which produces two net-to-gross ratios:

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

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[1] The "Difference of Differences" methodology is discussed in the Net Savings Methodology Chapter, and is also presented in the Net Savings Chapter.

First lets focus on the participant net-to-gross ratio. The participant net-to-gross is an estimate of program-induced savings, less what the participants would have done absent the program (i.e., free-ridership), as a percentage of participant gross savings. This ratio is most closely comparable to net-to-gross ratios calculated for past NRNC program evaluations conducted in California. Referring to Table 2, the participant net-to-gross is 59.3%, which means 59% of the energy savings are a direct result of the SBD program, while the difference (40.7% of the savings) is considered program free-ridership.

	Self-Report Estimate (MWh)	**Calculation**
Program Tracking Savings	90,288	A
Gross Savings	96,244	B
Gross Realization Rate	106.6%	(B/A)
Net Participant Savings	57,092	C
Participant Net Realization Rate	63.2%	(C/A)
Participant Net -to Gross Ratio	59.3%	(C/B)
NP Spillover Savings	21,397	D
Total Net Savings	78,489	(C+D)
Comprehensive Net Realization Rate	86.9%	(C+D)/A
Comprehensive Net-to-Gross Ratio	81.6%	(C+D)/B

Table 2: Program Net Savings

In order to understand why the program is experiencing 40% free-ridership we drew on data collected as part of the decision maker surveys to better understand NRNC market conditions, attitudes, and behaviors. First however we point to other dynamic influences that most certainly have contributed to free-ridership, as well as historic net-to-gross ratios that back the BEA findings.

Beginning with the latter issue, Table 3 shows net-to-gross ratios from past NRNC evaluation studies, in addition to the simple average net-to-gross ratio.

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

Table 3: Historic Net to Gross Ratios for NRNC Studies

In addition, we believe that the events that took place in the energy industry in 1999-2001 certainly had a hand in reshaping the way buildings are constructed and operated. The NRNC industry was first impacted beginning in 2000 with rolling blackouts and steep price increases in the SDG&E service territory, followed by planned SCE/PG&E rate increases and widespread speculation of price manipulation that was created by a planned deregulation of the energy industry. This uncertainty in the market likely increased interest in making buildings more efficient. This was further fueled by numerous and effective add campaigns such as “Flex Your Power” and the “20/20” program. Moreover, in the earlier stages of the “California energy crisis” the California economy was peaking, which may have led to greater investments in energy efficient products and services.

Figure 1 begins to substantiate these observations by comparing participant and non-participant efficiency as a percentage of baseline energy consumption. Figure 1 shows that non-participants are using 13% less energy than their baseline consumption. This is an improvement over RLW’s 1999 NRNC Baseline Study[2] results, which at that time showed non-participants to be using 11% less energy than baseline consumption. While the participant efficiency has slightly decreased between the two studies (16% BEA and 17% Baseline), non-participant efficiency grew a few percentage points. This increased efficiency among the non-participants may be due to the market influences discussed above, or other factors. Other factors may include other NRNC programs offered by the IOUs, such as Energy Design Resources (EDR), and also to a market that appears to be transforming.

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

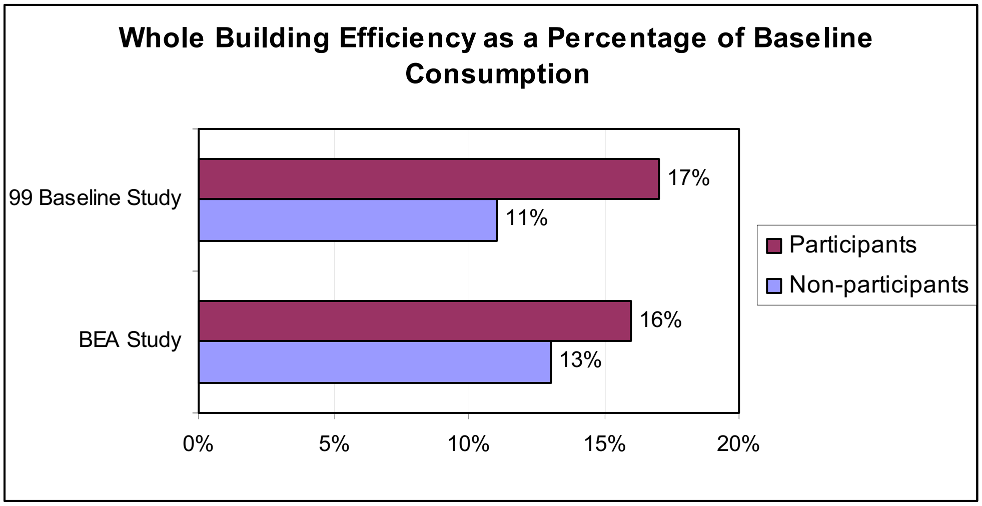

Figure 1: Comparison of Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption

Responses analyzed from the process surveys provide further insight as to why program free-ridership is exceeding 40% of the gross savings:

- **Nearly 40% of SBD participants reported having used "stock" buildings plans to construct their building.** Use of stock plans suggests a standardized building procedure that would inherently reproduce energy efficiency features and qualities time and time again.
- **Just over 30% of participants participated in the program due to previous program participation.** Where possible, utilities should look to expand their participation base of customers to reduce the saturation of customers that have previously participated.
- **40% percent of participants claim that SBD has not changed their standard building practice.** When asked why, verbatim responses suggest that for many institutions finding all available incentives is standard practice, even though energy efficiency is already a top priority. It should be noted that a fraction of these respondents would likely revert back to less efficiency design practices without the incentive, although a higher proportion of responses supported energy efficiency being standard practice.

Non-participant Spillover

The self-reported methodology used to calculate participant net savings was used in a similar way to calculate non-participant net savings. Non-participant net savings are savings that occur for non-participants as a result of prior program influence or influence from the new construction rep or program material. Using the non-participant survey responses, the non-participant engineering models were adjusted to reflect what non-participant owners reported they would have done absent any prior program influence. The results for the non-participant sample were then weighted to the non-participant population to produce an independent estimate of program-induced savings in the non-participant population.[3] Including non-participant spillover in the net savings calculation results in a second estimate of net savings, referred to in Table 2 as the comprehensive net-to-gross ratio.

As seen above in Table 2, the comprehensive net-to-gross ratio adds 21,397 MWh of energy savings attributed to spillover to the 57,092 MWh or participant net savings. The sum of these two estimates is then divided by the program gross evaluated savings, which produces a comprehensive net-to-gross ratio of 82%.

The self-reported net savings approach not only provided a means for tracking non-participant spillover, it also provided the added benefit of evaluating specific areas the program has influenced the most. Non-participants attributed nearly 18,000 MWh of lighting energy savings to the NRNC program, or about 85% of all spillover.

Another benefit of this methodology is that it produces relatively conservative estimates of both free-ridership and spillover. Decision makers will often take credit for decisions made, even though in truth they may not have been responsible for the decision they now take credit for. Since the program participant may be more likely to take credit for a good decision, than give credit to the program, we believe we are likely estimating free-ridership conservatively. Likewise, consider the program non-participant who gives the program credit for efficiency decisions rather than taking the credit. We also consider this to be conservative, since once again people are generally less likely to give credit than to take credit for good decisions made.

The statewide BEA findings show that non-participants are designing efficient lighting systems, as they are performing equally as well as the program participants. At least amongst the market segments studied for the BEA, it appears that market transformation has occurred for lighting power density measures. Figure 2 compares the LPD of participants and non-participants as a percentage of lighting baseline consumption. The results show that at the statewide level program participants and non-participants have similar end-use efficiency in LPD. Note that the statewide results are heavily influenced by the SCE service territory results which shows non-participants outperforming participants by approximately 3%, while PG&E and SDG&E participants are both performing better than non-participants.

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

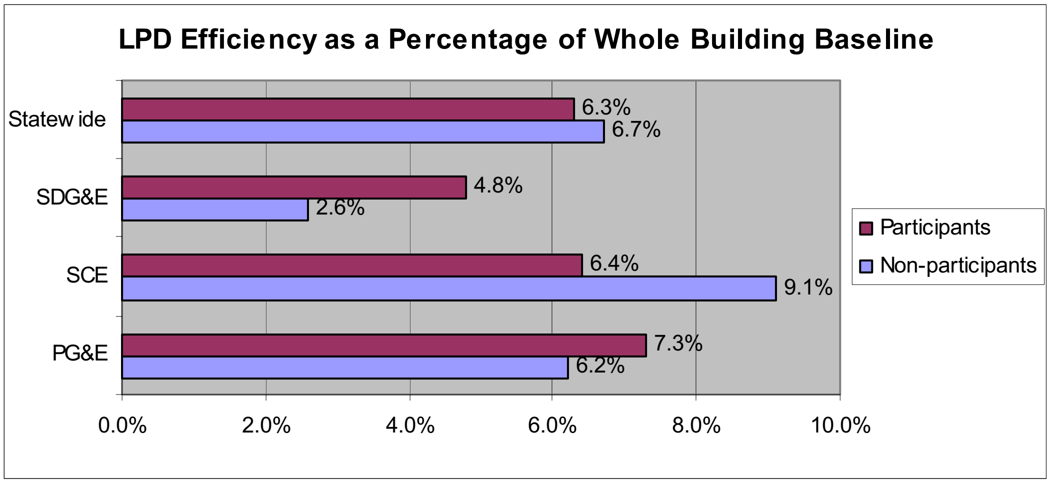

Figure 2: LPD Efficiency as a Percentage of Baseline Energy Consumption

Process Findings

Unlike past impact evaluations conducted for the CA IOUs, the BEA Study included a process evaluation component. Telephone surveys were conducted with either the building owners, or primary decision makers, in addition to the key design team member. The process questions addressed several general categories of interest:

- **Financial Criteria** – General building information such as ownership type and financial criteria used in energy efficient investments;
- **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-makers' perceptions of energy efficiency of their building;
- **Savings By Design Program Questions** – Awareness of program, motivations to participate, and barriers to participation.

Financial Criteria

Participants appear to be more sophisticated with respect to financial criteria used to justify energy efficient purchases and design decisions. Nearly 50% of participants report lowest lifetime cost as the most important financial criteria used when making energy efficiency decisions, compared to 30% of non-participants. Moreover, 20% of non-participants report lowest first cost as their primary financial criteria, contrasted with 10% of participants. This sophistication may be an adaptation resulting from program participation since one aspect of the program is teaching participants to use more complex approaches to understanding the long-term benefits of energy efficiency decision-making.

Design Team Qualifications

Forty-seven percent (47%) of participant owners considered energy efficiency qualifications when selecting their design teams, compared to 21% of non-participant owners. Participant owners are shown to have greater interest in selecting design teams with experience and qualifications in energy efficient design practice. This may be in part due to the fact that owners have more of a vested interest in exceeding Title-24 in order to qualify for the SBD incentive.

Energy Efficiency Attitudes

Program participants and non-participants have similar attitudes toward energy efficiency. Participants and non-participants alike put a high value on the efficiency of the building during design and construction and also on daily building operation. Approximately 55% of both participants and non-participants have an energy management policy.

Energy Performance

Participants and non-participants believe that their buildings are efficient. Survey respondents were asked to evaluate how efficient they thought their buildings were compared to code. Participants and non-participants were equally as likely to believe their buildings were much better than required by code. A large majority (85%) of participants believe their buildings are better than code. Most of those (52% of total) believe their buildings are slightly better than code Non-participants were significantly more likely to believe their buildings were <u>just</u> efficient enough to comply with code.

Savings By Design Program Questions

The Savings By Design incentive is the key factor that influences energy efficient building design and construction, illustrated by the following findings:

- Sixty percent (60%) of participant owners claim that the owner incentive was instrumental in changing their design practices to be more energy efficient.
- Nearly 70% of design team respondents also report the owner incentive as being very or somewhat influential.
- Seventy-seven (77%) of non-participants who were aware of SBD, but not it's incentives, and 85% of non-participants who were completely unaware of SBD before their project started report a high likelihood of designing their building to perform better than Title-24 had they known about the availability of Savings By Design incentives.

Just over 20% of participants say that the incentive was somewhat unimportant or very unimportant as a factor in their participation in the SBD program. This finding suggests that the program has other services not linked to the incentive that customers value. This is supported by the 21% of respondents who said that the Design Assistance component of the program was the most influential reason for participating.

The administrative requirements of participation continue to present SBD with a participation barrier. Forty percent (40%) of non-participants were aware of the program before design and construction began. Detailed responses suggest that this group does not see enough benefit in participating when compared to the "red tape" requirements. It also appears that improved communications between SBD program representatives and building decision makers would increase program penetration through better understanding of the program requirements and offerings.

Design Assistance/Analysis gets high marks from design team members. Of the twelve design teams surveyed that received Design Assistance/Analysis, 83% reported the service as "very valuable" and the remaining 17% reported it as "somewhat valuable". Moreover, 63% of participating design teams report the SBD program will have a lasting effect on the way they design buildings.

Many design teams are aware of SBD, but are not aware of the design team incentives that are available. Forty percent (40%) of non-participant design teams that were aware of SBD were not aware of the design team incentives. Sixty percent (60%) of non-participant design teams who were unaware of design team incentives or design assistance responded that they would have been somewhat or very likely to build a building that exceeded Title-24 by 15% or more had they been aware of design team incentives, and that they would have pursued Design Assistance/Analysis had they been aware of it. Better collaboration between the SBD representatives and the design teams will maximize future opportunities for this aspect of the program.

Practice of simulation modeling at the design stages (integrated design) is nowhere near being standard practice. About one-quarter of the design teams surveyed stated that use of computer simulation modeling for design interactions was standard practice. Verbatim responses do suggest that for many firms there has been a recent trend toward a more holistic design approach. This trend may be a result of building owners requesting an integrated design, since 70% of participant owners and 40% of non-participant owners reported having requested their design teams use an integrated design approach.

Section 1 Introduction and Overview

Introduction

RLW Analytics, Inc. (RLW) conducted an impact and a process evaluation of the 1999 – 2001 Savings By Design (SBD) Program, California's statewide non-residential new construction (NRNC) energy efficiency program, administered by PG&E, SCE, and SDG&E. Southern California Gas (SCG) also runs the program also runs the program but is not included in our study because they did not join the program until late 2000, after the BEA study had begun.

This document is the final report for the Building Efficiency Assessment (BEA) study for the statewide Non-Residential New Construction (NRNC) program area, covering program years 1999-2001. This report contains summary results for both program participants of Savings By Design (SBD) and program non-participants from 4th quarter 1999 to 4th quarter 2001. The key objectives of the study are to:

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

Evaluation Overview

RLW Analytics (RLW) of Sonoma, California is the prime contractor on this project and carried out all statistical analysis for this report. Architectural Energy Corporation (AEC) of Boulder Colorado 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) program. Our methodology builds on our prior experience evaluating the 1994, 1996, 1998 and 1999 NRNC programs for PG&E and SCE, as well as our work on the CBEE California Statewide Non-residential New Construction Baseline study.

The participant population for this study consisted of 486 sites paid in the statewide SBD program from 4th quarter 1999 to 4th quarter 2001. 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. We used a participant sample that was 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. The final participant sample size was 109 sites.

This study used a matched sample of participants and non-participants. The 1999-2001 F. W. Dodge New Construction Database was used to obtain the non-participant population. The non-participant sample was selected from those Dodge projects that have the same building type, construction start quarter, climate zone, and approximately the same square footage as the participant. The final non-participant sample size was 109 sites.

The gross savings evaluation is based on DOE-2 engineering models that are informed by detailed onsite audits and statistically projected to the program population.

The net savings self-reported free-ridership 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 one of the two ways net savings are calculated within this report. This report also presents net savings computed using the difference-of-differences + spillover methodology.

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 net savings, in addition to the difference-of-differences approach. We feel that the "comprehensive" net savings obtained from the self-report approach provides the more accurate measure of actual program savings.

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 participation paths, the systems approach and the whole building (performance) approach. The incentive structure targets both the building owner and the building design team.

Systems Approach

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

Shell Measures

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

Daylighting Systems

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

Interior Lighting Systems

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

- High-efficiency lamps
- Efficient ballasts
- Occupancy sensors
- 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[4]

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.

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

Whole Building Approach

The Whole Building Approach offers a comprehensive package of services designed to analyze energy-efficient, cost-effective design alternatives. The Whole-Building Approach is not limited to particular measures, but provides incentives based on reduced energy consumption relative to Title-24. This program component provides design assistance and 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 simulation computer tool. DOE-2, eQUEST, EnergyPro, Carrier HAP and Trane Trace are examples of computer tools approved for use by the program.

Owner Incentives

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

Under the whole building approach, the overall efficiency of the building is evaluated using a computer simulation program. If the building is at least 10% better than baseline, incentives are available. The incentives range from $0.06/annualized kWh savings to $0.18/annualized kWh savings, dependant on the amount of savings relative to Title-24. The maximum incentive is $150,000 per freestanding building or individual meter.

Under the systems approach, energy savings and incentives are calculated system-by-system, based on the quantities and efficiencies of qualifying components. Owner incentives are calculated at a rate of $0.03/annualized kWh to $0.12/ annualized kWh savings, with a maximum incentive of $75,000 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.

Savings By Design Program Activity 1999 – 2001 and Sample Summary

This section provides an overview of the statewide Savings By Design (SBD) program for the time period of 4th quarter of 1999 through 4th quarter of 2001. The following tables demonstrate the variation of results due to sponsoring utility, project size and participation path. Analysis of these differences provides insight into the underlying patterns and trends within the program delivery history, and provides a foundation for future program modifications.

Program Tracking Savings

Table 4 shows the number of projects, the total associated program tracking energy savings, and the energy savings per square foot by utility for the Savings By Design program. SCE projects account for nearly 60% of the energy savings, even though they only account for approximately 35% of the projects, suggesting that the SCE projects tend to save more energy per project than those from the other utilities. This is supported by the fact that SCE has the highest amount of energy savings per square-feet for participant projects at 2.59.

	# Projects	Total MWh	Average MWh	kWh / SQFT
PG&E	127	19,418	152.90	2.11
SCE	169	53,835	318.55	2.59
SDG&E	190	17,034	89.65	1.96
Statewide	**486**	**90,288**	**185.78**	**2.34**

Table 4: Savings By Design Program Tracking Savings

Program Participation Method

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

Table 33 shows the number of projects, the associated energy savings and savings per square foot by participation approach. During the first two years of operation Savings By Design had a total of 49 Whole Building (WBA) projects, or 10% of the total. SDG&E had the most performance projects of any utility, with 30. However SDG&E had the least amount of energy savings per WBA project SCE had the fewest number of performance projects, with six, but saved the most energy per project. SDG&E had the highest ratio of performance to systems projects, with 15% of their participation being performance based, compared to 4% for SCE and 10% for PG&E.

Statewide, Whole Building projects are expected to save more energy per square foot than are system projects. This holds true for both PG&E and SDG&E. Only SCE, with 6 performance projects, has a greater estimated savings per sqft for systems projects as compared to performance projects. On average, the SBD program tracking database estimates 2.34 kWh savings per square foot for all participants.

	PG&E			SCE			SDG&E			Statewide		
	# Projects	MWh Savings	kWh / SQFT	# Projects	MWh Savings	kWh / SQFT	# Projects	MWh Savings	kWh / SQFT	# Projects	MWh Savings	kWh / SQFT
Systems Approach	114	13,868	2.01	163	46,285	2.60	160	12,677	1.78	437	72,830	2.29
Whole Building Approach	13	5,550	2.44	6	7,550	2.56	30	4,357	2.78	49	17,458	2.57
Overall	127	19,418	2.11	169	53,835	2.59	190	17,034	1.96	486	90,288	2.34

Table 5: Savings By Design Participation Approach: System vs. Whole Building

Program Participation & BEA Sample Size

Table 6 shows Savings By Design quarterly program participation and evaluation sample sizes by utility. Approximately 60% of both the population and sample were paid during the 2nd quarter of 2001 through the 4th quarter of 2001. Notice that PG&E had a relatively late start, with only five completed projects by the second quarter of 2000, while SCE and SDG&E had 24 and 14 completed by the same time, respectively.

Quarter	PG&E		SCE		SDG&E		Statewide	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample
1999_4	-	-	8	5	7	1	15	6
2000_1	-	-	6	1	6	1	12	2
2000_2	5	1	10	5	1	-	16	6
2000_3	7	1	14	5	21	4	42	10
2000_4	10	3	16	5	27	2	53	10
2001_1	2	-	14	3	27	5	43	8
2001_2	21	6	27	9	22	1	70	16
2001_3	42	8	43	13	17	2	102	23
2001_4	40	8	31	11	62	7	133	26
Overall	**127**	**27**	**169**	**59**	**190**	**23**	**486**	**109**

Table 6: Savings By Design Program Participation by Quarter and Utility (Number of Projects)

Table 7 shows SBD program population and sample sizes by stratum and utility service territory. Stratum 1 is for small sites, in terms of energy savings and 6 is for large sites. For a complete description of the stratum definitions, refer to the participant sample design section of this report. The majority of the sites from the larger strata (i.e. the sites with the larger values of program tracking kWh savings) are from the SCE territory. SCE had 17 of 22 stratum 6 sites. This explains why SCE reports having two to four times more energy savings per project than PG&E and SDG&E, respectively (Table 5).

Stratum	PG&E		SCE		SDG&E		Statewide	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample
1	45	5	47	6	93	8	185	19
2	43	7	45	6	59	5	147	18
3	15	4	24	8	19	6	58	18
4	12	4	15	12	12	2	39	18
5	9	4	21	13	5	1	35	18
6	3	3	17	14	2	1	22	18
Overall	127	27	169	59	190	23	486	109

Table 7: Savings By Design Program Participation by Stratum and Utility

Table 8 presents the number of sites and average square footage for the participant sample for 4th quarter 1999 – 4th quarter 2001, by building type and utility. A larger percentage of SCE sites were sampled than PG&E and SDG&E sites since the sample was designed using energy savings as the stratification variable.

Building Type	PG&E		SCE		SDG&E		Statewide	
	# Sites	Ave. SQFT	# Sites	Ave. SQFT	# Sites	Ave. SQFT	# Sites	Ave. SQFT
C&I Storage	3	228,847	17	402,150	3	91,750	23	339,058
Grocery Store	1	52,564	3	94,955	-	-	4	84,358
General C&I Work	2	195,000	13	228,589	4	71,583	19	191,999
Medical / Clinical	1	13,800	-	-	-	-	1	13,800
Office	10	122,916	6	188,559	9	53,092	25	113,534
Other	-	-	2	57,219	-	-	2	57,219
Religious Worship, Auditorium, Convention	-	-	2	40,543	1	53,000	3	44,695
Restaurant	1	6,000	2	3,102	1	3,804	4	4,002
Retail and Wholesale Store	8	110,838	7	140,359	3	114,184	18	122,876
School	1	85,477	3	43,348	2	18,646	6	42,136
Theater	-	-	2	70,000	-	-	2	70,000
Gymnasium	-	-	1	71,000	-	-	1	71,000
Libraries	-	-	1	183,495	-	-	1	183,495
Total	**27**	**124,083**	**59**	**219,207**	**23**	**64,176**	**109**	**162,931**

Table 8: Participant Sample by Building Type and Utility

Section 2 Presentation of Results

- **Gross Savings Results**
- **Net Savings Results**
- **Process Evaluation**
- **Program Observations and Recommendations**

Gross Savings Results

This section presents the gross energy savings and demand reduction results. Energy savings and demand reduction results for the combined building total as well as for shell, lighting power density, daylighting controls, other lighting controls, motors, HVAC, and refrigeration measure groups are presented in this chapter. Projects that were incented under the Whole Building Approach are reported under the measure group labeled "Whole Building", while the difference between the baseline consumption and as-built consumption for the population of projects will be referred to as the "Combined Total."

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[5]. 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.

Statewide Energy Findings

All Measures

We begin the energy impacts section by reporting findings for all measures. Table 9 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 96,244 MWh, representing a gross realization rate of 106.6%.

Program Tracking Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Estimated Energy Savings (MWh)	Realization Rate
90,288	46,710	51.7%	96,244	106.6%

Table 9: Combined Total Annual Gross Energy Savings

Figure 3 shows the composition of annual gross energy savings by measure type. Lighting measures (i.e. lighting power density, daylighting controls, and other lighting controls) account for just over 50% of the annual energy savings among program participants. Approximately 20% of the savings are due to Whole Building measures, while HVAC and Motors measures each comprise an additional 10%.

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

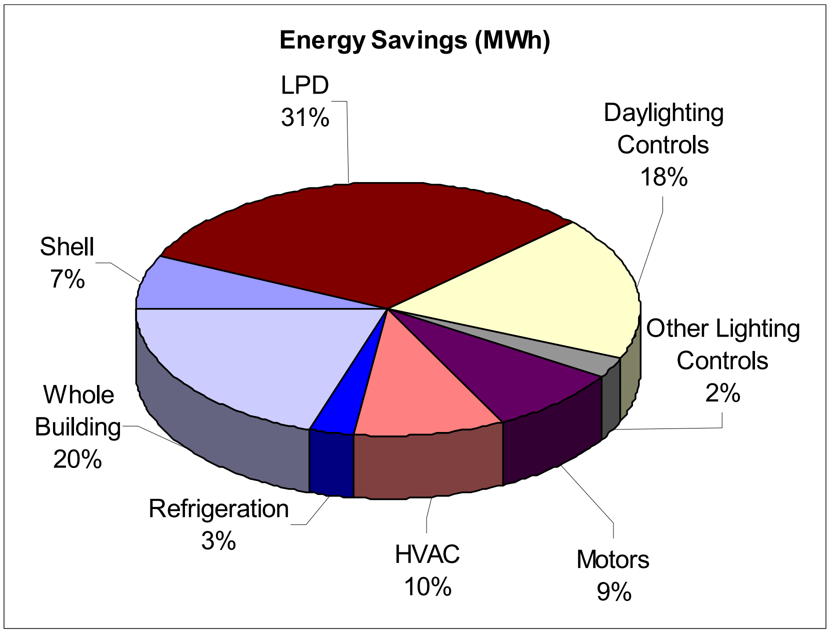

Figure 3: Composition of Annual Gross Energy Savings as % of the Combined Total

Table 10 shows the estimated energy savings and error bound by measure type as well as for the combined total. The combined total energy savings were 96,244 MWh, with an error bound of 9,541 MWh, yielding a 90% confidence interval of (86,703, 105,785) MWh.

Each end use is a category of energy consuming measures that contribute to the total energy consumption of a building. The 'measure categories' in this report refer to the measures that define each of the DOE-2 parametrics. The 'shell' measure category has no value in the final column labeled 'Savings as % of End Use Baseline' because 'shell' measures do not directly consume energy and thus have no end use baseline consumption.

	Measure Category	Energy Savings (MWh)	Error Bound	Relative Precision	Savings as % of End Use Baseline
Systems Approach	Shell	6,808	3,023	44.4%	-
	LPD	29,868	5,964	20.0%	16.9%
	Daylighting Controls	17,596	3,675	20.9%	10.0%
	Other Lighting Controls	2,305	939	40.8%	1.3%
	Motors	8,364	2,869	34.3%	10.7%
	HVAC	9,342	2,687	28.8%	5.8%
	Refrigeration	2,733	1,786	65.3%	14.3%
	Whole Building	19,227	5,036	26.2%	28.6%
	Combined Total	96,244	9,541	9.9%	16.2%

Table 10: Annual Gross Energy Savings

Statewide Energy Savings as a Percentage of Baseline

This section compares the participant savings to the non-participant savings. The participant group was *more* energy efficient than the non-participant group. Figure 4 shows the savings of both program participants and non-participants expressed as a percentage of baseline for each group. The figure also presents the relative performance of each group's building total baseline usage. The participants were 16.2% better than baseline on average, while the non-participant comparison group was 13.4% better than baseline. For this analysis we have included the whole building projects with the systems approach projects by disaggregating the end-uses into the categories presented below. The participants are more efficient than the non-participants for HVAC, motors, daylighting controls and shell. However the non-participants were found to be slightly more efficient than the participants for the lighting power density, other lighting controls, and refrigeration end uses.

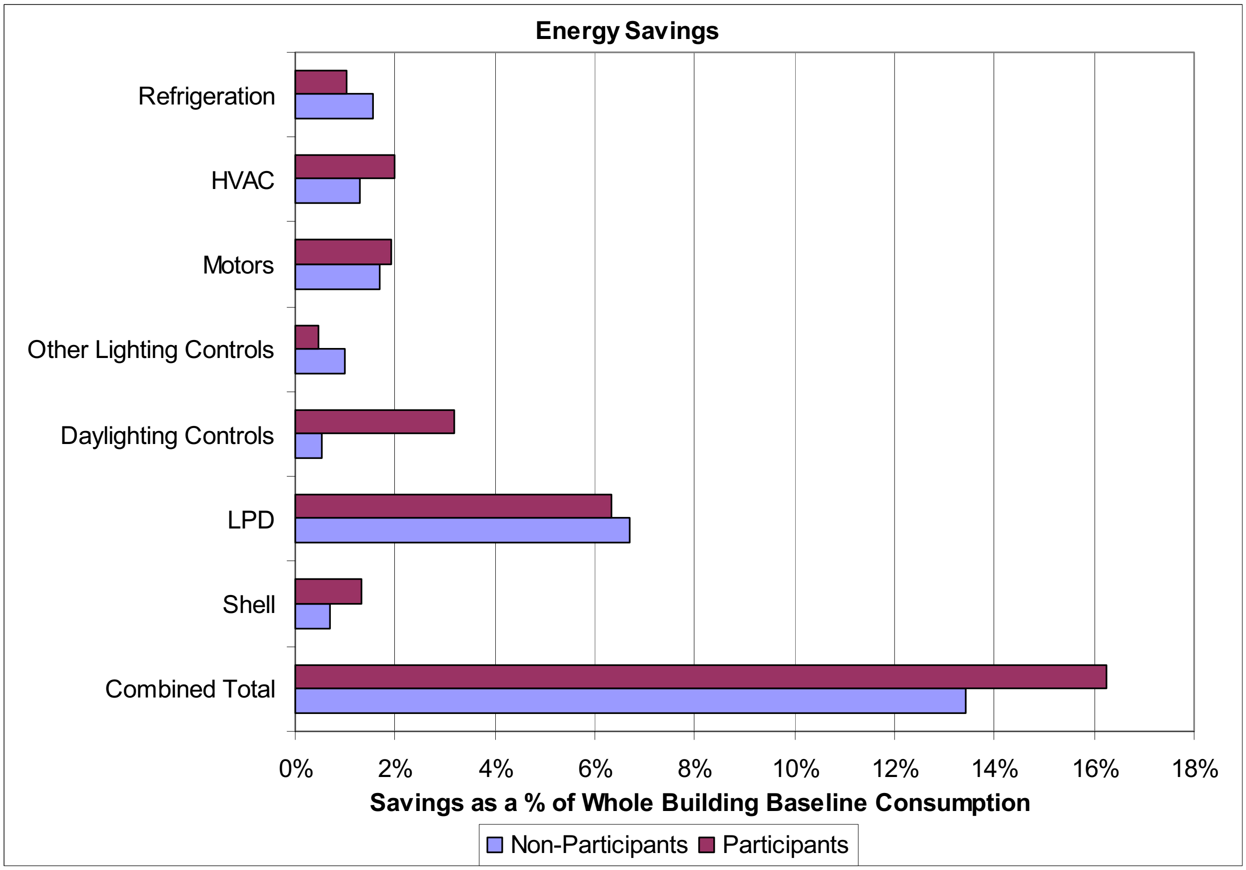

Figure 4: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption

Incented Measures

Incented measures refer only to the measures explicitly paid for within a specified end-use. Table 11 summarizes the annual gross energy savings due to incented measures relative to the energy savings from the program tracking databases. For all program participants, the combined total annual gross energy savings due to incented measures were estimated to be 74,920 MWh, representing a gross realization rate of 83.0%.

Program Tracking Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Estimated Energy Savings (MWh)	Measures Only Realization Rate
90,288	46,710	51.7%	74,920	83.0%

Table 11: Annual Gross Energy Savings– Incented Measures Only

Table 12 shows the estimated annual gross energy savings and gross realization rates for incented measures only. Just over 25% of the savings due to incented measures are accounted for by whole building approach measures. The lighting power density and daylighting controls measures comprise nearly an additional 50% of the savings due to incented measures with each accounting for over 21,000 MWh and 15,000 MWh of savings, respectively. Table 12 also displays whole building measures yielding the largest program savings as a percentage of the end use baseline energy usage, producing approximately 29% savings above the end use baseline energy usage.

Table 12 also shows that whole building measures are the only measure type with a gross realization rate of 100% or greater. HVAC and motors measures are experiencing the lowest gross realization rates.

	Measure Category	Energy Savings (MWh)	Error Bound	Relative Precision	Savings as % of End Use Baseline	Program Tracking Energy Savings (MWh)	Gross Realization Rate
Systems Approach	Shell	1,151	736	64.0%	-	1,382	83.3%
	LPD	21,782	4,850	22.3%	24.7%	23,267	93.6%
	Daylighting Controls	15,800	3,386	21.4%	25.2%	19,389	81.5%
	Other Lighting Controls	-	-	-	-	-	-
	Motors	5,382	1,943	36.1%	14.1%	9,804	54.9%
	HVAC	9,507	2,122	22.3%	8.3%	15,874	59.9%
	Refrigeration	2,071	1,353	65.3%	18.3%	2,981	69.5%
	Whole Building	19,227	5,036	26.2%	28.6%	17,591	109.3%
						-	0
	Combined Total	74,920	8,426	11.2%	12.6%	90,288	83.0%

Table 12: Annual Gross Energy Savings and Realization Rates by Measure Category – Incented Measures Only[6]

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

Figure 5 shows the composition of the total estimated annual gross energy savings for incented measures only.

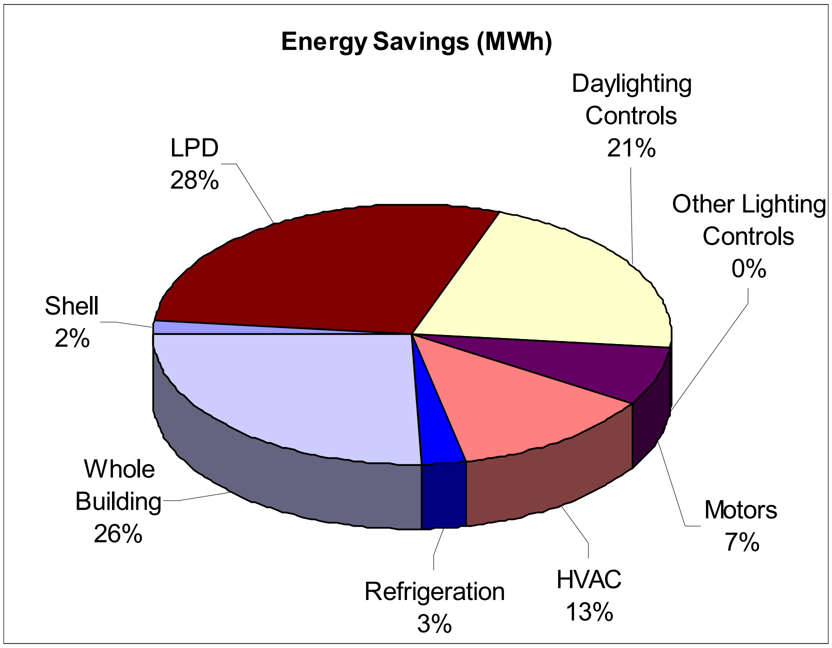

Figure 5: Composition of Annual Energy Savings – Incented Measures Only

Figure 6 shows the annual gross savings for incented measures expressed as a percentage of each end use's baseline usage. As Figure 6 shows, daylighting controls and LPD were more efficient relative to whole building baseline consumption than were other measures. For the whole building measure category, the annual gross savings relative to whole building baseline consumption was 9.4%. The annual gross energy savings resulting from daylighting control measures were nearly 2.7% of whole building baseline usage. For LPD measures, the annual gross energy savings were 3.7% of whole building baseline usage.

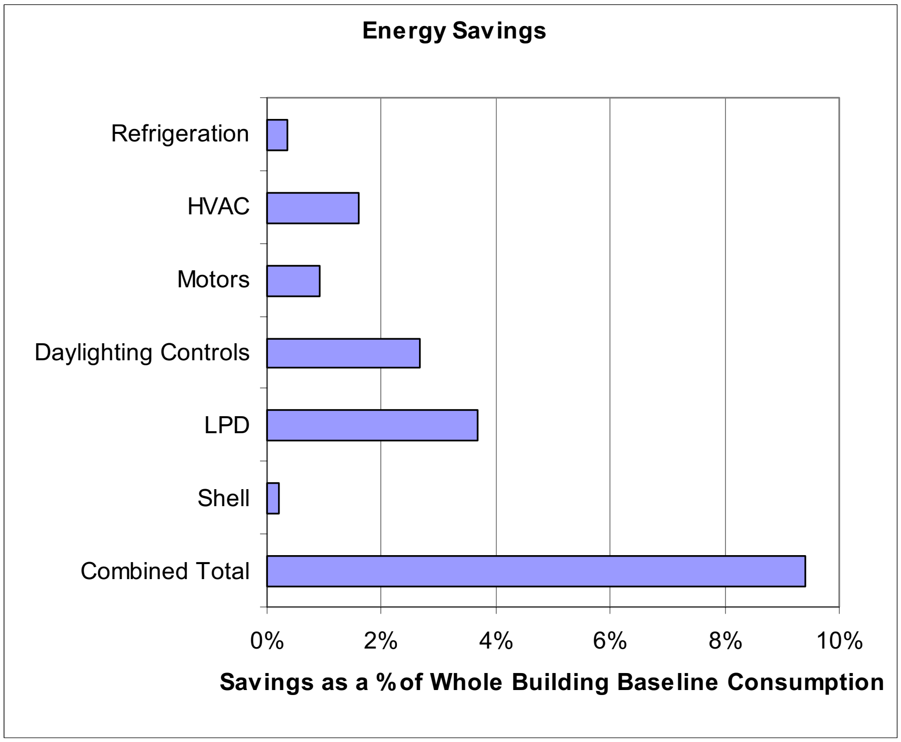

Figure 6: Energy Savings as Percentages of Whole Building Baseline – Incented Measures Only

Energy Findings by Utility Service Territory

All Measures

Table 13 presents gross energy savings by utility and the associated realization rates. Note that the sum of the savings by utility does not equal the overall program level savings presented above. This is because the program level savings are based on a combined ratio estimator, and the disaggregated results are separate ratio estimators. Since ratio estimation is a non-linear process, the results from the separate ratio estimators are non-additive.[7] SCE projects, which account for most of the gross energy savings have the lowest gross realization rate, 96.2%, while PG&E's and SDG&E's gross realization rates are 113.4% and 145.9%, respectively.

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[7] We have opted to calculate the program level savings results using the combined ratio estimator rather than the sum of the separate ratio estimators. This is because the ratio estimator is by definition a biased estimator, and the combined ratio estimator is less biased than the sum of the separate ratio estimators.

	Program Tracking Energy Savings (MWh)	Sampled Energy Savings (MWh)	% Energy Savings Sampled	Estimated Energy Savings (MWh)	Gross Realization Rate
PG&E	19,418	9,327	48.0%	22,029	113.4%
SCE	53,835	33,763	62.7%	51,811	96.2%
SDG&E	17,034	3,620	21.3%	24,855	145.9%
Overall	**90,288**	**46,710**	**51.6%**	**96,244**	**106.6%**

Table 13: Gross Realization Rates by Utility

Table 14 presents the gross energy savings by measure category and utility. Projects in SCE's territory account for approximately 50% of the gross energy savings, with PG&E and SDG&E each accounting for roughly 25% of the energy savings. PG&E's savings were primarily from the LPD and Whole Building measures. The SCE savings result primarily from LPD and daylighting controls. The majority of SDG&E's energy savings are represented by HVAC and Whole Building measures.

	Measure Category	Energy Savings							
		PG&E		SCE		SDG&E		Overall	
		MWh	% of MWh	MWh	% of MWh	MWh	% of MWh	MWh	% of MWh
Systems Approach	Shell	860	3.9%	3,344	6.5%	3,339	13.4%	6,808	7.1%
	LPD	10,056	45.7%	15,219	29.4%	4,102	16.5%	29,868	31.0%
	Daylighting Controls	-	-	15,355	29.6%	1,523	6.1%	17,596	18.3%
	Other Lighting Controls	182	0.8%	941	1.8%	1,599	6.4%	2,305	2.4%
	Motors	1,973	9.0%	4,069	7.9%	2,750	11.1%	8,364	8.7%
	HVAC	1,633	7.4%	3,179	6.1%	6,095	24.5%	9,342	9.7%
	Refrigeration	1,071	4.9%	1,243	2.4%	377	1.5%	2,733	2.8%
	Whole Building	6,255	28.4%	8,462	16.3%	5,070	20.4%	19,227	20.0%
	Combined Total	22,029		51,811		24,855		96,244	

Table 14: Gross Energy Savings by Utility

Table 15 shows energy savings per square foot of participant projects for each utility, by measure category. This table shows that the savings by square footage mostly matches the percent savings results above, with the exception of SCE's Whole Building category. The Whole Building Approach per square foot savings is much higher than any of the Systems Approach measures.

	Measure Category	**Energy Savings**							
		PG&E		**SCE**		**SDG&E**		**Overall**	
		MWh	**kWh / SQFT**	**MWh**	**kWh / SQFT**	**MWh**	**kWh / SQFT**	**MWh**	**kWh / SQFT**
Systems Approach	Shell	860	0.12	3,344	0.19	3,339	0.47	6,808	0.19
	LPD	10,056	1.46	15,219	0.85	4,102	0.58	29,868	0.92
	Daylighting Controls	-	-	15,355	0.86	1,523	0.21	17,596	0.57
	Other Lighting Controls	182	0.03	941	0.05	1,599	0.22	2,305	0.07
	Motors	1,973	0.29	4,069	0.23	2,750	0.39	8,364	0.28
	HVAC	1,633	0.24	3,179	0.18	6,095	0.86	9,342	0.38
	Refrigeration	1,071	0.16	1,243	0.07	377	-	2,733	0.06
	Whole Building	6,255	2.75	8,462	2.87	5,070	3.23	19,227	2.64
	Combined Total	22,029	2.40	51,811	2.50	24,855	2.86	96,244	2.49

Table 15: Utility Gross Energy Savings per Project Square Foot

Energy Savings as a Percentage of Baseline by Utility

This section presents the energy savings results graphically by utility. Figure 7 through Figure 9 show the savings of both program participants and non-participants expressed as a percentage of each group's whole-building baseline usage. For these results we have included the Whole Building Approach projects with the Systems Approach projects by disaggregating the measures into categories.

Figure 7 shows the PG&E savings of both program participants and non-participants expressed as a percentage of each group's whole-building baseline usage. As Figure 7 shows, the PG&E participants were 14.7% better than baseline on average, while the non-participant comparison group was 12.6% better than baseline. The PG&E participants are more efficient than the non-participants for HVAC, motors, daylighting controls, LPD and shell. However the non-participants were found to be slightly more efficient than the participants for other lighting controls, and refrigeration measures.

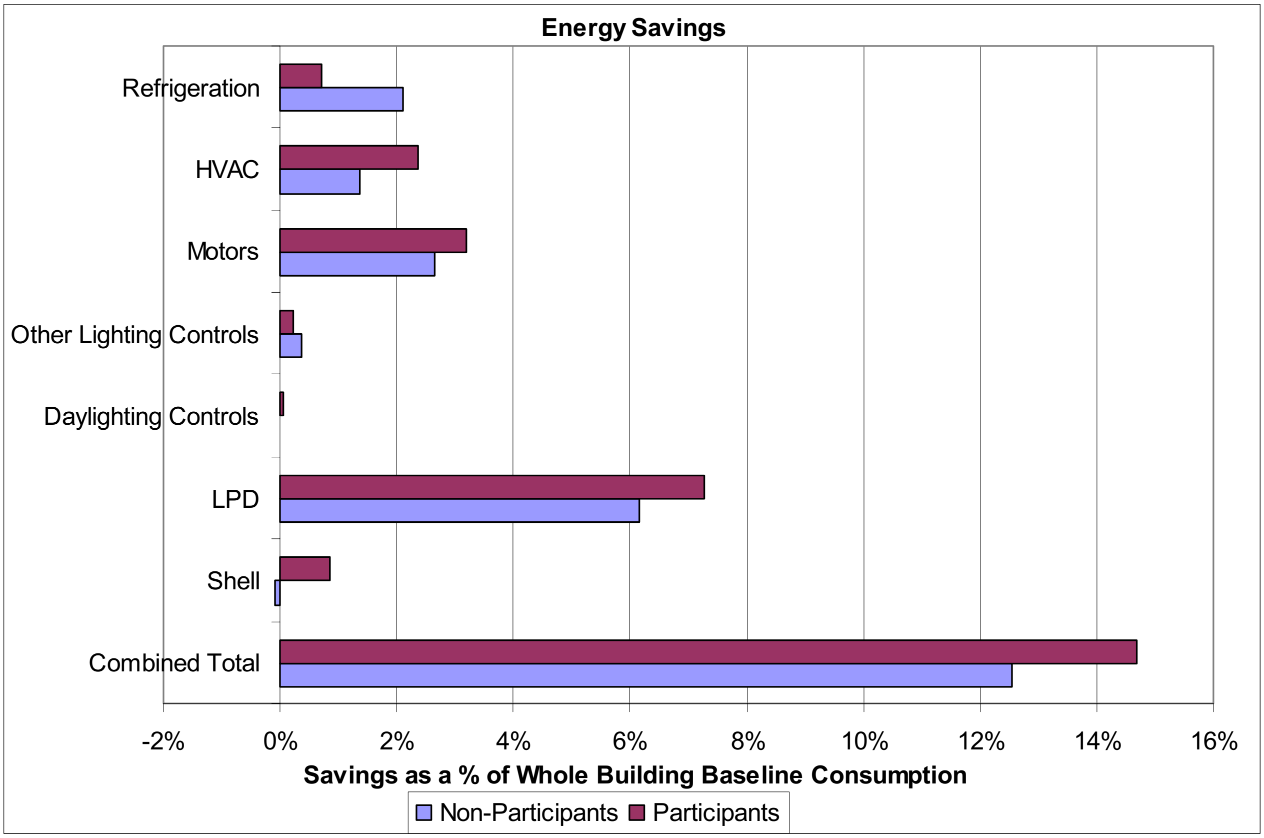

Figure 7: PG&E Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption[8]

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[8] There was one participant and no non-participants using daylighting controls. There were seven participants and four non-participants using other lighting controls. There were 2 participants and 3 non-participants using refrigeration.

Figure 8 shows the SCE savings of both program participants and non-participants expressed as a percentage of each group's whole-building baseline usage. As Figure 8 shows, the SCE participants were 17.4% better than baseline on average, while the non-participant comparison group was 14.9% better than baseline. The participants are more efficient than the non-participants for shell, daylighting controls, and refrigeration. However the non-participants were found to be more efficient than the participants for the LPD, other lighting controls, and motors end uses. For HVAC, the participants were found to be equally as efficient as the non-participants. Most notable is the performance difference between the participants and the non-participants in the LPD and daylighting controls end uses. The participants appear to be installing higher wattages per square foot but then taking advantage of daylighting controls to manage their energy consumption, whereas the non-participants appear to simply install lower watts per square foot.

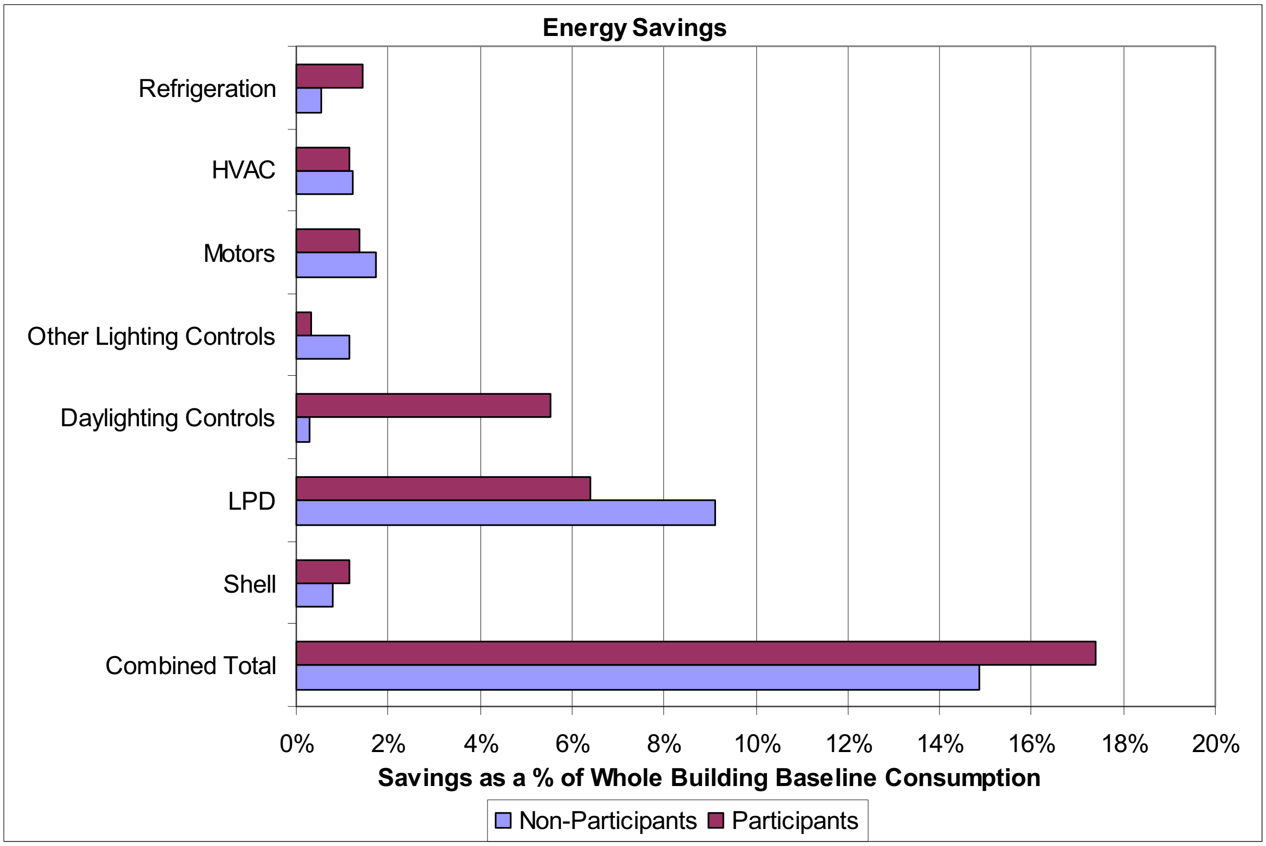

Figure 8: SCE Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption[9]

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[9] There were 30 participants and four non-participants using daylighting controls. There were twenty-four participants and twenty-one non-participants using other lighting controls. There were three participants and one non-participant using refrigeration.

Figure 9 shows the SDG&E savings of both program participants and non-participants expressed as a percentage of each group's whole-building baseline usage. As Figure 9 shows, the SDG&E participants were 15.1% better than baseline on average, while the non-participant comparison group was 12.1% better than baseline. The SDG&E participants are more efficient than the non-participants for HVAC, motors, LPD and shell. However the non-participants were found to be more efficient than the participants for the daylighting controls, other lighting controls, and refrigeration end uses.

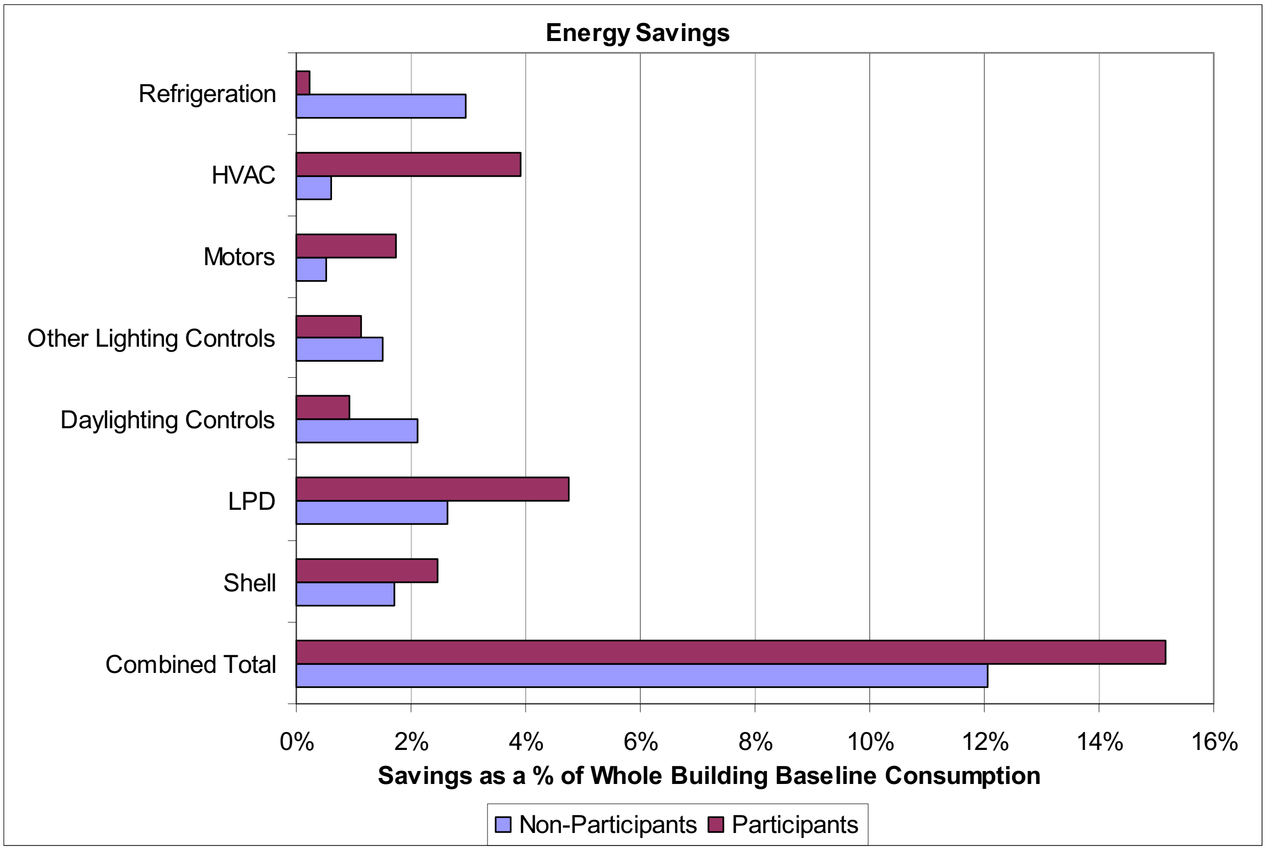

Figure 9: SDG&E Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption[10]

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[10] There was one participant and two non-participants using daylighting controls. There were ten participants and six non-participants using other lighting controls. There was one participant and one non-participant using refrigeration.

Table 16 presents the participant and non-participant energy savings as a percentage of the building baseline consumption by utility.

Measure Category	PG&E		SCE		SDG&E	
	P	NP	P	NP	P	NP
Shell	0.9%	-0.1%	1.2%	0.8%	2.5%	1.7%
LPD	7.3%	6.2%	6.4%	9.1%	4.8%	2.6%
Daylighting Controls	0.0%	0.0%	5.5%	0.3%	0.9%	2.1%
Other Lighting Controls	0.2%	0.4%	0.3%	1.2%	1.1%	1.5%
Motors	3.2%	2.6%	1.4%	1.7%	1.7%	0.5%
HVAC	2.4%	1.4%	1.1%	1.2%	3.9%	0.6%
Refrigeration	0.7%	2.1%	1.4%	0.5%	0.2%	3.0%

Table 16: Participant and Non-participant Energy Savings as a Percentage of Baseline Consumption by Utility

Incented Measures

Table 17 shows the gross savings by measure category and utility service territory for incented measures only. The overall incented measure savings as a percentage of total energy savings are relatively similar to the all measure savings as a percentage of total energy savings shown in Table 14. The shell and motors measure categories constitute a lower percentage of savings for incented measures, while the other categories constitute a higher percentage.

Note that the sum of the savings by utility does not equal the overall program level savings presented above. This is because the program level savings are based on a combined ratio estimator, and the disaggregated results are separate ratio estimators. Since ratio estimation is a non-linear process, the results from the separate ratio estimators are non-additive.[11]

Projects in SCE's territory account for over 50% of the energy savings resulting from measures incented through SBD, with PG&E and SDG&E each accounting for just over 20% of the energy savings. PG&E's savings from incented measures were primarily comprised of savings from the LPD and Whole Building measures. The savings associated with SCE incented measures result primarily from LPD and daylighting controls measures. The majority of SDG&E's energy savings are from LPD, HVAC, and Whole Building measures.

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[11] We have opted to calculate the program level savings results using the combined ratio estimator rather than the sum of the separate ratio estimators. This is because the ratio estimator is by definition a biased estimator, and the combined ratio estimator is less biased than the sum of the separate ratio estimators.

	Measure Category	Energy Savings							
		PG&E		SCE		SDG&E		Overall	
		MWh	% of MWh	MWh	% of MWh	MWh	% of MWh	MWh	% of MWh
Systems Approach	Shell	229	1.4%	429	1.0%	649	3.9%	1,151	1.5%
	LPD	7,080	42.2%	10,832	25.5%	3,801	22.9%	21,782	29.1%
	Daylighting Controls	-	0.0%	13,688	32.2%	1,523	9.2%	15,800	21.1%
	Other Lighting Controls	-	0.0%	-	0.0%	-	0.0%	-	0.0%
	Motors	917	5.5%	3,369	7.9%	1,135	6.8%	5,382	7.2%
	HVAC	1,540	9.2%	4,711	11.1%	4,072	24.5%	9,507	12.7%
	Refrigeration	756	4.5%	959	2.3%	346	2.1%	2,071	2.8%
	Whole Building	6,255	37.3%	8,462	19.9%	5,070	30.6%	19,227	25.7%
	Combined Total	16,778		42,450		16,595		74,920	

Table 17: Gross Energy Savings by Utility – Incented Measures Only

Table 18 shows gross realization rates by measure category and utility service territory for incented measures only. PG&E's gross realization rate for LPD is lower than either SCE's or SDG&E's, while PG&E's gross realization rate for motors and refrigeration is higher than both of SCE's and SDG&E's. The most notable difference among the utilities occurs in the HVAC measure category, where PG&E's gross realization rate is 60.9%, SCE's is 49.3%, and SDG&E's is 107.4%.

		PG&E			SCE			SDG&E		
	Measure Category	Estimated Energy Savings (MWh)	Program Tracking Energy Savings (MWh)	Gross Realization Rate	Estimated Energy Savings (MWh)	Program Tracking Energy Savings (MWh)	Gross Realization Rate	Estimated Energy Savings (MWh)	Program Tracking Energy Savings (MWh)	Gross Realization Rate
Systems Approach	Shell	229	145	158.2%	429	326	131.4%	649	911	71.3%
	LPD	7,080	9,292	76.2%	10,832	10,359	104.6%	3,801	3,617	105.1%
	Daylighting Controls	-	-	-	13,688	17,864	76.6%	1,523	1,525	99.8%
	Other Lighting Controls	-	-	-	-	-	-	-	-	-
	Motors	917	1,067	85.9%	3,369	6,672	50.5%	1,135	2,064	55.0%
	HVAC	1,540	2,532	60.9%	4,711	9,552	49.3%	4,072	3,790	107.4%
	Refrigeration	756	832	90.9%	959	1,513	63.4%	346	637	54.3%
	Whole Building	6,255	5,550	112.7%	8,462	7,550	112.1%	5,070	4,490	112.9%
	Combined Total	16,778	19,418	86.4%	42,450	53,836	78.9%	16,595	17,034	97.4%

Table 18: Gross Realization Rates by Measure Type and Utility – Incented Measures Only

Statewide Demand Reduction Findings

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

All Measures

Table 19 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 27.4 MW, representing a gross realization rate of 102.6%. It is important to point out that the demand savings is calculated based on the utility coincident peak, while the program calculates demand savings based on building peak demand.

Program Tracking Demand Reduction (MW)	Sampled Demand Reduction (MW)	% Demand Reduction Sampled	Estimated Demand Reduction (MW)	Realization Rate
26.7	11.9	44.8%	27.4	102.6%

Table 19: 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 40% of the summer peak demand reduction among program participants. Approximately 15% of the reduction is due to whole building measures, while HVAC measures comprise an additional 20% of the savings. HVAC and shell measures represent a larger share of the demand savings when compared to the energy savings, while the whole building and LPD demand reductions are less than the energy savings as a percent of total.

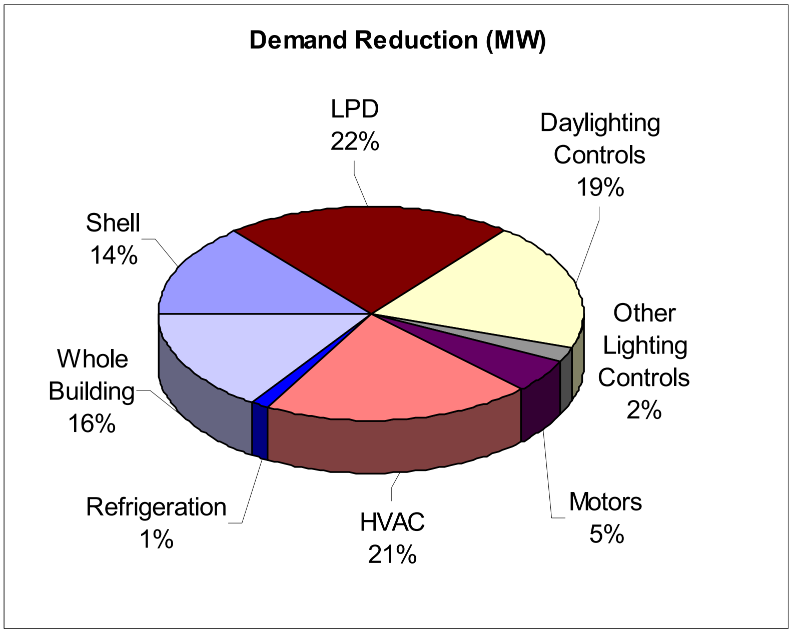

Figure 10: Composition of Summer Peak Demand Reduction

Table 20 shows the estimated gross summer peak demand reduction and error bound by measure type, as well as for combined total. The combined total gross summer peak demand reduction was 27.4 MW, with an error bound of 3.2 MW, yielding a 90% confidence interval of (24.2, 30.6) MW. In general, the demand reduction for each measure category as a percentage of its end use baseline demand is very similar to the energy savings as a percentage of its end use baseline consumption.

	Measure Category	Demand Reduction (MW)	Error Bound	Relative Precision	Reduction as % of End Use Baseline
Systems Approach	Shell	3.8	1.3	35.6%	-
	LPD	6.0	1.5	24.5%	18.8%
	Daylighting Controls	5.3	1.1	21.3%	16.7%
	Other Lighting Controls	0.6	0.3	50.0%	2.0%
	Motors	1.3	0.6	42.1%	9.5%
	HVAC	5.7	1.2	20.9%	9.7%
	Refrigeration	0.3	0.2	68.9%	14.2%
	Whole Building	4.3	1.4	31.9%	28.2%
	Combined Total	27.4	3.2	11.6%	21.1%

Table 20: Summer Peak Demand Reduction

Similar to the energy findings, the participant group was more efficient than the non-participant group in terms of coincident peak demand reduction. 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 21% better than baseline on average, while the non-participant comparison group was about 16% better than baseline. Figure 11 also shows these results by end use. For these results we have included the whole building projects with the systems approach projects by disaggregating the end-uses into the categories presented below. The participants are much more efficient than the non-participants for daylighting controls. They are also more efficient for HVAC, motors, LPD, and shell measures. However the non-participants are slightly more efficient than the participants for the other lighting controls, and refrigeration measure types.

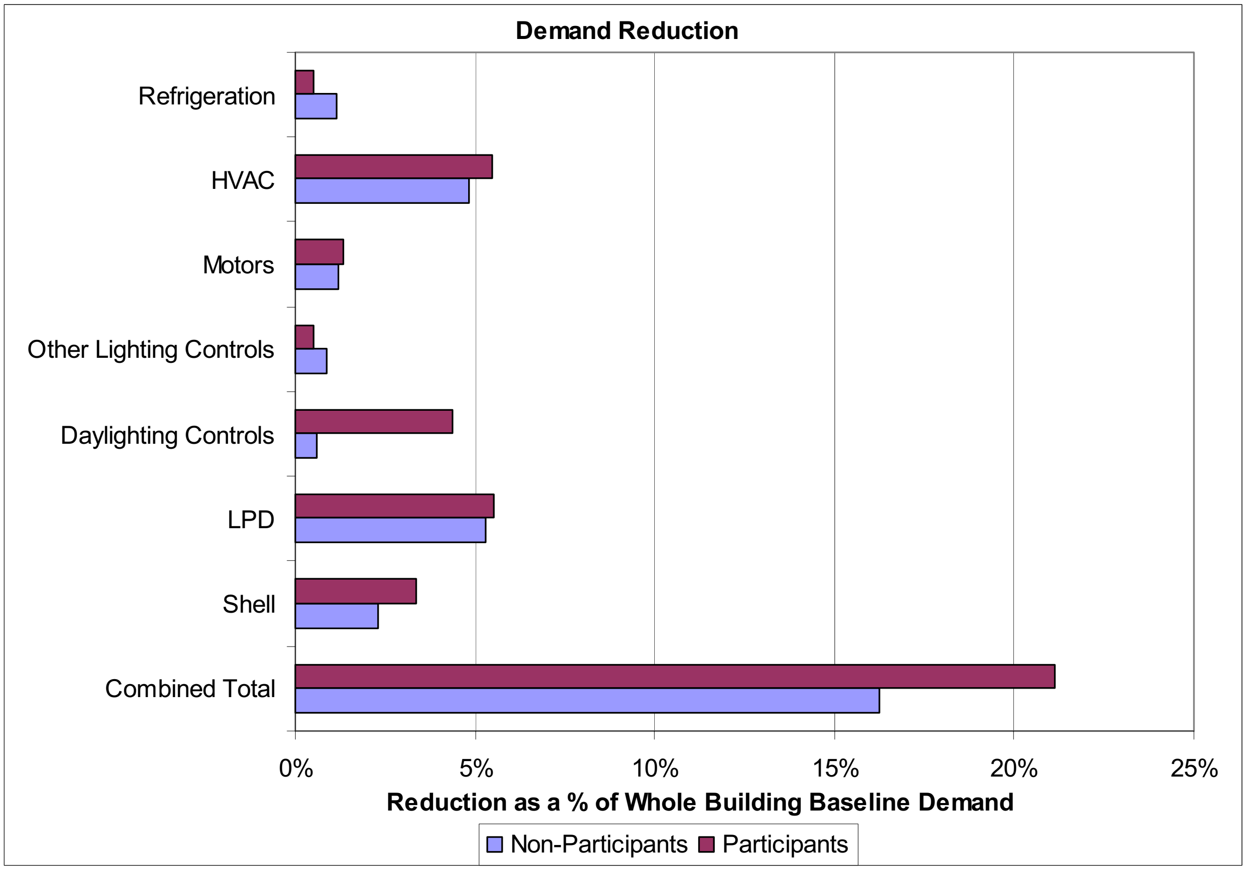

Figure 11: Participant and Non-participant Demand Reduction as a Percentage of Baseline Demand

Incented Measures

Table 21 summarizes the gross summer peak demand reduction due to incented measures relative to the summer peak demand reduction from the program tracking databases. For all program participants, the combined total gross summer peak demand reduction due to incented measures was estimated to be 20.1 MW, representing a gross realization rate of 75.3%. The demand measures only realization rate is slightly lower than the energy measures only realization rate, which was shown to be 83.0% in Table 11.

Program Tracking Demand Reduction (MW)	Sampled Demand Reduction (MW)	% Demand Reduction Sampled	Estimated Demand Reduction (MW)	Measures Only Realization Rate
26.7	11.9	44.7%	20.1	75.3%

Table 21: Summer Peak Demand Reduction – Incented Measures Only

Table 22 shows the estimated gross summer peak demand reduction and gross realization rates for incented measures only. About 21% of the reduction due to incented measures is accounted for by whole building projects. The lighting power density and daylighting controls measures comprise nearly an additional 45% of the reduction due to incented measures with each accounting for over 4 MW of reduction. HVAC measures account for approximately 24% of the demand reduction occurring from incented measures. As shown in Table 22, daylighting controls measures also yield the largest program demand reduction as a percentage of the end use baseline demand, producing approximately 49% savings above the lighting baseline demand.

Table 22 shows the estimated gross summer peak demand reduction and gross realization rates for incented measures only. About 21% of the reduction due to incented measures is accounted for by whole building projects. HVAC and daylighting controls measures each account for approximately 24% of the demand reduction occurring from incented measures. These two measures yield the largest program demand reduction as a percentage of the end use baseline demand, producing approximately 49% savings above the lighting baseline demand. The lighting power density and daylighting controls measures comprise an additional 45% of the reduction due to incented measures with each accounting for over 4 MW of reduction.

Shell and motors are the only measures with gross realization rates of 100% or greater. HVAC and whole building measures are experiencing the lowest gross realization rates.

	Measure Category	Demand Reduction (MW)	Error Bound	Relative Precision	Reduction as % of End Use Baseline	Program Tracking Demand Reduction (MW)	Gross Realization Rate
Systems Approach	Shell	0.7	0.4	61.7%	-	0.6	118.4%
	LPD	4.2	1.1	25.5%	25.6%	5.4	76.7%
	Daylighting Controls	4.7	1.0	21.6%	48.7%	5.7	82.5%
	Other Lighting Controls	-	-	-	-	-	-
	Motors	0.9	0.4	42.4%	15.4%	0.8	114.6%
	HVAC	5.0	1.1	22.3%	12.4%	7.6	66.5%
	Refrigeration	0.3	0.2	69.2%	19.7%	0.3	88.5%
	Whole Building	4.3	1.4	31.9%	28.2%	6.2	68.6%
	Combined Total	20.1	2.4	11.8%	15.5%	26.7	75.3%

Table 22: Summer Peak Demand Reduction and Realization Rates by Measure Category – Incented Measures Only

Figure 12 shows the composition of the total estimated gross summer peak demand reduction for incented measures only.

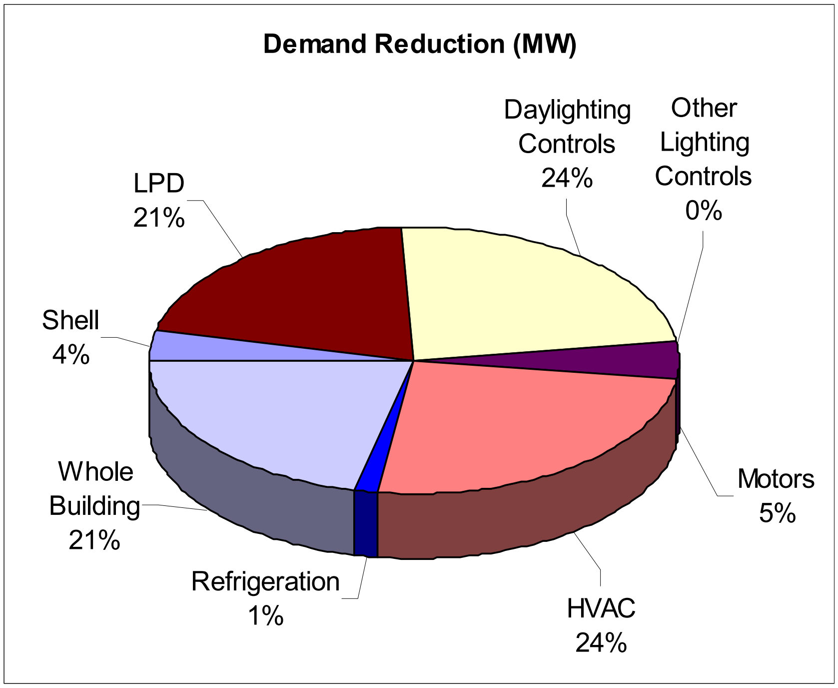

Figure 12: Composition of Summer Peak Demand Reduction – Incented Measures Only

Figure 13 shows the efficiency of the incented measures expressed as a percentage of each end use's baseline demand[12]. As Figure 13 shows, HVAC measures were more efficient relative to baseline than were other measures. For the whole building measure category, the summer peak gross demand reduction relative to whole building baseline demand was 12.2%. The LPD demand reduction arising from incented LPD measures was about 3% of the whole building baseline demand.

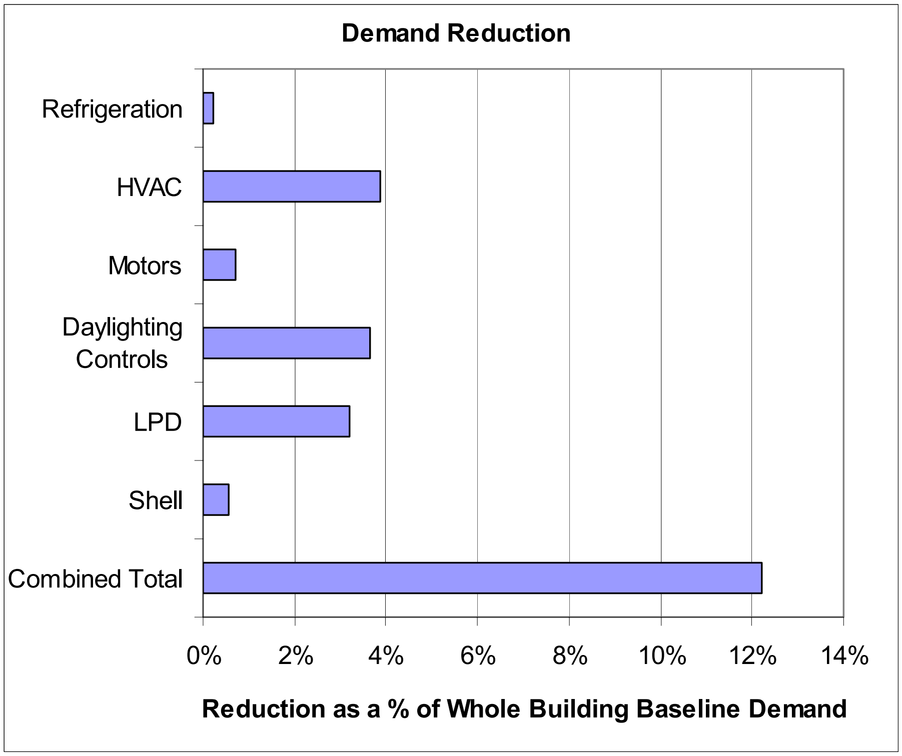

Figure 13: Demand Reductions as Percentages of Whole Building Baseline – Incented Measures Only

Demand Reduction Findings by Utility Service Territory

All Measures

Table 23 presents gross demand reduction by utility and the associated realization rates. Note that the sum of the savings by utility does not equal the overall program level savings presented above. This is because the program level savings are based on a combined ratio estimator, and the disaggregated results are separate ratio estimators. Since ratio estimation is a non-linear

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

process, the results from the separate ratio estimators are non-additive.[13] PG&E has the lowest gross realization rate, 94.5%, and SDG&E has the highest, with a gross realization rate of 118.1%. Similarly, Table 13 shows that SDG&E has the highest energy savings gross realization rate of 145.9%. However, unlike demand, PG&E has the second highest energy realization rate of 113.4% and SCE has the lowest at 96.2%.

	Program Tracking Demand Reduction (MW)	**Sampled Demand Reduction (MW)**	**% Demand Reduction Sampled**	**Estimated Demand Reduction (MW)**	**Gross Realization Rate**
PG&E	7.8	3.3	42.0%	7.3	94.5%
SCE	12.7	7.5	59.3%	13.5	106.5%
SDG&E	6.3	1.2	18.8%	7.4	118.1%
Overall	**26.7**	**11.9**	**44.8%**	**27.4**	**102.6%**

Table 23: Gross Realization Rates by Utility

Table 24 presents the gross demand reduction by measure category and utility. Projects in SCE's territory account for approximately 50% of the gross demand reduction, with PG&E and SDG&E each accounting for roughly 25% of the demand reduction. PG&E's reductions were primarily comprised of savings from the LPD, HVAC, shell, and whole building measures. The reduction associated with the SCE program results primarily from LPD, daylighting controls, HVAC, and shell measures, while the majority of demand reduction arising from incented measures in SDG&E's territory are represented by shell, LPD, HVAC, and whole building measures.

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[13] We have opted to calculate the program level savings results using the combined ratio estimator rather than the sum of the separate ratio estimators. This is because the ratio estimator is by definition a biased estimator, and the combined ratio estimator is less biased than the sum of the separate ratio estimators.

	Measure Category	**Demand Reduction**							
		PG&E		**SCE**		**SDG&E**		**Overall**	
		MW	**% of MW**	**MW**	**% of MW**	**MW**	**% of MW**	**MW**	**% of MW**
Systems Approach	Shell	1.1	15.1%	1.6	11.8%	1.3	17.7%	3.8	13.8%
	LPD	2.2	30.3%	2.8	20.6%	0.9	12.8%	6.0	21.9%
	Daylighting Controls	-	-	4.6	34.4%	0.5	6.6%	5.3	19.5%
	Other Lighting Controls	0.1	0.9%	0.2	1.7%	0.4	6.1%	0.6	2.3%
	Motors	0.2	2.5%	0.8	6.2%	0.3	4.7%	1.3	4.9%
	HVAC	1.4	19.0%	2.2	16.5%	2.6	35.7%	5.7	20.8%
	Refrigeration	0.1	1.4%	0.2	1.3%	0.1	0.8%	0.3	1.3%
	Whole Building	2.3	30.9%	1.0	7.4%	1.2	15.7%	4.3	15.6%
	Combined Total	7.3		13.5		7.4		27.4	

Table 24: Gross Demand Reduction by Utility

Table 25 shows demand reduction per square foot of participant projects for each utility, by measure category. This table shows that the demand results by square footage mostly match the percent savings results above, with the exception of SCE's Whole Building category. The Whole Building Approach demand reduction per square is much higher than any of the Systems Approach measures.

	Measure Category	**Demand Reduction**							
		PG&E		**SCE**		**SDG&E**		**Overall**	
		MW	**W / SQFT**	**MW**	**W / SQFT**	**MW**	**W / SQFT**	**MW**	**W / SQFT**
Systems Approach	Shell	1.1	0.16	1.6	0.09	1.3	0.18	3.8	0.12
	LPD	2.2	0.32	2.8	0.16	0.9	0.13	6.0	0.19
	Daylighting Controls	-	-	4.6	0.26	0.5	0.07	5.3	0.17
	Other Lighting Control	0.1	0.01	0.2	0.01	0.4	0.06	0.6	0.02
	Motors	0.2	0.03	0.8	0.05	0.3	0.05	1.3	0.04
	HVAC	1.4	0.20	2.2	0.12	2.6	0.37	5.7	0.18
	Refrigeration	0.1	0.01	0.2	0.01	0.1	0.01	0.3	0.01
	Whole Building	2.3	1.00	1.0	0.34	1.2	0.74	4.3	0.63
	Combined Total	7.3	0.80	13.5	0.65	7.4	0.85	27.4	0.71

Table 25: Utility Gross Demand Reduction per Project Square Foot

Demand Reduction as a Percentage of Baseline by Utility

This section presents the demand reduction results graphically by utility.

Figure 14 through Figure 16 show the savings of both program participants and non-participants expressed as a percentage of each group's whole-building baseline usage. For these results we have included the Whole Building Approach projects with the Systems Approach projects by disaggregating the measures into categories.

Figure 14 shows the PG&E demand reduction of both program participants and non-participants expressed as a percentage of each group's whole-building baseline demand. As Figure 14 shows, the PG&E participants were 19.2% better than baseline on average, while the non-participant comparison group was 14.7% better than baseline. Similarly, the participant's energy savings as a percentage of baseline consumption also outperformed that of non-participants. Like energy savings, PG&E participants are more efficient than the non-participants for HVAC, LPD, shell, and marginally motors. However the non-participants were found to be slightly more efficient than the participants for the other lighting controls and refrigeration measure types.

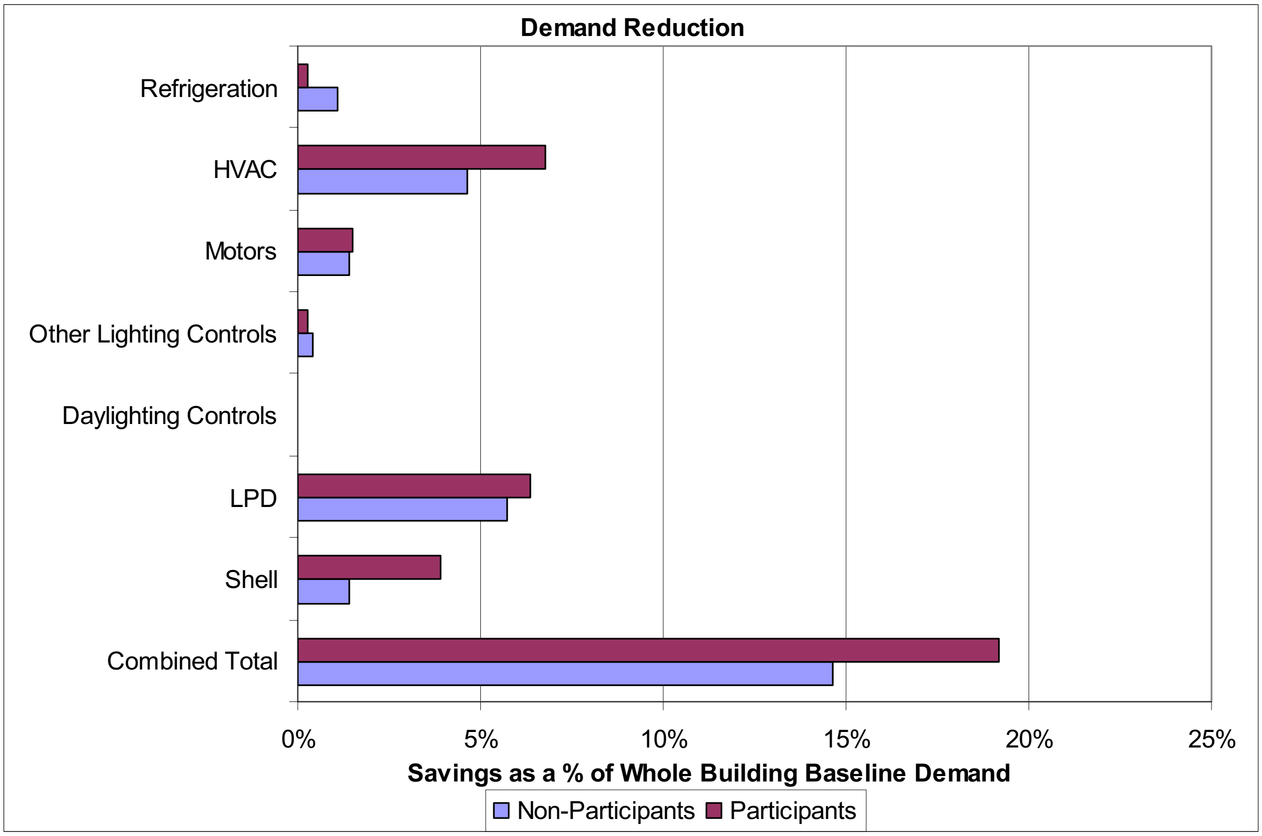

Figure 14: PG&E Participant and Non-participant Demand Reduction as a Percentage of Baseline Demand[14]

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[14] There was one participant and no non-participants using daylighting controls. There were seven participants and four non-participants using other lighting controls. There were 2 participants and 3 non-participants using refrigeration.

Figure 15 shows the SCE demand reduction of both program participants and non-participants expressed as a percentage of each group's whole-building baseline demand. As Figure 15 shows, the SCE participants were 23.2% better than baseline on average, while the non-participant comparison group was 19.5% better than baseline. Participants also outperformed non-participants in energy savings as a percentage of baseline consumption as presented in Figure 8. Very similarly to energy savings, participants are much more efficient than the non-participants for daylighting controls. Participants are also more efficient for refrigeration as with their energy savings. However, like SCE's energy results the non-participants were found to be more efficient than the participants for the LPD, other lighting controls, and HVAC measures. For motors and shell measures, the participants and non-participants were found to be roughly equally efficient. Most notable is the performance difference between the participants and the non-participants in the LPD and daylighting controls end uses. The participants appear to be installing higher wattages per square foot but then taking advantage of daylighting controls to manage their demand, whereas the non-participants appear to simply install lower watts per square foot.

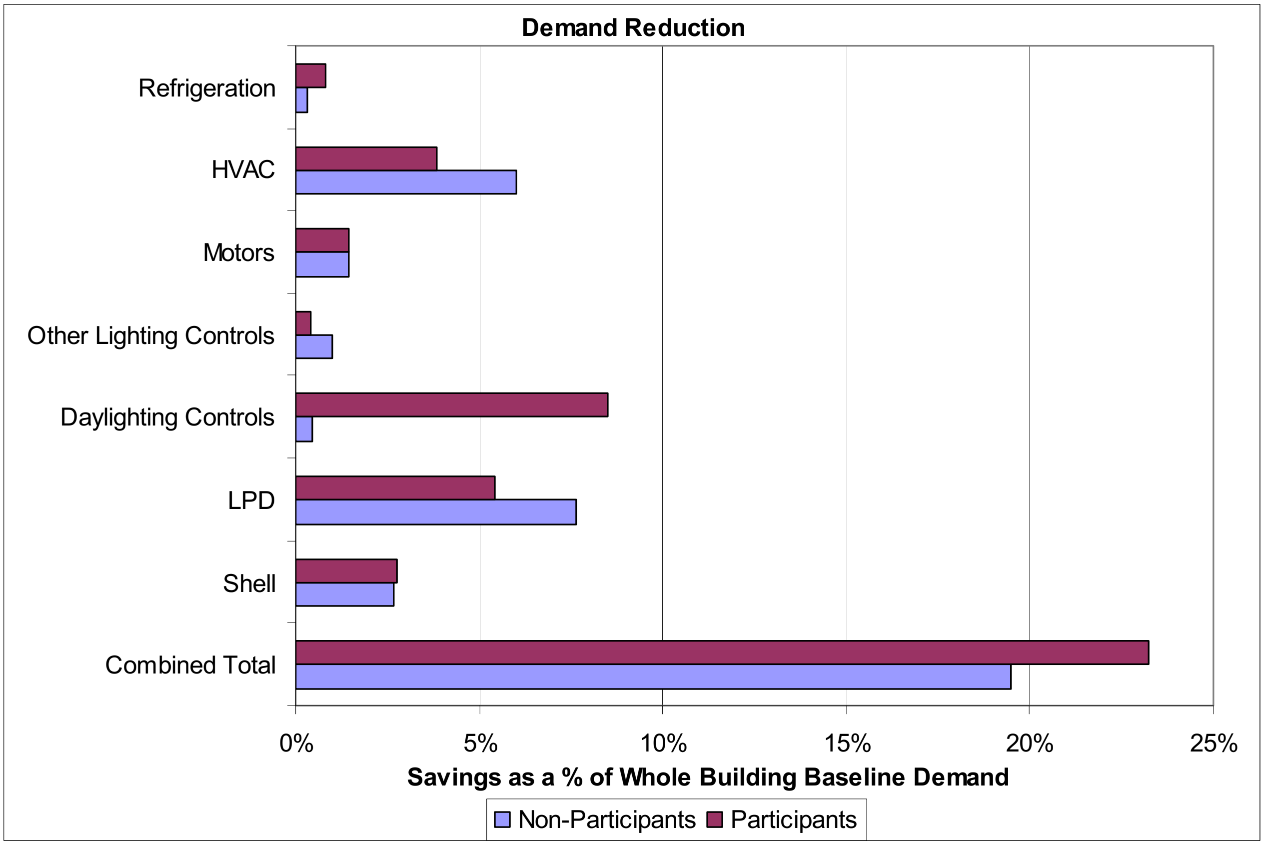

Figure 15: SCE Participant and Non-participant Demand Reduction as a Percentage of Baseline Demand[15]

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[15] There were 30 participants and four non-participants using daylighting controls. There were twenty-four participants and twenty-one non-participants using other lighting controls. There were three participants and one non-participant using refrigeration.

Figure 16 shows the SDG&E demand reduction of both program participants and non-participants expressed as a percentage of each group's whole-building baseline demand. SDG&E's results are also very similar to it's energy savings results as presented in Figure 9 with the exception of the shell measure where participants outperformed non-participants in energy savings as a percentage of baseline consumption. As Figure 16 shows, the SDG&E participants were 19.1% better than baseline on average, while the non-participant comparison group was 14.8% better than baseline. The SDG&E participants are more efficient than the non-participants for HVAC, motors, and LPD. However the non-participants were found to be more efficient than the participants for the daylighting controls, other lighting controls, and refrigeration measures.

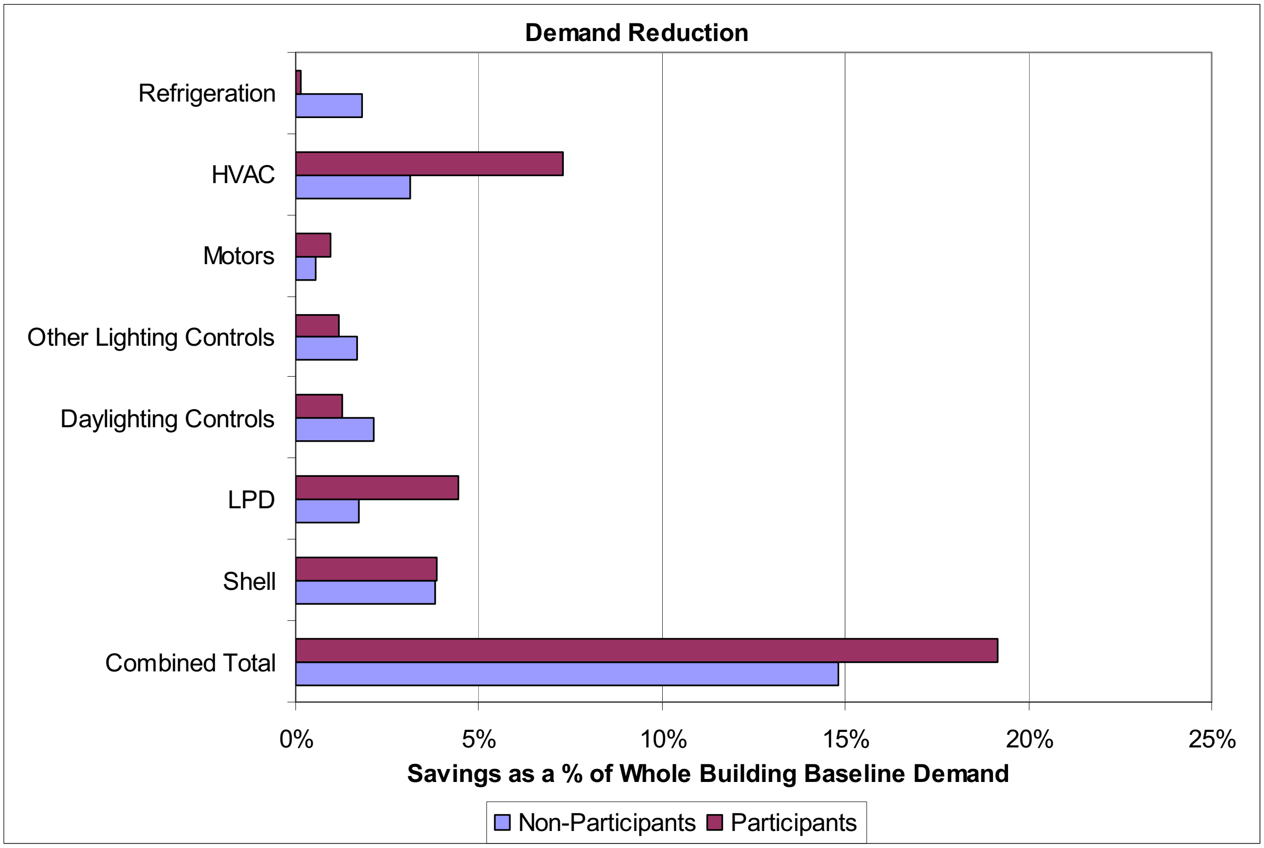

Figure 16: SDG&E Participant and Non-participant Demand Reduction as a Percentage of Baseline Demand[16]

Table 26 presents the participant and non-participant demand reduction as a percentage of the building baseline demand by utility.

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[16] There was one participant and two non-participants using daylighting controls. There were ten participants and six non-participants using other lighting controls. There was one participant and one non-participant using refrigeration.

Measure Category	PG&E		SCE		SDG&E	
	P	NP	P	NP	P	NP
Shell	3.9%	1.4%	2.8%	2.6%	3.9%	3.8%
LPD	6.4%	5.7%	5.4%	7.6%	4.5%	1.7%
Daylighting Controls	0.1%	0.0%	8.5%	0.4%	1.3%	2.1%
Other Lighting Controls	0.3%	0.4%	0.4%	1.0%	1.2%	1.7%
Motors	1.5%	1.4%	1.4%	1.5%	0.9%	0.6%
HVAC	6.8%	4.6%	3.9%	6.0%	7.3%	3.1%
Refrigeration	0.3%	1.1%	0.8%	0.3%	0.2%	1.8%

Table 26: Participant and Non-participant Demand Reduction as a Percentage of Baseline Demand by Utility

Incented Measures

Overall, incented measures have a lower percentage of demand reduction than all measures with the exception of daylighting controls and HVAC.

Table 17 shows the gross summer peak demand reduction by measure category and utility service territory for incented measures only. Note that the sum of the reduction by utility does not equal the overall program level reduction presented above. This is because the program level savings are based on a combined ratio estimator, and the disaggregated results are separate ratio estimators. Since ratio estimation is a non-linear process, the results from the separate ratio estimators are non-additive[17].

Projects in SCE's territory account for approximately 50% of the demand reduction resulting from measures incented through SBD, with PG&E and SDG&E each accounting for approximately 25% of the demand reduction. The PG&E incented measures demand reduction comes primarily from the whole building measure category. The demand reduction associated with SCE incented measures result primarily from LPD, daylighting controls, and whole building measures. The SDG&E demand reduction from incented measures is primarily from the HVAC measure category.

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[17] We have opted to calculate the program level savings results using the combined ratio estimator rather than the sum of the separate ratio estimators. This is because the ratio estimator is by definition a biased estimator, and the combined ratio estimator is less biased than the sum of the separate ratio estimators.

	Measure Category	**Demand Reduction**							
		PG&E		**SCE**		**SDG&E**		**Overall**	
		MW	**% of MW**	**MW**	**% of MW**	**MW**	**% of MW**	**MW**	**% of MW**
Systems Approach	Shell	0.3	5.0%	0.2	2.0%	0.3	5.8%	0.7	3.5%
	LPD	1.5	27.1%	1.9	18.9%	0.8	15.7%	4.2	20.7%
	Daylighting Controls	-	0.0%	4.1	40.4%	0.5	9.5%	4.7	23.5%
	Other Lighting Controls	-	0.0%	-	0.0%	-	0.0%	-	0.0%
	Motors	0.2	2.8%	0.6	5.8%	0.2	3.5%	0.9	4.6%
	HVAC	1.2	21.6%	2.2	21.5%	2.1	41.8%	5.0	25.1%
	Refrigeration	0.1	1.4%	0.1	1.5%	0.1	1.1%	0.3	1.4%
	Whole Building	2.3	42.1%	1.0	9.9%	1.2	22.6%	4.3	21.3%
	Combined Total	5.4		10.1		5.1		20.1	

Table 27: Gross Demand Reduction by Utility – Incented Measures Only

Table 28 shows gross realization rates by measure category and utility service territory for incented measures only. PG&E's gross realization rate for LPD is lower than either SCE's or SDG&E's, while PG&E's gross realization rate for motors is higher than both of SCE's and SDG&E's. The most notable difference among the utilities occurs in the HVAC measure category, where PG&E's gross realization rate is 60.9%, SCE's is 57.5%, and SDG&E's is 112.8%.

		PG&E			**SCE**			**SDG&E**		
	Measure Category	**Estimated Demand Reduction (MW)**	**Program Tracking Demand Reduction (MW)**	**Gross Realization Rate**	**Estimated Demand Reduction (MW)**	**Program Tracking Demand Reduction (MW)**	**Gross Realization Rate**	**Estimated Demand Reduction (MW)**	**Program Tracking Demand Reduction (MW)**	**Gross Realization Rate**
Systems Approach	Shell	0.3	0.1	269.6%	0.2	0.1	165.2%	0.3	0.3	117.6%
	LPD	1.5	2.1	70.0%	1.9	2.3	84.3%	0.8	1.1	75.0%
	Daylighting Controls	-	-	-	4.1	5.2	78.4%	0.5	0.5	91.6%
	Other Lighting Controls	-	-	-	-	-	-	-	-	-
	Motors	0.2	0.1	152.7%	0.6	0.5	116.9%	0.2	0.2	121.4%
	HVAC	1.2	1.9	60.9%	2.2	3.8	57.5%	2.1	1.9	112.8%
	Refrigeration	0.1	0.1	86.9%	0.1	0.1	115.6%	0.1	0.1	58.0%
	Whole Building	2.3	3.5	63.9%	1.0	0.5	188.3%	1.2	2.2	53.8%
	Combined Total	5.4	7.8	68.8%	10.1	12.5	80.6%	5.1	6.2	83.3%

Table 28: Gross Realization Rates by Measure Type and Utility – Incented Measures Only

Systems Projects vs. Whole-Building Projects

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

The first comparison uses total building savings (incented and non-incented measures) to contrast the two approaches to program participation. The second, and more accurate comparison is the measures only savings for systems participants vs. whole-building participants. This analysis is more accurate because the SBD program savings estimates for systems projects are based entirely on the calculated savings at the measure level, whereas in the first comparison, systems projects are also credited for non-incented measures, or total building savings.

Statewide Systems vs. Whole-Building

Table 29 compares the energy savings of systems projects to whole-building projects. As shown in the table for the statewide program, whole-building projects save more energy per square foot and also experience a higher gross realization rate than systems projects. Note that the systems approach in this analysis includes other efficient systems and interactions not incented by the SBD program.

	kWh / SQFT	Gross Realization Rate
Systems Approach	2.42	105.7%
Whole Building Approach	2.83	110.1%

Table 29: Systems vs. Whole-Building Projects – Annual Energy

Table 30 compares the demand reduction of systems projects to whole-building projects. As shown in the table for the statewide program, whole-building projects experience a slightly lower demand reduction per square foot and also experience a lower gross realization rate than systems projects. Similar to the energy results, the systems approach in this analysis includes other efficient systems and interactions not incented by the SBD program, thus inflating the gross realization rate for this approach. It is also important to recall that the demand savings are calculated based on the utility coincident peak, while the program calculates demand savings based on building peak demand.

	W / SQFT	Gross Realization Rate
Systems Approach	0.73	113.7%
Whole Building Approach	0.63	67.1%

Table 30: Systems vs. Whole-Building Projects – Summer Peak Demand

Statewide Systems Measures Only vs. Whole-Building

Table 31 compares the savings of whole-building projects to system projects for incented measures only. As shown in the table, whole-building projects save in excess of 150% of the systems energy savings per square foot, and they also experience a higher gross realization rate than systems projects.

	kWh / SQFT	Gross Realization Rate
Systems Approach	1.75	76.5%
Whole Building Approach	2.83	110.1%

Table 31: Systems vs. Whole-Building Projects – Incented Measures Only – Annual Energy

Table 32 compares the summer peak demand reduction of whole-building projects to system projects for incented measures only. As shown in the table, whole-building projects reduce demand by nearly 25% more per square foot than systems projects. However, whole-building projects experience a lower gross realization rate than systems projects. The demand realization rate is lower for the whole building approach because RLW used actual operating schedules while the tracking estimates were obtained using standard Title-24 operating hours.

	W / SQFT	Gross Realization Rate
Systems Approach	0.50	77.9%
Whole Building Approach	0.63	67.1%

Table 32: Systems vs. Whole-Building Projects – Incented Measures Only – Summer Peak Demand

When comparing systems approach savings in Table 29 and Table 31 it becomes evident that 30% of the evaluated savings are due to non-incented measures. Under the evaluation methodology employed in the previous 8 years of our evaluation experience, the utilities are credited for these savings because they are thought to be program induced.

Utility Systems Measures vs. Whole-Building

To interpret the findings presented in this section, it is helpful in understanding the number of projects and their associated energy savings and savings per square foot by participation approach for each utility. Table 33 shows that during the first two years of operation, Savings By Design had a total of 49 whole-building projects, or 10% of the total. SDG&E had the most whole-building projects of any utility, with 30. However SDG&E also had the least amount of energy savings per whole-building project when compared to PG&E and SCE. SCE had the fewest number of whole-building projects, with six, but saved the most energy per project.

SDG&E had the highest ratio of whole-building to systems projects, with 15% of their participation being whole-building based, compared to 4% for SCE and 10% for PG&E.

	PG&E			SCE			SDG&E			Statewide		
	# Projects	**MWh Savings**	**kWh / SQFT**	**# Projects**	**MWh Savings**	**kWh / SQFT**	**# Projects**	**MWh Savings**	**kWh / SQFT**	**# Projects**	**MWh Savings**	**kWh / SQFT**
Systems Approach	114	13,868	2.01	163	46,285	2.60	160	12,677	1.78	437	72,830	2.29
Whole Building Approach	13	5,550	2.44	6	7,550	2.56	30	4,357	2.78	49	17,458	2.57
Overall	127	19,418	2.11	169	53,835	2.59	190	17,034	1.96	486	90,288	2.34

Table 33: Savings By Design Participation Approach: System vs. Whole-Building

Table 34 shows the number of whole-building projects by building type and utility service territory. Five of the six SCE whole-building projects are C&I Storage buildings (including one refrigerated warehouse), while eleven of the thirteen PG&E whole-building projects are offices. Most of the SDG&E whole-building projects are either office or school. C&I storage buildings typically have a lower LPD and lower installed HVAC capacity than offices and schools. Therefore the available savings per sqft are lower. This explains further why the energy and peak demand of SCE is dramatically lower than the others, as reported in Table 37.

Title 24 Bldg Type	**# of Whole-Building Projects**		
	PG&E	**SCE**	**SDG&E**
C&I Storage	-	5	-
General C&I Work	-	-	4
Medical / Clinical	-	-	1
Office	11	-	9
Other	1	-	-
Religious Worship, Auditorium, Convention	-	-	1
Retail and Wholesale Store	-	-	1
School	1	-	13
Gymnasium	-	1	-
Libraries	-	-	1
Total	**13**	**6**	**30**

Table 34: Number of Whole-Building Projects by Building Type and Utility

Energy Savings by Participation Path and Utility

Table 35 compares systems vs. whole-building energy savings by utility. For all three utilities, whole-building projects outperform their system project counterparts for energy savings per square foot. SDG&E has the largest energy savings per square foot for both approaches. For participants in the SDG&E service territory, the gross realization rate for systems projects is larger than that of whole-building projects, while for participants in SCE's program, the converse is true. Note that the differences in the realization rates are due to the fact that early in the evaluation, a few of the daylighting systems in the SCE territory were not functioning. As can be seen above in Table 17 and Table 27, daylighting is the greatest fraction of savings for any systems measures, therefore these sites lowered the overall gross realization rate.

	kWh / SQFT			Gross Realization Rate		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
Systems Approach	2.28	2.43	2.78	113.7%	93.7%	156.1%
Whole Building Approach	2.75	2.87	3.23	112.7%	112.1%	116.4%

Table 35: Systems vs. Whole-Building Projects by Utility – Annual Energy Savings

It is also interesting to note that each of the utilities have overestimated system project savings. This is illustrated in Table 38 and Table 36 where gross realization rates for the measures only savings are all under 100%. Meanwhile the credited energy savings for non-incented measures, which is included in the gross savings realization rates in Table 35, is substantial, nearly doubling the energy savings for SDG&E.

Table 36 shows systems incented measures only vs. whole-building project energy savings per square foot for each utility.

	kWh / SQFT			Gross Realization Rate		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
Systems Approach	1.52	1.91	1.62	75.9%	73.4%	90.9%
Whole Building Approach	2.75	2.87	3.23	112.7%	112.1%	116.4%

Table 36: Systems vs. Whole-Building Projects by Utility – Incented Measures Only – Annual Energy Savings

Demand Reduction by Participation Path and Utility

Table 37 compares systems vs. whole-building demand reduction by utility. SDG&E's systems and whole-building projects reduce demand nearly equally. PG&E's whole-building projects reduce demand more than their systems projects. Interestingly, SCE whole-building projects reduce demand significantly less than their system projects. This, and the relationship between the SCE whole-building energy savings and the SCE whole-building Demand savings are notable. A very large refrigerated warehouse that was qualified using the whole building approach heavily influenced these numbers. This site had greatly enhanced wall and roof insulation as well as VFDs and refrigeration measures. These measures all contribute significantly to the energy savings but contribute relatively little to the demand savings. Note that SCE's whole-building approach demand realization rate of 135.2% relatively high. This is largely due to anomalies in several sites: a refrigerated warehouse site which had no peak period usage of their refrigeration equipment and two sites in which tracking square footage was extremely underestimated. Thus we have found that the tracking savings were underestimated for these sites leading to a much higher realization rate than expected. The SCE whole-building results are discussed above with the results of Table 34.

	W / SQFT			Gross Realization Rate		
	PG&E	**SCE**	**SDG&E**	**PG&E**	**SCE**	**SDG&E**
Systems Approach	0.73	0.70	0.88	120.3%	104.7%	149.1%
Whole Building Approach	1.00	0.34	0.74	63.9%	135.2%	55.7%

Table 37: Systems vs. Whole-Building Projects by Utility – Summer Peak Demand Savings

Table 38 shows systems incented measures only vs. whole-building project summer peak demand reduction per square foot for each utility. Interestingly, even though SCE whole-building projects are experiencing the lowest demand reduction per square foot, these projects have the highest gross realization rate.

	W / SQFT			Gross Realization Rate		
	PG&E	**SCE**	**SDG&E**	**PG&E**	**SCE**	**SDG&E**
Systems Approach	0.45	0.51	0.56	73.9%	76.4%	94.9%
Whole Building Approach	1.00	0.34	0.74	63.9%	135.2%	55.7%

Table 38: Systems vs. Whole-Building Projects by Utility – Incented Measures Only – Summer Peak Demand Savings

Net Savings Results

This chapter presents the net savings results calculated using 3 different methodologies: the self-reported net savings methodology the difference-of-differences net savings methodology, and the difference-of-differences + spillover adjustment net savings methodology[18]. The 3 methodologies are fundamentally different; therefore a comparison of the results across methodologies should not be performed.

Results for both annual energy savings and summer peak demand reduction are presented in this chapter. Furthermore, results are shown by utility service territory, building type, end use, and system vs. whole-building projects. Assessments of free-ridership by measure category and assessments of spillover by end use are shown, where applicable.

Energy Findings

Self-Reported Free-ridership and Spillover Net Savings Results

To calculate self-reported free-ridership and spillover, RLW surveyed decision makers on their efficiency choices for incented measures and measures more efficient than baseline, for participants and non-participants respectively. Based on the survey responses the engineering simulation models were adjusted to reflect these efficiency choices absent Savings By Design. The engineering models were then re-simulated. The results of these simulations were then analyzed to obtain the self-reported net savings for participants and spillover savings for non-participants.

Table 39 shows the total net program impacts taking into account both self-reported participant free-ridership and self-reported non-participant spillover. Using the self-report methodology, the net participant savings are 57,092 MWh, which corresponds to a net realization rate of 63.2% and a net-to-gross ratio of 59.3%. Spillover savings in the non-participant population are 21,397 MWh. These two results together suggest a total net program impact of 78,489 MWh, yielding a net realization rate of 86.9% and a net-to-gross ratio of 81.6%.

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[18] A complete description of these three net savings methodologies is located in the “Net Savings Methodology” chapter.

	Self - Report Estimate (MWh)	**Calculation**
Program Tracking Savings	90,288	A
Gross Savings	96,244	B
Gross Realization Rate	106.6%	(B / A)
Net Participant Savings	57,092	C
Participant Net Realization Rate	63.2%	(C / A)
Participant Net-to-Gross Ratio	59.3%	(C / B)
NP Spillover Savings	21,397	D
Total Net Savings	78,489	C + D
Net Realization Rate	86.9%	(C + D)/A
Net-to-Gross Ratio	81.6%	(C + D)/B

Table 39: Total Net Energy Program Impacts – Self-Report Methodology

Table 40 displays the estimated spillover savings in the non-participant population by end use. The lighting power density end use accounts for more than 80% of the spillover energy savings that are occurring in the non-participant population. The remaining spillover is occurring in the Shell, Motors, and HVAC end uses. No spillover is occurring for lighting control measures.

	Measure Category	**Non-participant Spillover Energy Savings (MWh)**
Systems Approach	Shell	1,159
	LPD	17,878
	Daylighting Controls	(818)
	Other Lighting Controls	(170)
	Motors	1,924
	HVAC	1,386
	Refrigeration	37
	Combined Total	21,397

Table 40: Non-participant Spillover Energy Savings

Table 41 shows the total net program impacts by measure type, taking into account both self-reported participant free-ridership and self-reported non-participant spillover. Not surprisingly, the LPD measure has significant spillover. The shell and refrigeration measure types have net-to-gross ratios exceeding 90%. Motors have a net-to-gross ratio of 73.2%. Daylighting controls, other lighting controls, and HVAC are the end uses with the worst net-to-gross ratios (just over

50%), under the self-report net savings methodology. Note that for this analysis we have disaggregated the measure categories by end-uses in order to present a comparison between participants and non-participants.

Measure Category	Net Participant Savings (MWh)	NP Spillover Savings (MWh)	Total Net Savings (MWh)	Gross Savings (MWh)	Net-to-Gross Ratio
Shell	6,293	1,159	7,452	7,906	94.3%
LPD	20,750	17,878	38,628	37,515	103.0%
Daylighting Controls	11,463	-818	10,645	18,861	56.4%
Other Lighting Controls	1,667	-170	1,497	2,695	55.6%
Motors	6,438	1,924	8,362	11,425	73.2%
HVAC	4,788	1,386	6,174	11,824	52.2%
Refrigeration	5,694	37	5,731	6,020	95.2%
Combined Total	57,092	21,397	78,489	96,244	81.6%

Table 41: Total Net Energy Program Impacts by Measure Type – Self-Report Methodology

Table 42 shows the total net program impacts by utility service territory, taking into account both self-reported participant free-ridership and self-reported non-participant spillover. Non-participant spillover savings are savings that occur as a result of prior program influence or influence from the new construction rep or program material. Using the self-report methodology, PG&E has the largest net-to-gross ratio (102.1%), while SDG&E has the lowest (63.1%). SCE's net-to-gross ratio under the self-report net savings methodology is 74.9%.

	Net Participant Savings (MWh)	NP Spillover Savings (MWh)	Total Net Savings (MWh)	Gross Savings (MWh)	Net-to-Gross Ratio
PG&E	13,628	8,874	22,503	22,029	102.1%
SCE	32,253	6,561	38,814	51,811	74.9%
SDG&E	11,497	4,185	15,683	24,855	63.1%
Combined Total	57,092	21,397	78,489	96,244	81.6%

Table 42: Total Net Energy Program Impacts by Utility – Self-Report Methodology

Table 43 shows the total net program impacts by building type, taking into account both self-reported participant free-ridership and self-reported non-participant spillover. Using the self-report methodology, C&I Storage, Grocery Store and Retail and Wholesale Store are the market segments that are performing the best, with each having a net-to-gross ratio exceeding 100%, which indicates that the non-participant spillover exceeds the participant free-ridership for these market segments. Medical / Clinical buildings, offices, and schools all have a net-to-gross ratio between 75-86%. The worst performing market segments under the self-report methodology are Theater, Libraries, and Religious Worship, Auditorium, and Convention.

In the table below, the 'Other' building type has positive gross savings and negative net participant savings. There are 2 sample sites in this building type, both of which had large amounts of free-ridership. Since there are no program-induced savings, we forced the lower bound of the net-to-gross ratio to be 0%.

The 'Gymnasium' building type has both negative gross savings and negative net participant savings. There is only 1 sample site in this building type that had large amounts of free-ridership. Since the site is already performing worse than Title-24, we do not know the extent of the lack of compliance that would occur in the absence of the program. Therefore we have not reported a net-to-gross ratio for this building type.

Building Type	Net Participant Savings (MWh)	NP Spillover Savings (MWh)	Total Net Savings (MWh)	Gross Savings (MWh)	Net-to-Gross Ratio
C&I Storage	17,126	6,085	23,210	22,580	102.8%
Grocery Store	6,502	1,775	8,276	8,124	101.9%
General C&I Work	14,177	-	14,177	25,451	55.7%
Medical / Clinical	1,200	-	1,200	1,463	82.0%
Office	13,868	7,577	21,445	25,149	85.3%
Other	-488	-	-488	76	0.0%
Religious Worship, Auditorium, Convention	568	-	568	1,174	48.4%
Restaurant	281	-	281	449	62.5%
Retail and Wholesale Store	4,227	4,812	9,039	7,855	115.1%
School	4,265	1,148	5,413	7,207	75.1%
Theater	179	-	179	753	23.8%
Gymnasium	-823	-	-823	-600	-
Libraries	79	-	79	911	8.7%

Table 43: Total Net Energy Program Impacts by Building Type – Self-Report Methodology

Free-ridership by Measure Category – Incented Measures Only

Table 44 shows the free-ridership rate by measure category, based on the self-report methodology. According to the decision-makers, the program appears to be experiencing a relatively high rate of free-ridership for most measures. The greatest amount of free-ridership is occurring in the shell measure category with a rate of 100%. The free-ridership rate exceeds 50% for LPD, daylighting controls, motors and HVAC measures. For whole building measures, the free-ridership rate is about 45%. There is essentially no free-ridership in the refrigeration measure category, with a free-ridership rate of 0.1%.

Table 44 also shows net realization rates by measure category for incented measures only. Refrigeration and whole building measures are the only measures with a net realization rate greater than 50%. LPD and daylighting controls each have net realization rates approximately equal to 40%, and motors and HVAC have net realization rates approximately equal to 25%.

	Measure Category	Participant Net Energy Savings (MWh)	Measures Only Gross Savings	Net-to-Gross Ratio	Free-Ridership Rate	Program Tracking Energy Savings (MWh)	Net Realization Rates
Systems Approach	Shell	(147)	1,151	0.0%	100.0%	1,382	0.0%
	LPD	9,739	21,782	44.7%	55.3%	23,267	41.9%
	Daylighting Controls	7,747	15,800	49.0%	51.0%	19,389	40.0%
	Other Lighting Controls	-	-	-	-	-	-
	Motors	2,478	5,382	46.0%	54.0%	9,804	25.3%
	HVAC	4,228	9,507	44.5%	55.5%	15,874	26.6%
	Refrigeration	2,070	2,071	99.9%	0.1%	2,981	69.4%
	Whole Building	10,415	19,227	54.2%	45.8%	17,591	59.2%

Table 44: Participant Free-Ridership and Net Realization Rates by Measure Category – Incented Measures Only

Table 45 presents net realization rates by measure category and utility service territory for incented measures only. PG&E's highest net realization rates are in the motors and refrigeration measure categories. SCE's highest net realization rates are in the refrigeration and whole building measure categories. SDG&E's highest net realization rate is in the refrigeration measure categories.

Measure Category	PG&E			SCE			SDG&E		
	Estimated Energy Savings (MWh)	Program Tracking Energy Savings (MWh)	Net Realization Rate	Estimated Energy Savings (MWh)	Program Tracking Energy Savings (MWh)	Net Realization Rate	Estimated Energy Savings (MWh)	Program Tracking Energy Savings (MWh)	Net Realization Rate
Shell	43	145	29.3%	(32)	326	0.0%	(228)	911	0.0%
LPD	3,609	9,292	38.8%	4,857	10,359	46.9%	973	3,617	26.9%
Daylighting Controls	-	-	-	7,169	17,864	40.1%	-	1,525	0.0%
Other Lighting Controls	-	-	-	-	-	-	-	-	-
Motors	906	1,067	84.9%	971	6,672	14.6%	682	2,064	33.0%
HVAC	1,050	2,532	41.5%	2,102	9,552	22.0%	1,229	3,790	32.4%
Refrigeration	755	832	90.8%	956	1,513	63.2%	345	637	54.1%
Whole Building	2,176	5,550	39.2%	7,115	7,550	94.2%	613	4,490	13.7%
Combined Total	8,539	19,418	44.0%	23,138	53,836	43.0%	3,613	17,034	21.2%

Table 45: Net Realization Rates by Measure Category and Utility – Incented Measures Only

Difference-of-Differences Net Savings Results

In the difference-of-differences approach the non-participants are considered to indicate the energy efficiency that would be expected in the absence of the program. The difference between the energy efficiency of the participants and non-participants is used to estimate the net impact of the program.

Table 46 presents the difference-of-differences calculations for net annual energy savings. The calculations result in a program level 16,637 MWh of net annual energy savings. These net savings correspond to a net-to-gross ratio of 17.3%.

	Participants	**Non-Participants**	**Participant Net Savings**
Baseline (MWh)	592,724	407,463	
As-Built (MWh)	496,480	352,738	
Savings (MWh)	96,244	54,725	16,637
Savings (% of Baseline)	16.2%	13.4%	2.8%
Net-to-Gross Ratio			17.3%

Table 46: Difference-of-Differences Net Savings – Annual Energy

Table 47 presents the results of the difference-of-differences for each of the utilities. Using this method, SDG&E has a slightly higher net-to-gross ratio (20.4%) than either SCE (14.5%) or PG&E (14.5%).

	PG&E			**SCE**			**SDG&E**		
	P	**NP**		**P**	**NP**		**P**	**NP**	
Baseline (MWh)	150,117	105,479		297,855	180,411		164,104	121,650	
As-Built (MWh)	128,088	92,240		246,044	153,575		139,249	106,975	
Savings (MWh)	22,029	13,239	3,188	51,811	26,837	7,504	24,855	14,675	5,058
Savings (% of Baseline)	14.7%	12.6%	2.1%	17.4%	14.9%	2.5%	15.1%	12.1%	3.1%
Net-to-Gross Ratio			14.5%			14.5%			20.4%

Table 47: Difference-of-Differences by Utility

Table 48 shows the results of the difference-of-differences calculation by building type. The table displays the total number of sampled projects and the baseline and net savings. The table also shows that the highest participant and non-participant savings as a percentage of baseline consumption are in the C&I Storage building type. The final column of the table presents the net-to-gross ratio for each building type. Most of the lowest net-to-gross ratios, indicating the highest amount of free-ridership, occurs in the building types with the most participants, C&I Storage, General C&I Work, Office, and Retail and Wholesale Store. Retail and wholesale store is the only market segment for which the non-participants are more efficient than the participants, resulting in a zero net-to-gross ratio.

Building Type	**Sample Size**		**Baseline MWh**		**Savings MWh**		**Savings as a % of Baseline**		
	P	**NP**	**P**	**NP**	**P**	**NP**	**P**	**NP**	**Net-to-Gross Ratio**
C&I Storage	23	23	73,706	63,401	22,580	12,377	30.6%	19.5%	36.3%
Grocery Store	4	4	26,661	48,323	8,124	8,082	30.5%	16.7%	45.1%
General C&I Work	19	19	187,622	67,893	25,451	6,448	13.6%	9.5%	30.0%
Medical / Clinical	1	1	11,585	10,750	1,463	357	12.6%	3.3%	73.7%
Office	25	26	145,123	111,845	25,149	14,713	17.3%	13.2%	24.1%
Other	2	-	4,348	-	76		1.7%	-	100.0%
Religious Worship, Auditorium, Convention	3	3	9,450	3,101	1,174	244	12.4%	7.9%	36.6%
Restaurant	4	4	8,140	5,822	449	(228)	5.5%	-3.9%	171.0%
Retail and Wholesale Store	18	18	77,486	62,540	7,855	9,262	10.1%	14.8%	0.0%
School	6	6	41,334	19,512	7,207	3,104	17.4%	15.9%	8.8%
Theater	2	2	9,235	8,872	753	213	8.2%	2.4%	70.6%
Gymnasium	1	2	3,916	813	(600)	(37)	-15.3%	-4.6%	-
Libraries	1	1	5,612	4,591	911	189	16.2%	4.1%	74.6%

Table 48: Difference-of-Differences by Building Type[19]

In order to better understand why the retail and wholesale market segment has such a poor net-to-gross ratio, we have delved deeper into this market segment. Table 49 shows participant and non-participant energy savings as a percentage of building baseline consumption by measure type for retail and wholesale stores. As the table shows, the non-participants are significantly outperforming the participants in the LPD measure type (10.3% versus 3.3%, respectively). Most of the savings for non-participants are coming from LPD, which is driving the overall result. Participants are also showing savings in the daylighting controls and HVAC measure categories.

Measure Category	**Savings as a % of Building Baseline**		**Net-to-Gross Ratio**
	P	**NP**	
Shell	0.4%	0.7%	0%
LPD	3.3%	10.3%	0%
Daylighting Controls	3.6%	1.5%	59.5%
Other Lighting Controls	0.05%	0.4%	0%
Motors	-	-	-
HVAC	2.8%	2.0%	27.3%
Refrigeration	-	-	-
Combined Total	10.1%	14.8%	0%

Table 49: Retail and Wholesale Store Savings as a Percentage of Baseline by End Use

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[19] One of the participants in the “Other” building type was matched to an office, and the other participant in the “Other” building type was matched to a gymnasium.

Table 50 presents the net savings resulting from the difference-of-differences methodology by measure type. Daylighting controls are the only measure type with a net-to-gross ratio greater than 50%. Both HVAC and shell have net-to-gross ratios between 35% and 50%. The other lighting controls, refrigeration, and LPD end uses all have zero net-to-gross ratios, indicating that the non-participants are outperforming their participant counterparts for these measure types.

	Building Baseline MWh		**Savings MWh**		**Savings as a % of Baseline**		
Measure Category	**P**	**NP**	**P**	**NP**	**P**	**NP**	**Net-to-Gross Ratio**
Shell	592,724	407,463	7,906	2,805	1.3%	0.7%	48.4%
LPD	592,724	407,463	37,515	27,218	6.3%	6.7%	0.0%
Daylighting Controls	592,724	407,463	18,861	2,165	3.2%	0.5%	83.3%
Other Lighting Controls	592,724	407,463	2,695	4,069	0.5%	1.0%	0.0%
Motors	592,724	407,463	11,425	6,854	1.9%	1.7%	12.7%
HVAC	592,724	407,463	11,824	5,254	2.0%	1.3%	35.4%
Refrigeration	592,724	407,463	6,020	6,359	1.0%	1.6%	0.0%
Combined Total	**592,724**	**407,463**	**96,244**	**54,725**	**16.2%**	**13.4%**	**17.3%**

Table 50: Difference-of-Differences by Measure Category

Difference-of-Differences + Spillover Adjustment Net Savings Results

In this approach we use the results from each of the two aforementioned approaches. First a preliminary estimate of the net program percent savings is estimated using the difference-of-differences approach. Next, the results from the non-participant surveys are used to adjust the DOE-2 models in order to calculate end-use and whole building level spillover. The calculated spillover expressed as a percent energy savings is then added to the difference-of-differences results. The 5,669 MWh in non-participant spillover savings should not be compared to the non-participant spillover savings of 21,397 presented in Table 39 of the self-reported net savings section. The two methodologies are fundamentally different in the manner in which the savings are projected to the population, resulting in different magnitudes of non-participant spillover savings. A complete description of the net savings methodologies is located in the “Net Savings Methodology” chapter.

Table 51 presents the difference-of-differences + spillover Adjustment calculations for net annual energy savings. The calculations result in a program level 24,884 MWh of net annual energy savings. These net savings correspond to a net-to-gross ratio of 25.9%. The spillover adjustment has resulted in an 8.6% increase in the program level net-to-gross ratio (25.9% versus 17.3%).

	Participants	Non-Participants	NP Spllover	Participant Net Savings
Baseline (MWh)	592,724	407,463	407,463	
As-Built (MWh)	496,480	352,738		
Savings (MWh)	96,244	54,725	5,669	24,884
Savings (% of Baseline)	16.2%	13.4%	1.4%	4.2%
Net-to-Gross Ratio				25.9%

Table 51: Difference-of-Differences + Spillover Adjustment Net Savings – Annual Energy

Table 52 presents the results of the difference-of-differences + spillover net savings results for each of the utilities. Using this method, SCE has a slightly higher net-to-gross ratio (28%) than either SDG&E (26.0%) or PG&E (20.5%). The spillover adjustment is responsible for a 6% increase in PG&E's net-to-gross ratio (20.5% versus 14.5%), a 13.5% increase in SCE's net-to-gross ratio (28.0% versus 14.5%), and a 5.6% increase in SDG&E's net-to-gross ratio (26.0% versus 20.4%), suggesting that SDG&E is experiencing more spillover than the other two utilities.

	PG&E				SCE				SDG&E			
	P	NP (Total)	NP Spillover	P Net	P	NP (Total)	NP Spillover	P Net	P	NP (Total)	NP Spillover	P Net
Baseline (MWh)	150,117	105,479			297,855	180,411			164,104	121,650		
As-Built (MWh)	128,088	92,240			246,044	153,575			139,249	106,975		
Savings (MWh)	22,029	13,239	932	4,514	51,811	26,837	4,235	14,497	24,855	14,675	1,042	6,464
Savings (% of Baseline)	14.7%	12.6%	0.9%	3.0%	17.4%	14.9%	2.3%	4.9%	15.1%	12.1%	0.9%	3.9%
Net-to-Gross Ratio				20.5%				28.0%				26.0%

Table 52: Difference-of-Differences + Spillover Adjustment by Utility

Table 53 shows the results of the difference-of-differences + spillover adjustment calculation by building type[20]. Most of the building types are virtually unaffected by the spillover adjustment. For the C&I Storage market segment, the net-to-gross ratio increases 19.9%, from 36.3% to 56.2%. Non-participant retail and wholesale stores are more efficient than the participants, resulting in a zero net-to-gross ratio. For retail and wholesale stores, the net-to-gross ratio has increased to -35.7% from -46.1%.

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[20] One of the participants in the "Other" building type was matched to an office, and the other participant in the "Other" building type was matched to a gymnasium.

Building Type	Sample Size		Baseline MWh		Savings MWh			Savings as a % of Baseline				
	P	NP	P	NP	P	NP (Total)	NP Spillover	P	NP (Total)	NP Spillover	P Net	Net-to-Gross Ratio
C&I Storage	23	23	73,706	63,401	22,580	12,377	3,863	30.6%	19.5%	6.1%	17.2%	56.2%
Grocery Store	4	4	26,661	48,323	8,124	8,082	138	30.5%	16.7%	0.3%	14.0%	46.1%
General C&I Work	19	19	187,622	67,893	25,451	6,448	-	13.6%	9.5%	0.0%	4.1%	30.0%
Medical / Clinical	1	1	11,585	10,750	1,463	357	-	12.6%	3.3%	0.0%	9.3%	73.7%
Office	25	26	145,123	111,845	25,149	14,713	913	17.3%	13.2%	0.8%	5.0%	28.8%
Other	2	-	4,348	-	76		-	1.7%	-	-	1.7%	100.0%
Religious Worship, Auditorium, Convention	3	3	9,450	3,101	1,174	244	-	12.4%	7.9%	0.0%	4.5%	36.6%
Restaurant	4	4	8,140	5,822	449	(228)	-	5.5%	-3.9%	0.0%	9.4%	171.0%
Retail and Wholesale Store	18	18	77,486	62,540	7,855	9,262	657	10.1%	14.8%	1.1%	-3.6%	0.0%
School	6	6	41,334	19,512	7,207	3,104	98	17.4%	15.9%	0.5%	2.0%	11.6%
Theater	2	2	9,235	8,872	753	213	-	8.2%	2.4%	0.0%	5.8%	70.6%
Gymnasium	1	2	3,916	813	(600)	(37)	-	-15.3%	-4.6%	0.0%	-10.7%	-
Libraries	1	1	5,612	4,591	911	189	-	16.2%	4.1%	0.0%	12.1%	74.6%

Table 53: Difference-of-Differences + Spillover Adjustment by Building Type

Table 54 presents the net savings resulting from the difference-of-differences + spillover adjustment methodology by measure type. Comparing Table 50 with Table 54 shows that the LPD end use is the only end use that is experiencing a significant amount of spillover, as the LPD net-to-gross ratio increased by about 16%, while the Shell, Motors, and HVAC end uses only show a 2% - 3% increase in their net-to-gross ratios. Other lighting controls, and refrigeration are experiencing no spillover.

Measure Category	Building Baseline MWh		Savings MWh			Savings as a % of Baseline				
	P	NP	P	NP (Total)	NP Spillover	P	NP (Total)	NP Spillover	P Net	Net-to-Gross Ratio
Shell	592,724	407,463	7,906	2,805	127	1.3%	0.7%	0.0%	0.7%	50.7%
LPD	592,724	407,463	37,515	27,218	5,476	6.3%	6.7%	1.3%	1.0%	15.7%
Daylighting Controls	592,724	407,463	18,861	2,165	-314	3.2%	0.5%	-0.1%	2.6%	80.9%
Other Lighting Controls	592,724	407,463	2,695	4,069	-29	0.5%	1.0%	0.0%	-0.6%	0.0%
Motors	592,724	407,463	11,425	6,854	235	1.9%	1.7%	0.1%	0.3%	15.7%
HVAC	592,724	407,463	11,824	5,254	171	2.0%	1.3%	0.0%	0.7%	37.5%
Refrigeration	592,724	407,463	6,020	6,359	3	1.0%	1.6%	0.0%	-0.5%	0.0%
Combined Total	**592,724**	**407,463**	**96,244**	**54,725**	**5,669**	**16.2%**	**13.4%**	**1.4%**	**4.2%**	**25.9%**

Table 54: Difference-of-Differences + Spillover Adjustment by End Use

Summer Peak Demand Findings

Self-Reported Free-ridership and Spillover Net Savings Results

Table 55 shows the total net program impacts for summer peak demand reduction, taking into account both self-reported participant free-ridership and self-reported non-participant spillover. Using the self-reported methodology, the net participant savings are 16.8 MW, which corresponds to a net realization rate of 62.9% and a net-to-gross ratio of 61.3%. Spillover savings in the non-participant population are 6.7 MW. These two results together suggest a total net program impact of 23.5 MW, yielding a net realization rate of 88.1% and a net-to-gross ratio of 85.9%.

	Self - Report Estimate (MW)	Calculation
Program Tracking Savings	26.7	A
Gross Savings	27.4	B
Gross Realization Rate	102.6%	(B / A)
Net Participant Savings	16.8	C
Participant Net Realization Rate	62.9%	(C / A)
Participant Net-to-Gross Ratio	61.3%	(C / B)
NP Spillover Savings	6.7	D
Total Net Savings	23.5	C + D
Net Realization Rate	88.1%	(C + D)/A
Net-to-Gross Ratio	85.9%	(C + D)/B

Table 55: Total Net Demand Program Impacts – Self-Report Methodology

Table 56 displays the estimated spillover demand reduction in the non-participant population by measure category. The lighting power density end use accounts for approximately 55% of the spillover demand reduction that is occurring in the non-participant population. The remaining spillover is occurring primarily in the Shell, and HVAC measures.

	End Use	Non-Participant Spillover Demand Reduction (MW)
Systems Approach	Shell	1.4
	LPD	3.7
	Daylighting Controls	(0.2)
	Other Lighting Controls	(0.1)
	Motors	0.5
	HVAC	1.2
	Refrigeration	0.1
	Combined Total	6.7

Table 56: Non-participant Spillover Demand Reduction

Table 57 shows the total net program demand reduction by utility service territory, taking into account both self-reported participant free-ridership and self-reported non-participant spillover.

Using the self-report methodology, PG&E has the largest net-to-gross ratio (109.7%), while SDG&E has the lowest (59.8%). SCE's net-to-gross ratio under the self-report net savings methodology is 73.9%.

	Net Participant Reduction (MW)	NP Spillover Reduction (MW)	Total Net Reduction (MW)	Gross Reduction (MW)	Net-to-Gross Ratio
PG&E	4.6	3.4	8.0	7.3	109.7%
SCE	9.0	1.0	10.0	13.5	73.9%
SDG&E	3.2	1.2	4.4	7.4	59.8%
Combined Total	16.8	6.7	23.5	27.4	85.9%

Table 57: Total Net Demand Program Reduction by Utility – Self-Report Methodology

Table 58 shows the total net program demand reduction by building type, taking into account both self-reported participant free-ridership and self-reported non-participant spillover. Using the self-report methodology, Retail and Wholesale Stores have net-to-gross ratios exceeding 100%, which indicates that the non-participant spillover exceeds the participant free-ridership for these market segments. Schools, Offices and Grocery Stores have net-to-gross ratios between 93%-100%, suggesting that non-participant spillover is roughly equal to participant free-ridership for offices and grocery stores. C&I Storage buildings have a net-to-gross ratio equal to 89.7%. General C&I Work, Medical / Clinical buildings, and Religious Worship, Auditorium, Convention all have a net-to-gross ratio approximately equal to 60%.

Building Type	Net Participant Reduction (MW)	NP Spillover Reduction (MW)	Total Net Reduction (MW)	Gross Reduction (MW)	Net-to-Gross Ratio
C&I Storage	3.4	0.7	4.2	4.7	89.7%
Grocery Store	1.2	0.4	1.5	1.6	93.8%
General C&I Work	3.3	-	3.3	5.8	56.8%
Medical / Clinical	0.4	-	0.4	0.7	58.3%
Office	6.0	3.8	9.8	10.2	95.6%
Other	0.1	-	0.1	0.1	46.5%
Religious Worship, Auditorium, Convention	0.2	-	0.2	0.2	61.0%
Restaurant	0.0	-	0.0	0.1	47.5%
Retail and Wholesale Store	1.6	1.4	3.1	2.9	104.8%
School	1.3	0.4	1.7	1.7	98.3%
Theater	0.1	-	0.1	0.3	34.1%
Gymnasium	-0.1	-	-0.1	-0.1	-
Libraries	0.02	-	0.02	0.2	7.7%

Table 58: Total Net Program Demand Reduction by Building Type – Self-Report Methodology

Table 59 shows the total net program demand reduction by measure type, taking into account both self-reported participant free-ridership and self-reported non-participant spillover. Using the self-report methodology, the shell, LPD, and refrigeration measures have net-to-gross ratios exceeding 100%. Motors have a net-to-gross ratio of 88.7%. Daylighting controls, other lighting controls, and HVAC are the measures with the worst net-to-gross ratios (roughly 60%), under the self-report net savings methodology.

Measure Category	Net Participant Reduction (MW)	NP Spillover Reduction (MW)	Total Net Reduction (MW)	Gross Reduction (MW)	Net-to-Gross Ratio
Shell	3.7	1.4	5.1	4.4	117.6%
LPD	4.0	3.7	7.7	7.2	107.5%
Daylighting Controls	3.5	-0.2	3.3	5.7	58.3%
Other Lighting Controls	0.5	-0.1	0.4	0.7	57.0%
Motors	1.1	0.5	1.6	1.8	88.7%
HVAC	3.4	1.2	4.7	7.1	66.1%
Refrigeration	0.6	0.1	0.8	0.7	115.1%
Combined Total	16.8	6.7	23.5	27.4	85.9%

Table 59: Total Net Demand Program Reduction by Measure Type – Self-Report Methodology

Free-ridership by Measure Category – Incented Measures Only

Table 60 shows the free-ridership rate for summer peak demand reduction by measure category for incented measures only, based on the self-report methodology. According to the decision-makers, the program appears to be experiencing a relatively high rate of free-ridership for most measures. The table shows that the greatest amount of free-ridership is occurring from the shell measure. LPD, and HVAC measures have free-ridership rates exceeding 50%. For whole building measures and daylighting controls, the free-ridership rate is approximately 50%. The refrigeration measure category is experiencing virtually no free-ridership.

Table 60 also shows net realization rates by measure category for incented measures only. Refrigeration and motor measures are the only measures with a net realization rate greater than 50%. Whole building, LPD and daylighting controls each have net realization rates between 30% - 40%, motors and HVAC has a net realization rate just under 30%.

	Measure Category	Participant Net Demand Reduction (MW)	Measures Only Gross Reduction	Net-to-Gross Ratio	Free-Ridership Rate	Program Tracking Net Demand Reduction (MW)	Net Realization Rate
Systems Approach	Shell	0.02	0.7	3.1%	96.9%	0.6	3.6%
	LPD	1.8	4.2	44.3%	55.7%	5.4	34.0%
	Daylighting Controls	2.4	4.7	51.2%	48.8%	5.7	42.2%
	Other Lighting Controls	-	-	-	-	-	-
	Motors	0.5	0.9	55.6%	44.4%	0.8	63.7%
	HVAC	2.2	5.0	42.7%	57.3%	7.6	28.4%
	Refrigeration	0.3	0.3	99.9%	0.1%	0.3	88.4%
	Whole Building	2.2	4.3	51.7%	48.3%	6.2	35.4%

Table 60: Participant Free-Ridership and Net Realization Rates by Measure Category – Incented Measures Only

Table 61 presents net realization rates by measure category and utility service territory for incented measures only. PG&E's highest net realization rates are in the motors and refrigeration measure categories. SCE's highest net realization rates are in the refrigeration and whole building measure categories. SDGE's highest net realization rates are in the motors and refrigeration measure categories. Interestingly, the net realization rate for SCE whole building measures is significantly higher than that of PG&E or SDG&E.

Measure Category	PG&E			SCE			SDG&E		
	Estimated Energy Savings (MW)	Program Tracking Energy Savings (MW)	Net Realization Rate	Estimated Energy Savings (MW)	Program Tracking Energy Savings (MW)	Net Realization Rate	Estimated Energy Savings (MW)	Program Tracking Energy Savings (MW)	Net Realization Rate
Shell	0.1	0.1	63.4%	0.01	0.1	11.9%	(0.1)	0.3	-35.4%
LPD	0.6	2.1	30.4%	1.0	2.3	42.1%	0.2	1.1	18.9%
Daylighting Controls	-	-	-	2.2	5.2	43.1%	-	0.5	0.0%
Other Lighting Controls	-	-	-	-	-	-	-	-	-
Motors	0.1	0.1	147.8%	0.3	0.5	52.5%	0.1	0.2	67.4%
HVAC	0.8	1.9	39.9%	0.9	3.8	22.9%	0.6	1.9	31.7%
Refrigeration	0.1	0.1	86.8%	0.1	0.1	115.3%	0.1	0.1	57.6%
Whole Building	1.1	3.5	29.8%	0.9	0.5	167.5%	0.2	2.2	8.9%
Combined Total	2.7	7.8	35.0%	5.4	12.5	42.9%	1.1	6.2	17.3%

Table 61: Net Realization Rates by Measure Category and Utility – Incented Measures Only

Difference-of-Differences Net Demand Reduction Results

Table 62 presents the difference-of-differences calculations for net summer peak demand reduction. The calculations result in a program level net summer peak demand reduction of 6.3 MW. This net demand reduction corresponds to a net-to-gross ratio of 23.0%.

	Participants	**Non-Participants**	**Participant Net Savings**
Baseline (MW)	129.6	100.8	
As-Built (MW)	102.2	84.4	
Savings (MW)	27.4	16.4	6.3
Savings (% of Baseline)	21.1%	16.3%	4.9%
Net-to-Gross Ratio			23.0%

Table 62: Difference-of-Differences Net Reduction – Summer Peak Demand

Table 63 presents the results of the summer peak demand difference-of-differences methodology for each of the utilities. PG&E has the highest net-to-gross ratio (23.7%) and SCE has the lowest (16.0%).

	PG&E			**SCE**			**SDG&E**		
	P	**NP**		**P**	**NP**		**P**	**NP**	
Baseline (MW)	38.2	31.7		58.1	36.3		38.7	33.5	
As-Built (MW)	30.9	27.1		44.6	29.2		31.3	28.6	
Savings (MW)	7.3	4.7	1.7	13.5	7.1	2.2	7.4	5.0	1.7
Savings (% of Baseline)	19.2%	14.7%	4.5%	23.2%	19.5%	3.7%	19.1%	14.8%	4.3%
Net-to-Gross Ratio			23.7%			16.0%			22.6%

Table 63: Difference-of-Differences by Utility

Table 64 shows the results of the difference-of-differences calculation by building type. As seen in the table, building types that have a net-to-gross ratio less than 50% are General C&I Work; Office, Religious Worship, Auditorium, Convention; Retail and Wholesale Store, and Schools. Retail and wholesale store is the only market segment for which the non-participants are more efficient than the participants.

Building Type	Sample Size		Baseline MW		Savings MW		Savings as a % of Baseline		
	P	NP	P	NP	P	NP	P	NP	Net-to-Gross Ratio
C&I Storage	23	23	12.0	10.7	4.7	2.0	39.3%	18.9%	52.0%
Grocery Store	4	4	4.4	6.9	1.6	1.3	37.5%	18.5%	50.6%
General C&I Work	19	19	34.7	13.6	5.6	1.4	16.1%	10.0%	37.4%
Medical / Clinical	1	1	4.6	3.5	0.7	0.1	14.8%	2.7%	81.9%
Office	25	26	44.4	42.9	9.9	8.0	22.2%	18.6%	16.1%
Other	2	-	0.7	-	0.1	-	20.6%	-	100.0%
Religious Worship, Auditorium, Convention	3	3	1.4	0.2	0.2	0.0	18.1%	15.7%	13.0%
Restaurant	4	4	1.6	1.1	0.1	0.0	3.4%	0.3%	92.5%
Retail and Wholesale Store	18	18	16.9	13.8	2.9	2.7	17.4%	19.4%	0.0%
School	6	6	8.7	4.6	1.7	0.8	19.6%	16.9%	13.8%
Theater	2	2	1.9	1.7	0.3	0.1	16.6%	7.2%	56.6%
Gymnasium	1	2	1.0	0.3	(0.1)	0.03	-9.7%	8.4%	-
Libraries	1	1	1.1	1.4	0.2	0.0	20.0%	0.9%	95.5%

Table 64: Difference-of-Differences by Building Type - Demand Savings[21]

Table 65 presents the net savings resulting from the difference-of-differences methodology by end use. Similar to the energy results, daylighting controls are the only end use with a net-to-gross ratio greater than 50%, with a net-to-gross ratio of 86.0%. Shell has a net-to-gross ratio just over 30%. The HVAC and Motors end uses have net-to-gross ratios just over 10%. The other lighting controls and refrigeration end uses have zero net-to-gross ratios, suggesting that the non-participants are outperforming their participant counterparts for these end uses. Compared to the energy findings, the LPD end use has increased from a zero net-to-gross ratio to 3.9%.

End Use	Building Baseline MW		Savings MW		Savings as a % of Baseline		
	P	NP	P	NP	P	NP	Net-to-Gross Ratio
Shell	129.6	100.8	4.4	2.3	3.4%	2.3%	32.0%
LPD	129.6	100.8	7.2	5.3	5.5%	5.3%	3.9%
Daylighting Controls	129.6	100.8	5.7	0.6	4.4%	0.6%	86.0%
Other Lighting Controls	129.6	100.8	0.7	0.9	0.5%	0.9%	0.0%
Motors	129.6	100.8	1.8	1.2	1.4%	1.2%	12.8%
HVAC	129.6	100.8	7.1	4.9	5.5%	4.9%	11.5%
Refrigeration	129.6	100.8	0.7	1.2	0.5%	1.1%	0.0%
Combined Total	**129.6**	**100.8**	**27.4**	**16.4**	**21.1%**	**16.3%**	**23.0%**

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[21] One of the participants in the “Other” building type was matched to an office, and the other participant in the “Other” building type was matched to a gymnasium.

Table 65: Difference-of-Differences by End Use - Demand Savings

Difference-of-Differences + Spillover Adjustment Net Savings Results

Table 66 presents the difference-of-differences + spillover Adjustment calculations for net summer peak demand reduction. The calculations result in a program level 7.8 MW of net summer peak demand reduction. These net savings correspond to a net-to-gross ratio of 28.4%. The spillover adjustment has resulted in a 5.4% increase in the program level net-to-gross ratio (28.4% versus 23.0%).

	Participants	Non-Participants	NP Spllover	Participant Net Savings
Baseline (MW)	129.6	100.8	100.8	
As-Built (MW)	102.2	84.4		
Savings (MW)	27.4	16.4	1.2	7.8
Savings (% of Baseline)	21.1%	16.3%	1.1%	6.0%
Net-to-Gross Ratio				28.4%

Table 66: Difference-of-Differences + Spillover Adjustment Net Savings – Summer Peak Demand

Table 67 presents the results of the difference-of-differences + spillover net demand reduction results for each of the utilities. Using this method, SCE has a smaller net-to-gross ratio (22.0%) than either SDG&E (27.1%) or PG&E (30.4%). Furthermore, the spillover adjustment is responsible for a 6.7% increase in PG&E's net-to-gross ratio (30.4% versus 23.7%), a 6.0% increase in SCE's net-to-gross ratio (22.0% versus 16.0%), and a 4.5% increase in SDG&E's net-to-gross ratio (27.1% versus 22.6%).

	PG&E				SCE				SDG&E			
	P	NP (Total)	NP Spillover	P Net	P	NP (Total)	NP Spillover	P Net	P	NP (Total)	NP Spillover	P Net
Baseline (MW)	38.2	31.7			58.1	36.3			38.7	33.5		
As-Built (MW)	30.9	27.1			44.6	29.2			31.3	28.6		
Savings (MW)	7.3	4.7	0.4	2.2	13.5	7.1	0.5	3.0	7.4	5.0	0.3	2.0
Savings (% of Baseline)	19.2%	14.7%	1.3%	5.8%	23.2%	19.5%	1.4%	5.1%	19.1%	14.8%	0.9%	5.2%
Net-to-Gross Ratio				30.4%				22.0%				27.1%

Table 67: Difference-of-Differences + Spillover Adjustment by Utility

Table 68 shows the results of the difference-of-differences + spillover adjustment calculation by building type[22]. Similar to the energy results, Retail and Wholesale Stores are affected by the

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[22] One of the participants in the "Other" building type was matched to an office, and the other participant in the "Other" building type was matched to a gymnasium.

spillover adjustment. Retail and wholesale store is the only market segment for which the non-participants are more efficient than the participants.

Building Type	Sample Size		Baseline MW		Savings MW			Savings as a % of Baseline				
	P	NP	P	NP	P	NP (Total)	NP Spillover	P	NP (Total)	NP Spillover	P Net	Net-to-Gross Ratio
C&I Storage	23	23	12.0	10.7	4.7	2.0	0.5	39.3%	18.9%	4.2%	24.7%	62.7%
Grocery Store	4	4	4.4	6.9	1.6	1.3	0.03	37.5%	18.5%	0.4%	19.4%	51.8%
General C&I Work	19	19	34.7	13.6	5.6	1.4	-	16.1%	10.0%	-	6.0%	37.4%
Medical / Clinical	1	1	4.6	3.5	0.7	0.1	-	14.8%	2.7%	-	12.1%	81.9%
Office	25	26	44.4	42.9	9.9	8.0	0.4	22.2%	18.6%	1.0%	4.6%	20.8%
Other	2	-	0.7	-	0.1	-	-	20.6%	-	-	20.6%	100.0%
Religious Worship, Auditorium, Convention	3	3	1.4	0.2	0.2	0.0	-	18.1%	15.7%	-	2.4%	13.0%
Restaurant	4	4	1.6	1.1	0.1	0.0	-	3.4%	0.3%	-	3.2%	92.5%
Retail and Wholesale Store	18	18	16.9	13.8	2.9	2.7	0.2	17.4%	19.4%	1.4%	-0.6%	0.0%
School	6	6	8.7	4.6	1.7	0.8	0.04	19.6%	16.9%	0.9%	3.6%	18.6%
Theater	2	2	1.9	1.7	0.3	0.1	-	16.6%	7.2%	-	9.4%	56.6%
Gymnasium	1	2	1.0	0.3	(0.1)	0.0	-	-9.7%	8.4%	-	-18.1%	-
Libraries	1	1	1.1	1.4	0.2	0.0	-	20.0%	0.9%	-	19.1%	95.5%

Table 68: Difference-of-Differences + Spillover Adjustment by Building Type

Table 69 presents the net demand reduction resulting from the difference-of-differences + spillover adjustment methodology by measure type. Comparing Table 65 with Table 69 shows that the LPD end use is the only end use that is experiencing a significant amount of spillover, as the LPD net-to-gross ratio increased by approximately 15 %, while the Shell, Daylighting Controls, Motors, and HVAC end uses only show a 2% to 5% increase in their net-to-gross ratios.

Measure Category	Building Baseline MW		Savings MW			Savings as a % of Baseline				
	P	NP	P	NP (Total)	NP Spillover	P	NP (Total)	NP Spillover	P Net	Net-to-Gross Ratio
Shell	129.6	100.8	4.4	2.3	0.2	3.4%	2.3%	0.2%	1.2%	36.8%
LPD	129.6	100.8	7.2	5.3	0.9	5.5%	5.3%	0.9%	1.1%	19.7%
Daylighting Controls	129.6	100.8	5.7	0.6	-0.1	4.4%	0.6%	-0.1%	3.7%	84.2%
Other Lighting Controls	129.6	100.8	0.7	0.9	0.0	0.5%	0.9%	-0.01%	-0.4%	0.0%
Motors	129.6	100.8	1.8	1.2	0.1	1.4%	1.2%	0.1%	0.2%	16.6%
HVAC	129.6	100.8	7.1	4.9	0.2	5.5%	4.9%	0.1%	0.8%	14.2%
Refrigeration	129.6	100.8	0.7	1.2	0.0	0.5%	1.1%	0.01%	-0.6%	0.0%
Combined Total	**129.6**	**100.8**	**27.4**	**16.4**	**1.2**	**21.1%**	**16.3%**	**1.1%**	**6.0%**	**28.4%**

Table 69: Difference-of-Differences + Spillover Adjustment by End Use

Summary

It is remarkable how contradictory the net savings results are when we compare these three approaches. In previous reporting we found that the difference-of-differences approach resulted in a much better net-to-gross ratio (NTGR) than did the self-reported method. In this round we have found the opposite, the self-reported method is showing a plausible NTGR, while the difference-of-differences approach is giving very low results, which we have not seen in any past evaluation. Of course the energy crisis has complicated the interpretation of these results. Yet the results still beg the question, which method should we be using?

A key issue is non-participant spillover, which only begins to be addressed by the difference-of-differences approach with the spillover correction. In previous evaluations we found very little non-participant spillover occurring. However the utility programs appear to be transforming the market, at least in the lighting power density (LPD) measure category. This category traditionally was heavily targeted as a program area with high returns. From 4th quarter 2000 to 1st quarter 2001, we found significant spillover in the non-participant population, specifically in the LPD measure category.

If spillover is actually occurring, the difference-of-differences methodology will certainly provide a badly biased estimate of the impact of the program. The difference of difference approach is based on the assumption that the non-participants indicate the level of energy efficiency to be expected in the absence of the program. If the program is in fact generating substantial improvements in energy efficiency of the non-participants, then the non-participants are not a suitable comparison group for assessing the impact of the program. If, ignoring this, we do use the non-participants in this way, then we are penalizing the program for its impact on the non-participants rather than giving the program credit for this impact. In other words, by using the difference-of-differences methodology we are not crediting the utilities with market changes for which they are responsible.

Therefore we feel that the self-reported methodology provides the most accurate measure of actual program savings since it accounts for both free-ridership and program induced non-participant spillover at the measure level.

From 4th quarter 1999 to 3rd quarter 2000, we found very little non-participant spillover, which is easily explained by the efficiency of the non-participants relative to baseline. From 3rd quarter 2001 to 4th quarter 2001, non-participants have experienced a tremendous growth in efficiency when compared to the baseline, however as we have shown in this section a remarkable amount of the added non-participant efficiency has been reported as program induced savings, further evidence that the spillover is real.

Now we appear to be seeing that the program is beginning to transform the NRNC market. That is, we may be seeing measurable spillover. If so, we will have to accept the need to replace the difference-of-difference methodology that has served well in the past. Is the self-reporting approach a suitable tool for measuring spillover? It is probably too early to know for sure. Historically California program evaluations have stayed away from the use of self-reported information. But is there any feasible alternative?

We also point out that while 82% is the estimated comprehensive net-to-gross, it remains uncertain how high this estimate may climb in the future. It is very likely that as Savings By Design continues to deliver energy savings through owner and design team incentives and training that the program will change standard practice related to energy efficiency design practices. Moreover, so long as SBD program administrators strive to bring new customers to the program, while at the same time limiting service to those that have previously participated, the net-to-gross may vary well exceed 100%. Such results would suggest an adoption of energy efficient technologies without the need for utility subsidy. Of course as energy efficiency technologies change and become more efficient it will be the role of SBD to push the envelope by helping emerging technologies become more mainstream.

In our prior evaluations of the NRNC programs under CADMAC rules, we sought to estimate net program savings using an econometric approach. Basically the approach was the following.

1. Use onsite audits and DOE-2 engineering simulation models to estimate the gross energy efficiency of each sample building relative to the Title-24 baseline.

2. Ask the owners and design teams associated with each building in the sample how strongly their design decisions about energy efficiency have been affected by the program.
3. Build an econometric model that relates the observed energy efficiency of the sample buildings to the reported influence of the program as well as to other characteristics of the building.
4. Use the econometric model to predict what the energy efficiency of the program participants would have been in the absence of any program influence; use this to estimate the free ridership among the participants.
5. Use the econometric model to predict what the energy efficiency of the program non-participants would have been in the absence of any program influence; use this to estimate the spillover among the non-participants.

This approach still depended on self-reported information from the participants and non-participants about the influence of the program on their decision. Moreover, the results often seemed to be quite sensitive to the specification of the model and the weight given to highly influential observations. In addition, the approach required large sample sizes – larger than feasible with the BEA study budget allocation, relative to previous evaluations. Therefore we did not attempt to replicate this approach.

Instead we sought to strengthen the self-reporting methodology itself. In this study we complete our decision maker survey no more than three months after the building is occupied, whereas in the prior studies the decision maker survey was completed at least a year and in most cases two or more years after occupancy. We believe this makes it easier for the respondent to remember the actual decision making process. In addition, we ask about each of the individual measures that are more efficient than the Title-24 baseline, whereas in the prior survey we just asked about the overall design. Finally, we use the DOE simulations to quantify the energy implications of the information that we collect, whereas before we used an econometric model to relate the general information to energy efficiency. Finally, we collect information about decision making in the broader context of a rather extensive process evaluation. For all these reasons, we believe the current approach of using the self-reported method is robust and defensible. We look forward to see how it performs in subsequent BEA studies.

Process Evaluation

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.

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. The responses are presented in a format that facilitates comparison of Non-participants to participants.

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-makers' perceptions of energy efficiency of their buildings;
- Savings By Design program questions - program awareness, motivations to participate, and barriers to participation.

A total of 210 owner surveys were completed. Of the 210 surveys, 106 were with participant owners and 104 were 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.

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

Building Descriptive Statistics

Table 70 shows the building ownership type by program participation status. While the vast majority of projects are privately owned, the percentage of non-participant private projects (76.5%) is significantly lower than that of participants (91.2%). The low percentage of publicly owned buildings in the participant population suggests that the utilities are avoiding program free-ridership that would result from mandated efficiency requirements in the public sector.

	% of Respondents	
	Participants	**Non-Participants**
Private	91.2%	76.5%
Public	8.8%	22.7%
Don't Know	-	0.9%

Table 70: Building Ownership[23]

Table 71 shows the building occupancy intent during construction by program participation status. Research has shown that owner-occupied buildings are designed more efficiently. [24] The pattern of ownership is similar between the two groups.

	% of Respondents	
	Participants	**Non-Participants**
Owner-Occupied	59.2%	62.7%
Lease All Spaces	40.1%	35.3%
Both	0.7%	2.0%

Table 71: Occupancy Intent During Construction

Table 72 presents the "most important financial criteria" used to make energy efficient investments during construction by program participation status. Both participants and non-participants consider "lowest lifetime cost" the most important financial criteria, however a significantly higher percentage of participants (49.3%) than non-participants (29.9%) gave this response.

The percentage of participants (12.5%) who responded "simple payback" was significantly higher than that of non-participants (5.9%). The only criterion where the percentage of non-participant responses (18.7%) was significantly higher than that of participants (10.5%) was "lowest first cost". Participants appear to be more concerned with life cycle costs than are the non-participants. The participants are much more likely to implement more comprehensive methods (i.e., lifetime cost, ROI, simple payback) in making energy efficiency purchasing decisions, as compared to the non-participants who are more likely to make decisions based on lowest first cost. A significant percentage of non-participants were unable to answer the question.

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

[24] 2000 Non-residential New Construction Baseline Study

	% of Respondents	
	Participants	**Non-Participants**
Lowest Lifetime Cost	49.3%	29.9%
Simple Payback	12.5%	5.9%
Return on Investment	19.1%	16.5%
Lowest First Cost	10.5%	18.7%
Other	1.1%	4.1%
None	3.6%	5.4%
Don't Know	3.9%	18.6%
Refused	-	0.9%

Table 72: Most Important Financial Criteria

Table 73 displays the percentage of participants and non-participants that used a set of stock plans in the design of the building. If 38% of participants are using stock plans without any modifications, the results suggest that 38% of participants are program free-riders. The tracking data showed that many participants had multiple projects receiving incentives under SBD using stock plans. Program managers may want to encourage SBD representatives to be aware of those using stock plans as their inclusion may contribute to program free-ridership. However, in many cases SBD assists companies in increasing the efficiency of stock plans, which ultimately locks in the savings for future projects.

	% of Respondents	
	Participants	**Non-Participants**
Yes	38.2%	36.2%
No	59.0%	58.4%
Don't Know	2.8%	5.4%

Table 73: Use of Prototype Plans

Design Team Selection and Construction Practices

Table 74 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	94.4%	93.9%
No	5.6%	6.1%

Table 74: Use of Independent

Architect / Designer

Table 75 shows the percentage of respondents that considered qualifications in energy efficiency in selecting the design team. Not surprisingly, a significantly higher percentage of participants (46.8%) considered energy efficiency qualifications in design team selection, while only 20.8% of non-participants took this into consideration.

	% of Respondents	
	Participants	Non-Participants
Yes	46.8%	20.8%
No	44.9%	66.6%
Don't Know	8.3%	12.6%

Table 75: 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

"We had to talk the design team into exceeding codes. We were especially concerned with lighting options as we did not want overhead fluorescents."

"We were considering energy efficiency. Fortunately for us, the design team we chose had participated in previous years of the Savings by Design program."

"Decisions were based on being competitive, and keeping operation and maintenance costs low for our tenant."

Non-participants

"We are concerned with overall standards, we interviewed multiple designers to see if they can meet our requirements as well as all energy efficiencies."

"Definitely a consideration, as the owner we pay for the utilities so we want the lowest possible energy costs."

"Our concerns are threefold: capability, cost, and innovative ideas in terms of equipment choice."

Table 76 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 (70%) than were non-participants (34%). Although the numbers here are significantly different, it is interesting that such a high number of non-participants requested energy efficient designs without the incentives of the program encouraging them to do so.

	% of Respondents	
	Participants	**Non-Participants**
Yes	69.8%	33.9%
No	24.7%	56.8%
Don't Know	5.5%	9.2%

Table 76: 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. Below are some verbatim responses:

Participants

“We use energy efficient equipment if it saves us money and accomplishes the same task.”

“We knew about the incentive program so we asked our designers to keep that in mind which encouraged us to design beyond Title-24 requirements.”

"We asked our designers to use T-8 lamps with reflectors, premium efficient motors on the HVAC units, and waterside economizers for air handling units.”

Non-participants

"We pursue anything beyond Title-24 as long as the payback is within 3.75 years.”

"We build about 5 million square feet of buildings like this every year. If we have a prospective tenant we are more likely to design an efficient building beyond Title-24."

"We were particularly concerned with the efficiency of the envelope. We wanted the most efficient equipment available on the market with the least maintenance.”

All survey respondents were asked if they were familiar with the practice of designing new buildings using an “Integrated Design” approach, and those that were aware were then asked to explain what they believed the approach was. Table 77 presents the results by program participation status. The percentage of participants that were familiar with the practice was 40.3% compared to 32.5% of non-participants.

	% of Respondents	
	Participants	**Non-Participants**
Yes	40.3%	32.5%
No	54.4%	57.2%
Don't Know	5.3%	10.2%

Table 77: 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

"In sizing the HVAC units there were numerous factors including lighting loads, skylights, and occupancy.”

"Designers used data on expected growth and heat output from air conditioning units to size equipment.”

"Absolutely this approach was used, we considered occupancy, criteria used for electric loads, and expected heat loads.”

Non-participants

"We start with basic power, step by step we integrate lighting heat loads, ambient temperatures, humidity, manufacturing loads and occupancy.”

"We reviewed the power requirements for an average warehouse and then tailored them to our needs.”

“When sizing the HVAC units we consider lighting loads, occupancy, ambient temperatures, humidity and design from there.”

These responses indicate that the integrated design theory is beginning to be understood by building owners. Some of this knowledge may be attributed to the SBD program which is 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 their designer(s) to follow an Integrated Design approach. Table 78 summarizes the responses. Participants who were familiar with the approach were significantly more likely to ask the designer to follow the Integrated Design approach.

	% of Respondents	
	Participants	**Non-Participants**
Yes	70.0%	39.6%
No	24.8%	50.9%
Don't Know	5.2%	9.5%

Table 78: Occurrence of Requesting Integrated Design Approach Among Those Familiar with the Approach

The survey respondents who asked the 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 told the architect to use a select group of mechanical engineers who factored in the heat gain from lighting and occupants."

"Engineers looked at design in reference to mechanical system and meeting demands."

"Cold storage requires full building integration."

Non-participants

"Yes, the architects worked with us to design the cooling system."

"We specified to the architect that the HVAC needed the greatest amount of focus at that time."

"We're not familiar with name in that context but our mechanical engineers are taking into consideration when sizing the HVAC, glazing and lighting layouts."

All survey respondents were asked if they solicited competitive bids for construction of the building. As Table 79 shows, about four-fifths of both program participants and non-participants solicited competitive bids.

	% of Respondents	
	Participants	**Non-Participants**
Yes	82.0%	79.1%
No	14.5%	17.8%
Don't Know	3.5%	3.1%

Table 79: Solicitation of Competitive Bids

Table 80 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. The percentage of non-participants is higher than participants, at 15.2% and 10.6% respectively.

	% of Respondents	
	Participants	Non-Participants
Yes	10.6%	15.2%
No	78.7%	78.2%
Don't Know	10.7%	6.6%

Table 80: Occurrence of Changes to Energy Efficiency Features

Table 81 shows the percentage of respondents who claim they hired an independent construction manager or commissioning agent to help insure the final building followed the original design intent. Participants and non-participants were equally as likely to claim they used such an agent.

	% of Respondents	
	Participants	Non-Participants
Yes	31.4%	29.5%
No	66.8%	67.0%
Don't Know	1.8%	3.5%

Table 81: Use of Independent Construction Manager or Commissioning Agent

Energy Efficiency Attitudes

The following tables show the vast majority of respondents place a high value on energy efficiency during design and construction (Table 82), and in daily operations (Table 83). Furthermore, they are applying these attitudes in practical ways such as instituting energy management policy (Table 84), and including energy efficiency in employee performance evaluations (Table 85). Design teams are responding to this awareness of building owners by advertising energy efficient design practices (Table 99), and Integrated Design services (Table 100).

, The percentage of participants and non-participants considering energy efficiency during design and construction to be “very important” was 44.6% and 43.4% respectively, as shown in Table

82. Combining the "important" responses ("somewhat" and "very"), 88.6% of participants and 76.4% of non-participants considered energy efficiency during design and construction to be important. These results help to explain the high spillover rates documented in the previous sections.

	% of Respondents	
	Participants	**Non-Participants**
Very Important	44.6%	43.4%
Somewhat Important	44.0%	33.0%
Neither Important nor Unimportant	2.8%	14.3%
Somewhat Unimportant	8.1%	7.4%
Very Unimportant	0.5%	1.9%
Mean Rating :	4.24	4.09

Table 82: Importance of Energy Efficiency during Design and Construction

Participants and non-participants were asked to rate the importance of energy efficiency in daily operations from 1 to 5 with one meaning "very unimportant" and five meaning "very important." The results are listed below in Table 83. The participant and non-participant responses were similar. Interestingly, the energy efficiency considerations for design and construction were found to be less important than the energy efficiency considerations in daily operations, as indicated by the mean ratings from Table 82 and Table 83.

	% of Respondents	
	Participants	**Non-Participants**
Very Important	60.4%	63.2%
Somewhat Important	27.3%	20.7%
Neither Important nor Unimportant	5.9%	3.8%
Somewhat Unimportant	5.2%	6.9%
Very Unimportant	1.2%	2.4%
Don't Know	-	3.0%
Mean Rating:	4.41	4.40

Table 83: Importance of Energy Efficiency in Daily Operations

Table 84 presents the fraction of participants and non-participants whose companies have a policy on energy management. The findings suggest that one in every two companies has an energy management policy.

	% of Respondents	
	Participants	**Non-Participants**
Yes	54.8%	55.2%
No	36.4%	34.2%
Don't Know	8.8%	10.5%

Table 84: 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

"'We have reduced our energy needs by 20-30% in the last 6 months simply by reducing lighting and turning off systems not in use."

"Our EMS schedules all the lighting, and space conditioning to corporate standards. There are electronic set points for occupied and unoccupied times, to determine if there is lighting override. We monitor energy use at stores and track end use consumption."

"After the power crunch we started monitoring lights, created set-points on our HVAC and turned off all equipment when not in use."

Non-participants

"Our corporate policy is to reduce energy consumption using year 2000 as our baseline by 5% until 2004. We are on target with a 6% reduction in Sonoma County. We are also striving to meet ISO (Independent Systems Operation) compliance well beyond Title-24 baseline."

"Invest in sophisticated technological equipment with monitoring capabilities that can be reviewed on a local level or from corporate headquarters."

"Our EMS operates in conjunction with lighting and motion sensors to turn off lights not in use. We have periodic inspections to ensure facility is operating correctly, and our goal in to reduce energy usage by 20%."

Energy Performance

All survey respondents were asked if the company's energy performance was used in the review of any employee's performance or compensation. Table 85 summarizes the responses among both program participants and non-participants. Approximately 21% of participants and 16% of non-participants state that the energy performance of the company is used to review employee performance or compensation.

	% of Respondents	
	Participants	Non-Participants
Yes	21.4%	16.3%
No	64.2%	73.9%
Don't Know	14.3%	9.8%

Table 85: 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 86 presents the distribution of responses for both groups. Eighty five percent (85%) of participants believe their buildings are better than code. Most of those (52%) believe their buildings are slightly better than code. Participants and non-participants were equally as likely to believe their buildings were much better than required by code. However, non-participants were significantly more likely to believe their buildings were just efficient enough to comply with code. Participants and non-participants were equally as likely to believe their building was much better than required by code.

	% of Respondents	
	Participants	Non-Participants
Just Efficient Enough to Comply with Code	6.6%	23.4%
Slightly Better than Required by Code	52.6%	39.8%
Much Better than Required by Code	32.7%	29.8%
Don't Know	8.1%	7.0%

Table 86: Opinion of Building Efficiency Relative to Code

Table 87 summarizes the responses given when owners were asked to describe the energy performance of their building. Fifty one percent (51%) of participants believed their building to be either "an example of energy efficiency" or "as efficient as can be." This is significantly higher than non-participants (31%). However, roughly the same percentage of participants and non-participants stated that their buildings could be somewhat more efficient.

	% of Respondents	
	Participants	Non-Participants
Could be Much More Efficient	2.4%	8.0%
Could be Somewhat More Efficient	43.3%	46.1%
About as Efficient as Can Be	31.9%	22.0%
An Example of Energy Efficiency for Others to Follow	18.7%	9.4%
Don't Know	3.7%	14.5%

Table 87: 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 88, over three quarters of participants heard of the program through utility representative or previous utility program participation. The large proportion of participants that previously participated in NRNC programs (30.8%) suggests that the program may need to change its marketing strategy to attract more customers that have not previously participated, rather than focusing on the same customer pool p. This approach would likely lead to lower program free-ridership and a potential increase in non-participant spillover.

	% of Participants
Utility Representative	45.5%
Previous Utility Program Participation	30.8%
Architect	7.7%
Marketing Material	4.3%
Engineer	3.8%
Construction Manager	3.4%
Other	2.8%
Current Tenant/Previous Tenant	0.7%
Don't Know	0.7%
Manufacturer Representative	0.3%

Table 88: Source of Awareness of Savings by Design

Table 89 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 half of participant owners say they, the owners, were the biggest advocates for SBD participation. This supports the finding of our NRNC baseline study[25] that architects and engineers feel that the owners are the key decision-makers. Surprisingly, energy manager, facility manager and construction manager were cited much more often than designers as being the biggest advocate for participation. Those that are considered a part of the 'Other' category were often serving dual roles such as, energy manager and mechanical engineer.

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

	% of Participants
Owner/Developer	48.6%
Energy Manager/Facility Manager	21.1%
Construction Manager	10.8%
Other	7.0%
Lighting Designer/Electrical Engineer	3.9%
Architect	3.5%
Mechanical Engineer	3.4%
Don't Know	1.7%

Table 89: 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 90, nearly 33% of owners felt the incentive was very important. The percentage considering the incentive unimportant was slightly over 20% (12% + 8.5%).

The findings in Table 90 lead to the question, why are over 20% of the program participants participating if the incentive is unimportant to them? Other aspects of the program, such as design assistance and design analysis, may be the answer to this question. This indicates that these services are truly value-added services that the participants are not receiving outside of the program.

	% of Participants
Very Important	32.6%
Somewhat Important	37.5%
Neither Important Nor Unimportant	9.4%
Somewhat Unimportant	12.0%
Very Unimportant	8.5%

Table 90: Importance of Owner Incentive in Participation

All participants were asked to rate the level of influence of various SBD components on the design of the participant building. Table 91 shows the responses of those components. Fifty percent (50%) of the respondents replied that the incentive was somewhat or very influential. Forty percent (40%) said that the new construction representatives' recommendations were somewhat or very influential, however an equal percentage said the reps. recommendations were not influential.

	% of Participants	
	Owner Incentive	**NC Rep. Recommendation**
Very Un-influential	11.1%	17.1%
Somewhat Un-influential	16.0%	24.1%
Neither Un-influential Nor Influential	22.9%	16.9%
Somewhat Influential	24.6%	24.9%
Very Influential	25.4%	14.8%
Don't Know	-	2.2%

Table 91: Owner Incentive and NC Rep. Influence on Design of Building

All participant owners were asked if the design team received a design team incentive for the project. The great majority of respondents stated that the design team did not receive an incentive for the project, as shown in Table 92.

	% of Participants
Yes	6.2%
No	81.0%
Don't Know	12.8%

Table 92: Design Team Incentives

As shown in Table 93, 60% of participants stated SBD participation influenced them to change their standard building practices to lead to more efficient buildings. The message from the 39% answering “No” is less clear. If their “standard building practice” is an equivalent level of energy efficiency, then they are program free riders. If their standard practice is less than SBD requirements, then they would be expected to revert to less efficient practices in the absence of the program incentives, disregarding the benefits of building life cycle cost analysis. The comments by participants following the table below suggest that both characterizations apply.

	% of Participants
Yes	60.3%
No	39.3%
Don't Know	0.4%

Table 93: Incidence of SBD Participation Changing Standard 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 program has not influenced us because it has always been our standard practice to design for energy efficiency to maintain the lowest operating cost."*
>
> *"It's too expensive even though the O&M are lower in the long run. We had a change of ownership new owners are more concerned with lowest first cost rather than lowest life time cost which was the previous owners concern."*

"We are designing new building(s) with efficient lighting as apart of our standard practice, we would do this with or without incentives from the program."

All SBD participants who stated participation caused them to change their standard building practices to lead to more efficient buildings were asked which component(s) of the program was the most instrumental in causing this design practice change. Table 94 shows that over 60% of participants say the owner incentive was the most influential. The responses that are part of the 'other' category were often combinations of the three individual components. The responses suggest the cash incentive was the original basis for program participation.

The SBD incentive is likely the most influential because it covers the added cost of moving from standard efficiency to more efficient products and equipment. Perhaps the incentive reduces the perceived risk associated with building design changes, to acceptable levels. These risks would include the expenses associated with program participation and the additional time investment required to research and analyze new technologies and approaches. However, other aspects of the program, such as design assistance, reduce the associated risks and costs of participation. One would imagine that after the owners have had a favorable experience with program and have navigated the associated learning curve, they would install similar measures in the future. This reiterates the importance of incentive-based programs coupled with energy education, training and assistance, such as SBD, as a vehicle to transform the NRNC market to a more energy efficient and sustainable market.

	% of Participants
Owner Incentive	60.1%
Design Assistance	21.4%
Design Analysis	0.8%
Other	14.8%
Don't Know	2.9%

Table 94: Most Instrumental Component in Changing Building Practices

All participants were asked to provide any recommendations for change to the SBD program in order to improve its delivery to customers. These answers were unprompted, but have been categorized based on common responses. Table 95 shows that a third felt the no changes are needed. The most frequent recommendation was for the utility representatives to present the benefits more clearly.

	% of Participants
No changes needed	33.6%
Utility representatives need to present benefits more clearly	11.2%
Increase incentives	9.6%
More marketing to increase awareness of program	8.0%
Review and response from utility needs to be more rapid	6.4%
More interaction with design team	6.4%
Utilities should be involved earlier on in project	5.6%
Less paper work and bureaucracy	5.6%
Increase post-project evaluation	2.4%
Increase requirements to increase energy savings	0.8%
Other	8.0%
Don't know	2.4%

Table 95: Recommended Changes to Savings by Design

The “Other” category responses address issues that have not been presented above. They are as follows:

> *"Make the incentives available to all who exceeds Title-24 by at least 10% and complies with the requirements."*
>
> *"Make available on-line applications".*
>
> *"Simplify the procedure by having a personal representative for each utility to help with filling out forms etc.”*

Non-participants

All non-participants were asked if they were aware of the Savings By Design New Construction energy efficiency program before they began construction. Table 96 shows about 38% of non-participants were aware of the program before they began construction. These findings do suggest that the SBD program is reaching over one third of non-participants, but that they are choosing not to participate.

	% of Non-Participants
Yes	37.9%
No	56.4%
Don't Know	5.7%

Table 96: Awareness of SBD Before Construction Began

The 38% of non-participants who were aware of SBD before construction began were asked to state the reason why they did not participate in the program. Below are some of the responses that were provided.

"Too difficult to work with the utility. No incentives are given for exceeding Title-24 with prototypical drawings."

"This project was a "spec" building, during the design we didn't have any prospective tenants so we couldn't participate without a built-out space."

"The benefit was insignificant. It costs us more to fill out the paper work than the amount received for HVAC incentives."

"We were involved with SBD on another building but when we applied there was no more funding available through the utility."

These respondents (the 38% answering yes" in Table 96) were asked if they had any interaction with their utility's new construction program representative or SBD program material regarding the design and equipment specification of their project. The results are displayed in Table 97. A larger percentage of the respondents did not have any interaction with SBD staff or program material regarding design and equipment specifications.

	% of Non-Participants
Yes	42.9%
No	57.1%

Table 97: Interaction with SBD Staff or Program Material Regarding Design and Equipment Specifications

All non-participants who were aware of SBD were asked if they were aware of the incentive and if it would have motivated them to design their building to perform better than Title-24. The results are provided in Table 98. Sixty-two percent (62%) of non-participants who were aware of the incentive when construction began stated that they would have been very likely to design their building to perform better than Title-24 if they had known of the incentive. Among those who were unaware of SBD when construction began 55% stated that they would have been very likely to design their building to perform better than Title-24 had they known of the incentive. These findings correspond with the findings in Table 90 that indicate the cash incentive was the original basis for program participation of roughly 50% of program participants.

	% of Non-Participants	
	Aware of SBD	**Not Aware of SBD**
Very Likely	61.6%	55.0%
Somewhat Likely	16.2%	29.9%
Neither Likely Nor Unlikely	7.1%	1.6%
Somewhat Unlikely	5.9%	1.6%
Very Unlikely	8.0%	0.0%
Don't Know	1.2%	11.9%

Table 98: Likelihood of Designing Building to Perform Better than Title-24 if Aware of Financial Incentives

Design Team Surveys

A survey of one of the key members of the design team was conducted for each sampled site. A total of 85 participant and 74 non-participant design team surveys were completed for this study. Of the 85 participant surveys, 34 were with architects, 41 with engineers, and 10 with construction managers. Of the 74 non-participant design team surveys, 42 were with architects, 18 with engineers, and 14 with construction managers. Several of the design teams were involved in projects that were both participants and non-participants. In these cases, the design team was classified as a participant design team member when working on a participating site and a non-participant design team member when working on a non-participating site.

The design team surveys were conducted in order to assess the level of energy efficient design that is being practiced on new construction projects. The results also provide their responses about their attitudes toward the incentive program.

Questions regarding design practices address awareness of the integrated design for energy efficiency 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, construction manager or the architect, varying by project depending upon their knowledge of the building systems and the decision making process 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. Non-participants were asked the reasons behind their non-participation in SBD. Below are points addressed in the survey exclusively to participants and non-participants:

Participants

- Importance of incentive in motivation to participate in SBD
- Method of program delivery
- Design Analysis provided? If so, value of that service.
- Any changes to building after Design Analysis provided
- Importance of SBD program features 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
- Would you have design project 15% better than baseline if aware of incentive
- Computer simulation used to optimize and enhance the energy performance of the building

The response to and an analysis of their meaning are presented in this section of the report. The design team survey responses were not weighted to represent the total population, 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 99 presents the results by program participation status. Participant design teams were more likely to advertise energy efficient design practices than non-participant design teams. Note that "Not Applicable" refers to respondents who had in-house designers and therefore did not have a need to advertise.

	% of Respondents	
	Participants	Non-Participants
Yes	36.6%	23.3%
No	46.3%	65.7%
Not Applicable	12.2%	5.5%
Don't Know	4.9%	5.5%

Table 99: Advertisement of Energy Efficient Design Practices

All survey respondents were then asked if their firm advertised "Integrated Design". Note that if the respondents were unfamiliar with "Integrated Design" we gave an example of "Integrated

Design". Table 100 shows that participants and non-participants were about equally likely to advertise integrated design. Over half of participants and almost two thirds of non-participants did not advertise integrated design. Note that "Not Applicable" refers to respondents who had in-house designers and therefore did not have a need to advertise.

	% of Respondents	
	Participants	**Non-Participants**
Yes	34.1%	30.1%
No	51.2%	60.3%
Not Applicable	12.0%	5.5%
Don't Know	2.4%	4.1%

Table 100: Advertisement of Integrated Design

Participant Design Teams

Of the 85 participant design teams only nine (9) received a Design Team incentive. All nine participant design teams that received an incentive were asked to indicate how important the incentive was in motivating them to participate in the program. Table 101 summarizes the responses. All respondents stated the incentive was somewhat important or very important in motivating their participation.

	% of Participants
Very Unimportant	-
Somewhat Unimportant	-
Neither Important or Unimportant	-
Somewhat Important	77.8%
Very Important	22.2%
Number of Respondents	**9**

Table 101: Importance of Incentive in Motivating Program Participation

All designer participants were asked to recall which method of program delivery was used on their project, either the Whole Building Approach or the Systems Approach. 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. The results in Table 102 indicate that more than a third did not know the method of used for program delivery. This indicates that a good portion of the designers are unfamiliar with the specifics of the program they are involved in. This is also explained by the lack of participation by designers in the SBD program. Among those that provided an answer, 50% answered correctly.

	% of Participants
Whole Bldg. Approach	28.6%
Systems Approach	35.7%
Don't Know	35.7%

Table 102: Correctly Identified Method Used for Program Delivery

Table 103 shows the responses given when the participant design teams that received utility-provided design analysis on their project were asked to indicate the level of value of the Design Analysis component of SBD. The vast majority, 83%, found this component of the program to be very valuable.

	% of Participants
Very Valueable	83.3%
Somewhat Valueable	16.7%
Very Insignificant	
Somewhat Insignificant	
Neither Valuable nor Insignificant	
Number of Respondents	**11**

Table 103: Value of Design Analysis

All designer participants were asked to rate the level of influence of various SBD components on the design of the building. Table 104 shows that 66% of the design team respondents found the owner incentive to be influential on the design of their building. This significantly exceeds the owner's assessment of the influence of the owner incentive (27%, Table 91). Twenty-seven percent (27%) of the respondents rated the design team incentive as very or somewhat influential. The utility representatives' influence appears to be fairly neutral overall.

	% of Participants		
	Owner Incentive	Design Team Incentive	NC Rep. Recommendation
Very Influential	44.0%	25.0%	16.7%
Somewhat Influential	22.6%	25.0%	9.5%
Neither Un-influential Nor Influential	13.1%	37.5%	28.6%
Somewhat Un-influential	3.6%	-	13.1%
Very Un-influential	6.0%	12.5%	13.1%
Don't Know	10.7%	-	19.0%

Table 104: Owner Incentive, Design Team 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. The three most frequently stated responses were owner/developer (42%), mechanical engineer (29%), and architect (17%) as indicated in Table 105 below. Comparing these to the results in Table 89 we see that both the designers and the owners most often credited the owner as being the biggest advocate for program participation. However, the second most common responses are very different. Owners cited energy managers/facility managers as the second biggest advocate for the program whereas designers cited mechanical engineers.

	% of Participants
Owner/Developer	41.7%
Architect	16.7%
Lighting Designer / Electrical Engineer	4.8%
Mechanical Engineer	28.6%
Energy Manager	1.2%
Construction Manager	4.8%
Other	1.2%
Don't Know	1.2%

Table 105: 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 106 shows that 63% of the participants stated that their standard design practices were influenced by SBD. This is very similar to the 60% of participant owners who stated that their standard design practices were influenced by SBD as shown in Table 93.

	% of Participants
Yes	62.7%
No	34.9%
Don't know	2.4%

Table 106: 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 (35%) were asked why they were not influenced. Below are a few examples of the responses:

"We don't have the latitude to make those decisions it's driven by our client."

" We already design with the highest energy efficiency available, the only influence from the program is in payback period."

"We have not experienced any program influence to this date. The incentive was to the end user (owner). Certainty if we received an incentive it may influence our decisions. However we continue to pass information about the program to the owners."

"Both the incentive and the design assistance are important, but it's the incentive that sells efficiency to the owner."

Non-participant Design Teams

All non-participant design team respondents were asked if they were familiar with Savings By Design. As shown in Table 107, 43% of the non-participants were familiar with the program. Non-participant design teams were slightly more likely to be aware of SBD than were non-participant owners (38%).

	% of Non-Participants
Yes	43.2%
No	55.4%
Don't Know	1.4%

Table 107: 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 108 shows that among the 43% of respondents who were aware of the program (Table 107), 60% of them were aware that an incentive might have been available. This equates to approximately 25% of all the non-participants being aware of the design team incentive.

	% of Non-Participants
Yes	60.0%
No	40.0%
Don't Know	-

Table 108: Awareness of Incentive – NP Design Team

The 25% 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:

"We told the developer about the program he choose not to pursue it because the tenant didn't have a big electric demand."

"We worked with the mechanical engineers and tried to get the building to meet the SBD requirements, but we wanted to use a lot of glazing. Even with the dual glazing we couldn't get the building to qualify."

"The program incentives offset some initial cost of the project but it was still not cost effective."

All non-participants who were unaware of SBD, and all non-participants who were aware of SBD but unaware of the design team incentive were then asked the following question: "If you had known about the incentive, how likely it is that you would have pursued the incentives by designing your project to perform at least 15% better than Title-24." Table 109 presents the percentage breakdown of the responses. Over 35% of the respondents stated that they would have been "very likely" and 27% would have been "somewhat likely" to have designed a more efficient project**.** This would indicate that further communication between design teams and the SBD representatives would be productive.

	% of Non-Participants
Very Likely	35.9%
Somewhat Likely	26.6%
Neither Likely Nor Unlikely	7.8%
Somewhat Unlikely	9.4%
Very Unlikely	14.0%
Don't Know	6.3%

Table 109: 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:

"Fast-track project. The design assistance was too time consuming and equipment choices were design build."

"It would have been difficult to qualify since the project was a renovation of existing facility. Budget constraints also prohibited the ability to design better than Title-24 baseline."

A common theme of many of the other responses conveyed the lack of owner interest due to the perceived budget impact. In response to this development, design teams are expanding their marketing in energy efficiency as demonstrated in Table 79 and Table 80.

All non-participants who were unaware of SBD and 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 110 shows that over three quarters of respondents would have been likely to pursue the Design Assistance and Design Analysis component of SBD.

	% of Non-Participants
Very Likely	47.6%
Somewhat Likely	28.6%
Neither Likely Nor Unlikely	6.3%
Somewhat Unlikely	6.3%
Very Unlikely	6.3%
Don't Know	3.2%
Refused	1.6%

Table 110: Likelihood of Pursuing Design Assistance and Design Analysis if Aware of Design Team Incentives

Among respondents who were unaware of the design team incentive, approximately one-third were also unaware of design assistance and design analysis. 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:

> *"It's tough to evaluate if the building could have exceeded Title-24 by at least 15%; don't know if owner could afford to make the building that efficient even with the dual glazed windows we installed."*

"The owners are concerned with initial cost and marketing image, energy design is not a high priority."

All non-participant designers (architectural, electrical, mechanical) 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 111, the use of computer modeling is only used by approximately one quarter of non-participants.

	% of Non-Participants
Yes	27.0%
No	66.2%
Don't Know	6.8%

Table 111: Use of Computer Simulation Modeling Design

The 27% 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 112 shows that almost two thirds of those non-participants stated that a computer simulation was standard practice. This translates into 17% of all non-participant design teams utilizing computer simulations as standard practice.

	% of Non-Participants
Standard Practice	63.6%
Request of Clients	13.6%
Don't Know	22.8%

Table 112: Computer Simulation as Standard Practice

Those 27% 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:

"The building department likes to see these models. Our mechanical engineers have been using them for the last 3-4 years."

"We've been using computer models since 1988 before '88 we did models by hand. We use them to get a more accurate sizing of the HVAC units."

"In the last 6-7 years, our number of stores started expanding from 1000 to 3000, operating costs increase, promoting the need for energy models."

Summary

In conclusion, participants appear to be more sophisticated with respect to financial criteria used to justify energy efficient purchases and design decisions. This sophistication may be an adaptation resulting from program participation since one aspect of the program is teaching participants to use more complex approaches to understanding the long-term benefits of energy efficiency decision-making.

Forty-seven percent (47%) of participant owners considered energy efficiency qualifications when selecting their design teams, compared to 21% of non-participant owners. Participant owners are shown to have greater interest in selecting design teams with experience and qualifications in energy efficient design practice. This may be in part due to the fact that owners have more of a vested interest in exceeding Title-24 in order to qualify for the SBD incentive.

Program participants and non-participants have similar attitudes toward energy efficiency. Participants and non-participants alike put a high value on the efficiency of the building during design and construction and also on daily building operation. Approximately 55% of both participants and non-participants have an energy management policy.

Participants and non-participants believe that their buildings are efficient. Survey respondents were asked to evaluate how efficient they thought their buildings were compared to code. Participants and non-participants were equally as likely to believe their buildings were much better than required by code. A large majority (85%) of participants believe their buildings are better than code. Most of those (52% of total) believe their buildings are slightly better than code Non-participants were significantly more likely to believe their buildings were just efficient enough to comply with code.

The Savings By Design incentive is the key factor that influences energy efficient building design and construction, illustrated by the following findings.

Just over 20% of participants say that the incentive was somewhat unimportant or very unimportant as a factor in their participation in the SBD program. This finding suggests that the program has other services not linked to the incentive that customers value. This is supported by the 21% of respondents who said that the Design Assistance component of the program was the most influential reason for participating.

The administrative requirements of participation present SBD with a participation barrier. Forty percent (40%) of non-participants were aware of the program before design and construction began. Detailed responses suggest that this group does not see enough benefit in participating when compared to the “red tape” requirements. It also appears that improved communications between SBD program representatives and building decision makers would increase program penetration through better understanding of the program requirements and offerings.

Design assistance/analysis is highly valued by design team members. Of the twelve design teams surveyed that received Design Assistance/Analysis, 83% reported the service as “very valuable” and the remaining 17% reported it as “somewhat valuable”. Moreover, 63% of participating design teams report the SBD program will have a lasting effect on the way they design buildings.

Many design teams are aware of SBD, but are not aware of the design team incentives that are available. Forty percent (40%) of non-participant design teams that were aware of SBD were not aware of the design team incentives. Sixty percent (60%) of non-participant design teams who were unaware of design team incentives or design assistance responded that they would have been somewhat or very likely to build a building that exceeded Title-24 by 15% or more had they been aware of design team incentives, and that they would have pursued Design Assistance/Analysis had they been aware of it. Better collaboration between the SBD representatives and the design teams will maximize future opportunities for this aspect of the program.

The practice of simulation modeling at the design stages (integrated design) is nowhere near being standard practice. About one-quarter of the design teams surveyed stated that use of computer simulation modeling for design interactions was standard practice. Verbatim responses do suggest that for many firms there has been a recent trend toward a more holistic design approach. This trend may be a result of building owners requesting an integrated design, since 70% of participant owners and 40% of non-participant owners reported having requested their design teams use an integrated design approach.

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.

The California "energy crisis"

Remember this? In the early phases of the BEA Study the energy crisis was at its height. During the first years of the SBD program the energy markets of California experienced a tremulous period of time. Caused by rolling blackouts, rate increases, uncertainty, and a major push for energy efficiency, these events most certainly affected upstream and downstream market actors in California's NRNC market. To many people these events are distant memories, with the last California rolling blackout occurring in the summer of 2001, add campaigns such as Flex Your Power and 20/20 are history, and for the time being rates appear to have stabilized through long term contracts and a halt to planned deregulation. Energy efficiency decision-making was certainly made easier as energy prices increased by making investments in energy efficiency more economically justifiable. It is not entirely clear how these events affected specific findings of this report, but it is clear that building efficiencies have improved, reflected by market actor attitudes and building efficiency relative to Title-24. Whether there will be lasting change in the market is yet to be seen, future BEA Studies will produce the needed data to evaluate industry trends.

Lighting Controls

Daylighting controls measures captured a much larger share of the program's total energy savings when compared to past NRNC programs implemented by California IOUs. The increased penetration of daylighting control measures was found to be in the SCE service territory. The majority of these measures are found in storage and large retail/wholesale segments. Early in the BEA study it was determined that many of the surveyed daylighting systems were not operating for a variety of reasons, mainly commissioning related. Later in the evaluation it became evident that SCE had begun to address the problems that had been discovered, evidenced by a much higher proportion of functioning daylighting controls during later site visits.

Other lighting controls, such as occupancy sensors, have a very low saturation among program participants. These types of lighting control measures comprise only three tenths of total program gross energy savings. Such findings suggest an area with little program penetration that SBD could target.

SBD Project Delays

Throughout the study 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 unavailable and took far too much time processing paperwork. Some smaller project participants reported they would not again participate because the incented 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 that past participation in other programs has taught them not to do so anymore because of the amount of "red tape" required to fulfill their requirements.

The Whole Building Approach

Savings by Design provides two separate mechanisms for receiving owner incentives, the Systems Approach and the Whole Building Approach. SBD program implementers and stakeholders made the decision to move the SBD program design in a direction that was heavily influenced by teaching and incenting integrated design practice. Even SBD program marketing materials added great emphasis to the whole building approach over previous NRNC program materials. At the close of 2001, only 10% of completed (completed is defined as paid) projects were whole building projects, while the rest were systems projects. This is likely due to the timing of the evaluation. Historically the larger buildings are those that use the whole building method, these projects can take up to several years to complete. Therefore it is entirely possible that the utilities have many whole building projects in the "pipeline" and one would surmise that the saturation of these projects will rapidly increase as the program ages. Table 113 supports this theory, showing a noticeable increase in whole building projects over the course of the BEA Study.

Program Year	Systems Projects	Whole Building Projects	All Projects
1999	15	0	15
2000	116	7	123
2001	306	42	348
Total	**437**	**49**	**486**

Table 113: Number of Whole Building Projects by Program Year

SDG&E notably not only had the highest fraction of whole building projects, approximately 20%, but was also able to apply the whole building approach to small commercial projects in nearly all cases, whereas PG&E and SCE reserved whole building projects for the very large commercial buildings.

Since the SBD program only allows design teams to earn incentives for whole building projects, design teams were only eligible for incentives in about 10% of the total projects. Among these projects the design teams fared well, achieving the design team incentive in 42 of 49 cases.

It is less clear why so few design teams have taken advantage of SBD's new offerings that are designed to teach integrated design techniques and provide incentives for implementing these methods. Survey data suggest that the majority of design teams were not aware of these aspects of the program, had they been aware it was likely that they would have participated in some capacity. Survey findings also suggest that the design team members think it difficult to exceed Title-24 by 15% without causing substantial increases in projects cost that the owner would not desire. More focus on teaching design teams how to present building owners with return on investment opportunities for installing energy efficiency technologies may help overcome this participation barrier.

Lastly, the data supports the added emphasis the utilities have placed on the whole building approach. A comparison of system projects to whole building projects shows greater savings per project square foot for whole building projects, in all utility service territories. The utilities have also demonstrated that this can be accomplished with both large and small projects, putting little limitation on what types of buildings are right for the whole building approach.

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.

Stock Building Plans

A large proportion of participants responding to the decision maker survey reported that they used stock plans. Use of stock plans suggests a standardized procedure that would inherently reproduce energy efficiency features and qualities time and time again, once energy efficiency improvements are implemented. Our understanding of SBD rules is that the program may assist an organization developing a stock building plan as part of design assistance/analysis. Analysis of the program tracking database, tabulated by respondents reporting that they used stock plans, showed that many participants had multiple projects (up to 15 projects) all receiving incentives under the SBD program using stock plans.

Program managers may want to encourage SBD representatives to be aware of those using stock plans as their inclusion may contribute to program free-ridership. However, increasing the efficiency of stock plans locks in the savings for future projects. Program managers should continue to work with these customers to alert them to new opportunities as they emerge.

Measure Incentives and Measure Trade-offs

The participant raw data suggest that participants are receiving incentives for measures that are also used to trade-off for inefficient lighting for Title-24 compliance. The building performances for 10 of the 109 sites investigated were below the Title-24 baseline. Seven participants had a whole building performance of less than 5% better than Title-24 baseline. Building type misclassification and other program vs. modeling anomalies were responsible for some of these results. However, the poor performance of most of these participant buildings is the result of using the higher performance of one measure to allow higher LPD values than Title-24 LPD requirements. These incented trade-offs included HVAC and daylighting control measures. Incentives, totaling approximately $200,000, were paid to projects that either just met code or even performed worse than Title-24 whole building baseline.

This program deficiency could be addressed by requiring the entire Title-24 package to be submitted for program documentation. This would be required for those measures that are qualified using the systems approach. Currently, only the information pertaining to the system that is incented is submitted, such as HVAC. The performances of the other components are not reviewed, such as lighting. Many retailers appear to have taken advantage of this to allow over-lighting of the store while also receiving an incentive for the efficient HVAC system. This system would have been required by Title-24 to compensate for the inefficient lighting. Requiring the Title-24 package for program compliance would also allow for a more thorough program evaluation.

LPD Market Transformation

The results in this report indicate that efficient lighting has significantly penetrated the market in California. Comparisons of LPD savings for program participants and non-participants do not indicate a significant difference between the two. The majority of sites visited, for both groups, had an installed LPD at least 10% better than the Title-24 baseline. These results suggest that a strengthening of the lighting requirements for program qualification is in order.

Section 3 Study Methodology

- **Data Sources and Sampling Plan**
- **Gross Savings Methodology**
- **Net Savings and Spillover Methodology**
- **Engineering Models**
- **Data Collection**
- **Participant and Non-participant Recruiting Results**

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
- Engineering and manufacturers' reference material
- California Energy Commission weather data

California's Investor Owned Utilities (IOU) databases, Title-24 compliance certificates, and program files are used to identify participating buildings, estimated savings, and incented measures. The F.W. Dodge database provided the basis of the non-participant sample frame. The other secondary sources were used to support the modeling and calibration effort.

Primary data sources include:

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

Data were obtained from the primary sources through quantitative interviews and surveys. Buildings were surveyed and simulated.

The new construction decision-makers include building owners/managers, architects, and specifying engineers. The program files and the F. W. Dodge database identified these individuals.

Sampling Plan

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

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

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

Once the sample size had been determined, we developed the participant sample design. We used a participant sample that is efficiently stratified by the tracking estimate of annual energy savings, with proportional representation of utilities, 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, building type, and construction start quarter. In other words, the non-participant sample was selected from those Dodge projects that have the same building type, construction start quarter, climate zone, and approximately the same square footage as the participant.

Theoretical Foundation

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

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

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

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 17 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 17 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.

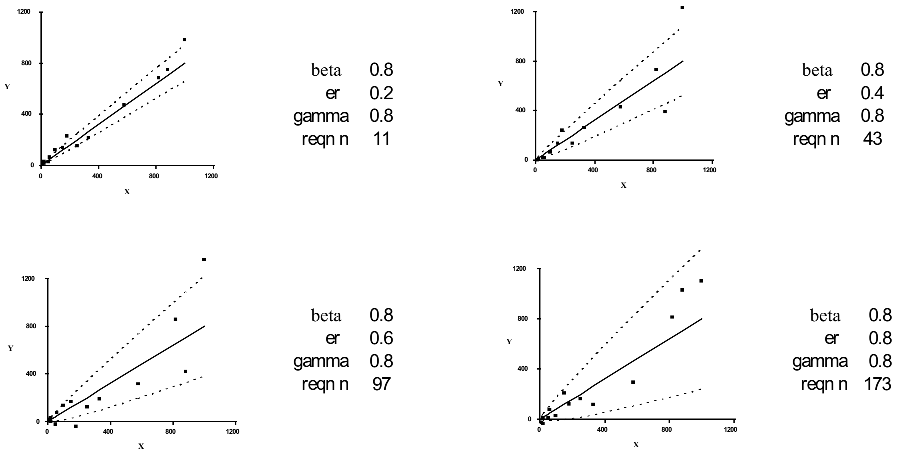

Figure 17: Examples of MBSS Ratio Models

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 114.

Parameter	Value
β	1.00
γ	0.50
Error ratio	1.00

Table 114: Sample Design Model Parameters

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

Parameter	Value
β	1.06
γ	0.71
Error ratio	0.86

Table 115: Actual Model Parameters

Participant Sample Design

For the purposes of this study, a participant building was defined to be a building that received an incentive through the Savings By Design program for installing energy efficient equipment during the 4th quarter of 1999 through the 4th quarter of 2001.

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 116 shows the results. The projections shown in Table 116 include both commercial and industrial projects. The actual number of commercial projects and savings for the fourth quarter of 1999 through the fourth quarter of 2001 are presented in Table 119 and Table 120.

		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 116: 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 MWh. 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 116.

Next we used MBSS methodology to develop an optimal sample design. The results indicated that we would need a sample of 143 projects 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 117 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 117: 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 117.
3. Randomly select the specified number of projects.

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

Final Statewide Participant Sample Design

The participant case weights were calculated using balanced post-stratification[26]. 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

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

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.

Table 118 shows the final participant sample design that was used to calculate the participant case weights. In this case, a sample of 109 participant sites has been equally divided among six strata, so there are 18 sites per stratum (with the exception of stratum 1 which consists of 19 sites). 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 19 sites in the first stratum is 185 / 19 = 9.74.

Stratum	Max kWh	Number	Total kWh	Sample	Fraction	Weight
1	36,106	185	3,034,752	19	0.103	9.736842
2	126,929	147	10,195,742	18	0.122	8.166667
3	250,160	58	10,474,475	18	0.310	3.222222
4	382,743	39	11,870,768	18	0.462	2.166667
5	749,804	35	20,007,095	18	0.514	1.944444
6	5,472,536	22	34,704,695	18	0.818	1.222222

Table 118: Final Participant Sample Design

Table 119 and Table 120 present the actual quarterly SBD participation and sample by utility for the fourth quarter of 1999 through the fourth quarter of 2001. Table 119 shows the number of commercial projects participating and Table 120 shows the kWh savings associated with these projects. In general, the larger projects in the population were PG&E and SCE projects. The SDG&E projects tended to be smaller projects that were in the smaller strata. Since the smaller strata have lower sampling fractions, SDG&E had smaller sample sizes than PG&E and SCE.

Quarter	PG&E		SCE		SDG&E		Statewide	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample
1999_4	-	-	8	5	7	1	15	6
2000_1	-	-	6	1	6	1	12	2
2000_2	5	1	10	5	1	-	16	6
2000_3	7	1	14	5	21	4	42	10
2000_4	10	3	16	5	27	2	53	10
2001_1	2	-	14	3	27	5	43	8
2001_2	21	6	27	9	22	1	70	16
2001_3	42	8	43	13	17	2	102	23
2001_4	40	8	31	11	62	7	133	26
Overall	**127**	**27**	**169**	**59**	**190**	**23**	**486**	**109**

Table 119: Actual Quarterly SBD Participation and Sample by Utility – Number of Projects

Quarter	PG&E		SCE		SDG&E		Statewide	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample
1999_4	-	-	4,122,361	3,958,216	1,099,385	106,675	5,221,746	4,064,891
2000_1	-	-	2,172,918	551,782	128,899	20,680	2,301,817	572,462
2000_2	231,572	105,744	3,270,350	3,122,423	28,631	-	3,530,553	3,228,167
2000_3	1,403,775	716,940	4,556,045	3,047,046	2,029,309	510,347	7,989,129	4,274,333
2000_4	1,212,451	844,636	4,186,233	1,999,029	2,356,695	91,125	7,755,379	2,934,790
2001_1	44,156	-	1,528,585	1,005,103	2,549,450	1,061,649	4,122,191	2,066,752
2001_2	4,760,481	2,377,517	6,220,762	4,249,291	2,349,036	786,085	13,330,279	7,412,893
2001_3	8,358,835	4,017,970	18,022,704	9,040,140	1,203,442	242,334	27,584,981	13,300,444
2001_4	3,406,863	1,264,539	9,755,391	5,655,881	5,289,198	800,886	18,451,452	7,721,306
Overall	**19,418,133**	**9,327,346**	**53,835,349**	**32,628,911**	**17,034,045**	**3,619,781**	**90,287,527**	**45,576,038**

Table 120: Actual Quarterly SBD Participation and Sample by Utility – kWh Savings

Non-participant Sample Design

For the purposes of the this study, a non-participant building is defined to be a building that completed construction during 1999 – 2001 and did not receive any incentives from a utility-sponsored energy efficiency program.

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

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

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

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

The non-participant sample was matched to the participant sample on a site-by-site basis based on building type, construction start quarter, utility service territory, CEC Climate zone, and square footage. This was done to ensure a relevant comparison group for the net-to-gross analysis.

Table 121 and Table 122 present the number of sites and average square footage for the participant and non-participant samples for 4th quarter 1999 – 4th quarter 2001, by building type and utility. Table 121 shows the participant sample and Table 122 details the non-participant sample. The participant buildings are, on average, larger than their non-participant counterpart buildings. The high level of program penetration into the large building segment was one major factor. This and other considerations are discussed in the next section entitled “Non-participant Sampling and Recruiting Difficulties”.

Building Type	**PG&E**		**SCE**		**SDG&E**		**Statewide**	
	# Sites	**Ave. SQFT**	**# Sites**	**Ave. SQFT**	**# Sites**	**Ave. SQFT**	**# Sites**	**Ave. SQFT**
C&I Storage	3	228,847	17	402,150	3	91,750	23	339,058
Grocery Store	1	52,564	3	94,955	-	-	4	84,358
General C&I Work	2	195,000	13	228,589	4	71,583	19	191,999
Medical / Clinical	1	13,800	-	-	-	-	1	13,800
Office	10	122,916	6	188,559	9	53,092	25	113,534
Other	-	-	2	57,219	-	-	2	57,219
Religious Worship, Auditorium, Convention	-	-	2	40,543	1	53,000	3	44,695
Restaurant	1	6,000	2	3,102	1	3,804	4	4,002
Retail and Wholesale Store	8	110,838	7	140,359	3	114,184	18	122,876
School	1	85,477	3	43,348	2	18,646	6	42,136
Theater	-	-	2	70,000	-	-	2	70,000
Gymnasium	-	-	1	71,000	-	-	1	71,000
Libraries	-	-	1	183,495	-	-	1	183,495
Total	**27**	**124,083**	**59**	**219,207**	**23**	**64,176**	**109**	**162,931**

Table 121: Participant Sample by Building Type and Utility

Title 24 Building Type	**PG&E**		**SCE**		**SDG&E**		**Statewide**	
	# Sites	**Ave. SQFT**	**# Sites**	**Ave. SQFT**	**# Sites**	**Ave. SQFT**	**# Sites**	**Ave. SQFT**
C&I Storage	5	213,512	17	315,099	1	59,920	23	281,920
Grocery Store	2	51,250	1	60,000	1	41,382	4	50,971
General C&I Work	4	85,965	13	52,593	2	72,500	19	61,715
Medical / Clinical	1	12,061	-	-	-	-	1	12,061
Office	10	136,051	7	82,683	9	53,639	26	93,156
Other	-	-	-	-	-	-	-	-
Religious Worship, Auditorium, Convention	-	-	3	34,081	-	-	3	34,081
Restaurant	1	6,100	2	2,757	1	3,000	4	3,653
Retail and Wholesale Store	5	34,157	11	106,901	2	123,477	18	88,536
School	1	60,000	4	38,321	1	21,000	6	39,048
Theater	-	-	1	64,795	1	64,000	2	64,398
Gymnasium	-	-	2	23,413	-	-	2	23,413
Libraries	1	8,100	-	-	-	-	1	8,100
Total	**30**	**104,383**	**61**	**134,881**	**18**	**59,112**	**109**	**113,975**

Table 122: Non-participant Sample by Building Type and Utility

Gross Savings Methodology

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

Definitions

Some definitions would be helpful to clarify the discussion.

Baseline A consistent standard of energy efficiency against which all buildings will be measured. This is defined as the output of a DOE-2.1E simulation 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.

Model-Based Statistical Sampling

This project used a statistical methodology called Model-Based Statistical Sampling or MBSS™. MBSS has been used for many evaluation studies to select the sites or projects to be studied and to extrapolate the results to the target population. MBSS has been used for all of California’s IOUs, NEES, Northeast Utilities, Consolidated Edison, The New York Power Authority, Wisconsin Electric, Sierra Pacific Power Company, and Washington Power and Light among others. MBSS was used in the end-use metering component of the 1992 evaluation of PG&E’s CIA program, the 1994, 1996, and 1998 NRNC evaluations for PG&E and Southern California Edison, and the 1998 NRNC Baseline Study for the CBEE. A complete description of MBSS methodology is available if further discussion of the methodology is required.[27]

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

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

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

$$Y = y/x\ X$$

Where:

Y is the population total measured savings

y is the average measured savings in the sample

X is the population total program estimated savings

x is the average program estimated savings in the sample

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

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

Case Weights

Theoretical Foundation

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

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

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

Motivated by the preceding equation, we estimate the population mean in each stratum using the corresponding sample mean. This gives the conventional form of the stratified-sampling estimator, denoted $\hat{Y}$, of the population total *Y:*

$$\hat{Y} = \sum_{h=1}^{H} N_h \bar{y}_h$$

With a little algebra, the right-hand side of this equation can be rewritten in a different form:

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

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

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

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

Participant Case Weights

Balanced post-stratification[28] was used to calculate the case weights associated with the final participant sample. 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.

Table 123 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 six 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 36,106 kWh. The maximum kWh in each stratum is called the stratum cut point. There are 185 projects in this stratum and they have a total tracking savings of 3,034,752 kWh. The estimate of gross impact was obtained from the measured savings found in a total sample of 109 projects. Column 5 of Table 123 shows that the

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[28] We opted to use balanced post-stratification to calculate the participant sample case weights because one of our original certainty sites (Boeing Central Plant) was dropped from the study due to the lack of a suitable non-participant match.

sample contains 19 projects from the first stratum. Each of these 18 projects can be given a case weight of 185/19 = 9.73.

Stratum	Max kWh	Number	Total kWh	Sample	Fraction	Weight
1	36,106	185	3,034,752	19	0.103	9.736842
2	126,929	147	10,195,742	18	0.122	8.166667
3	250,160	58	10,474,475	18	0.310	3.222222
4	382,743	39	11,870,768	18	0.462	2.166667
5	749,804	35	20,007,095	18	0.514	1.944444
6	5,472,536	22	34,704,695	18	0.818	1.222222

Table 123: Participant Case Weights

Non-participant Case Weights

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

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

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

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

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

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

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

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 were projected to the population using model-based statistical methods described above.

The end-use savings are the difference between the whole-building energy use under the baseline and as-built measures associated with a particular end-use category of measures. 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)

Net Savings and Spillover Methodology

In this chapter, the methodology used to calculate the net savings results is presented. We have used three different methodologies to calculate the net savings attributable to the SBD program. We will discuss our rationale for using three different approaches as well as the advantages and disadvantages of each approach.

Background

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

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

The present study has a significant advantage over the prior impact evaluations in that the data collection will take place much closer to the time that the actual decisions were made about each project. In the prior studies, we were often talking to decision-makers about projects that were completed several years prior to the survey. In this study, we are discussing projects that have just been completed in the prior 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.

In the 1999-2001 BEA study the RLW Team identified three practical theories to measuring program net savings, they include:

- Difference-of-Differences,
- Self-reported measure/end-use level decision-making, and
- Difference-of-Differences, including self-reported spillover.

First, the difference-of-differences methodology is shown. The difference-of-differences approach is the simplest of the three approaches and is the approach that has been historically the approved methodology for calculating net savings results. One assumption of the difference-of-differences approach is that the participant free-ridership rate is equal to the non-participant spillover rate. For this reason, we have calculated net savings results based on two alternative methodologies based on decision-maker survey responses: the self-report methodology and the differences-of-differences + spillover adjustment methodology.

Differences of Differences Methodology

In the difference-of-differences approach the non-participants are considered to indicate the energy efficiency that would be expected in the absence of the program. The difference between the energy efficiency of the participants and non-participants is used to estimate the net impact of the program. Since the 1996 NRNC evaluation, CADMAC has accepted the difference of difference approach as the most accurate and defensible approach to evaluating program net impacts. .

The difference-of-differences algorithm has strengths and weaknesses. Recognized strengths of the approach are the natural inclusion of free-ridership. By comparing a suitable sample of non-participant projects to participant projects it is thought that naturally occurring non-participant efficiency relative to the baseline accounts for program free-ridership. In other words, non-participants' efficiency choices are indicative of the efficiency choices participants would have made absent the program. Another strength to this approach is that this methodology has been the CALMAC/ORA accepted evaluation methodology for NRNC programs since 1996.

The first obvious weakness to this approach is that it cannot account for free-ridership at the measure level. Another recognizable weakness of the approach is that it does not account for any program induced non-participant spillover. Now that NRNC programs have been in place in California for nearly a decade it is not unthinkable to believe that these programs have changed the way buildings are designed outside of the program.

Conducting this analysis is relatively straightforward. To calculate the difference-of-differences net savings, it is necessary to take the ratio of both participant and non-participant baseline whole building consumption over participant and non-participant as-built energy consumption. Next it is necessary to calculate the difference of these two ratios. Then the product of the difference and the participant baseline whole building consumption provides the net savings. Figure 18 illustrates the calculation.

$$\left[\left(\frac{P_{ab}}{P_b}\right)-\left(\frac{NP_{ab}}{NP_b}\right)\right]\times P_b$$

Where :

NP = Non-participants

P = Participants

b = baseline whole building kWh

ab = as-built whole building kW

Figure 18: Difference-of-Differences Equation

We next illustrate the calculation for the net annual energy savings results. An analogous approach was used to analyze summer peak demand reduction.

Table 124 summarizes the derivation of the net savings and 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 4th quarter 2001. For example, the table shows that we would estimate that all program participants would have an aggregate annual consumption of 496,480 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 352,738 MWh.

	Participants	**Non-Participants**	**Participant Net Savings**
Baseline (MWh)	592,724	407,463	
As-Built (MWh)	496,480	352,738	
Savings (MWh)	96,244	54,725	16,637
Savings (% of Baseline)	16.2%	13.4%	2.8%
Net-to-Gross Ratio			17.3%

Table 124: Difference-of-Differences Net Savings Calculation – Annual Energy

In the difference-of-differences approach, the as-built energy use is considered relative to the baseline. In proportion to the respective baseline energy use of each sample, the gross savings were 16.2% for the participant sample and 13.4% for the non-participant sample. 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 are 2.8% of baseline use. Multiplying 592,724 MWh by 2.8%, the net savings of the population of 4th quarter 1999 through 4th quarter 2001 can be estimated to be 16,596 MWh.

The net-to-gross ratio can also be calculated two equivalent ways. One is to divide the participants' net savings (16,637 MWh) by their gross savings (96,244 MWh). The other is to divide the participants' net percent savings (2.8%) by their gross percent savings (16.2%). Either approach gives the difference-of-differences estimate of 17.3% for the net-to-gross ratio for annual energy.

Self-Report Methodology

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).

In the 1999-2001 BEA study the RLW Team prepared a decision maker survey that asked measure specific questions of program participants, and end-use specific questions of non-participants (only for measures more efficient than Title-24). The survey questions elicited information describing why the efficiency choices were made and the various influences on these decisions.

The purpose of the measure/end-use questions was to reconstruct what might have happened absent program influences. Using a scoring methodology developed early in the study, the surveys were scored and then given to the surveyor responsible for the project DOE-2 modeling. Using a “net savings report” furnished by the analyst, the surveyor adjusts the DOE-2 model to reflect program influences. The models are then re-simulated and compared to the as-built and baseline parametric models to develop end-use and measure level estimates of participant free-ridership and non-participant spillover. For a more detailed description of this process, see page 159 in the Appendix.

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

One shortcoming of the difference-of-differences approach is that it does not provide measure specific estimates of free-ridership and spillover. To address this deficiency, 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 (spillover) at the measure (end use) level. Results are calculated at the measure (end use) level in order to inform the SBD program staff of measures that are experiencing a high level of free-ridership and/or spillover.

Some definitions may be helpful.

Level of efficiency	The reduction in energy or demand of the as-built site as a percentage of the Title-24 baseline, determined from the onsite audit and DOE-2 simulation.
Program participants	Sites that received a program incentives.
Partial participants	Sites that did not receive a program incentives but were at least partly affected by the program.
Non-participants	Sites that were evidently unaffected by the program.
Direct net impact	The savings of the program participants relative to the level of efficiency expected in the absence of the program.
Spillover	The savings among the non-participants relative to the level of efficiency expected in the absence of the program.
Total net savings	The sum of the direct net savings and the spillover savings.

Free-ridership Analysis Methodology

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

Free-ridership is calculated as the difference between the baseline and what would have been installed absent the program, divided by the difference between baseline and what actually was installed. For example, assume a project used a lighting baseline of 2.0 watts/sqft, and the participant received incentives for and installed lighting equipment resulting in 1.3 watts/sqft. If the participant would have installed lighting at 2.0 watts/sqft in the absence of the program, then the baseline is accurate and free-ridership would be zero. If lighting equipment equaling 1.3 watts/sqft had been installed in the absence of the program, then the free-ridership would be 100 percent. In reality, however, such a project may have had 1.8 watts/sqft equipment installed without the program, this would result in a free-ridership rate of 28.5%.[29]

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),

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

- Lighting Systems w/reduced power density (LPD),
- High efficiency package units or heatpumps,
- Premium Efficiency Motors.

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

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

Spillover Impact Analysis Methodology

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

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

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

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

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

Case Weights

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

Non-participant Case Weights

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

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

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

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

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

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

Figure 19 summarizes the approach. In Step A, the set of all program participants is taken as the target population. The sample of participants is post-stratified by building type and the tracking estimate of savings due to the measures funded by the program. The savings-based strata are constructed using balanced post-stratification. Then case weights are calculated as the reciprocal of the sampling fraction in each stratum. The weighted sample of participants can be considered to be a statistical representation of the population of program participants[30].

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

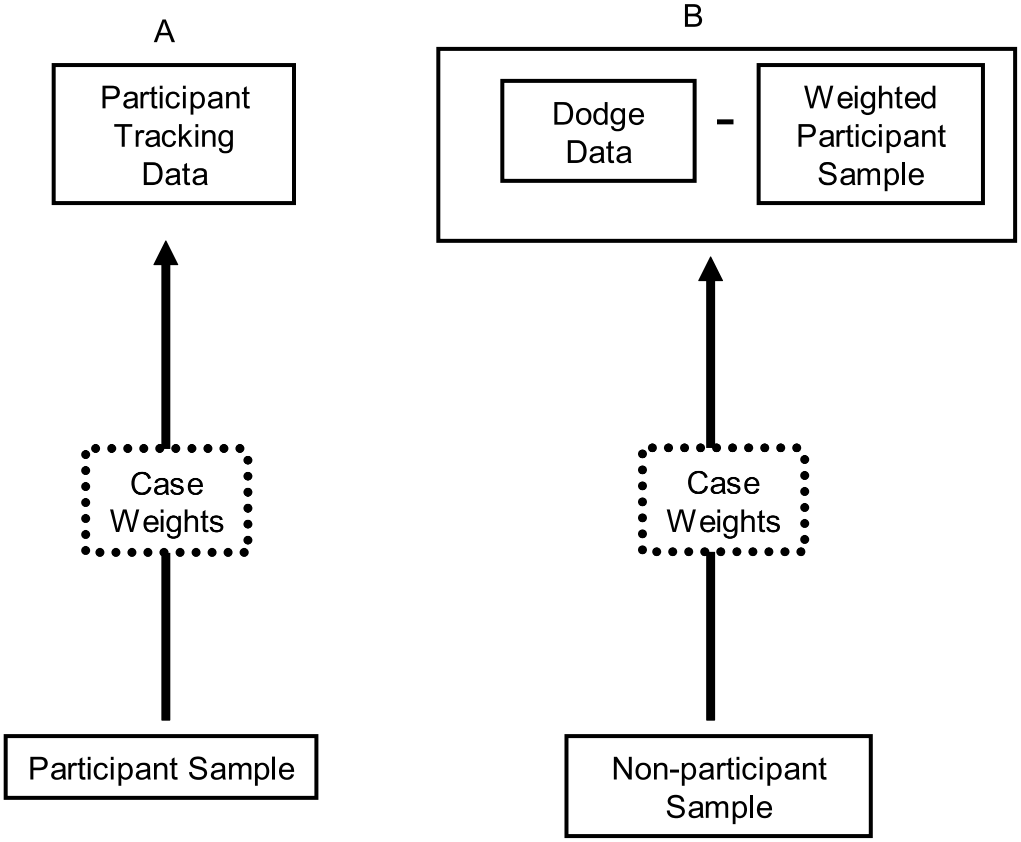

Figure 19: Approach to Non-participant Case Weights

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

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

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

Technical Description

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

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

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

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

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

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

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

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

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

Then

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

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

Difference-of-Differences and Self-reported Spillover

In this approach we use the results from each of the two aforementioned approaches. First a preliminary estimate of the net program percent savings is estimated using the difference-of-differences approach. Next, the results from the non-participant surveys are used to adjust the DOE-2 models in order to calculate end-use and whole building level spillover. The calculated spillover expressed as a percent energy savings is then added to the difference-of-differences results.

This is mathematically equivalent to the following, slightly different approach. First use the non-participant surveys to calculate the percent savings among the non-participants that is naturally occurring, i.e., not due to the program. Next reduce the gross percent savings of the participants by the naturally occurring savings among the non-participants.

Consider the following numerical example: Suppose the participants are found to be 25% more efficient than baseline and the non-participants are 10% more efficient than baseline. Then the difference of difference approach would conclude that the net savings of the participants is 15% (25% - 10%) of their baseline. Suppose, however, that the non-participants reported that 4% of their efficiency is spillover that is attributable to the program and 6% is naturally occurring. Then our suggestion would be to estimate the net program savings as 19% (15% + 4%). This can also be calculated as 25% - 6%.

The strength to this methodology is that we are able to use a defensible approach, namely difference of differences, while still accounting for program spillover that would otherwise bias the difference of difference estimate. The disadvantage of the approach compared to the self-reported approach is that the program is not credited for the actual energy savings of the non-participants that is due to the program.

We can illustrate this issue by expanding the previous example. Suppose the participants reported that 16% of their savings was due to the program and 9% was naturally occurring. Suppose furthermore that the baseline energy use of the participants was 1,000 MWh and the baseline energy use of the non-participants was 5,000 MWh. Then under the self-reported savings approach we would credit the program with a net savings of 360 MWh (0.16 * 1,000 + 0.04 * 5,000). This is 160 MWh of net savings among the participants and 200 MWh of spillover savings among the non-participants. Under the difference of difference approach we would credit the program with a net savings of 150 MWh (0.15 * 1,000). Under the third approach we would credit the program with a net savings of 190 MWh (0.19 * 1,000).

We next illustrate the calculation for the net annual energy savings results. An analogous approach was used to analyze summer peak demand reduction.

Table 125 summarizes the derivation of the net savings and the net-to-gross ratio for annual energy using the difference-of-differences + spillover adjustment approach. Similar to the difference-of-differences method, 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 4th quarter 2001. For example, the table shows that we would estimate that all program participants would have an aggregate annual consumption of 496,480 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 352,738 MWh. In proportion to the respective baseline energy use of each sample, the gross savings were 16.2% for the participant sample and 13.4% for the non-participant sample. Non-participant spillover is estimated to be 1.4% of the non-participant baseline usage.

	Participants	Non-Participants	NP Spllover	Participant Net Savings
Baseline (MWh)	592,724	407,463	407,463	
As-Built (MWh)	496,480	352,738		
Savings (MWh)	96,244	54,725	5,669	24,884
Savings (% of Baseline)	16.2%	13.4%	1.4%	4.2%
Net-to-Gross Ratio				25.9%

Table 125: Difference-of-Differences + Spillover Adjustment Net Savings Calculation – Annual Energy

In the difference-of-differences + spillover adjustment approach, the net savings can be estimated as the difference between the percentage savings of the participants and non-participants, after adjusting the percentage savings of the non-participants for spillover. In this case, the participant net savings are 4.2% (16.2% - (13.4% - 1.4%)) of baseline use. Multiplying 592,724 MWh by 4.2%, the net savings of the population of 4th quarter 1999 through 4th quarter 2001 can be estimated to be 24,894 MWh.

The net-to-gross ratio can also be calculated two equivalent ways. One is to divide the participants' net savings (24,894 MWh) by their gross savings (96,244 MWh). The other is to divide the participants' net percent savings (4.2%) by their gross percent savings (16.2%). Either approach gives the difference-of-differences + spillover adjustment estimate of 25.9% for the net-to-gross ratio for annual energy.

Engineering Models

Overall Modeling Approach

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

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

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

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

Loads

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

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

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

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

Infiltration schedule. The infiltration schedule was established from the fan system schedule. Infiltration was scheduled “off” during fan system operation, and was scheduled “on” when the fan system was off.

Shell materials. A single-layer, homogeneous material was described which contained the conductance and heat capacity properties of the exterior surfaces of the building. The thermal conductance and heat capacity of each wall and roof assembly was taken from the Title-24 documents, when available. If the Title-24 documents were not available, default values for the conductance and heat capacity were assigned from the wall and roof types specified in the on-site survey, and the observed R-values. If the R-values were not observed during the on-site survey and the Title-24 documents were not available, an “energy-neutral” approach was taken by assigning the same U-value and heat capacity for the as-built and baseline simulation runs.

Windows. Window thermal and optical properties from the building drawings or Title-24 documents (when available) were used to develop the DOE-2 inputs. If these documents were not available, default values for the glass conductance were assigned according to the glass type specified in the on-site survey. Solar radiation pyranometers were used during the on-site survey when possible to measure the as-built solar transmission of the glazing. The glass shading coefficient was calculated from the glass type and measured solar transmittance. The results of these calculations were input into the model. If the glass properties were not measurable during the on-site survey and the Title-24 documents were not available, an “energy-neutral” approach was taken by assigning the same U-value and shading coefficient for the as-built and baseline simulation runs.

Solar and shading schedules. The use of blinds by the occupants, as reported by the occupants, was simulated by the use of solar and shading schedules. The glass shading coefficient values were modified to account for the use of interior shading devices.

Lighting kW. Installed lighting power was calculated from the lighting fixture inventory reported on the survey. A standard fixture wattage was assigned to all fixture types identified by the surveyors. Lighting fixtures were identified by lamp type, number of lamps per fixture, and ballast type as appropriate.

Lighting controls. The presence of lighting controls was identified in the on-site survey. For occupancy sensor and lumen maintenance controls, the impact of these controls on lighting consumption was simulated as a reduction in connected load, according to the Title-24 lighting control credits. Daylighting controls were simulated using the “functions” utility in the Loads portion of DOE-2. Since the interior walls of the zones were not surveyed, it was not possible to use the standard DOE-2 algorithms for simulating the daylighting illuminance in the space. A daylight factor, defined as the ratio of the interior illuminance at the daylighting control point to the global horizontal illuminance was estimated for each zone subject to daylighting control. Typical values for sidelighting applications were used as default values. The daylight factor was entered into the function portion of the DOE-2 input file. Standard DOE-2 inputs for daylighting control specifications were used to simulate the impacts of daylighting controls on lighting schedules.

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

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

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

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

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

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

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

Systems

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

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

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

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

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

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

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

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

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

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

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

Commercial Refrigeration. The algorithms used in release 119 of the DOE-2.1E program were 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 were surveyed. The automated modeling software provided DOE-2 models of both the building and the refrigeration systems, providing an accurate representation of the refrigeration system performance, and the interactions between the refrigeration system and the building HVAC system.

Plant

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

Chillers. The DOE-2 input parameters required to model chiller performance included chiller type, full-load efficiency and capacity at rated conditions, and performance curves to adjust chiller performance for temperature and loading conditions different from the rated conditions.

Chiller type was assigned based on the type code selected during the on-site survey. Surveyors also gathered chiller make, model number, and serial number data. These data were used to develop performance data specific to the chiller installed in the building. Program data and/or manufacturers' data were used to develop the input specifications for chiller efficiency.

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

Model Review and Quality Checks

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

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

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

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

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

An example of some of the QC criteria that were utilized is shown below in Table 126. Data falling outside of the QC range were validated during the QC process.

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

Table 126: Model Quality Control Criteria

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

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

Table 127: Survey It^{tm} Quality Control EUI Reference Table

Parametric Runs

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

As-Built Parametric Run

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

Baseline Parametric Run

Key building performance parameters were reset to a baseline condition to calculate gross energy savings for participants and non-participants. The 1998 California Building Energy Efficiency Standard (Title-24) was the primary reference for establishing baseline performance parameters. Title-24 specifies minimum specifications for building attributes such as:

- Opaque shell conductance
- Window conductance
- Window shading coefficient
- HVAC equipment efficiency
- Lighting power density

Title-24 applies to most of the building types covered in the programs covered under this project, with the exception of:

- Hospitals
- Unconditioned space (including warehouses)

Incentives are also offered by the program for building attributes not addressed by Title-24. In situations where Title-24 does not address building types or equipment covered under the program, baseline parameters equivalent to those used for the program baseline efficiencies were used for both participants and non-participants.

Envelope

Opaque shell U-values were assigned based on Title-24 requirements as a function of climate zone and heat capacity of the observed construction. For windows, Title-24 specifications for maximum relative solar heat gain were used to establish baseline glazing shading coefficients. Fixed overhangs were removed from the baseline building. Glass conductance values as a function of climate zone were applied. For skylights, shading coefficients and overall conductance were assigned according to climate zone.

Mechanical

Baseline specifications for HVAC equipment efficiency were derived from the Title-24 requirements as a function of equipment type and capacity. Maximum power specifications for fans were established based on Title-24 requirements, which address fan systems larger than 25 hp. Specific fan power was held energy neutral (as built W/CFM = baseline W/CFM) for fan systems under 25 hp. Additionally, all systems larger than 2500 CFM or 75,000 Btu/hr of cooling capacity (except for hospitals) were simulated with economizers in the baseline run. All variable-volume pumps were simulated with throttling valve control.

HVAC System Sizing

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

Lighting

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

Grocery Store Refrigeration Systems

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

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

Additional Parametric Runs

Once the as-built and baseline building models were defined, an additional set of parametric runs were done to estimate the program impact on the lighting, HVAC, shell / daylighting, and refrigeration measure groups. The baseline model was returned to the as-built design in a series of steps outlined as follows:

1. *Shell, measures only*. Baseline envelope properties (glazing U-value and shading coefficient; and opaque surface insulation) for incented measures only were returned to their as-built condition.
2. *All Shell.* All baseline envelope properties were returned to their as-built condition.

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

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

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.

Throughout the course of this two-year project, a total of 811 buildings were selected from the dodge database for non-participant recruitment. Of the 811 sites, 109 were scheduled and visited, 390 sites remain on-hold, 88 sites were dropped, 77 sites refused to participate, 31 sites were not reachable, and 116 were found to be participants. More detailed descriptions of why sites were put on hold, dropped, refused, or were unreachable can be found in the appendix.

Decision-maker Data

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

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

Building characteristics

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

Interaction with utility

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

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

Decision-maker (DM) Attitudes/Behaviors

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

Energy Efficient Design Practices

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

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

Scoring the Surveys

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

Recruiting and Decision-maker Survey Data Entry

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

On-Site Surveys

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

The on-site audits began with a 20 minute interview with the site contact to gather basic information about the building – operating schedules, number of occupants, Title-24 compliance method, etc. The surveyor then walked through the building to examine the energy-using systems (e.g. lighting, HVAC, energy management systems, etc.) System types and sizes were cataloged, along with information about the condition of the equipment. For participants, the presence of measures were verified. If plans were available, the surveyor used the plans to gather information on building shell and inaccessible equipment.

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

Training of On-Site Survey Staff

The process of gathering accurate, timely field data was the foundation upon which the project's analysis ultimately rested. Training surveyors to collect the proper field information was the first step in the building this foundation. Lead surveyors/engineers Matt Brost and Pete Jacobs from RLW Analytics and AEC respectively, conducted the training for the audit phase of the project. The surveyors were technical personnel experienced as surveyors and building simulation practitioners, or in most cases, both. The training built upon the lessons learned during the evaluation of the 1994, 96, and 98 commercial new construction programs and the 1998 CBEE NRNC baseline study, and upon the considerable building survey experience of the surveyors.

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

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

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

Engineering File Reviews

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

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

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

Instruments

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

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

The on-site survey form is similar to the one used in the 1998 PG&E NRNC evaluation 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.

Short Term Monitoring of Daylighting Controls

Due to the emphasis on daylighting controls in the Savings by Design program, the surveyors install short-term monitoring devices on fixtures or circuits controlled by daylighting controls to verify their operation. These devices are programmed to collect time-series data on controls operation for a two to four week period. At the conclusion of the monitoring period, the loggers are removed (generally by on-site personnel) and returned to RLW Analytics for downloading and data processing. Use of these devices allows the surveyor to get a better understanding of the effectiveness of the daylighting controls than is possible during the course of the on-site visit.

Non-participant Sampling and Recruiting Difficulties

This section documents some of the difficulties we experienced in recruiting appropriate non-participant buildings. We begin the chapter with a summary of the participant and non-participant recruiting dispositions. We then discuss four key factors that were impediments to locating and recruiting appropriate non-participant buildings for the study. The difficulties described throughout this chapter resulted in increased project costs, lengthier project duration, and a non-participant sample comprised of smaller buildings than their participant counterpart buildings.

Recruiting Dispositions

Table 128 shows the dispositions resulting from the participant recruiting effort. As seen in the table, a total of 124 SBD participants were contacted to recruit 109 participants for the study. Nearly 90% of the participants that were contacted agreed to participate in the study.

Outcome	# of Participants	% of Participants
Dropped	6	4.8%
Not Reachable	1	0.8%
On-hold	4	3.2%
Refused	4	3.2%
Scheduled	109	87.9%
Total	124	

Table 128: Participant Recruiting Dispositions

Table 129 shows the dispositions of the non-participant recruiting. In order to schedule 109 non-participant buildings appropriate for the study, we contacted a total of 799 projects listed in the Dodge database. Most noticeable are the quantity of projects with an "on-hold" disposition, comprising approximately 50% of the non-participants contacted. Projects were categorized as "on-hold" for a number of reasons, most notably reasons included:

- Construction not completed
- Shell construction completed, waiting for tenant improvements
- Project completed, no tenants, and
- A different non-participant site of equal matching ability to the participant was scheduled, so the site is "on-hold" until it adequately matches another participant.

Of the 799 projects from the Dodge database that were contacted, nearly 15% (or 116 projects) were identified to be program participants. Approximately 10% of the projects were dropped from consideration, either because they were identified to receive electric and gas from utilities other than PG&E, SCE, and SDG&E or because the construction project square footage consisted of a campus of small buildings.

Outcome	# of Non-Participants	% of Non-Participants
Dropped	83	10.4%
Not Reachable	32	4.0%
On-hold	386	48.3%
Participant	116	14.5%
Refused	73	9.1%
Scheduled	109	13.6%
Total	799	

Table 129: Non-participant Recruiting Dispositions

Similar to the participant recruiting dispositions the non-participants also had a low rate of refusal. Less than 10 percent of all non-participants out right refused, while the remaining reasons of non-response resulted from technical problems, such as not reachable, building not completed or occupied, and out of scope projects. The point is that although 799 customers were contacted, the study actually had a quite low refusal rate. This suggests that study bias due to non-response is likely low.

Difficulties Locating Appropriate Non-participant Buildings

There were four contributing factors that were primarily responsible for the difficulties we experienced in locating and recruiting appropriate non-participant buildings for the study. These four factors are:

1. For certain building types, the program has a high level of penetration, particularly among the larger buildings.
2. The square footage listed in the Dodge database is often incorrect or is for a campus of buildings, and the building representatives are often unable to accurately estimate or confirm the square footage of the building.
3. The building function listed in the Dodge database is often not the dominant function, and the building representatives are sometimes unable to properly confirm the classification of the dominant function of the building.
4. Sampling on a quarterly basis limited the number of projects in Dodge for matching purposes because project timing was part of the matching criteria.

Each of these factors will be discussed in greater detail in the remainder of this section.

Program Penetration in Particular Building Types

The Dodge database lists all new construction projects that are scheduled to start during a specific time frame. The projects in the Dodge database include both participant and non-participant buildings. There are some Title-24 building types where the program penetration among the larger buildings is so great that it is a significant impediment to locating non-participant buildings comparable to the participant buildings.

Table 130 compares the program population to the projects listed in the Dodge database. The table shows the number of projects and the average square footage of these projects by Title-24 building type for both the program population and the Dodge database. The projects comprising the program population are, on average, larger projects than the projects listed in the Dodge database. For C&I Storage buildings, the average program participant is twice the size of the average project in Dodge.

	# Projects		**Average SQFT**	
	Program Tracking Data	**Dodge Data**	**Program Tracking Data**	**Dodge Data**
C&I Storage	68	666	204,253	101,230
Community Center	1	249	57,026	17,028
Fire/Police/Jails	1	125	8,400	21,056
General C&I Work	73	381	77,887	43,751
Grocery Store	14	216	62,789	44,463
Gymnasium	2	85	56,050	24,141
Hotels/Motels	1	122	18,000	89,344
Libraries	3	58	79,568	23,914
Medical/Clinical	19	243	45,777	53,881
Office	124	1,237	82,956	74,180
Other	6	151	66,460	83,245
Religious Worship, Auditorium, Conventi	16	205	26,216	22,546
Restaurant	24	396	4,696	8,020
Retail and Wholesale Store	46	810	68,081	37,002
School	83	808	24,862	38,947
Theater	5	28	92,305	46,214

Table 130: Number of Projects and Average Project Size (SQFT) by Title-24 Building Type – Program Tracking Data vs. Dodge Data

Two building types were particularly difficult to locate appropriate non-participant matching sites: C&I Storage and General C&I Work. We believed this to be a result of the high level of program penetration among the larger buildings with these building functions. For this reason, we compared the number of large and small projects in the program tracking data to the Dodge data.

For four of the building types that comprise a significant portion of the program population, we defined a square footage cutoff to classify projects as either large or small. The cutoffs were defined as follows:

- 200,000 square feet for C&I Storage,
- 80,000 square feet for both General C&I Work and Office, and
- 70,000 square feet for Retail and Wholesale Store.

Table 131 shows the program penetration among large projects and small projects for these four building types. The program penetration relative to the Dodge data is 27.5% for large C&I Storage buildings and 62.8% for General C&I Work buildings. Comparing these levels of program penetration to the levels seen by the large Office and Retail and Wholesale Store buildings (14.1% and 13.3% respectively) shows that the program has penetrated a significant portion of the new construction market associated with large C&I Storage and General C&I Work buildings, thereby making it difficult to effectively match non-participants in these market segments.

Also consider that nearly 70% of all non-participants contacted were either put "on-hold", "refused" or were "dropped", effectively eliminating a large number of the non-participant sample candidates. In view of this high dropout percentage and the minimal number of projects to call for large projects it is clear why recruiting was so difficult in the two C&I market segments.

	# Large Projects		**% of Dodge Data**	**# Small Projects**		**% of Dodge Data**
	Program Tracking Data	**Dodge Data**		**Program Tracking Data**	**Dodge Data**	
C&I Storage	22	80	27.5%	46	586	7.8%
General C&I Work	27	43	62.8%	46	338	13.6%
Office	44	312	14.1%	80	925	8.6%
Retail and Wholesale Store	15	113	13.3%	26	697	3.7%

Table 131: Program Penetration – Larger Projects vs. Smaller Projects

Incorrect Building Types

Table 132 shows the incidence of incorrect classifications of the dominant building function in the Dodge database by the original Title-24 building type as generated in the Dodge database among buildings that we attempted to call. For buildings where the Dodge building function indicated the project was a General C&I Work building, 17 of the 121 buildings we called were incorrectly classified and the primary building function was not General C&I Work.

Dodge Classification of Dominant Building Function	**Projects Called**	
	Dodge Incorrect	**Dodge Correct**
C&I Storage	4	122
General C&I Work	17	104
Grocery Store	3	31
Gymnasium	-	9
Libraries	-	14
Medical/Clinical	-	5
Office	19	269
Religious Worship, Auditorium, Convention	-	19
Restaurant	-	30
Retail and Wholesale Store	4	114
School	-	55
Theater	-	4

Table 132: Incidence of Incorrect Dominant Building Function in Dodge Data

Incorrect Square Footages

The prevalence of incorrect and misleading square footages recorded in the Dodge database impedes locating appropriately sized buildings for the non-participant sample. Generally, the Dodge database tends to over-estimate the square footages of the projects, either because of a typo or because the square footage listed is for a campus of individual buildings.

Table 133 describes the incidence of misleading or inaccurate square footages listed in the Dodge database among the buildings we attempted to call. Of the 126 C&I Storage buildings we attempted to call, 10 had square footages recorded for the aggregate of three or more buildings, making the individual buildings much smaller than originally believed, and 5 had a square footage recorded that varied from the actual square footage by more than 50%. Similarly, of the 121 General C&I Work buildings we attempted to call, 4 had square footages recorded for the aggregate of three or more buildings, making the individual buildings much smaller than originally believed, and 9 had a square footage recorded that varied from the actual square footage by more than 50%.

Dodge Classification of Dominant Building Function	**Projects Called**		
	SQFT for 3+ Bldgs	**Dodge SQFT Incorrect by >50%**	**Total Called**
C&I Storage	10	5	126
General C&I Work	4	9	121
Grocery Store	-	-	34
Gymnasium	-	1	9
Libraries	-	2	14
Medical/Clinical	-	-	5
Office	12	14	288
Religious Worship, Auditorium, Convention	-	-	19
Restaurant	-	-	30
Retail and Wholesale Store	4	2	118
School	-	-	55
Theater	-	-	4

Table 133: Incidence of Incorrect Square Footages in Dodge by Title-24 Building Type

Construction Timing

In past NRNC studies we were able to use at least an entire year's worth of Dodge construction starts in order to match non-participants because we were evaluating a complete years worth of construction at one time. As part of this study design we were asked to prepare quarterly program samples in order to track trends in the NRNC program area. This approach limited the non-participant sample selection to projects with similar construction timelines, further burdening our ability to select non-participants because of the limits that were imposed on the non-participant selection criteria.

Summary

In summary, the issues described above have created a high level of difficulty in recruiting non-participant matches for the participant sample, particularly for C&I Storage and General C&I Work buildings. These issues have several ramifications on the BEA study, including increased project costs, lengthier project duration, and a non-participant sample comprised of smaller buildings than their participant counterpart buildings.

All four issues potentially lead to increased project costs and lengthier project duration. Specifically, when attempting to recruit the non-participant building, significant resources and time were expended to verify the participation status of the building, the dominant function of the building, and the square footage of the building. Often, a series of phone calls to several building representatives and SBD program representatives were required to adequately verify this information. Sometimes, even after investing the resources to validate the building as an appropriate non-participant, after completing the on-site survey of the building, we would observe or receive additional information invalidating the site, resulting in the need to drop the site from the sample, and therefore begin the recruiting process again.

The high level of program penetration in the larger C&I Storage and General C&I Work buildings has also potentially led to a non-participant sample comprised of smaller buildings than those in the participant sample. As discussed above, the projects comprising the program population are, on average, larger projects than the projects listed in the Dodge database. Furthermore, we have shown that the program has penetrated a significant portion of the new construction market associated with large C&I Storage and General C&I Work buildings, thereby making it difficult to effectively locate equally sized non-participants in these market segments.

Some of the issues described above are a function of the data in the Dodge database, and consequently, there is little the RLW Team could have done differently to avert the difficulty. Specifically, with regard to the incorrect dominant building functions and square footages generated by the Dodge database, other than carefully verifying the correct information with the building representative during the recruiting phase, there is no way to effectively eliminate the issue.

One way to potentially avert some of these issues would be to modify the participant sample design methodology. One option would be to consider the participant building types at the time of the participant sample design. For this current study, in an attempt to minimize the relative precision associated with the savings estimates of the participants, the participant sample was selected by stratifying the participant population by program-estimated energy savings[31]. This led to sampling the largest projects in the program at a higher rate than the smaller projects. The largest projects were predominantly C&I Storage and General C&I Work buildings, which also have the highest levels of program penetration. By considering the building types during the participant sample design, one could try to ensure the existence of adequate non-participant sites. Another option would be to modify the gamma parameter used to define the strata cutpoints during the participant sample design so that the larger projects are sampled at a lower rate. By lowering the value of the gamma parameter, the sampling rate in each stratum will begin to equalize. The same relative precision can still be achieved by simply slightly increasing the overall sample size. By reducing the sampling rate in the larger strata, the participant sample is expected to contain broader mix of project sizes and building types

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[31] A thorough description of the participant sample design methodology is located in the “Data Sources and Sampling Plan”' chapter of this report.

Section 4 Appendices

Title-24 Building Types

Table 134 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 134: 17 Key Title-24 Building Types

Detailed Daylighting Controls Observations

The incented daylighting controls were verified to be properly operating in 88% of the buildings in the sample for this current reporting cycle. The controls at only one site were not functioning in any capability. The remaining sites had either all or a majority of the daylighting controls functioning properly. In a couple of instances there were some minor discrepancies between the amount of connected lighting load indicated in the program file and what the surveyor determined on-site and through phone conversations with the controls contractor.

For the Round 2 sites the percentage of the lighting load connected to properly functioning daylighting controls is 63%, as is evident in **Table 135**. Of the 1,240 kW of lighting connected to the controls, 779 kW was determined to be functioning as designed. This finding is supported with short term metered data and physical observations made on-site by the surveyors.

Surveyed Daylighting Control Participants	***Round Two Total***
Quantity of Sites	9
kW - Connected	1240
kW - Operable	779.3
% of Connected Load Functioning	63%

Table 135: Functioning Daylighting Controls

Table 136 presents the data by quarter for this reporting cycle. It is clearly evident that the operation of the controls has improved dramatically since fourth quarter of 2000. This could be explained by the fact that the on-sites for projects in the first and second quarters of 2001 occurred shortly after the PG&E and SCE rate increases occurred at the end of second quarter 2001. The on-sites for the projects in fourth quarter 2000 occurred before the rate increases.

Surveyed Daylighting Control Participants	***Round Two***		
	2001-2	**2001-1**	**2000-4**
Quantity of Sites	4	1	4
kW - Connected	622.4	16.3	601.6
kW - Operable	555.8	16.3	207.3
% of Connected Load Functioning	89%	100%	34%

Table 136: Functioning Daylighting Controls by Quarter

This round of evaluation covering the fourth quarter of 2000 through the second quarter of 2001 included nine participants that were incented for installing daylighting controls. Unlike the sample in the previous round, retail and wholesale stores constituted a portion of the sample buildings that had daylighting controls in the current round. Table 137 indicates that four of the nine buildings in this round were either retail or wholesale stores.

Building Type	**Daylighting Controls - Particpant Sample Size**
C&I Storage	5
Retail and Wholesale	4

Table 137: Building Types of Daylighting Control Sample

The breakdown of sampled building types per quarter is shown below Table 138. The sample size was smallest for the first quarter of 2001 participants and of equal size for the fourth quarter of 2000 and second quarter of 2001.

Building Types	***Round Two***		
	2001-2	**2001-1**	**2000-4**
C&I Storage	3	0	2
Retail and Wholesale	1	1	2
Total Sites	**4**	**1**	**4**

Table 138: Building Types by Quarter

Short term monitoring of the incented lighting fixtures or physical observations made on-site by the surveyor, or both, were utilized to determine whether the daylighting controls were properly functioning. Event series lighting loggers were left for at least two weeks in a fixture that is connected to the daylighting controls. This method produced results that indicate the incented daylighting controls observed while on-site were properly functioning in roughly 88% of the participant buildings. Only one site had the daylighting controls observed as 100% non-operable and the metered data shows this.

Figure 20 shows the load shape of a monitored fixture in this site that isn't being controlled by the incented daylighting controls. Looking at the figure, one can observe the light is on during the peak of the day for 100% of the time. The shoulder of the load shape indicates the lights are turned on and off at various times as the percentage ramps up in the morning to 100% and ramps down in the evening starting around 9:00 pm.

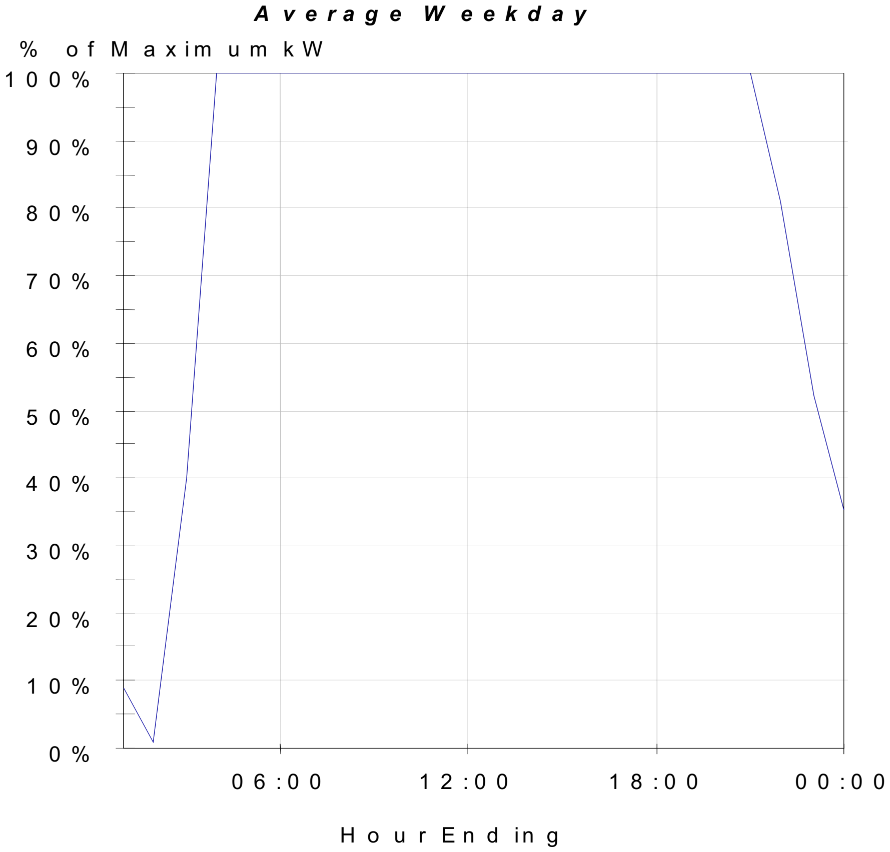

Figure 20: Non-Functioning Daylighting Controls

On the contrary, Figure 21 shows the load shape of a monitored fixture that is being properly controlled by the incented daylighting controls. The dip in the load shape during the mid-day hours indicates that the daylighting controls are in fact turning the fixture off when expected to do so.

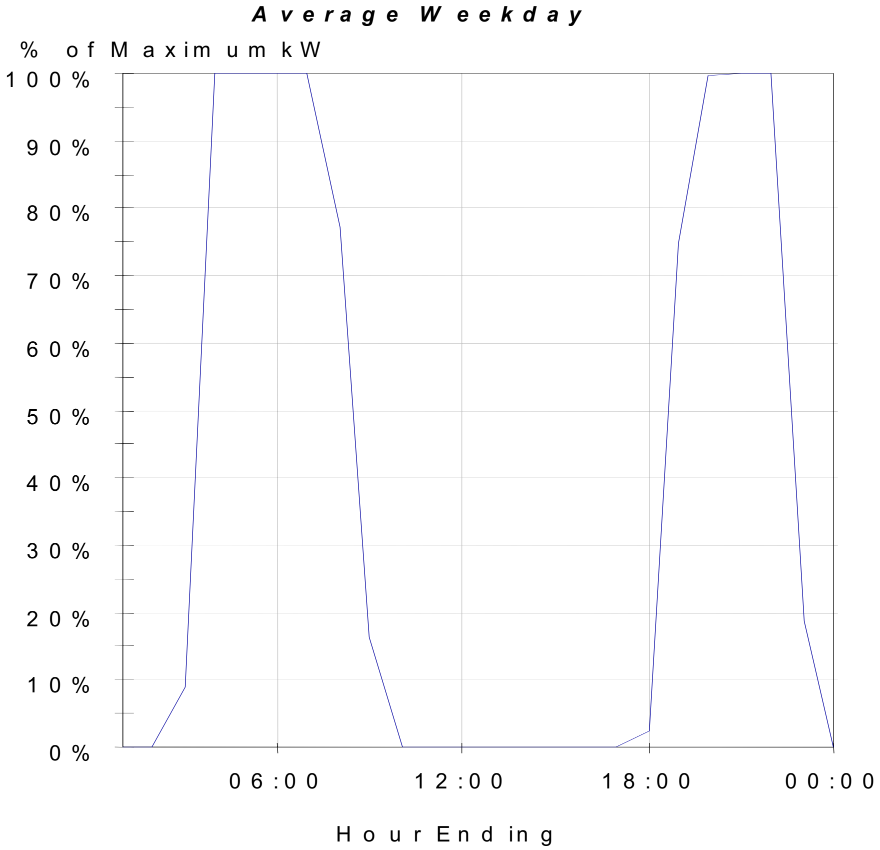

Figure 21: Functioning Daylighting Controls

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 incentive, 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 representative 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 DOE-2 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 question 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 question 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:

$$SpilloverSavings = GrossSavings - NetSavings:$$

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

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.

Recruiting Outcome Descriptions

Throughout the course of this two-year project, a total of 811 buildings were selected from the dodge database for non-participant recruitment. Of the 811 sites, 109 were scheduled and visited, 390 sites remain on-hold, 88 sites were dropped, 77 sites refused to participate, 31 sites were not reachable, and 116 were found to be participants. Some reasons why sites were put on-hold, not reachable, dropped or refused are as follows:

On-hold – Held for use in future BEA projects:

- A better match to the participant already scheduled
- Building still under development
- Building type misclassified in dodge database
- Unoccupied building or not built-out
- Not in correct climate zone nor utility

Dropped – Removed from call list permanently:

- Project put on-hold indefinitely
- Corporation bankrupt building no longer in use
- Campus of buildings serves as a poor comparison
- Exterior renovations to old building.
- Serviced by a municipal utility (LADWP)
- Complied under newer Title-24 AB970

Refused:

- Too many parties involved to obtain approval
- Containments in the building are confidential
- Property Managers unwilling to reveal new owners
- Corporate policy will not to participate in research or surveys

Not Reachable:

- Not enough information available in dodge database on owners
- Owners are not listed & name or building address not listed.