Measuring Accomplishments of Energy Efficiency in California's Nonresidential New Construction Market

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ABSTRACT

Savings By Design (SBD) is the statewide non residential new construction (NRNC) energy efficiency program, currently administered by the four California investor-owned utilities. The goal of SBD is to foster a team approach with the objective of designing comfortable, energy efficient buildings. Through a better understanding of the NRNC market and its players, the integrated design approach has evolved into a key component of the SBD Program. The Program recognizes the importance of the individual role each member of the project team plays, offering benefits to each for their part in energy efficient building design and construction.

The Building Efficiency Assessment Study (BEA) is a process and impact evaluation of the SBD program administered by PG&E, SCE, and SDG&E. Although Southern California Gas (SCG) also runs the program, this study does not include SCG participants. The key objectives of the study are to:

- Develop on-going gross whole-building energy and demand impact estimates
- 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

The BEA methodology builds on the 1999 California NRNC Baseline study enabling a direct tracking of energy efficiency changes in the market over time. The study utilizes on-site surveys and energy simulation modeling to predict building energy efficiency and track building characteristics. The evaluation is based on DOE2 engineering models that are informed by detailed onsite audits 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. The study includes an assessment of both program participants and an equal number of program non-participants that were carefully matched to the participants. Non-participants serve as the control group for measuring SBD program impacts. A key innovation is the use of a real time customer self-report method for determining participant free-ridership and non-participant spillover.

Introduction

This paper describes the results to date of the BEA study for the NRNC program area, covering program years 2000-2001. The study is being conducted in three rounds representing nine quarters of new construction activity. The results are based on buildings that were completed and occupied during each period. Round 1 covers results for the 4th

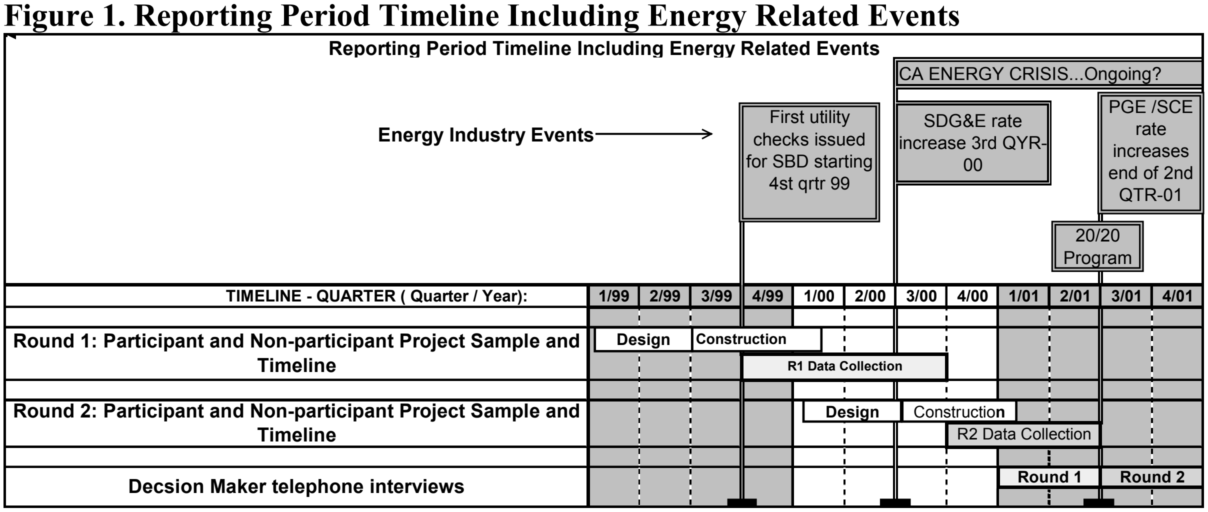
Quarter of 1999 through the 3rd Quarter of 2000. Round 2 covers results for the 4th Quarter of 2000 through the 2nd Quarter of 2001. Round 3, which is expected to be completed in Summer of 2002, will included data for 3rd and 4th quarter 2002.

This paper focuses on findings in two key study areas, non-participant efficiency relative to Title 24 baseline, and program net savings. In each of these areas the results are radically different from past California statewide NRNC program area studies conducted over the past six years. A comparison of results by round provides insight into the change in attitudes and practices over these two reporting periods. In particular, we believe we are seeing the first effects of the California energy crisis.

Figure 1 establishes the context of this statewide assessment with respect to the California energy crisis. The events are depicted by their relationship to the reporting timeline (by year and quarter) listed across the center of the figure. Here, for example, 4/99 represents the fourth quarter of 1999. The figure is shaded by year for visual clarity. Above the timeline the pertinent energy industry events are displayed to relate the unfolding crisis to our data acquisition. Below the timeline design and construction activity and data acquisition activity for the sample of projects are displayed in terms of the study round.

Figure 1 shows that the design and construction period for Round 1 projects occurred well before the beginning of the energy crisis, while the design and construction for Round 2 projects took place during the events leading up to and defining the energy crisis. For example, the initiation of the crisis, defined as the quarter SDG&E rates began their radical climb, coincides with the end of the design period for the Round 2 projects.
While the design and construction of the Round 2 sample took place prior to the SCE and PG&E rate increases, we suspect that anticipation of rate increases based on the experiences of SDG&E customers may have had an impact on statewide energy efficiency decision making in Round 2.

Figure 1. Reporting Period Timeline Including Energy Related Events



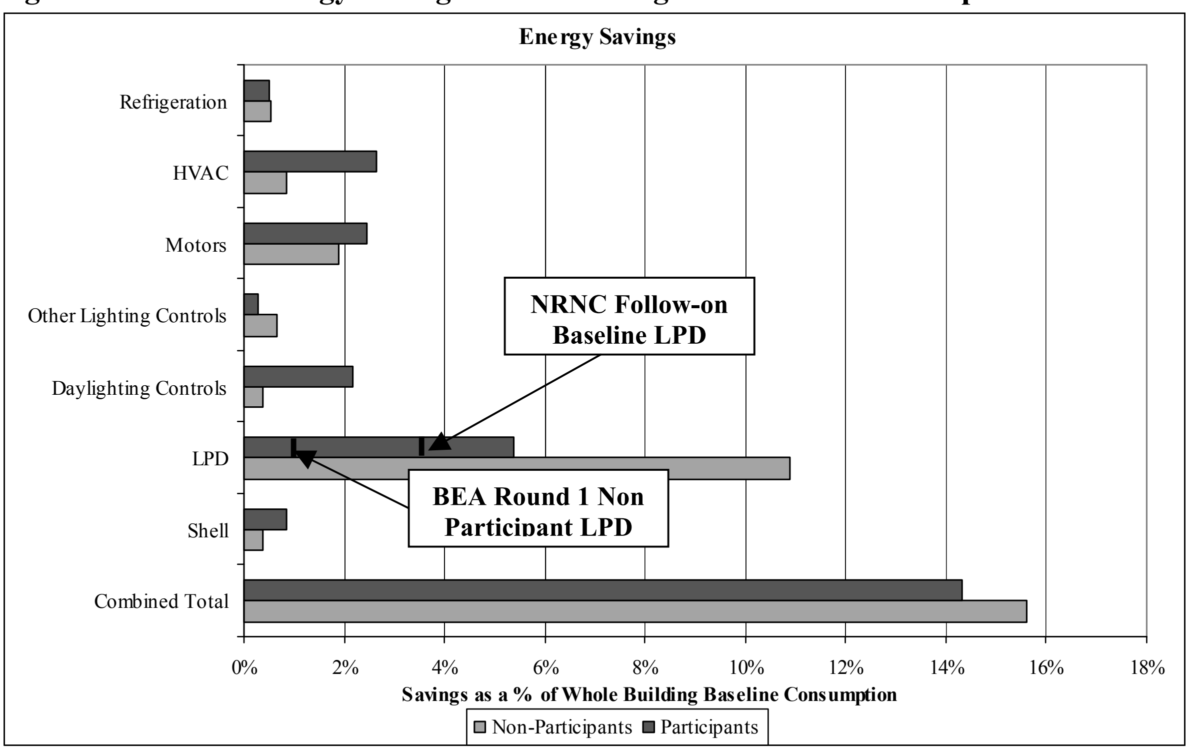
A new theme emerged in the Round 2 building data and survey responses. The attitudes and practices of owners and building professionals appear to have been profoundly affected by the California energy crisis. The findings presented in this paper suggest that the energy efficiency of non-participant buildings has experienced a dramatic increase between the two reporting rounds. We believe, based on the timeline presented above, that the energy crisis may have had an impact both on the design of the buildings in our sample, and our surveys with the owners and designers of these buildings.

Findings

Figure 2 shows the Round 2 savings of both program participants and non-participants by measure and total expressed as a percentage of each group's whole-building baseline usage. Contrary to expectations, the participant group was *less* energy efficient overall than the non-participant group. As illustrated by the bottom bar in the graph, the participants were 14% better than baseline on average, while the non-participant comparison group was 15% better than. The non-participants were found to be much more efficient than the participants in the lighting end-use (LPD), respectively 11% and 5% better than the whole building baseline. This dramatic efficiency in lighting power density on the part of the non-participants is a major driver of the overall building efficiency improvement, ultimately causing the non-participant combined total efficiency to be slightly better than the participants.

These results are unlike anything we have seen in previous studies. For example, in the NRNC Follow-on Baseline Study we found the non-participant lighting end-use to be 4% better than whole building baseline, while in Round 1 of the BEA study we found the non-participant group to be approximately 1% better than whole building baseline.

Figure 2. Round 2 Energy Savings as a Percentage of Baseline Consumption

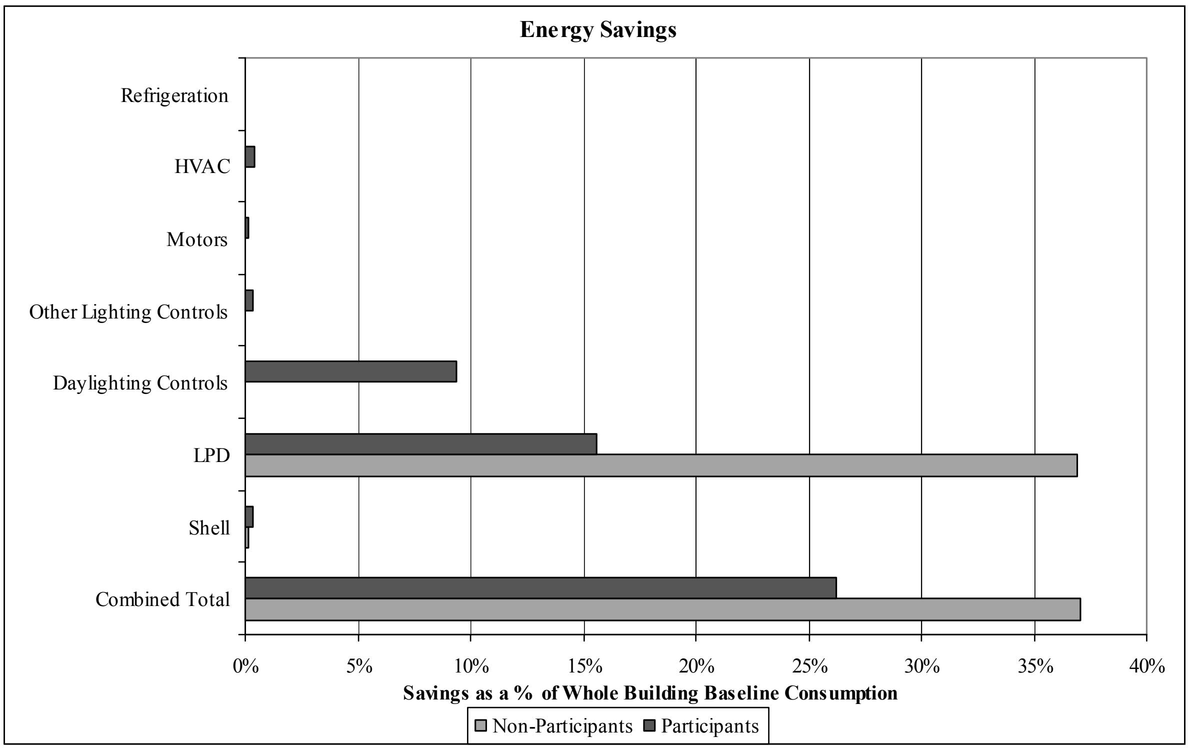


Source: RLW Analytics, Inc. et al. 2002

A review of the non-participant buildings revealed that many of the most efficient non-participant buildings were warehouses. For a better understanding of the results, we repeated the analysis for warehouses alone. Figure 3 shows the results for the warehouses only. Non-participant warehouses significantly outperformed participant warehouses, particularly in the lighting end use. Consequently, non-participant warehouse total savings were approximately 37% better than the whole building baseline consumption, compared to 26% for participants. These results represent seven participants and seven non-participants, so one should exercise caution when interpreting these findings.

In order to understand what is driving these findings we took a closer look at the lighting end-use. Among the warehouses, the non-participant average lighting power density is only 0.38 watts/square foot, about 23% less than the value for participants and much lower than code.

Figure 3. Energy Savings as a Percentage of Baseline Consumption—Warehouses

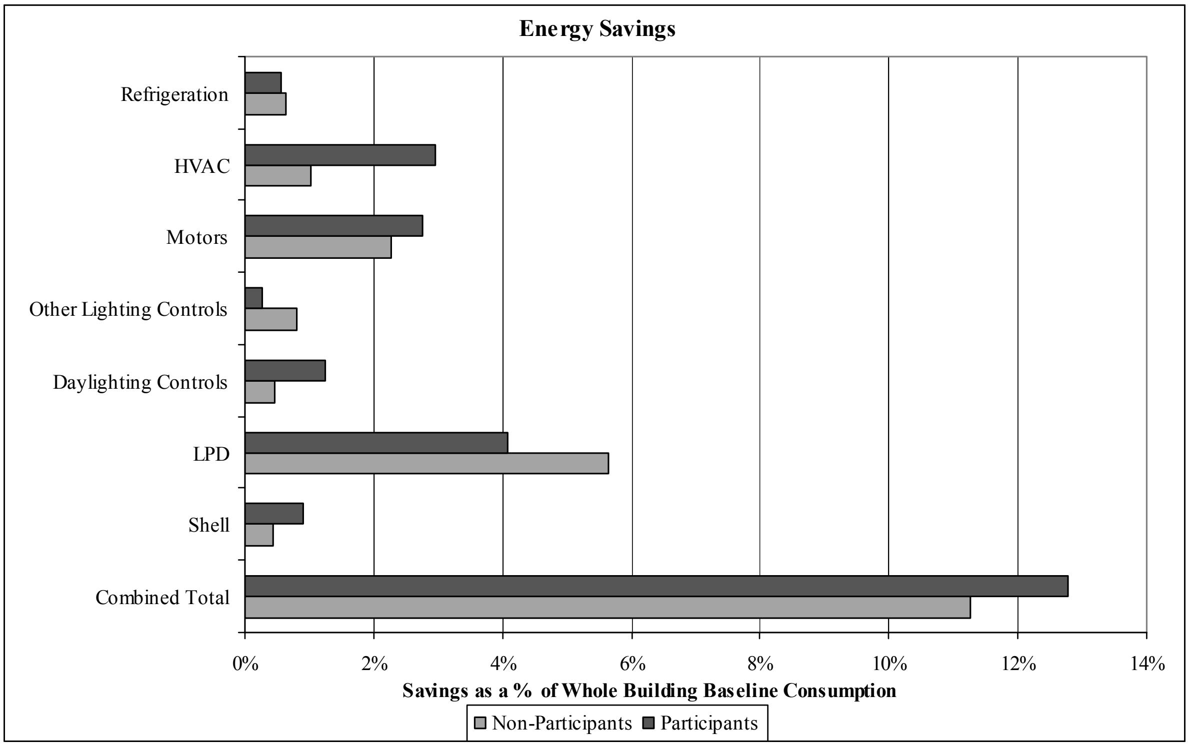


Source: RLW Analytics, Inc. et al., 2002

Closer scrutiny of the warehouse sample revealed a single owner with four of the seven buildings, which appears to be biasing the results. This particular owner also claims to be highly energy and cost conscious, constructing his buildings to use as little energy as practical. Closer investigation of the Dodge data showed that he is responsible for approximately 20% of C&I storage new construction during the quarters being studied. Therefore, a better sample would have only included two of his projects (2/7=28%), replacing the other two with different owners' buildings. This may help to explain the results of the warehouse sample.

We conducted the same review for all of the non-warehouse buildings. Figure 4 shows these results for the non-warehouse buildings. In this group the non-participants are somewhat more efficient than the participants in the lighting category, but overall, the participants are slightly more efficient than the non-participants.

Figure 4. Round 2 Energy Savings as a Percentage of Baseline Consumption—Non-Warehouses



Source: RLW Analytics, Inc. et al. 2002

In our attempt to understand these results, we compared other characteristics of the buildings by rounds. Figure 5 is an adaptation of Figure 1. Round 1 and Round 2 sample statistics and non-participant building owner survey responses are shown. The timing of the survey responses relative to the California energy events can be seen in Figure 1. While the vast majority of projects are privately owned, the percentage of non-participant public projects increased significantly from 6% in Round 1 to 31% in Round 2. Research has shown that public buildings are designed more efficiently than owner occupied and speculative development buildings (1999 Baseline Study, pages 24-25). While the research does not necessarily address the energy savings differences for the warehouse sample, the research may account for at least some of the difference in the other building types.

Figure 5goes on to illustrate owner attitudes with regard to energy efficient decision making. The importance of lowest lifetime cost as the most important financial criteria increased three-fold, from 12% to 38%. Owners familiar with an "integrated design approach" nearly doubled, while the importance of energy efficiency during design and construction increased resoundingly, from 8% to 47%. The importance of energy efficiency in daily operations experienced a sizeable increase, and 71% of non-participants now report to have an energy management policy, compared to only 12% of non-participants in Round 2. Finally, just over half of the Round 2 non-participants reported that they were aware of the Savings By Design program before they began construction, more than a two-fold increase over Round 1.

Clearly, the events of the energy crisis influenced the non-participant owner population with regard to their interest in energy efficiency. What is unclear at this point is whether the actual energy efficiency choices that went into the construction of the Round 2 building sample were influenced by the energy crisis, or if various characteristics of the sample can be credited along with other market influences. Only until the BEA Study is completed and many more buildings are added to the sample can we begin to analyze the results across various characteristics of the sample, such as ownership status. These kinds of analysis should provide the needed insight to determine if, and how much, the California energy events shaped non-participant new construction practices with regard to energy efficiency. In the following section we look at another factor that appears to be contributing to this shift, utility program influences.

Figure 5. Sample Ownership and Non-Participant Survey Responses

Shift in Non-participant Sample	Round 1 and Round 2 Samples	Round 1	Round 2
	Publicly Owned Building	6%	31%
	Owner Occupied Building	46%	65%
Evolution of Energy Concerns	**Non-participant Owners**		
	"Yes", Most Important Financial Criteria is Lowest Lifetime Cost	12%	38%
	"Yes", Familiar with "Integrated Design Approach" (IDA)	27%	55%
	"Yes", Energy Efficiency is Very Important During Design and Construction	8%	47%
	"Yes", Energy Efficiency is Very Important in Daily Operations	29%	62%
	"Yes", We Have an Energy Management Policy	12%	71%
	"Yes", We Were Aware of SBD Before Construction Began	23%	52%

Net Savings

The design of the BEA study includes two approaches to estimating the net program savings. The first approach is termed the "difference of differences" methodology (SCE NRNC Evaluation, 55-57). In this approach, non-participants are used 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. In past evaluations, the difference of difference approach has been considered the accepted methodology for reporting net program savings, yielding reasonable net-to-gross ratios.

The second approach used for the BEA study is a self-reported method. In this approach, project decision makers associated with both participant and non-participant buildings are asked what they would have designed absent the program. The responses of the participants are used to adjust the gross savings for free ridership and the responses of the non-participants are used to estimate spillover. Both of these approaches are described in the methodology of the BEA report (BEA Round 1 Report, 61-65). The self-report method has been an accepted approach to measuring net impacts in commercial retrofit programs, but has not been widely used in NRNC new construction evaluations[1] primarily because of the difficulty in assessing "absent the program" conditions. Past NRNC evaluations were not appropriate for self-reporting because the evaluations were done one or more years after the completion of the project, making it difficult to track down the appropriate decision makers. Once the decision makers were located, asking them to recall what they may have done absent the program at the time of construction would have been challenging, at best, given the length of time that had elapsed.

[1] A self report method was used for PG&E's "PRE-1998 Non-Residential New Construction Energy Efficiency Incentive Program 1999 Carry Over Impact Evaluation". March 2001.

The BEA study was intentionally designed to allow for more timely discussion with the project decision makers. While the difficulty of determining whom the appropriate decision maker (i.e., owner, architect, engineer, construction manager) is for the various energy efficiency choices still remains a difficult task, the BEA study design cut the elapsed time from years to months. This has made it easier for respondents to recall the specifics of their decisions, including parties responsible for making key energy efficiency decisions.

Net Energy Savings, "Difference-of-Differences"

Table 1 presents the difference-of-differences calculations for net annual energy savings. Due to the low lighting power density practices of non-participants, the program appears to be experiencing negative net savings. The calculations result in a program level net annual energy savings of –2,926 MWh. These net savings correspond to a net-to-gross ratio of –9.0%. Round 1 was significantly different, with a 79% net-to-gross ratio, these results are much more like what we have seen in the past.

Table 1. Round 2 Difference of Differences Net Savings—Annual Energy

		Baseline (MWh)	As-Built (MWh)	Savings (MWh)	Savings (% of Baseline)	Net-to-Gross Ratio
Round 2	Participants	227,578	195,005	32,573	14.3%	
	Non participants	128,923	108,813	20,110	15.6%	
	Participant Net Savings			-2,926	-1.3%	-9.0%
Round 1	Participants	101,558	82,171	19,387	19.1%	
	Non participants	60,028	57,696	2,332	3.9%	
	Participant Net Savings			15,442	15.2%	79.7%

The results shown for Round 2 in Table 1 are dramatically different from what we have seen in previous studies. However they are supported by the non-participant lighting efficiency characteristics discussed in the previous section.

Net Energy Impacts, Self-Reported Method

Realizing that the difference of differences approach did not account for spillover, the BEA study design also included a net savings assessment using a self report methodology. Decision-maker surveys were used to determine measure-level free-ridership and spillover occurring as a result of SBD. Free-ridership and spillover were quantified by asking the building owners and design teams a series of questions regarding the influence CA NRNC programs have had on their energy efficiency decision making. Analysis of the survey results produced estimates of measure level free-ridership for the participant group, and estimates of end-use level spillover for the non-participant group.

Participant measures and non-participant end-uses were 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 lighting power density.

Free-ridership and spillover were calculated by re-running the as-surveyed DOE-2 models modified for program influences. Dichotomous measures were either left in the models or removed from the model, depending upon the score given. For measures with continuous or incremental energy efficiency ratings, an energy rating was calculated and the model was adjusted proportionately. The output from the as-surveyed models were then compared to the models adjusted for free-ridership and spillover to determine changes in energy and demand. A more detailed methodology on this approach is described in the Round 1 Building Efficiency Assessment report.

Table 2 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 16,730 MWh. Spillover savings in the non-participant population are 14,533 MWh. These two results together suggest a total net program impact of 31,264 MWh. These net savings correspond to a net-to-gross ratio of +96.0%.

Table 2. Round 2 Total Net Program Impacts—Self Report Methodology

	Self - Report Estimate (MWh)	Calculation
Program Tracking Savings	25,029	A
Gross Savings	32,573	B
Gross Realization Rate	130.1%	(B / A)
Net Participant Savings	16,730	C
Participant Net Realization Rate	66.8%	(C / A)
Participant Net-to-Gross Ratio	51.4%	(C / B)
NP Spillover Savings	14,533	D
Total Net Savings	31,264	C + D
Net Realization Rate	124.9%	(C + D)/A
Net-to-Gross Ratio	96.0%	(C + D)/B

Interestingly, the spillover being reported in the non-participant population is nearly all from the lighting end-use (LPD), accounting for 13,917 of the total 14,533 MWh of spillover. This supports the non-participant efficiency shown early in Figure 2. In Round 1 of the BEA study we found negligible amounts of spillover, which is also supported by Round 1 non-participant lighting efficiency relative to baseline (+1.0%).

Table 3. Round 2 Spillover by End-Use

End Use	Non-Participant Spillover Energy Savings (MWh)
Shell	(32)
LPD	13,917
Daylighting Controls	-
Other Lighting Controls	20
Motors	-
HVAC	532
Refrigeration	96
Combined Total	14,533

How Should Net Savings Be Measured?

It is remarkable how contradictory the net savings results are when we compare these two approaches. In Round 1 reporting we found that the results of the difference of differences approach was nearly identical to the self-reported analysis results. In Round 2 we have found the opposite, the self-reported method is showing a plausible net-to-gross ratio, while the difference of differences approach is giving answers we have never seen in any past evaluation, -9.0%. 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 is not addressed by the difference-of-differences approach. In previous studies we found very little non-participant spillover. However the enduring California utility programs appear to be transforming the market, at least in regard to lighting efficiency. This measure category has traditionally been heavily targeted as a program area with high returns. In this second round of the BEA study we have found significant spillover in the non-participant population, specifically in the lighting efficiency 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.

In Round 1 we found very little non-participant spillover. In Round 2 the non-participants experienced a tremendous growth in efficiency when compared to the baseline. However as shown in this section a large amount of the non-participant efficiency has been reported by project decision makers as program induced savings.

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. The California tradition of program evaluation has frowned on the use of self-reported information. But is there any feasible alternative?

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 planned in the current BEA study. Therefore the econometric approach was not appropriate for the study.

Instead we sought to strengthen the self-reporting methodology itself. In the current 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 is a reasonable and defensible approach for the purposes of the BEA study.

Summary

At the time of writing this paper, two of three reporting rounds for the BEA study have been completed. The results to date of our study have focused primarily on comparing Round 1 results to Round 2 results. We expect the Round 3 results will provide a much better overall picture of the NRNC market by adding more sampled projects over a longer period of time. We are eager to see how the self-reported net analysis methodology performs in Round 3 and to see if the results from Round 3 help to explain the long-term impacts of the California energy crisis. The complete results of the BEA study will be rolled into one cumulative report. The results compiled so far indicate a major shift in attitudes and design practices due to the energy crisis of 2000. The next round of results will help determine if these changes are only temporary or whether the energy crisis will produce a profound lasting impact on the efficiency of NRNC in California. We also expect the cumulative BEA report to provide significant guidance in determining the most suitable way to estimate net savings impacts for non-residential new construction.