Evaluation of a Small Commercial Prescriptive Lighting Program

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ABSTRACT

In response to California's electricity supply and demand crisis of 2001, the Sacramento Municipal Utility District (SMUD) implemented a portfolio of programs funded by the California Legislature, through Senate Bill 5X. As part of its SB5X portfolio, SMUD implemented a Small Commercial Prescriptive Lighting program. SMUD's initial goal for the program was to achieve installation 450 installations by December 31, 2002. SMUD's initial targets were to reduce summer capacity by 1.8 MW and reduce energy consumption by 6.7 GWh/yr.

An evaluation study was undertaken to estimate the actual energy savings and demand reduction achieved by the program. This paper describes the study methodology, discuss the success of the program, including participant satisfaction and present the gross and net energy savings and demand reduction evaluation results. The paper also presents the savings results in detail and discusses challenges encountered during the evaluation.

Introduction

The purpose of the program was to obtain immediate peak-load reduction and energy savings in the hard-to-reach small commercial sector through the installation of prescribed, pre-approved, energy efficient lighting measures. Incentives were designed to cover the full cost of the lighting equipment. Incentives were typically paid directly to contractors. As part of the energy savings calculation process, contractors were required to furnish SMUD with pre- and post-installation equipment inventories and operating hours of the replaced equipment. Eligible technologies included T-8 lamps with electronic ballasts, delamping, compact fluorescent lamps, controls, LED exit signs and occupancy sensors.

The first phase of the program was rolled out in May 2001 and completed in July 2002. The second phase of the program started in January 2003 and completed in June 2003. Results are presented for the first phase of the program. The program completed 742 projects with estimated energy savings of 6.78 GWh, estimated demand reduction of 1.87 MW for the 2-6 PM peak period, and estimated demand reduction 1.51 MW for the 1-9 PM peak period.

Methodology

The measurement and verification of the program was conducted in order to evaluate the effectiveness of the program offerings. The evaluation methodology consisted of utilizing various approaches to analyze the program. It included the development of a tracking system, on-site data collection, a decision-maker survey, and analysis of energy savings. The tracking system collected site-specific information. Data collection included complete inventories of all lighting equipment, and the installation of lighting loggers to verify program assumptions and calculate gross savings.

Savings were estimated for a statistically representative sample, and expanded to the population using sampling weights. Gross demand (kW) savings were calculated based on the quantity and wattage of the installed lighting measures compared to the existing system. Gross energy (kWh) savings were calculated based on the kW reduction and actual operating hours.

The net-to-gross analysis estimated the portion of the lighting savings directly credited to the program. To do this, we attempted to understand the free-ridership rate associated with each participant, based on responses from a decision-maker survey.

The survey was also used to assess customer satisfaction with the program. For each question about satisfaction levels, a mean rating was calculated among participants who were able to provide a rating. Mean ratings were calculated for the overall program, as well as by contractor.

Sample Design

The impact evaluation was conducted with a random sample of 51 program participants, stratified by "specialist". The "specialist" refers to who initiated the program process for the participant: SMUD or the contractor. The sample was selected after the first phase of the program had been fully subscribed with a total of 742 projects[1]. Based on a projected total of 450 participants, an error ratio of 0.5 will yield a statistical precision of ±11% at the 90% level of confidence. Sampling methods extrapolated the findings from the sample sites to the target population of all program participants.

Data Collection

The on-site survey consisted of a comprehensive lighting inventory, including measure identification and quantification. The lighting inventory included complete counts of all fixtures in the retrofitted space. Fixture details, including quantity and type of lamps and ballasts, were collected. The presence of lighting controls, whether new or existing, was recorded. Standard time-of-use ("TOU") lighting loggers were used to measure hours of operation for lighting measures. They were placed in the retrofitted spaces for a period of 1-2 weeks to record on/off time. These loggers used a photocell sensor to sense and recorded the dates and times that a light fixture turns on and off. The data were downloaded from the logger to a PC where computer software provided for the reporting of various analysis needs. Spot wattage measurements were performed to calibrate estimates of electrical demand.

While on site, the surveyors also conducted a decision-maker survey with the customer. The decision-maker survey was used to establish the baseline for customer free-ridership and determine customer satisfaction with the program.

Impact Analysis

Gross demand reduction and energy savings were determined for each sample site. Gross demand reduction was calculated, using spreadsheet analysis, based on the quantity and wattage of the installed lighting system compared to the existing system. Gross energy savings were calculated based on the kW reduction and actual operating hours. The baseline for the gross savings analysis was the existing load for each site, as provided by the Contractor. The hours of operation were assumed to be constants for the analysis, except in cases where lighting control measures were installed.

Net demand reduction and energy savings were based on decision-maker responses. The net-to-gross analysis estimated the portion of the lighting savings directly credited to the program. To do this, we assessed the free-ridership rate associated with each participant, based on responses from a decision-maker survey.

[1] Results will be recalculated after the final program completion.

The gross and net results were expanded to the program population. Both gross and net savings were compared to the initial tracking system savings estimates to determine the effectiveness of the program.

Customer Satisfaction

A decision-maker survey was used to determine customer satisfaction with the program. The survey asked a number of questions designed to gauge participant satisfaction levels with various aspects of the program, including the contractor, the program process, SMUD direct contact, and the resultant lighting system. Participant satisfaction levels were rated on a one-to-five scale, where a one represents very satisfied and a five represents very dissatisfied. The customer satisfaction results are presented in more depth further in the paper.

Results

This section summarizes the gross savings, net savings, and the associated net-to-gross ratios for the Small Commercial Prescriptive Lighting program. Case weights have been used to extrapolate the sample data to the program population. Results are presented both by specialist (the party that initiated contact between the participant and SMUD) and for the overall program. Based on prior experience by the program manager, project savings was strongly influenced by the specialist. Specialists were divided into two classes: SMUD driven projects and Contractor driven projects.

Table 1 summarizes the program tracking totals and the impact evaluation results. We estimated that the program had annual energy savings of 4.77 GWh. We considered this to be the gross savings of the program, resulting in a gross realization rate of 0.70. Using information collected during the decision-maker survey, we estimated that the net energy savings represent a net-to-gross ratio of 96%, indicating that the program is experiencing very little free-ridership among its participants.

Table 1 also presents the demand reduction results. The gross demand reduction for the 2-6 PM peak period was 1.38 MW and 1.13 MW for the 1-9 PM peak period. The net demand reduction for the 2-6 PM and 1-9 PM peak periods were 1.32 MW and 1.09 MW, respectively.

Table 1. Impact Evaluation Results

	Energy (MWh)	2-6 Demand (MW)	1-9 Demand (MW)
Program Tracking	6,770	1.87	1.51
Gross Estimated	4,765	1.38	1.13
Gross Realization Rate	0.70	0.74	0.75
N/G Ratio	0.96	0.95	0.96
Net Estimated	4,592	1.32	1.09
Net Realization Rate	0.68	0.70	0.72

Gross Savings

Table 2 presents the gross energy savings for the overall program. It saved 4,765 MWh, with a relative precision of 11.4%, yielding a 90% confidence interval of (4,223, 5,308) MWh. The estimated energy savings corresponded to a gross realization rate of 70%. The program was reducing electric demand during 1 – 9 PM by 1.129 MW, for a gross realization rate of 75%. The associated relative precision was 10%, yielding a 90% confidence interval of (1.01, 1.24) MW.

Table 2. Gross Energy Savings by Specialist

Specialist	Estimated MWh	Program Tracking MWh	Gross Realization Rate	Relative Precision
SMUD	1,128	2,639	0.43	0.27
Contractor	3,638	4,131	0.88	0.12
Overall	4,765	6,770	0.70	0.11

Table 3 and Table 4 present the gross demand reduction for the 2-6 PM and 1-9 PM peak periods. The program reduced electric demand during for both peak periods by 1.38 MW, for a gross realization rate of 74%. The associated relative precision was 11%, yielding a 90% confidence interval of (1.23, 1.53) MW.

Table 3. Gross Demand Reduction for 2-6 PM by Specialist

Specialist	Estimated MW	Program Tracking MWh	Gross Realization Rate	Relative Precision
SMUD	0.32	0.60	0.53	0.28
Contractor	1.06	1.28	0.89	0.10
Overall	1.38	1.87	0.74	0.11

Table 4. Gross Demand Reduction for 1-9 PM by Specialist

Specialist	Estimated MW	Program Tracking MWh	Gross Realization Rate	Relative Precision
SMUD	0.26	0.50	0.53	0.25
Contractor	0.87	1.01	0.89	0.12
Overall	1.13	1.51	0.74	0.10

Net Savings Results

Table 5 presents the net energy savings for the program. The program net savings were 4,592 MWh, with a relative precision of 12%, yielding a 90% confidence interval of (4,038, 5,146) MWh. The estimated energy savings corresponded to a net realization rate of 68%.

Table 5. Net Energy Savings by Specialist

Specialist	Estimated MWh	Program Tracking MWh	Gross Realization Rate
SMUD	1,025	2,639	0.39
Contractor	3,567	4,131	0.93
Overall	4,592	6,770	0.68

Table 6 presents the net demand reduction for the 2-6 PM peak period. The net demand reduction, for the 2 – 6 PM time period, was1.32 MW resulting in a net realization rate of 70%. The associated relative precision was 11%, yielding a 90% confidence interval of (1.17, 1.47) MW.

Table 6. Net Demand Reduction for 2-6 PM by Specialist

Specialist	Estimated MW	Program Tracking MWh	Gross Realization Rate
SMUD	0.28	0.60	0.47
Contractor	1.04	1.28	0.87
Overall	1.32	1.87	0.70

Table 7 presents the net demand reduction for the 1-9 PM peak period. The net demand reduction, for the 1 – 9 PM time period, was1.09 MW resulting in a net realization rate of 72%. The associated relative precision was 11%, yielding a 90% confidence interval of (0.97, 1.20) MW.

Table 7. Net Demand Reduction for 1-9 PM by Specialist

Specialist	Estimated MW	Program Tracking MWh	Gross Realization Rate
SMUD	0.24	0.50	0.47
Contractor	0.85	1.01	0.90
Overall	1.09	1.51	0.72

Table 8 shows the net-to-gross ratios for the program. The net energy savings represented a net-to-gross ratio of 96%, indicating that the program was experiencing very little free-ridership among its participants. The net-to-gross ratio for energy demand reduction was similar for the two peak periods. There were slight differences between specialist types with contractor driven projects achieving a higher net-to-gross ratio.

Table 8. Net to Gross Ratios by Specialist

Specialist	MWh	MW 2-6 PM	MW 1-9 PM
SMUD	0.91	0.88	0.90
Contractor	0.98	0.98	0.98
Overall	0.96	0.95	0.96

Customer Satisfaction

This section summarizes program participant responses from the satisfaction section of the decision-maker survey. The satisfaction section was designed to gauge participant satisfaction levels with various aspects of the program, including the contractor, the program itself, and the resultant lighting system. Case weights have been used to extrapolate the sample data to the program population.

Participant satisfaction levels were rated on a one to five scale, where one represents very satisfied and five represents very dissatisfied. For each question about satisfaction levels, the mean rating[2] was calculated among participants who were able to provide a rating. Statistically significant differences in mean ratings between participants with different contractors are shaded in gray. All statistical significance tests were conducted at the 90% level of significance.

Results are presented by contractor (the party that installed the lighting system). The three contractor categories were Contractor A, Other, and Self-Install. Contractor A was the main contractor in the program, completing the majority of the projects. The Other category consisted of the remaining

[2] The mean is the same as average. Lower mean ratings indicate higher levels of satisfaction.

projects completed by various contractors. Self-Install refers to projects completed by the participant. Results are given by the contractor categories in order to determine whether there were differences in satisfaction between the groups.

Table 9 lists the satisfaction results for several program areas, including the program process, the lighting system, communication with SMUD, and the contractor. Nearly 88% of the participants were at least somewhat satisfied with the SMUD program process and the resulting lighting system. Over 75% of the participants rated their satisfaction with the contractor as Very Satisfied or Somewhat Satisfied. Overall, most participants were satisfied with the Small Commercial Prescriptive Lighting program.

Table 9. Overall Satisfaction Results

Satisfaction	SMUD Program Process	Lighting System	SMUD Contact*	Contractor**
Very Satisfied	63%	62%	74%	62%
Somewhat Satisfied	25%	26%	0%	14%
Neither Satisfied nor Dissatisfied	3%	5%	17%	5%
Somewhat Dissatisfied	5%	7%	0%	5%
Extremely Dissstisfied	0%	60%	0%	13%
Don't Know/ No Opinion	5%	0%	9%	1%
Mean Rating	1.47	1.58	1.37	1.93

**Satistfaction for Respondents Having Direct Contact with SMUD*
***Satistfaction for Respondent with Contractor Installed Projects*

Satisfaction with Program Process

Table 10 shows customer satisfaction with the program process by contractor. Nearly 90% of respondents that had the lighting installed by a contractor reported being very satisfied. Only 4.7% of the program participants reported dissatisfaction; all of the participants that feel dissatisfied with the program process had Contractor A as a contractor. Participants that had Contractor A as a contractor were significantly less satisfied with program process than are participants who used a different contractor or installed their lighting system themselves.

Table 10: Customer Satisfaction with the Program Process by Contractor

	Contractor A	Other	Self-Install	Total
Very Satisfied	58%	88%	68%	63%
Somewhat Satisfied	27%	8%	30%	25%
Neither Satisfied nor Dissatisfied	3%	4%	2%	3%
Somewhat Dissatisfied	6%	0%	0%	5%
Extremely Dissatisfied	0%	0%	0%	0%
Don't Know	6%	0%	0%	5%
Mean Rating	1.54	1.15	1.35	1.47

Satisfaction with the Lighting System

Over 60% of program participants stated they were very satisfied with the lighting system resulting from their participation in the Small Commercial Prescriptive Lighting program, and nearly 90% were at least somewhat satisfied with the resultant lighting system.

Interestingly, participants that did not install the lighting system themselves and had a contractor other than Contractor A appear to be the least satisfied with the resulting lighting system with nearly 20% reporting some level of dissatisfaction, even though these participants report the highest levels of satisfaction with the contractor and the program process. Participants that had Contractor A as a contractor were significantly more satisfied with the resultant lighting system than other participants.

Table 11. Customer Satisfaction with Lighting System by Contractor

	Contractor A	Other	Self-Install	Total
Very Satisfied	65%	58%	41%	62%
Somewhat Satisfied	27%	18%	37%	26%
Neither Satisfied nor Dissatisfied	3%	5%	22%	5%
Somewhat Dissatisfied	6%	15%	0%	7%
Extremely Dissatisfied	0%	4%	0%	1%
Mean Rating	1.50	1.86	1.80	1.58

Table 12 categorizes the verbatim reasons for being less than very satisfied with the resultant lighting system. Just over 40% of the respondents who provided a reason for being less than very satisfied with the resultant lighting system state that lamp and/or ballast failures were the source of this lack of complete satisfaction. Approximately another 33% of respondents who provided a reason for being less than very satisfied with the resultant lighting system stated that the lighting was not bright enough. Another 17% reported being less than very satisfied due to a lack of energy savings or increase in energy bills.

Table 12. Reasons for Being Less Than Very Satisfied with the Resultant Lighting System

Complaints	# of Respondents	% Less Than Very Satisfied
Lamp or Ballast Failures	5	41.7%
Lighting is Not Bright Enough	4	33.3%
Estimated Savings Not Realized	2	16.7%
I Don't Turn On the Lights Often	1	8.3%

Expected Energy Savings

Table 13 summarizes the responses given when participants were asked to compare their actual energy cost savings to their expectations. A full 40% of participants are unable to make this comparison, either because they did not know their actual energy cost savings or they did not know the magnitude of the expected energy cost savings. Participants that installed the lighting system themselves were the least able to compare their actual savings to their expected savings. Among participants who were able to make this comparison, the majority stated that the energy cost savings were either the same or greater than expected. About ten percent of participants reported savings that were less than their expectations.

Table 13. Actual Energy Cost Savings Compared to Respondent Expectations by Contractor

	Contractor A	Other	Self-Install	Total
Significantly Less	0%	8%	0%	1%
Slightly Less	10%	3%	6%	9%
The Same	22%	34%	28%	24%
Slightly More	18%	3%	0%	15%
Significantly More	11%	14%	0%	11%
Don't Know / Refused	39%	39%	67%	41%

Conclusions

The evaluation of SMUD's Small Commercial Prescriptive Lighting program was completed through the analysis of the gross and net annual energy savings and peak load reduction, and the study of customer satisfaction results from a decision-maker survey. It was concluded that the program achieved a net to gross ratio of 96% and a realization rate of 68%. The second phase of the program utilized lessons learned through the evaluation, modifying incentive amounts and participant qualifications. We expect that the realization rate will be greater for the second phase based on these modifications. From the decision-maker survey, we learned that nearly 88% of the participants were at least somewhat satisfied with the SMUD program process and the resulting lighting system. Also, over 75% of the participants rated their satisfaction with the contractor as Very Satisfied or Somewhat Satisfied. Overall, most participants were satisfied with the SMUD's Small Commercial Prescriptive Lighting program.