Persistence of Energy Savings in a Commercial Conservation Program

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An evaluation was conducted on the persistence of energy savings in a commercial retrofit program. In two program components, rebate and incentive, commercial customers received financial incentives for installing energy conservation measures in buildings.

First, second, and third year energy savings for 1987, 1988, and 1989 participants were determined by statistically comparing the pre- to post-program electrical consumption change for participants with the consumption change for nonparticipants. The first year savings per rebate building were 5 annual megawatt-hours (.6 megawatt-hours/1000 square feet), 5.3% of the pre-program consumption. The savings for three rebate cohorts ranged from 1.3 to 8.6 megawatt-hours. The persistence of the savings was 54% for 1987 participants and 67% for 1988 participants.

The average first year savings per incentive building were 151.7 annual megawatt-hours (2.5 megawatt-hours/1000 square feet), 10.1% of pre-program consumption. The savings for three groups of medium and large incentive participants ranged from 57.1 to 89.6 megawatt-hours, and were 1258.5 megawatt-hours for very large participants. The persistence in the savings was 89% for 1987 participants and 76% for 1988 medium and large participants. For very large participants, second year savings were 38% higher than first year savings.

The participants' savings were 79% of the projected savings with the savings being closer to the projected savings for incentive than for rebate participants. The evaluation findings are discussed in relation to the reliability of energy savings for commercial retrofit programs, the reasons for the erosion in energy savings over time, and research on the relationship between projected and measured energy savings.

Introduction

Seattle City Light signed a contract with the Bonneville Power Administration in November, 1985, to participate in the Commercial Incentives Pilot Program (CIPP). In this program, Seattle City Light offered financial incentives to customers for installing energy conservation measures in existing commercial buildings. These incentives were offered through two CIPP programs, rebate and incentive. In the rebate program, the incentives were offered for small commercial buildings (annual electricity consumption below 150,000 kilowatt-hours) which had cost-effective conservation measures on the Bonneville Power Administration's rebate checklist. In the incentive program, the incentives were offered for medium and large commercial buildings (annual consumption above 150,000 kilowatt-hours) which had cost-effective conservation measures. The Bonneville Power Administration reimbursed Seattle City Light for the payments to the participating customers.

A limited set of conservation measures were financed in the rebate portion of the CIPP program. These measures included lighting measures and a few building envelope and heating, ventilating, and air conditioning measures. For the incentive program, a large number of both simple and complicated conservation measures were financed. Examples of simple measures included insulating hot water tanks and installing an economizer on the heating, ventilating, and air conditioning system. Complicated measures were replacing resistance heating with heat pumps and installing automatic controls for temperature reset on the heating, ventilating, and air conditioning system.

Four evaluations have been conducted on the energy savings for participants in the CIPP program. Two of the evaluations were done at Seattle City Light (Coates 1989; Coates 1991a; Coates 1991b) with one evaluation each performed at Tacoma City Light (Perich-Anderson and Lerman 1991) and the Bonneville Power Administration (Cambridge Systematics 1990; Dagang 1990). Only one of the four studies examined energy savings beyond the first year following the installation of conservation measures in

the buildings. In this study, Coates (1991a) found that second year savings for 1987 CIPP participants were 93% of first year savings. Thus, there was considerable persistence in the energy savings for this group of CIPP participants.

Given the importance of long-term energy savings for commercial buildings in load forecasting and program cost-effectiveness, the primary purpose of the evaluation was to examine the persistence of energy savings for 1987 and 1988 program participants. For these cohorts, first year energy savings were available from earlier evaluations of the program (Coates 1989; Coates 1991a). To determine the second and third year energy savings, the pre- to post-program consumption change for program participants was compared with the consumption change for nonparticipants. Once the second and third year energy savings were known, the persistence of the savings was determined by comparing the participants' first year energy savings with their second or third year savings. A second purpose of the evaluation was to examine the first year energy savings for 1989 CIPP participants. As with 1987 and 1988 participants, energy savings for the 1989 cohort were determined by comparing the pre- to post-program consumption change for participants with the consumption change for nonparticipants.

The final purpose of the evaluation was to determine the accuracy of the projected energy savings for the three groups of program participants. This assessment was made by comparing the energy savings from the evaluation with the projected energy savings.

Method

1987 Program Participants

The evaluation approach was to statistically compare the pre- to post-program consumption change for 1987 program participants with the consumption change for nonparticipants. Annualized energy consumption data were collected from Seattle City Light's customer billing system for the years 1986 through 1990. The pre-program period was 1986 with the post-program periods being 1988, 1989, and 1990. There were 36 participants in the evaluation, 20 in the rebate program and 16 in the incentive program. Two incentive participants in 1987 were dropped from the evaluation because of bill history problems.

The nonparticipants were commercial customers who had indicated an interest in the CIPP program, but had not yet participated in it. They were selected in the first evaluation of the CIPP program (Coates 1989) to be similar to the participants on square footage of the facility and pre-program electrical consumption. Seventeen of the fifty-six nonparticipants were dropped from the current evaluation because they participated in the program during 1989 or 1990, or had bill history problems. With these removals, the nonparticipant group consisted of 39 commercial customers.

There are two major advantages in analyzing energy savings with an evaluation design comparing participants and nonparticipants on the changes in energy consumption over time. One advantage is that the comparison holds constant the year-to-year effect of outside influences (e.g., building operating hours, electricity prices) on energy consumption. Since these influences are likely to affect both the participant and nonparticipant groups, any differences between the groups in energy consumption can be attributed to the CIPP program. A second advantage of the evaluation design is that there is considerable comparability between the participant and nonparticipant groups on important correlates (e.g., building square footage) of energy consumption. With this comparability, participant-nonparticipant differences in gross energy savings are probably due to the program, rather than to group differences on the energy savings correlates.

1988 Program Participants

Energy savings for 1988 participants were determined by statistically comparing the pre- to post-program electrical consumption change for the three participant groups (rebate, medium and large incentive, very large incentive) with the consumption change over the same time period for comparable groups of nonparticipants. The pre-program period was 1987 with the post-program period being 1989 and 1990. The energy savings analysis was conducted on 42 of the 43 program participants in 1988. One rebate participant was dropped from the analysis because of bill history problems. Fourteen of the forty-two participants were in the rebate program with the remaining 28 participants being in the incentive program. The incentive participants were further subdivided for the savings analysis into 23 medium and large electrical consumers and 5 very large consumers.

The nonparticipants, who were part of the second evaluation of the program (Coates 1991a), were selected to be similar to the three participant groups on type of business, pre-program consumption, and square footage of the buildings. Nine of the nonparticipants were not available for the current evaluation because of bill history problems or their participation in the CIPP program during 1990, leaving 18 small, 46 medium and large, and 17 very large nonparticipants for the evaluation. The small and medium

and large customers had contacted the CIPP program prior to the evaluation, but had not yet participated in it. Only two very large nonparticipants had indicated an interest in the CIPP program. Given this situation, additional very large nonparticipants were drawn from a list of the largest commercial customers in the Seattle City Light service area.

1989 Program Participants

Energy savings for 1989 CIPP participants were assessed by statistically comparing the pre- to post-program consumption change for the two participants groups with the consumption change for like groups of nonparticipants. There were 54 CIPP participants in 1989 with 18 rebate and 29 incentive participants having usable consumption data for the analysis. The pre-program period was 1988 with the post-program period being 1990.

The nonparticipants for the energy savings analysis were customers on the CIPP waiting list. Customers were chosen who had usable megawatt-hour consumption data for the pre- and post-program periods, were in the same commercial subsector as the participants, and had pre-program electrical consumption that was within the range of consumption by subsector for the CIPP participants. With these procedures, the nonparticipant group consisted of 38 small customers and 71 large customers.

Projected Energy Savings

Seattle City Light's energy management analysts prepared projected energy savings for the conservation measures installed in the buildings of program participants. For rebate buildings, the projected savings were from hand calculations or savings developed in a building prototype analysis by the Bonneville Power Administration. For incentive buildings, the projected energy savings were calculated with standardized computer simulation programs such as ADM2 and VCACS. The projected energy savings were obtained from program records and compared to the savings found in this evaluation.

Results

1987 Program Participants

Nonparticipants for the energy savings analysis were chosen so that they were similar to the participants on building square footage and pre-program electrical consumption. To determine the adequacy of this selection procedure, t tests were performed comparing the participants and nonparticipants on the two variables. Each of the tests was not statistically significant (both p's $> .05$), suggesting comparability between the groups on building square footage and pre-program electrical consumption.

Table 1 presents the 1986, 1988, 1989, and 1990 electrical consumption for all program participants, for rebate and incentive participants, and for nonparticipants. Since the program participants and nonparticipants did not differ statistically on building square footage and pre-program electrical consumption, statistical tests were performed comparing the two groups on their pre-program (1986) to post-program (1988, 1989, and 1990) consumption change. Each of the three tests was statistically significant (all p's $< .05$), indicating that there were energy savings

Table 1. Mean Annual Megawatt-Hour Consumption and Energy Savings for 1987 Program Participants and Nonparticipants

	Year						
Group	1986	1988	1989	1990	First Year Savings	Second Year Savings	Third Year Savings
Participants (N=36)	161.6	132.7	135.8	138.6	30.4**	28.9**	26.1**
Rebate (N=20)	74.4	74.6	76.1	78.2	1.3	1.4	.7
Incentive (N=16)	270.6	205.4	210.4	214.1	66.7	63.3	59.6
Nonparticipants (N=39)	118.2	119.7	121.3	121.3			

Note: Energy savings with a (**) are statistically significant at the .05 level. Statistical tests were not done separately for rebate and incentive participants.

for 1987 CIPP participants in each of the post-program years.

Table 1 also presents the first, second, and third year net energy savings per building for all CIPP participants and separately for rebate and incentive participants. As shown in the table, the savings by year for all CIPP participants were: 1988 (30.4 mwh, 1.6 mwh/1000 square feet of conditioned building space); 1989 (28.9 mwh, 1.5 mwh/1000 square feet); and 1990 (26.1 mwh, 1.4 mwh/1000 square feet). The 1988 energy savings are 18.8% of the pre-program consumption.

There is considerable persistence in these savings figures with second and third year savings being 95.1% and 85.9% of first year savings. Additional evidence on the persistence of the savings was obtained by correlating 1988, 1989, and 1990 energy savings. Uniformly high and positive correlations were obtained ($r = .98$ for 1988 with 1989; $r = .93$ for 1988 with 1990; and $r = .93$ for 1989 with 1990), indicating that building with high savings in a given year were likely to have high savings in a subsequent year. Conversely, low savings in a given year were associated with low savings in a subsequent year. Each of the correlations was statistically significant at the .01 level.

1988 Program Participants

The adequacy of the selection procedure for nonparticipants was assessed with chi square or t tests comparing the relevant participant and nonparticipant groups on type of business, pre-program consumption, and building square footage. Each of the tests was not statistically significant (all p's $> .05$), suggesting comparability between the groups on each of the three variables.

Table 2 presents the 1987, 1989, and 1990 electrical consumption for small, medium and large, and very large participant and nonparticipant groups. T-tests comparing the pre- to post-program consumption change for participants with the like group of nonparticipants were statistically significant for the rebate participants in 1989 and for the very large program participants in 1989 and 1990 (all p's $< .05$). The t-tests approached significance for the medium and large participants in 1989 ($p < .06$), and were not statistically significant for the rebate and for the medium and large participants in 1990 (both p's $> .05$).

Table 2 shows the first and second year net energy savings per building for rebate, medium and large, and very large CIPP participants. As shown in the table, the average first year savings were 8.6 megawatt-hours for rebate participants, 89.6 megawatt-hours for incentive participants, and 1258.5 megawatt-hours for very large incentive participants. In percentage terms, the savings were 8.9% of the pre-program consumption for rebate participants, 11.4% for medium and large incentive participants, and 9.8% for very large incentive participants.

For rebate and medium and large incentive participants, savings in the second follow-up year, 1990, were somewhat lower than the first year savings (Table 2). The second year savings were 67.4% (rebate) and 75.9% (medium and large incentive) of the first year savings for the two groups. For very large incentive participants, there was considerable persistence in the savings as second year savings were 37.9% higher than the first year savings. The correlation between the two savings figures for all 1988 participants was positive and statistically significant ($r = .89$, $p < .01$), indicating that savings (or lack of savings) for individual buildings were maintained from 1989 to 1990.

1989 Program Participants

Statistical tests were performed to assess the similarity of the participant and nonparticipant groups on type of business, building square footage, and pre-program consumption. Each of the t-tests was not statistically significant (all p's $< .05$), suggesting comparability between the participants and nonparticipants on the three variables.

Table 3 presents the 1988 and 1990 electrical consumption for rebate and incentive participant and nonparticipant groups. A t-test comparing the pre- to post-program consumption change for incentive participants with the consumption change for nonparticipants was statistically significant ($p < .05$). For rebate participants, however, the t-test was not statistically significant ($p > .05$).

The net first year savings per building for rebate participants were 5.9 annual megawatt-hours (.5 megawatt-hours/1000 square feet); the savings for incentive participants were 57.1 megawatt-hours (1.8 megawatt-hours/1000 square feet). In percentage terms, the savings were 5.1% of the pre-program consumption for rebate participants and 7.2% for incentive participants.

Summary of First Year Energy Savings

Table 4 summarizes the first year energy savings by presenting the savings across all rebate and incentive participants. As shown in the table, the average first year savings per building for rebate participants were 5.0 annual megawatt-hours (.6 megawatt-hours/1000 square feet), 5.3% of the pre-program consumption. For

Table 2. Mean Annual Megawatt-Hour Consumption and Energy Savings for 1988 Program Participants and Nonparticipants

Group	Year 1987	1989	1990	First Year Savings	Second Year Savings
Rebate					
Participants (N=14)	96.4	91.4	98.1	8.6**	5.8
Nonparticipants (N=18)	88.7	92.3	96.2		
Medium and large incentive					
Participants (N=23)	783.8	717.9	737.3	89.6*	68.0
Nonparticipants (N=46)	839.7	863.4	861.2		
Very large incentive					
Participants (N=5)	12870.3	12493.6	12006.7	1258.5**	1734.9**
Nonparticipants (N=17)	10842.2	11724.0	11713.5		

Note: Energy savings are significant at the .06 level (*) or the .05 level (**).

Table 3. Mean Annual Megawatt-Hour Consumption and Energy Savings for 1989 Program Participants and Nonparticipants

Group	Year 1988	1990	First Year Savings
Rebate			
Participants (N=18)	116.8	111.7	5.9
Nonparticipants (N=38)	101.7	102.5	
Incentive			
Participants (N=29)	793.5	752.6	57.1**
Nonparticipants (N=71)	778.2	794.4	

Note: The megawatt-hour savings for participants are statistically significant at the .05 level (**).

incentive participants the average first savings per building were 151.7 annual megawatt-hours (2.5 megawatt-hours/ 1000 square feet), 10.1% of the pre-program consumption.

Table 4. Net First Year Energy Savings for All Rebate and Incentive Participants

Group	MWH	MWH/1000 Sq Ft	% Savings
Rebate	5.0	0.6	5.3
Incentive	151.7	2.5	10.1

Projected Energy Savings

Table 5 shows the mean projected and evaluation energy savings for 1987, 1988, and 1989 CIPP participants and the evaluation savings as a percentage of the projected savings. Except for 1989 participants, the evaluation savings for incentive participants were very close to the projected savings with the savings across the three participant groups being 82% of the projected savings. In contrast to these findings, the evaluation savings for the three groups of rebate participants were only 28% of the projected savings. The evaluation savings ranged from 9% to 45% of the projected savings for the three rebate groups.

Staff in the CIPP program conducted follow-up interviews with program participants on the reasons for the

Table 5. Mean Projected and Evaluation Energy Savings for Program Participants

Group	Projected Savings	Evaluation Savings	Mean Difference	Evaluation/Projected Savings (%)
Rebate				
1987	13.9	1.3	12.6	9.4
1988	19.1	8.6	10.5	45.0
1989	19.9	5.9	14.0	29.6
All rebate	17.4	4.9	12.5	28.2
Incentive				
1987	79.2	66.7	12.5	84.2
1988	290.5	298.3	-7.8	102.7
1989	139.2	57.1	82.1	41.0
All incentive	184.1	151.7	32.4	82.4
All participants	114.8	90.6	24.2	78.9

discrepancies between projected and evaluation energy savings. Table 6 shows that the four major reasons for the evaluation savings being lower than the projected savings were new equipment in the buildings following the installation of the conservation measures, longer hours of building operation, failure of the conservation measures, and inaccurate assumptions in the inputs used for calculating the projected savings.

Table 6. Reasons for Lower than Expected Energy Savings by 1987, 1988, and 1989 Program Participants

Reason	Number	Percentage
Operating hours changed	35	40
New equipment installed	14	16
Equipment operation	7	8
Conservation measures failed	14	16
Additional conservation measures installed	2	2
Assumptions in calculating projected savings	16	18

Discussion

First Year Energy Savings

Conservation measures are installed in commercial buildings to increase the efficiency of energy using equipment in the buildings. In the current research, efficiency was assessed through an analysis of the energy savings on billing records for a group of buildings which were retrofitted through the CIPP program. For these savings to be useful both to program planners and participants, the savings must be reliable. That is, the savings should occur under prescribed circumstance not once, but repeatedly.

The reliability of energy savings for the CIPP program was demonstrated in the research reported in this paper. Energy savings for rebate participants were consistent across three cohorts of program participants. The savings per building for 1987, 1988, and 1989 rebate participants ranged from .3 megawatt-hours/1000 square feet to 1.0 megawatt-hours/1000 square feet with the average savings per building across the three groups being .6 megawatt-hours/1000 square feet.

Reliability was also demonstrated in the energy savings for three cohorts of incentive participants. Excluding the very large incentive participants, the savings for 1987, 1988, and 1989 incentive participants ranged from 1.7 megawatt-hours/1000 square feet to 2.3 megawatt-hours/1000 square feet. For the very large incentive participants, the average savings per building were 3.3 megawatt-hour/1000 square feet.

The amount of energy savings for rebate and incentive participants is another demonstration of the reliability of the energy savings in this evaluation. Across the three cohorts of program participants, the energy savings were consistently higher for incentive participants than for rebate participants. When the savings are averaged across the three cohorts, the average savings per building for rebate participants were 5.0 annual megawatt-hours per building; for incentive participants, the average savings across the three groups were 152 megawatt-hours per building.

Persistence of Energy Savings

There was considerable persistence in the energy savings for incentive participants with the persistence from first year savings to second (or third) year savings being 89% for 1987 participants and 76% for 1988 medium and large participants. There was some persistence in the savings for rebate participants with this persistence being 54% for 1987 participants and 67% for 1988 participants.

A second way of looking at the energy savings for program participants is that there was erosion in the savings over time. This erosion in energy savings may be due to several factors, including changes in the participants' buildings following the installation of the energy conservation measures, removal of some measures, and the taking of energy conservation actions by nonparticipants. Some evidence on changes in the buildings was available from the follow-up interviews with program participants. In the interviews, several participants reported longer building operating hours and the adding of new energy using equipment following the installation of the measures.

Electricity savings beyond 1990 for CIPP participants are likely to vary with the degree of energy conservation awareness by participants and nonparticipants, the extent to which they install conservation measures on their own, maintenance of conservation equipment in the buildings, and changes in electricity prices (Hirst and Keating 1986; Keating 1991). Information on these factors would be needed to obtain an accurate estimate of future savings for CIPP participants, whether this information was used to forecast future savings or to conduct an evaluation of the energy savings at some future date.

It was also found in the evaluation that the second year energy savings for very large incentive participants were 38% higher than the first year savings. This finding for very large incentive participants may not be due to conservation related actions in the buildings. For one of the five participants, the follow-up interview with building personnel revealed that the substantial decrease in energy consumption following program participation was due in part to a sizable decrease in the number of building tenants. Given this interview finding and the small sample size for the very large incentive participants, some caution is needed in using the findings for this group on persistence of energy savings. Additional research on a case-by-case basis is needed with very large incentive buildings to further understand the extent to which their energy savings persist over time.

Projected Energy Savings

There was considerable variation in the relationship between the projected and evaluation energy savings for CIPP participants. For the three groups of rebate participants and for 1989 incentive participants, the evaluation energy savings were a small percentage (9% to 41%) of the projected savings. For 1987 and 1988 incentive participants, however, the evaluation savings were close (84% and 103%) to the projected savings.

These results are similar to the findings in studies reviewed by Nadel and Keating (1991). They found in 14 studies of commercial buildings that the evaluation savings were 75% of the projected savings, close to the 79% found in this evaluation. They also found considerable variation across the 14 studies in the relationship between evaluation and projected energy savings. Evaluation savings ranged from 36% to over 200% of projected savings with most of the studies reporting that the relationship was between 60% and 110%.

The follow-up interviews with building personnel are helpful in interpreting the relationship between the evaluation energy savings and the projected savings. Building personnel reported several reasons in the interviews for the evaluation savings being lower than the projected savings. The major reasons included the installation of new equipment in the building, changes in operating hours, failure of the conservation measures, and problems with the assumptions used in calculating the projected energy savings.

Future research should move beyond the simple comparison of projected and evaluation energy savings for a group of commercial buildings. One approach would be to examine the relationship of projected and evaluation savings for groups of buildings. Examples of these groups might include buildings which had different end-uses affected by the energy conservation measures or for which different methods were used in calculating the projected energy savings. Another approach would be to gather data on changes in the buildings from the pre- to the post-program period, and then relate these changes to the findings on projected and evaluation savings. Examples of these changes include occupancy hours, ratings for new equipment installed, and the number of tenants in the buildings.

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