Building Site Visits, A Look at Measure Retention as an Element of Program Evaluation

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Introduction and Background

In the last five years, the Bonneville Power Administration (Bonneville) has focused on the commercial sector as a rich resource for energy conservation. The Commercial Incentives Pilot Program (CIPP), in operation since 1986, is designed to harvest some of those resources by promoting the installation of Energy Conservation Measures (ECMs) in commercial buildings.

Beyond encouraging the installation of ECMs under CIPP to acquire resources, the question naturally arises as to the measure life of those resources. Commercial buildings frequently undergo changes that can impact energy consumption. Renovations, remodels or alterations in building use are some of the changes that can lead to ECM removal (Xenergy, 1987). If ECMs are removed prematurely, individual and combined measure life is shorter than estimated and commercial sector savings can fall below those projected. There is the potential to seriously overestimate the region's future conservation resource. In addition, if the measure life of the ECMs is less than the payback period, building owners and operators will not recover their costs, program penetration will be low and potential commercial sector resources may not be realized.

1990 Site Visits

During the winter of 1990, a billing history analysis of individual CIPP buildings revealed that there was a discrepancy between predicted and actual building energy use for a number of buildings (Hickman and Steele, 1991). And while engineering estimates typically overestimate savings potential, still, measure removal, decline in measure performance or other influences can account for savings loss. Bonneville decided to investigate the disposition of the CIPP buildings to determine the reasons for the discrepancy.

This was the first investigation of this kind to be performed and it consisted of visits to participating CIPP buildings and interviews with appropriate building personnel. Together with staff from the Commercial Programs Development and the Program Evaluation Sections 37, or 12 percent, of the 300 completed CIPP buildings were visited. The objectives were (1) to quantify the frequency and types of changes in participant buildings after the ECMs were installed, and (2) to determine what these changes meant for building energy consumption. In other words, could the discrepancy between predicted and actual building energy use be accounted for by any changes that might be found in the ECMs.

All buildings visited had undergone changes that could potentially impact energy consumption. For instance, there were changes in building occupancy, increases in business volume, changes to equipment and its use, and envelope modifications. The effect of these changes on building energy consumption is mixed. That is, discrepancies between predicted energy savings and billing histories could not be fully explained based on the types of information obtained during the site-visits. Further investigation and clarification was needed.

1991 Site Visits

In 1991, Bonneville decided to collect more specific information on the status of measures in the CIPP buildings. The objectives were not unlike those of the first study. The first objective was to observe and record any changes to the CIPP buildings since the initial building audit and then to categorize any changes in ECMs. The most important objective, however, was to understand whether these changes resulted in a decline in measure performance or whether they were relatively neutral to performance.

The scope of the 1991 site visits was: (1) to obtain as much relevant information on the recommended and installed measures as possible through interviews with the utility analyst for each building; (2) to visit each building and visually inspect for any obvious changes that might have affected the building's energy consumption or ECM effectiveness; and (3) to interview the owners/operators and building personnel for the express purpose of obtaining anecdotal information to supplement the other types being collected.

Research Approach

The research approach was to select a stratified random sample of fifty CIPP buildings based on geographical area. It was important to have a sample of large and small utility areas and different climate zones represented. Also, the buildings had to have been in the program for two years or less. The buildings were located in the operating areas of the City of Richland, Snohomish County PUD, Tacoma City Light, and Seattle City Light.

Next, in-person survey protocols were developed. The protocols for the qualitative data were designed to solicit information on when and how buildings were remodeled or renovated, and that impact on the ECMs. The protocols consisted of 30 questions utilizing both closed and open-ended questions. The interviews were estimated to take 45 minutes to one-hour to complete.

The utilities whose consumers were selected for the site visits, were contacted by Bonneville Area Office staff in order to obtain permission to visit the buildings. This contact by Bonneville Area Office staff was important because it provided entree to the consumers and aided in scheduling visits. The utilities were generous with their time and staff.

The site visits were conducted by staff from the Program Evaluation Section of Bonneville, however, staff from the appropriate CIPP utilities, and Branch, Richards, Anderson and CO. (BRACO) also went along on approximately one-half of the visits. BRACO is a company that works for the Area Office personnel and is knowledgeable on the technical aspects of ECMs.

Prior to going into the field to meet with the consumers, generally, there was a briefing by the utility auditor for the specific building that was scheduled to be visited. The briefing included a description of the measures that were installed, the dates they were installed, and any problems that were encountered. The briefings were short and usually lasted only 5 or 10 minutes.

The time allocated to complete all the site visits was two weeks. Four to five visits were completed per day with the interview and walk-through requiring about one-hour. With the exception of one utility, appropriate utility staff were present during all the site visits.

After the two weeks of observation and note taking for the site visits and interviews with utility analysts and building personnel, the data were entered into an ASCII data base for analysis in a software spread-sheet. Finally, after analyzing both the quantitative and qualitative data, two informal reports on the findings were written. Both reports were incorporated into two separate outside contractor documents that were later published.

The primary data sources, then, are the interviews conducted with auditors and building personnel and the information gathered from the walk-throughs. The benefit of these walk-throughs was twofold. First, they provided the auditors and building staff an opportunity to be reminded of important information not mentioned during the briefing or interviews. Second, they allowed the interviewer an opportunity to record information overlooked or not readily apparent to the building staff.

The findings below summarize the results of the site visits and interviews for the purpose of illustrating the type and frequency of changes that occurred in the buildings and the impact these changes may have had on ECMs and energy consumption.

Key Findings

The findings are presented on two levels, large-scale, or building level changes such as remodels and renovations, and smaller scale changes such as measure changes and removals. Due to a number of constraints, only 46 of the targeted 50 buildings were recruited for the research project. The four buildings that were not visited were: a private school the utility was unable to arrange an appointment with prior to the site-visit; a building destroyed by fire; and two other buildings whose personnel were unable to be contacted.

As can be seen from Figure 1, the sample buildings actually visited represent a wide variety of business types. The percentages that each building type represents of the total sample also are depicted.

Building Level Changes

As mentioned above, remodels and renovations can severely impact building level energy consumption. Changing the mix of measures, wall configurations and mechanical systems all have an effect. Almost half (N=21) of the buildings in the study were found to have undergone remodels or renovations in the 18 to 24 months since the program's inception. Thirteen of the changes were remodels and 8 were renovations.

In these 21 remodeled and renovated buildings, 47 different types of changes were identified. Many of the changes were small and a number were rather unsubstantial. The most common change to buildings was electrical system alterations. There were 13 electrical system

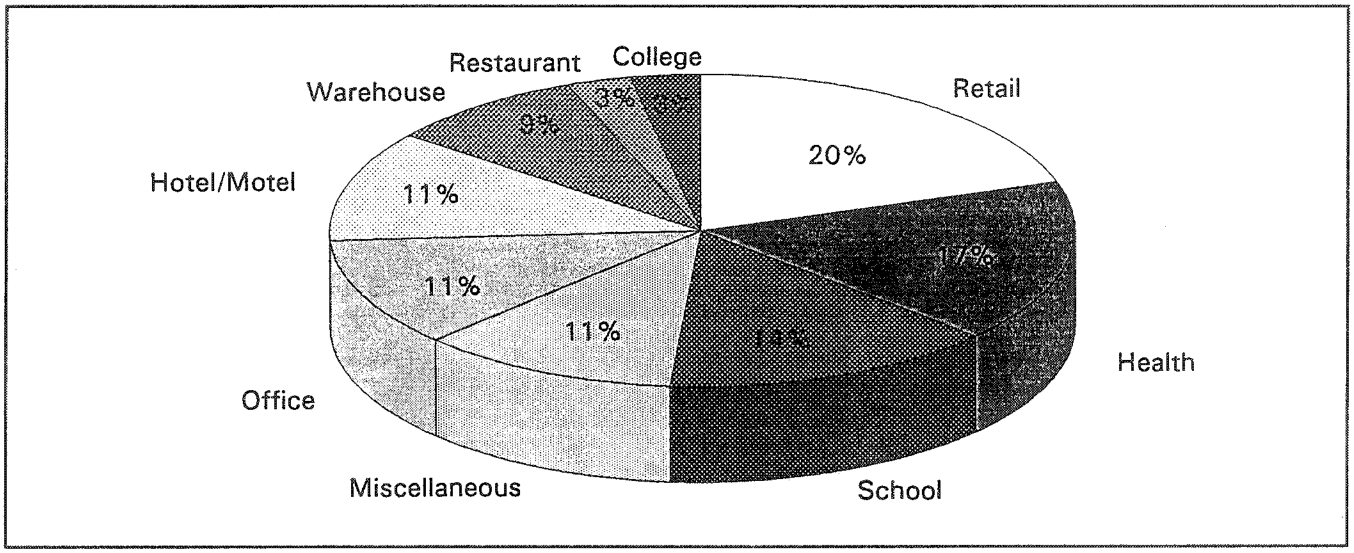

Figure 1. Type and Percent of Commercial Buildings Visited

changes, 11 changes to interior configurations, 11 changes to improve aesthetics or appearance, 8 changes due to building additions, 5 mechanical system changes and 2 changes to building envelopes. One building underwent all changes in the above categories. (See Figure 2.)

The interviews with respective building personnel revealed that the primary reason for these building level changes was due to growth and expansion. Walls had to be moved to accommodate larger more aesthetically pleasing work areas, electrical systems had to be altered to handle larger loads and additions were added on to increase the active work area. Other reasons for the building level changes were fairly evenly distributed among the need for repair, code compliance, competitive innovations, business function changes and building ownership changes.

Measure Level Changes

Vitally important to the realization of continued energy conservation, of course, is the life of the measures. Buildings that are renovated or remodeled very often have measures removed or have changes made in some way that affects measure efficiency. For instance, increasing the active work space of a building by adding on 30 percent more square footage decreases the efficiency, and therefore the measure life, of an HVAC system designed for a much smaller area.

For purposes of this paper, unless specifically designated separately, measure removal includes both total and partial removal of a previously installed ECM. As an example, partial ECM removal might mean that a 34 Watt *Econowatt* lamp was removed but the ballast remained in place. Table 1 shows the disposition of the measures in the 21 buildings that have been remodeled or renovated and those buildings that have not (N=25). The primary data sources for this table include information both from interviews and site-specific quantifiable data from building records.

For those buildings that have been remodeled or renovated, approximately 50 percent (N=10) have had measures removed and approximately 50 percent (N=11) have not. For those buildings that have not been remodeled, approximately one-third have had measures removed and approximately two-thirds have not. Clearly, measure removal is highest in buildings that are remodeled or renovated.

Of the 18 buildings which had measures removed, 8 were small buildings and 10 were large buildings. Small buildings are those with an annual electric energy consumption of under 150,000 kWh. Large buildings are those with an annual electric energy consumption of over 48,000 kWh.

Table 2 shows the percentage of buildings in each building type that had at least one measure removed. The categories of changes and building types are not exhaustive because this would render the cell sizes too small to be meaningful. For instance, 8 of the 46 buildings are not included here. In addition, partial change-outs or removals that occurred for lighting measures only (all the others

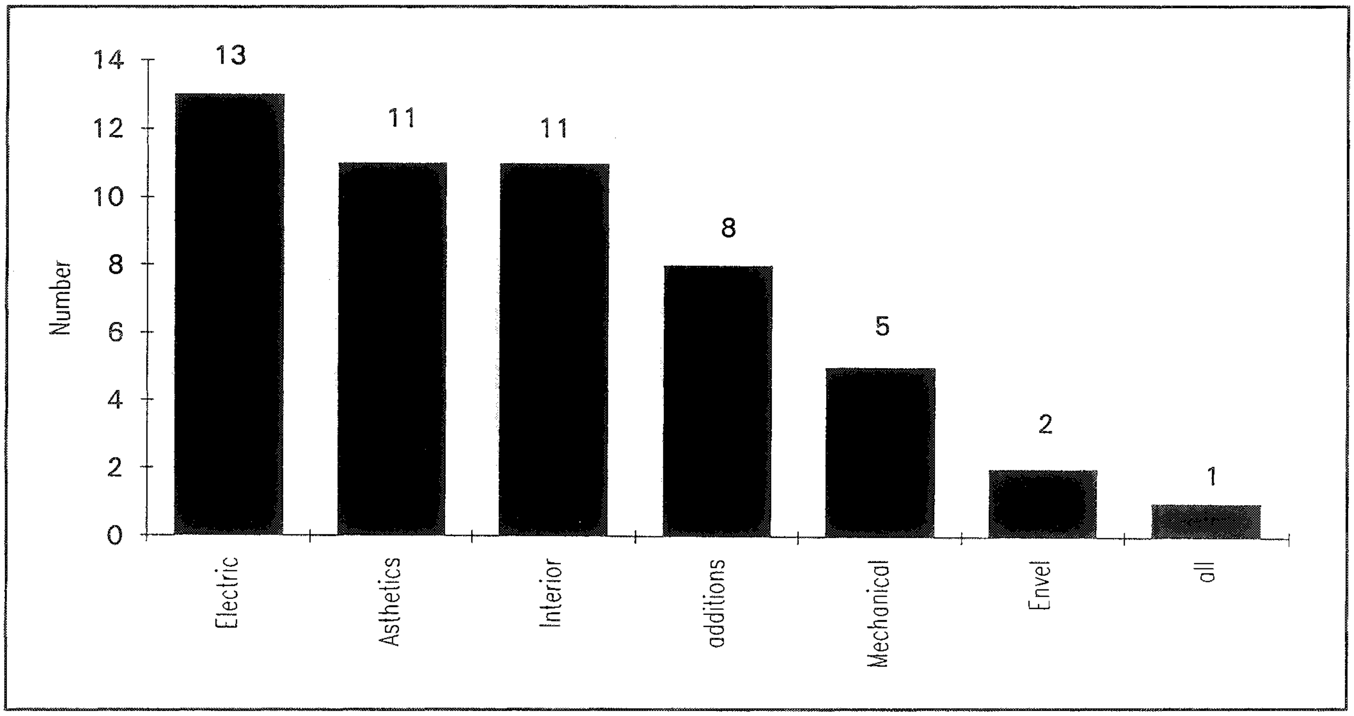

Figure 2. Building Level Changes

Table 1. Measure Removal by Building Remodel/Renovation

	Measure Status			
	Removed		Not Removed	
Remodel Renovation	Change	No Change	Change	No Change
Yes	10	0	10	1
No	6	2	12	5

were total measure changes), are not depicted. Not unexpectedly, there is a linear relationship between renovation and remodel and measure removal.

Of the 38 buildings in Table 2, hotels/motels and health facilities are the most volatile with regard to measure removal. A full 75 percent of hotels and 67 percent of health facilities had at least some of their measures removed. Close to half of the retail buildings (44 percent) show that measures were removed, with 30 percent and 20 percent of office and schools, respectively, having measures removed.

The effect of this measure removal on energy consumption was calculated from the CIPP data base housed at Bonneville. This data base contains information on the

Table 2. ECM Removals and Building Remodels by Building Type in Percent

Building Type	% Buildings With One or More ECMs Removed	Remodels/ Renovations
Hotels (N=4)	75%	100%
Health (N=6)	67	66
Retail (N=9)	44	22
Office (N=14)	29	29
Schools (N=5)	20	60

estimated kWh savings for the number and types of measures installed in the program buildings. Over the life of the measures, the potential savings for the 46 study buildings is estimated to be approximately 3 aMW, or 3,000,000 kWh. The potential savings for the measures that were removed is estimated to be approximately 7 percent of that.

The estimated loss of savings in just two years, then, if the measures are replaced with standard practice rather than energy efficient measures, is approximately 200,000 kWh for the study buildings. Extending this estimate of savings loss to the CIPP program as a whole, the two year estimate amounts to approximately 700,000 kWh.

Measure Specific Removals And Program Effects. While the combined information from the walk-throughs and interviews revealed an overall potential savings loss from measure removal to be approximately 7 percent, actual quantification of building specific measure installations and removals is possible for only 14 of the study buildings. Table 3 below, depicts the types of measures installed and removed and presents the effect of the study findings for these 14 buildings within the larger context of the CIPP program.

Approximately 80 percent of the measures installed under CIPP are lighting related, therefore Table 3 shows that the majority of ECMs removed are lighting related. Very few of the other program measures, such as setback thermostats and others, are quantifiable in terms of measure removal due to loss of records, inconsistent coding on building forms and other problems. For the 14 buildings represented here, 13 buildings had only one type of measure installed, a percentage of which was removed, and only one building had two measure types installed and removed.

The most frequently installed measures are 34 watt lamp replaced with 40 watt lamps and incandescent lamps replaced with fluorescent lamps. These two measures were also the most frequently removed representing 53 percent and 50 percent, respectively, of the total for these measure types installed in 8 buildings. Importantly, while the percentage of measures removed at the building level seems fairly high, the overall sample effect for these measure types is substantially less. The percentage of 40 watts lamps replaced with 34 watt lamps is 21 percent of the sample total. The incandescent lamps replaced with fluorescent lamps represents only 8% of the total installed in the 46 sample buildings.

For the remainder of the 6 measure types shown in Table 3, only one measure type was installed per building. This could render any discussion on the building level removals misleading in terms of the effect on the sample. For instance, 76 high pressure sodium fixtures were installed in one building and then they were all removed within the next two program years. The building removals are 100 percent but the sample level removals for that measure represent only 29 percent. The same holds true for the efficient lamps and the energy management system. Each shows 100 percent removal, but the sample effects are quite different.

The measure type lasting the longest is the one coded "existing fixtures replaced with efficient lamps and ballasts". A total of 207 were installed and only one was removed within two years. The building and sample level effect, then, is only .005 percent removal. Again, reporting measure removals for one measure type and one building only can be misleading in terms of overall program effects. The combination of miscoding, inaccurate recordkeeping for the buildings and the small study sample strongly indicates that the measure removals reported in Table 3 should be regarded as indices of measure removal rates for the two program years rather than absolute findings. Looking at the total number of measures removed in the 14 buildings (N=1,067) this represents 17% of the total number of measures installed in the 46 buildings. A much larger sample, randomized by building type and investigated by building sciences engineers, would have to be studied for the results to be extrapolated to the CIPP program as a whole.

When building personnel were asked to describe the reasons for the various types of measure removals, as might be expected, most gave more than one explanation. Figure 3 presents the percent of potential savings lost over the life of the measures and the explanations for the removals.

The greatest loss of kWh savings, 60% of the total savings lost, was due to vandalism. This is not because a large number of buildings were vandalized but because one building lost a large amount of potential savings (130,000 kWh) due to vandalism. The next most common explanation for measure removal was poor design of the ECM. By poor design building personnel meant that the ECM was too complex for easy operation. Setback thermostats in large buildings or other instruments that require a great deal of knowledge to operate are good examples. One building manager said that a good part of her day is spent resetting setback thermostats building staff attempted to adjust. With the exception of lighting, measure malfunction does not seem to be a big problem for the CIPP sample buildings. One building had all the ECMs removed at the request of the architect who was renovating the building.

Finally, it appears that the perceptions of the individuals who own, operate or are intimately involved in building maintenance do not match actual building practice. For instance, of all the buildings in the sample, 39 percent actually had measures removed, but 80 percent of those interviewed said that all of the ECMs were still in place

Table 3. Measure Removals for 14 CIPP Buildings

No. of Buildings[a]	Measure Description	Total Installed 14 Bldgs.	Total Removed 14 Bldgs.	% Removed 14 Bldgs.	Sample Total (N) 46 Bldgs.	% of Sample Removed
5	40 watt lamps replaced with 34 watt lamps	1624	852	53%	4034	21%
3	Incandescents replaced with Fluorescent Lamps	218	108	50	1440	8
1	Existing fixtures replaced with Efficient Lamp and Ballast	207	1	.005	207	.005
1	Efficient Outside Lighting	148	12	8	191	6
1	Energy Efficient Ballasts	90	13	15	180	7
1	High Pressure Sodium Fixtures	76	76	100	261	29
1	Efficient Lamps	4	4	100	40	10
1	Energy Management System	1	1	100	2	50

(a) Number of buildings does not total to 14 due to one building that had two types of measures installed.

and operating. Almost 60 percent said they had not removed any measures installed under the program.

When measures are removed for the various reasons mentioned above, most need to be replaced. That is, most buildings cannot operate effectively or efficiently without replacing the lights that burn out or the thermostats that are too complex to operate. It may be that, until reminded by the walk-throughs and physical inspections, building personnel forget that measures were removed and that the new technologies installed under the program must be replaced in kind rather than with the technologies in place before the program. Operation and maintenance schedules may have omitted information regarding the new ECMs and their replacement and building personnel turnover could contribute to a loss of information as well.

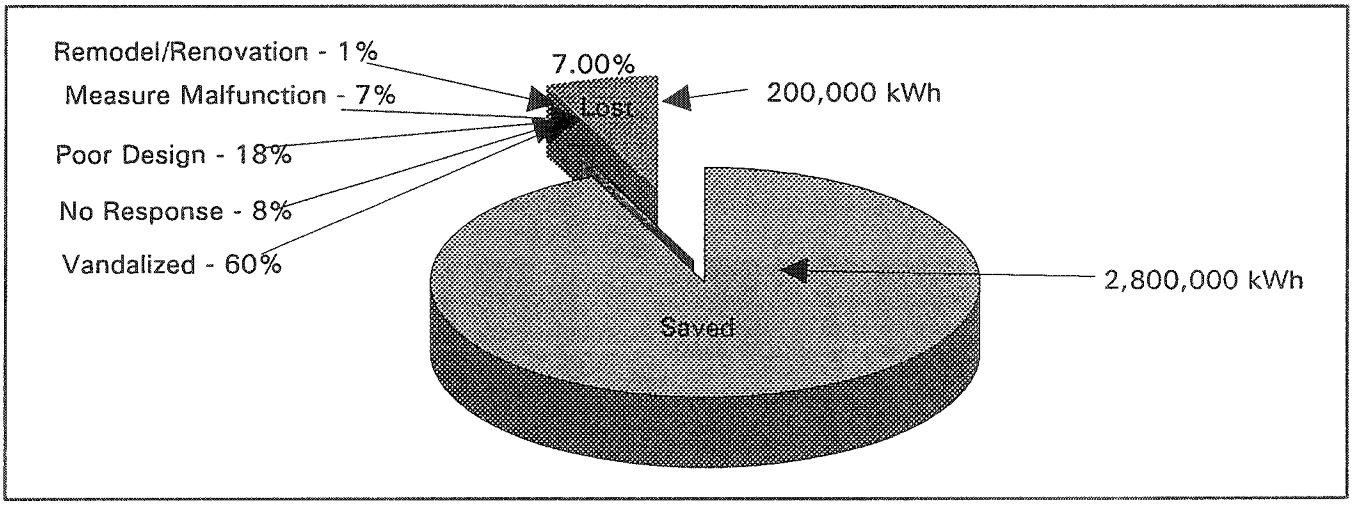

Figure 3. Measure Removal and Percent of Potential Savings Lost for 46 CIPP Buildings

Final Remarks and Recommendations

Almost half of the buildings in the study sample were remodeled or renovated within two years after entering the CIPP program. Forty-seven different types of changes were identified. Changes in the electrical system, interior configurations and building aesthetics were the most common. The building types in the sample most susceptible to these changes are those that experience high customer usage such as hotels and health facilities.

Associated linearly with these building level changes are measure life changes. Measure removal is higher for buildings that have been renovated or remodeled than those that have not been changed. Approximately 50 percent of the remodeled or renovated buildings in the sample had measures removed while buildings that were not remodeled had only one-third of the measures removed.

The loss of savings over two years for 42 of the 46 sample buildings due to measure removal is estimated to be approximately 7 percent. The primary data sources for these buildings consisted of anecdotal as well as actual building and program record inspections. Therefore, four buildings that had measures removed were not quantifiable because the information from these sources was incomplete.

Based on expected savings of 10,000,000 kWh for the CIPP program as a whole, the calculated loss of savings over the two years is 700,000 kWh. If the measure life of expected savings from ECMs continues to decline at this rate, and if the findings from CIPP apply to other commercial programs as well, future energy resources in this sector may not be as high as expected.

The deterioration of savings in the 14 buildings discussed in this paper should be tempered with the fact that 60% of the savings loss was caused by vandalism of outside high pressure sodium lights and fixtures. This loss may be a fluke and not common among the sample or the entire number of program buildings. There may also be a start up problem with some measures and that until institutionalized, may suffer a lack of measure life persistence (e.g., set back thermostats).

Actual quantification of measure specific installations and removals was possible for 14 of the 46 study buildings only. The most frequently installed measures were 40 watt lamps replaced with 34 watt lamps and incandescent lamps replaced with fluorescents. These two measures were installed in 8 of the 14 buildings and were also the most frequently removed. Building level removals seem fairly high with 53 percent and 50 percent, respectively, for each measure type. However, the overall sample effect for these measure types is substantially less with 40 watt lamps replaced with 34 watt lamps representing 21 percent of the sample total and incandescent lamps replaced with fluorescent lamps representing only 8 percent of the total installed in the sample.

Six other measure types were installed in the remaining 6 buildings, one per building. This renders discussion of building level removals misleading in terms of program effects. A high building level measure removal may be a very low program measure removal.

The measure type with the highest retention is the one coded "existing fixture replaced with efficient lamp and ballast." A total of 207 were installed and only one was removed within two years. The building and sample level effect, then, is only .005 percent removal.

These early CIPP studies were the first of their kind in the region and for the commercial sector. The methodology utilized is not as sophisticated as some of the more recent studies, however, it was sufficient for determining that there was a great need for more rigorous future research in the commercial sector. The combination of miscoding, inaccurate recordkeeping and the small study sample of 14 buildings suggests that the quantified results reported here be regarded as indices of measure removal rates for the two program years rather than absolute findings. A much larger sample, randomized by building type and investigated by building sciences engineers, is necessary in order for the results from this type of study to be considered generalizable to the CIPP program as a whole.

Finally, building owners and those intimately involved in building maintenance have perceptions of the disposition of ECMs in their buildings that are different from actual practice. Many were unaware that ECMs had been removed until an actual physical inspection of the buildings brought it to their attention.

What these findings suggest for future research is that site visits by utility auditors be conducted annually or bi-annually and that records of ECM operation and maintenance be updated and reviewed annually. It is vitally important that measure codes be consistent across buildings and programs and that they be recorded accurately. Without these procedures it may be impossible to accurately assess the conservation savings in the commercial sector.

Acknowledgments

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Appendix Details of Survey Questions

Has anything changed in the building which might have a significant impact on energy use?

How much do you feel the ECMs are really saving given the changes mentioned earlier?

Are the measures working as anticipated?

Were there any problems associated with the ECM installation?

Were there any problems associated with program since installation?

Have any of the energy conservation measures installed through CIPP been removed, replaced, disabled, or are any of the measures functioning poorly?

Why do you think the problem occurred?

Have there been any remodels or renovations?

How much of your premise was renovated or remodeled?

How did the remodel or renovation affect the existing facility?

How did the remodel or renovation affect the energy efficiency of the facility?