Persistence of Behavioral Energy Management Activities and Savings in Commercial Office Buildings

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ABSTRACT

Since 2007, the Northwest Energy Efficiency Alliance (NEEA) has offered the Market Partners Program (MPP), which engages the Northwest's commercial real estate firms to adopt strategic energy management (SEM) practices through the Commercial Real Estate (CRE) Initiative. SEM is a holistic organizational consulting process aimed at reducing energy use and encompasses efficient equipment and efficient behavioral activities. Requiring engagement from building staff at all levels, this approach is an ongoing process through which NEEA helps firms develop an action plan that they can implement and revise over several years.

This paper presents the results from a quantitative and qualitative study of the persistence of SEM behaviors and savings at the MPP firms. We quantified annual energy savings by year of participation using a billing analysis. Note that one limitation of this analysis is that it cannot assign savings to individual projects or distinguish between savings generated by new or past projects; therefore, we surveyed MPP staff members to determine which activities remain in place from previous years. After assessing survey responses and reviewing documentation, we attempted to explain the annual savings trends.

We found that the majority of SEM activities (55%) were implemented during the first year of participation, 27% during the second year, 13% during the third year, and 4% during the remaining years. Respondents confirmed that 71% of activities were still in place. Respondents were unsure about 23% of the activities; because all but one of these were capital equipment measures, there is a high probability that these are also still in place. These data did not explain the electricity savings trend, where savings were highest during the first year of participation, decreased during the second year, and then were sustained at just over 3% during the remaining years. Energy savings were calculated at the program level, so there could be many other explanations, such as the possibility firms are implementing SEM at different buildings during different years.

Introduction

NEEA has offered the Commercial Real Estate (CRE) Initiative since 2007, engaging the Northwest's commercial office real estate market to adopt Strategic Energy Management (SEM) practices to reduce energy use in this sector. SEM offers a holistic approach to managing energy that involves efficient equipment and behavioral activities and requires engagement from building staff at all levels. NEEA provides technical advice and training sessions for CRE cohorts to ensure that building managers have the knowledge and tools needed to track and measure energy consumption. For the CRE Initiative, NEEA defines SEM as:

- Adoption of a management-approved energy performance improvement goal at the firm, portfolio, and/or building level;
- Documentation of planned activities to achieve the goal;
- Allocation of resources (staff and training, capital, or both) toward the goal;

- Implementation of planned activities; and
- Regular management review of progress achieved toward energy performance goal and the effectiveness of SEM practices.

NEEA uses a variety of formats to promote the adoption of SEM practices. This research focuses on the Market Partners Program (MPP) cohort, in which NEEA applies an organizational coaching process to encourage leading Northwest real estate firms to make SEM an integral part of doing business. Firms engage with the MPP for up to five years. Each firm owns two or more commercial office buildings; firm executives decide which buildings should implement SEM and work with building operators to implement energy efficiency activities.

The objective of this study was to understand the energy savings rates during each year of a firm's participation and the persistence of the implemented energy management activities. This research is important because energy management programs are a relatively new method for obtaining additional savings from the commercial sector. Most comparable programs are still in the pilot stage, so there is little information about how long savings persist after a firm graduates from the program, particularly savings associated with building operations and maintenance and behavioral measures. Thus, studying savings persistence is important to supporting or revising the measure life assumptions that energy planners and evaluators use to assess the cost-effectiveness of these programs. Because NEEA's MPP is one of the longest-standing SEM programs, we can study persistence of measures during and after program engagement.

MPP Cohort Characteristics

The MPP cohort consists of 11 firms with 55 buildings, accounting for over seven million square feet. Forty-six of these buildings had billing data, accounting for 80% of the total building square footage in the cohort. Table 1 lists the characteristics of each firm.

Table 1. MPP Firm Characteristics

Firm	Year Firm Joined MPP	Participating Buildings in 2013		Number of Buildings with Billing Data	Primary Location
		Number	Square Feet		
1	2011	3	442,440	3	Spokane, WA
2	2009	2	233,073	2	Seattle, WA
3	2012	3	362,504	3	Seattle, WA
4	2011	3	249,566	3	Portland, OR
5	2011	11	764,538	8	Seattle, WA
6	2011	13	911,345	13	Spokane, WA
7	2009	6	561,021	6	Boise, ID
8	2008	3	85,950	3	Boise, ID
9	2007	6	2,707,433	5	Seattle, WA
10	2012	2	113,657	0	Seattle, WA
11	2009	3	885,130	0	Seattle, WA
Total		**55**	**7,316,657**	**46**	**ID/OR/WA**

Methodology

For each firm and year of participation, we used both quantitative and qualitative methods to assess energy savings persistence. We used a regression model to estimate annual energy savings. One limitation of this analysis is that it cannot assign savings to individual projects or distinguish between savings generated by new and past projects so we asked MPP firm executives which activities remain in place from previous years. Through an assessment of survey responses and documentation review, we attempted to explain the annual trends in energy savings. Our analysis steps were to:

1. Estimate energy savings using a billing analysis
2. Meet with the implementation team to inform the sample design
3. Design the sample of SEM activities to confirm which are still in place
4. Survey the MPP firm executives about the sample of SEM activities
5. Analyze measure lists and survey responses to try to explain energy savings results

Billing Analysis

Cadmus estimated an energy savings rate during each year of participation in the MPP after 2010. Ideally, each firm's baseline would have been defined as the full year preceding the firm's introduction into the MPP; however, this could lead to unrepresentative baselines for firms that joined the MPP between 2007 and 2009, during the recession. Instead, we chose the baseline year of 2010 for all such firms, as well as for firms joining in January 2011, and then estimated annual savings for 2011 through 2013. For firms that joined the MPP after January 2011, we used the year proceeding the firm's MPP start date as the baseline.

We specified an energy use intensity fixed-effects model to estimate savings. In a fixed-effect model, each building in each month is taken to have specific characteristics unique to that building, which are estimated separately from the other explanatory variables. In this way, we controlled for any effects from specific characteristics of a particular building (size, occupancy, insulation, etc.).

We used a difference model, where we took the difference of each month in the post-participation period with the corresponding month in the baseline period. Note that in the difference model, the building-month specific effects drop out. The advantage of using a difference model is that it controls for unobservable effects specific to a building and month (e.g., July consumption of building A is large every year for reasons that we cannot observe).

Cadmus estimated the model by Ordinary Least Squares, and the standard errors are Huber-White robust standard errors clustered on buildings. We used this equation:

$$\Delta kWh_{it,t\text{- baseline}} = \beta_1 \Delta HDD_{it,baseline} + \beta_2 \Delta CDD_{it,baseline} + \gamma_1 \Delta Post(1)_{it,baseline} * Y1(1)_{it,baseline} + \gamma_2 \Delta Post(1)_{it,baseline} * Y2(1)_{it,baseline} + \gamma_3 \Delta Post(1)_{it,baseline} * Y3(1)_{it,baseline} + \gamma_4 \Delta Post(1)_{it,baseline} * Y4(1)_{it,baseline} + \Delta \varepsilon_{it,baseline}$$

Here, the post-participation variable interacts with indicator variables for each year of participation, Y1, Y2, Y3, and Y4. In this model, the $\gamma_1, \gamma_2, \gamma_3,$ and γ_4 model estimates are the energy consumption per square foot savings estimates for year 1, year 2, year 3, and year 4 or more, respectively.

The regression model does not include occupancy data because the available occupancy data were for one point in time rather than monthly. The fixed effects model captures variation specific to each building and estimates a fixed (time independent) effect specific to the building. Including occupancy for a single point in time would be redundant, as the fixed-effects coefficient estimate captures the relative difference in occupancy among buildings.

Cadmus used the regression analysis results to calculate an annual energy savings rate for each year of participation. The units of the energy savings rate are the percentage of change in energy use intensity (EUI) per year. The savings rate is the ratio of the energy savings per square foot to the assumed pre-program usage:

$$S_{it}=\frac{U_{it}}{U_{it}+Y_{it}}$$

Where:

S_{it} = The savings rate for a group 'i' in time 't'

U_{it} = The energy savings per square foot for a group 'i' in time 't'

Y_{it} = The energy usage per square foot for a group 'i' in time 't'

Meet with Implementation Team

Cadmus met with the implementation team before designing the draft interview guide to collect information about the buildings in the cohort, determine any reasons to exclude a firm or building from the sample frame, and learn about the SEM activities the implementation team considers successful or unsuccessful and why.

Sample Design

Cadmus then selected a sample of activities, by firm and by year of implementation. Even though the energy savings analysis was limited to years 2011 through 2013, the sample included all activities implemented throughout the duration of participation as far back as 2009. Activities implemented prior to 2011 were included in the sample frame so that we had additional data to assess persistence. Table 2 shows the sample by year of participation and activity type.

Table 2. Sample by Year and Activity Type

Activity Type	Total Implemented Activities	Number of Sampled Activities Per Year of Participation						
		1st	2nd	3rd	4th	5th	6th	Total Sample
Capital	58	7	9	3	1	3	2	25
Operational	86	7	9	5	4	2	0	27
Total	**144**	**14**	**18**	**8**	**5**	**5**	**2**	**52**

Survey MPP Firm Executives

The implementation contractor e-mailed a list of the sampled activities to the firm executives, asking them to confirm that the activities were still in place. The e-mail contained a table with the list of sampled activities, along with additional context such as the building and year the activity was implemented. Firm executives responded with a "yes," "no," or "don't know" for whether each activity

was still in place. For activities that were no longer in place, the respondents were asked to provide any details they could about why the activity was discontinued.

Analyze Data

Cadmus analyzed the measure lists and survey responses for trends that could explain the energy savings results. We examined measure lists for each firm that showed the implemented activities during each year of participation and if those activities were estimated to have minor, significant, or substantial cost savings. [1] We also examined survey responses to determine the percentage of activities that remained in place and if the discontinued activities could have influenced the annual energy savings results.

Results

Energy Savings by Year of Participation

Table 3 shows the average annual electricity savings rates as a percentage of consumption by the number of years in the MPP. Savings are incremental, representing only the savings that occurred during that year of participation (i.e., savings are not cumulative). Results show savings were highest during the first year of participation, decreasing during the second year, and then were sustained at just over 3% during the remaining years of participation. Two firms had a considerable increase in energy consumption during their second year of participation, which may have driven the low savings during the second year.

Table 3. MPP Electricity Savings and Savings Rates by Length of Program Participation

Years in the MPP	Number and Square Feet of Buildings Used in Analysis	Avg. Monthly Savings (kWh per sq. ft.)	90% Confidence Interval		Percentage Savings
			Lower Bound	Upper Bound	
One Year	30 2,594,596	0.063	-0.048	0.17	4.7%
Two Years	30 2,594,596	0.0040	-0.12	0.13	0.29%
Three Years	35 3,026,186	0.047	-0.082	0.18	3.4%
Four or More Years	16 3,248,951	0.080	-0.20	0.36	3.5%

Activities Implemented by Year of Participation

Figure 1 shows the number of activities implemented during each year of participation and by level of cost savings. The MPP documentation provided an estimate of the savings level for some

1 Savings are difficult to quantify for individual measures, so these categories provide an approximation of an activity's impact. Cost savings for individual activities are expected to be less than 5% of total energy costs.

activities as minor, significant, or substantial cost savings.[2] Two commissioning activities were anticipated to have negative minor cost savings (indicating a small increase in energy consumption); one was implemented by a firm during its first year of participation and the second by a different firm during its third year of participation. Many activities were not assigned a cost savings level and are assigned to the "Unknown" category in Figure 1.

Figure 1 shows that the majority of activities (55%) were implemented during the first year of participation, 27% of activities during the second year, 13% during the third year, and 4% during the remaining years. The analysis did not reveal trends to show when firms were more likely to implement the substantial cost saving activities.

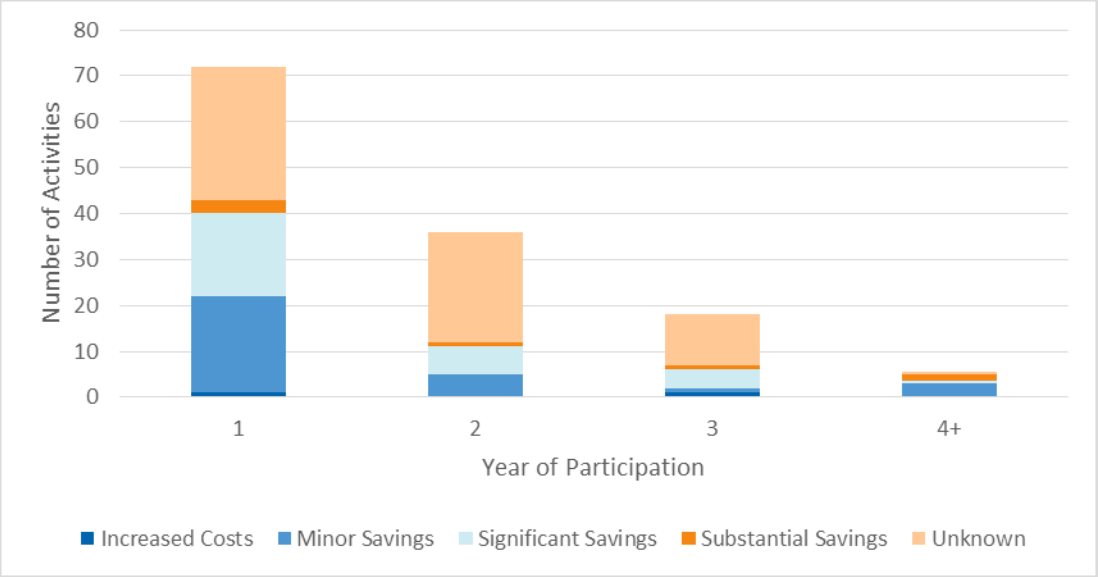

Figure 1. Activities Implemented During Each Year of Participation and by Level of Cost Savings for Program Years 2009 Through 2013

Figure 2 shows the same trend occurs when the analysis is limited to activities implemented during 2011 through 2013 to correspond to the years included in the energy savings analysis.

2 Savings are difficult to quantify for individual measures, so these categories provide an approximation of an activity's impact. Cost savings for individual activities are expected to be less than 5% of total energy costs.

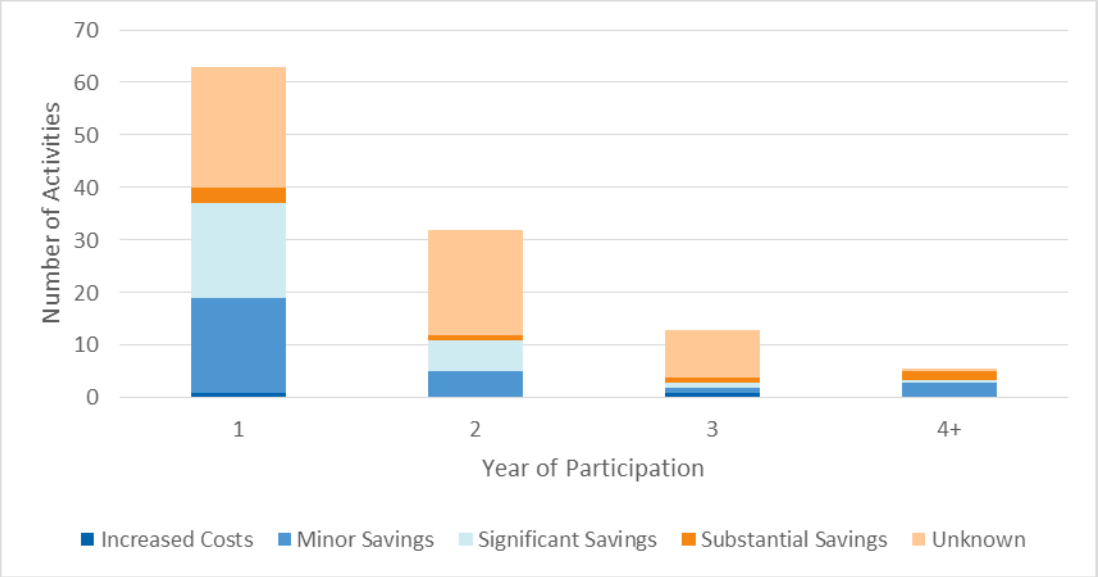

Figure 2. Activities Implemented During Each Year of Participation and by Level of Cost Savings for Program Years 2011 Through 2013

Measure Persistence

Cadmus analyzed the survey responses for the number of activities that were still in place. Table 4 shows that 71% of the activities were confirmed as still in place. Respondents reported that three activities were no longer active and they were unsure about 12 others. The three activities that were no longer active were implemented during years 1 and 2 of participation. Eleven of the 12 activities that respondents were unsure about were capital equipment measures so there is a high probability that they are still in place.

Table 4. Number of Activities Still in Place by Year of Participation that the Activity was Implemented

Year of Participation that Activity Was Implemented	Activity Still in Place?			% of Activities Confirmed
	Yes	No	Don't Know	
1	11	1	2	79%
2	12	2	4	67%
3	6	0	2	75%
4	4	0	1	80%
5	2	0	3	40%
6	2	0	0	100%
Total	**37**	**3**	**12**	**71%**

The team also examined if the level of cost savings had an impact on an activity remaining in place. Results are in Table 5. The savings level does not appear to have an impact on whether an activity was continued, however the cost savings was unknown for 45% of the activities.

Table 5. Number of Activities Still in Place by their Level of Cost Savings

Level of Cost Savings	Activity Still in Place?			% of Activities Confirmed
	Yes	No	Don't Know	
Minor	9	1	2	75%
Significant	9	0	1	90%
Substantial	7	0	3	70%
Unknown	12	2	6	60%
Total	**37**	**3**	**12**	**71%**

Conclusions

Based on the energy savings analysis, measure analysis, and survey responses, Cadmus offers the following conclusions.

- **The electricity savings trend was not explained by the measure analysis or survey responses.** Electricity savings were highest during the first year of participation, decreasing during the second year, and then were sustained at just over 3% during the remaining years of participation. The firms implemented the majority of activities during their first two years of participation, which contradicts the billing analysis result of low energy savings during the second year.
- **The timeline of activity implementation suggests that energy savings should be highest during the first year and then gradually decrease in subsequent years.** The majority of activities (55%) were implemented during the first year of participation, 27% during the second year, 13% during the third year, and 4% during the remaining years.
- **Persistence of implemented SEM activities appears to be high.** Respondents confirmed that 71% of activities were still in place. Respondents were unsure about 23% of the activities; however, all but one of these were capital equipment measures so there is a high probability these are also still in place.
- **Identifying which factors influence energy savings is difficult because there are too many variables.** The MPP targets firms that own and manage several buildings. Energy savings were calculated at the program level so there could be many other explanations for the energy savings trend. For example, it is possible firms are implementing SEM at different buildings during different years. Additionally, we did not include a control group in the billing analysis so other market effects could be influencing the energy savings results.

Recommendations for Future Research

Cadmus recommends that future analyses include billing data from a control group in the regression analysis. These data could explain changes in energy consumption that currently available data cannot explain and may allow for an in-depth analysis of savings trends.