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2013 Energy Savings Results for the Commercial Real Estate Cohorts

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MEMORANDUM

To: Rita Siong, NEEA

From: Heidi Ochsner, Alden Jones, and Jim Stewart, Cadmus

Subject: 2013 Energy Savings Results for the Commercial Real Estate Cohorts

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NEEA's Commercial Real Estate (CRE) Initiative, offered since 2007, engages the Northwest's commercial office real estate market to reduce energy use by adopting Strategic Energy Management (SEM) practices. SEM is a holistic approach that includes both efficient equipment and behavioral activities and requires engagement from organizational staff at all levels. NEEA provides technical advice and trainings to CRE cohorts to ensure that firm and building managers have the knowledge and tools to track and measure energy consumption and implement energy efficiency opportunities.

The CRE Initiative consists of two cohorts. These are:

1. Market Partners Program (MPP), which employs an organizational coaching process to integrate SEM into a property management firm's business practices. Firms typically participate for two years and receive support from NEEA in advancing energy management changes at the organizational and building levels. The firm's executive managers disseminate the information about energy efficiency to their building managers and tenants.
2. Commercial Office Efficiency Competitions (Office Competitions), which engage companies at the building level to adopt principles of SEM and energy management best practices. Buildings participate for one year. In 2013, NEEA held Kilowatt Crackdown competitions in Portland (OR) and Boise (ID).

This memo presents Cadmus' methodology and estimated electric and gas savings for buildings participating in MPP and Office Competitions during 2013.

Methodology

The methodology for determining electric and gas savings consisted of first preparing the data for analysis, then conducting a regression analysis of energy use intensity to estimate energy savings per square foot of floor space. Finally, Cadmus used the regression savings estimates to calculate the savings for 2013.

Data Preparation

NEEA provided Cadmus with billing data for 50 MPP buildings and 118 Office Competition buildings. Ten buildings were in both programs, and Cadmus included them in the MPP energy savings analysis. The regression analysis included billing data from January 2012 through September 2013. Due to the timing of the analysis, billing data for October through December 2013 were not yet available.

In preparing the data, Cadmus first assessed the amount of data available during 2012 and 2013 for each electric and gas meter for each building. The team identified missing data for some months in 2012 and 2013, and worked with NEEA and its implementer to obtain the missing billing data where possible.

Cadmus reviewed the billing meter types to determine which meters to include in the analysis. Some buildings had photovoltaic (PV) systems metered separately that were not installed as part of the building's participation in NEEA's program, so Cadmus calculated the total building electricity use by adding the electricity produced by the PV system to the electric billing data. Some buildings separately metered energy consumed for hot water or geothermal heating systems. Cadmus converted these data to therms, then added this to the gas billing data to calculate total gas consumption and capture any energy savings from these systems.

Next, Cadmus reviewed each building's energy consumption data for outliers or other suspect readings. The team then adjusted the billing periods to calendar months to be the same across buildings and for different meters of the same building.

Cadmus downloaded weather data corresponding to the location of each building. The team calculated base 65 heating degree days (HDDs) and cooling degree days (CDDs) for each calendar month, then merged the weather data with the electric and gas consumption data.

Regression Analysis

Cadmus specified the following electricity intensity fixed-effects model to estimate MPP and Office Competition savings:

$$kWh_{it} = \beta_1 HDD_{it} + \beta_2 CDD_{it} + \gamma Post(1)_{it} + \mu_{im} + \varepsilon_{it}$$

where:

kWh_{it}	=	Electricity use per square foot of floor space in building i in month t
HDD_{it}	=	Heating degree days for building i in month t
CDD_{it}	=	Cooling degree days for building i in month t
γ	=	Electricity savings per square foot of floor space per month
$Post(1)_{it}$	=	An indicator for building i that month t is in the program period
μ_{im}	=	Building month fixed effect, where m=1, 2, …, 11,12. This is the energy use for building i specific to a particular month after controlling for HDDs and CDDs. These unobservable effects are analogous to building fixed-effects, except they are specific to a building and month instead of just to a building.
ε_{it}	=	Random error term for building i in month t.

To estimate this model, Cadmus formed a 12-month difference by subtracting kilowatt-hours per square foot from a month in 2012 from the kilowatt-hours per square foot in that same month in 2013.[1]

The current energy use intensity is:

$$kWh_{it} = \beta_1 HDD_{it} + \beta_2 CDD_{it} + \gamma Post(1)_{it} + \mu_{im} + \varepsilon_{it}$$

The energy use intensity 12 months ago is:

$$kWh_{i(t-12)} = \beta_1 HDD_{i(t-12)} + \beta_2 CDD_{i(t-12)} + \gamma Post(1)_{i(t-12)} + \mu_{im} + \varepsilon_{i(t-12)}$$

The difference between the current energy use and that from 12 months ago is:

$$kWh_{it} - kWh_{i(t-12)} = (\beta_1 HDD_{it} + \beta_2 CDD_{it} + \gamma Post(1)_{it} + \mu_{im} + \varepsilon_{it}) - (\beta_1 HDD_{i(t-12)} + \beta_2 CDD_{i(t-12)} + \gamma Post(1)_{i(t-12)} + \mu_{im} + \varepsilon_{i(t-12)})$$

Expressing the differences using deltas (Δ) results in the following equation:

$$\Delta kWh_{it,t-12} = \beta_1 \Delta HDD_{it,t-12} + \beta_2 \Delta CDD_{it,t-12} + \gamma \Delta Post(1)_{it,\ t-12} + \Delta \varepsilon_{it,\ t-12}$$

Note that in the difference model, the building-month specific effects drop out. If the analysis sample is limited to 2012 and 2013, the $\Delta Post(1)_{it,\ t-12} = 1$ for all periods in 2013 and becomes the model intercept. The coefficient γ is the average savings per square foot per month.

Cadmus estimated the model by Ordinary Least Squares (OLS), and the standard errors are Huber-White robust standard errors clustered on buildings.

Note that the R^2 in this model is not comparable to the R^2 in the models used to calculate savings in previous program years, because the models have different dependent variables.[2] The dependent variable in previous evaluations is monthly energy use, while the dependent variable in the Cadmus difference models is the *change* in monthly energy use. The previous evaluation's model includes building fixed effects to control for differences between buildings in average energy use. The Cadmus approach uses differencing to remove (i.e., to control for) the variation in energy use between buildings and between months. Because this between-building and month variation in energy use was removed before estimating the difference model, the model cannot explain the variation, and the R^2 is relatively small.

The advantage of estimating 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). The approach used in previous evaluations controls for building-specific effects (building B has a small average monthly consumption) separately from month-specific effects (all buildings tend to use

[1] Any month in 2012 that did not have a matching month in 2013, or vice versa, was excluded from the model.

[2] The energy savings results and methodologies used for previous CRE cohort evaluations can be found at NEEA's website: http://neea.org/docs/default-source/reports/commercial-real-estate-initiative-2012-impact-analysis.pdf?sfvrsn=10

more energy in December), but does not control for monthly effects specific to buildings. The difference model should result in a more precise estimate of savings than a levels model with reduced bias.[3]

The regression model does not include occupancy data because the occupancy data are 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 between buildings. Data on occupancy that varied over time would be useful in the model if NEEA is able to collect that data in the future.

The model produces an estimate of average monthly energy savings per square foot using January through September data. The team calculated the annual energy savings per square foot by multiplying the average monthly savings by 12 months. The team then calculated the total 2013 savings for the buildings included in the analysis by multiplying by the total square feet corresponding to those buildings.

Energy Savings Results

The energy savings results for the Office Competition and MPP cohorts are summarized below.

Electricity Savings Results

Cadmus included 91 of the original 118 buildings in the Office Competition analysis and 47 of the original 50 buildings in the MPP analysis. The Office Competition buildings saved an average 0.023 kWh per square foot per month, resulting in a savings of 0.472 aMW during 2013. This was equivalent to 1.84% of building consumption. The MPP buildings saved an average 0.050 kWh per square foot per month, resulting in a savings of 0.420 aMW during 2013. This was equivalent to 3.79% of building consumption. Both results were significant at the 90% level.

[3] Bias in the estimate of γ would arise in the levels (but not difference) model if $Post(1)_{it}$ and μ_{im} were correlated. The unavailability of energy use data for a building during certain months of the program period could generate such correlation and thus bias. For example, if energy use during months with the highest consumption was missing, the missing data would confound the savings estimate (the low average consumption during the program would reflect the unavailability of data for certain months and not savings) and result in an estimate of γ that was biased downward (reflecting higher estimated savings than the true savings).

Table 1. Electric Savings in 2013

Cohort	Number and Square Feet of Buildings	Avg Monthly Savings (kWh per square foot)	Total Savings (aMW)*	90% Confidence Interval Bounds (aMW)		Percent Savings
				Lower	Upper	
Office Competition	91 14,991,580	0.023	0.472	0.024	0.921	1.84%
Market Partners Program	47 6,182,073	0.050	0.420	0.018	0.821	3.79%

*The total reported savings are *incremental* to 2013 (energy savings that may have occurred in previous years are not included) and *annualized* (the average monthly savings were estimated using up to 9 months of data from 2013 in the model, and were then multiplied by 12 months to calculate an annual savings value).

Both cohorts show lower savings in 2013 than in 2012. The Office Competition result in 2012 was 5.9% savings compared to 1.8% in 2013, and the MPP result in 2012 was 5.2% savings compared to 3.8% in 2013. The difference in the results for both programs is most likely due to the absence of 2013 data for October, November, and December. The results for both programs may change when these data are included in the model. These months have high energy use for heating and therefore have high savings potential for buildings with electric heating that implemented HVAC measures or actions.

Additionally, the Office Competition implementation was more complex in 2013 and cohort buildings did not implement energy efficiency projects until later in the year, and so there may not have been enough months of data to capture energy savings from these projects. NEEA's documentation shows that despite the late start, the cohort buildings plan to implement more energy saving activities as a result of the 2013 program than in previous years; however, as shown in Figure 1 and Figure 2, the majority of these activities did not begin until late 2013 or are planned for 2014. As previously noted, at the time of the analysis, the team did not have billing data for the fourth quarter of 2013, therefore results do not capture savings from activities conducted in late 2013 or in 2014.

Figure 1. Percentage of Activities Implemented Over Time for Portland Buildings

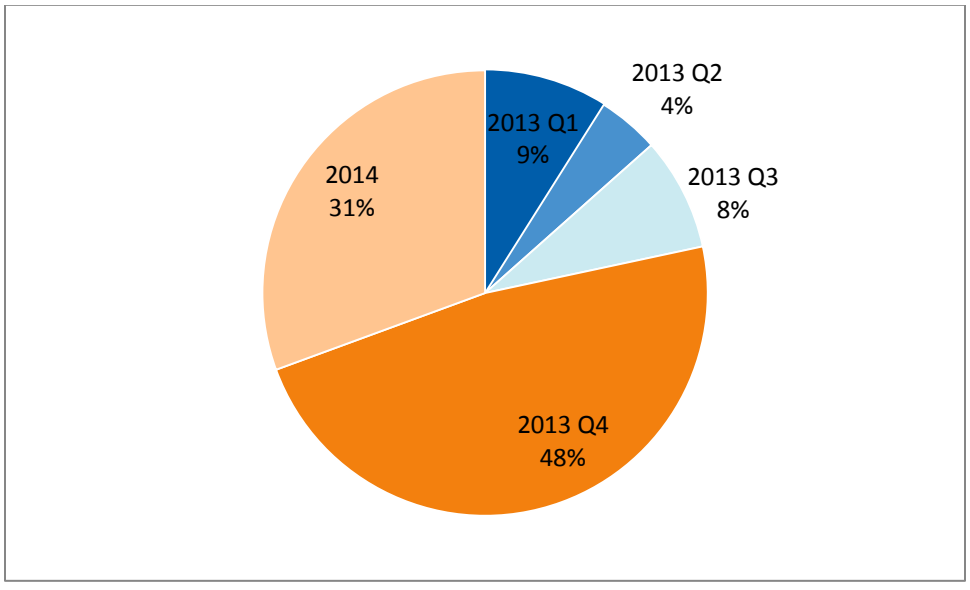
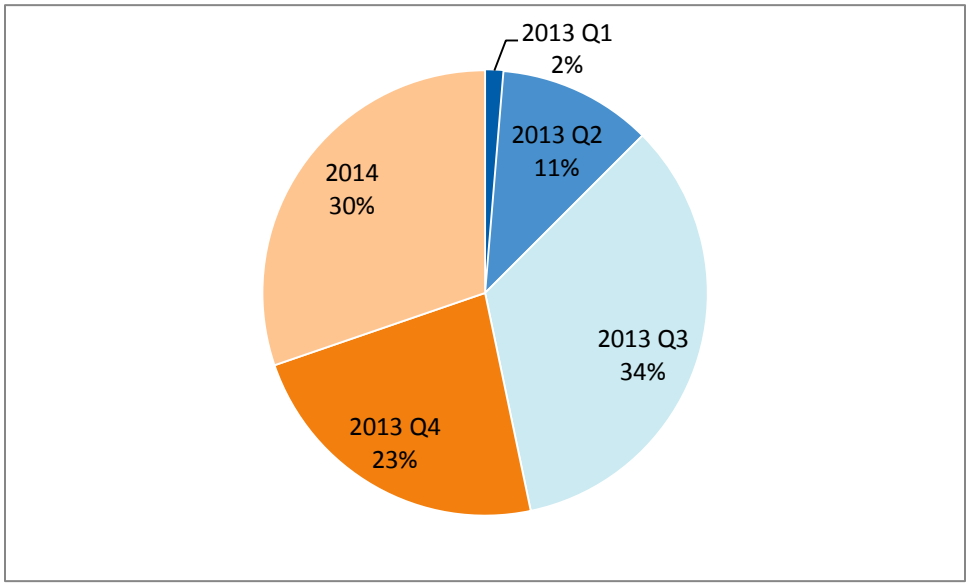


Figure 2. Percentage of Activities Implemented Over Time for Boise Buildings



Cadmus also analyzed electricity savings separately for Office Competition buildings in Boise and Portland/Vancouver. Table 2 shows the electric savings for the two cities. The savings for Portland buildings are positive (0.56 aMW) and statistically significant. The savings for Boise buildings are not statistically significant.

Table 2. Office Competition Electricity Savings by City

City	Number of Buildings	Avg Monthly Savings (kWh per sq. ft.)	Total sq. ft.	Total Savings (aMW)*	90% CI Lower Bound	90% CI Upper Bound	Percent Savings
Portland	64	0.0322	12,786,087	0.56	0.10	1.03	2.5%
Boise	27	-0.0044	2,205,493	-0.01	-0.12	0.09	N/A

*The total reported savings are *incremental* to 2013 (energy savings that may have occurred in previous years are not included) and *annualized* (the average monthly savings were estimated using up to 9 months of data from 2013 in the model, and were then multiplied by 12 months to calculate an annual savings value).

There are a few possible explanations for the Boise result. Cadmus first looked at the measure lists for Portland and Boise to see if Portland buildings had implemented more activities overall and if these activities were implemented earlier in 2013 than compared to the Boise buildings. Figure 1 and Figure 2 above summarize the implementation timing of measures for Portland and Boise, and do not reveal any large differences. The team also looked at whether Portland buildings implemented a higher percentage of capital measures than operational measures than Boise buildings in January through September, which would lead to immediate savings, but again did not find a large difference.

The next possible explanation is that the model could not detect energy savings due to the hotter summer in 2013 than in 2012. Though the model accounts for weather, the CDDs during baseline (2012) summer months are lower than the CDDs during 2013 summer months, and so the estimated coefficients for CDD and for the participation period may be confounded. It is possible the coefficient for

CDD does not fully capture the increase in energy consumption due to increased cooling. This could make it appear that energy use increased in 2013 due to the program activities rather than due to weather.

The other possible explanation is that the Boise buildings had changes in occupancy during 2013 that resulted in an increase in energy consumption. This would happen when building occupancy increases or when a company with a higher energy intensity replaces a company with a lower energy intensity. The Cadmus team is working with NEEA to investigate occupancy changes in Boise and Portland/Vancouver buildings to see what impact that may have had on the results.

Gas Savings Results

Table 3 shows the total gas savings and the average monthly savings per square foot for the MPP and Office Competition cohorts in 2013. The MPP analysis included 65 buildings and the Office Competition analysis included 27 buildings. Both cohorts showed an average monthly therm savings of 0.001 per square foot. For Office Competition, this resulted in 140,990 therms saved in 2013, or 7.53% of consumption. For MPP, this resulted in 44,334 therms saved in 2013, or 7.95% of consumption. The results are not significant at the 90% confidence level, but are significant at the 80% confidence level.

The estimate of annual gas savings may be biased downward because gas use for October, November, and December 2013 was unavailable at the time of the analysis. The missing months have high gas usage for heating and high potential for savings.

Table 3. Gas Savings in 2013

Cohort	Number and Square Feet of Buildings	Avg Monthly Savings (therms per sq. ft.)	Total Savings (therms)*	90% Confidence Interval Bounds		Percent Savings
				Lower	Upper	
Office Competition	65 11,021,742	0.001	140,990	-29,147	311,127	7.53%
Market Partner Program	27 3,625,579	0.001	44,334	-9,478	98,145	7.95%

*The total reported savings are *incremental* to 2013 (energy savings that may have occurred in previous years are not included) and *annualized* (the average monthly savings were estimated using up to 9 months of data from 2013 in the model, and were then multiplied by 12 months to calculate an annual savings value).

Cadmus also analyzed gas savings separately for office competition buildings in Boise and Portland. The savings were not statistically significant.

Recommendations

The reliability of the savings estimates may be improved if billing data can be obtained for a valid control group.[4] A control group would account for naturally occurring efficiency in cohort buildings that this analysis of cohorts cannot capture. Additionally, Cadmus recommends updating the analysis with the

[4] An estimate is internally valid if the estimator used is expected to yield an unbiased estimate of the savings.

October, November, and December data once it is available. The estimate of annual energy savings may be biased downward because electricity and gas consumption for October, November, and December 2013 was unavailable at the time of the analysis. The missing months have high usage for heating and potential for savings at buildings which implemented heating system upgrades.

Next Steps

The timeframe and results of this memo support NEEA's annual reporting deadline. Cadmus will complete several additional tasks to refine the analysis and further investigate the impact of the CRE Initiatives.

- The team will incorporate billing data from October through December 2013 and re-estimate the annual savings.
- The team is working with NEEA to construct and obtain billing data from a control group of non-participating commercial buildings. Once Cadmus receives these data, the team will update the energy savings analysis to include the control group.
- The team will conduct a survey to assess the level of SEM adoption at the MPP firms and the Office Competition buildings. For the Office Competition buildings, Cadmus will use this information to estimate the average savings at each level of SEM adoption. For the MPP, the team will refine the analysis to estimate average savings per building within each participating firm.
- The team will calculate a savings rate for each year of participation in the MPP.