Dude, Where's my Savings: An Investigation of Project Performance

Eva Urbatsch, Aerotek for Bonneville Power Administration
Erik Boyer, Bonneville Power Administration

ABSTRACT

Data about 128 projects in the Pacific Northwest intended to save energy in schools was collected from available documentation. Some were self-performed, but the majority used Energy Savings Performance Contracting (ESPC), with contractual guarantees to save energy. Some projects performed very well and the actual savings surpassed the guarantee. However, the majority of projects were found to have actual energy savings less to substantially less than the estimate. Many projects had no energy savings. Why?

To better understand the root causes of this divergence, several factors were considered. Factors analyzed include:

1. Contractual Measurement & Verification (M&V) strategy
2. Measure Type: e.g. HVAC equipment upgrade, shell measures (insulation & windows), controls.
3. Savings estimate methodology: e.g. rule of thumb, bin, physics models

The issues identified in this analysis can be used by program administrators and prospective facilities planning on implementing ESPC projects to better screen, plan, estimate, and verify savings for performance based projects.

Introduction

An ESPC is a contract vehicle allowing a facility to procure energy savings and facility improvements by using monies that would have been spent paying for utility bills, without upfront capital costs. While created for federal agencies in the Energy Policy Act of 1992, this mechanism has also been used by state and local governments for schools and public buildings. Under terms of this type of agreement, the energy services company (ESCO) guarantees that the improvements will generate sufficient energy cost savings to pay for the project over the term of the contract (typically 10-25 years).[1]

Obviously, determining savings of these projects is crucial to ensuring their financial viability. The International Performance Measurement and Verification Protocol (IPMVP) (Energy Valuation Organization, 2012) provides rigorous guidelines to address measurement and verification (M&V) standards, but these guidelines have proven to be haphazardly applied in the real world. Guidance for M&V of federal ESPCs comes from the Federal Energy Management Program (FEMP), but this is merely guidance, not a formal protocol. Generally, M&V is performed by the ESCO and not a third party. (Third party review, if it exists, typically consists of reviewing ESCO calculations, not considering whether the methodology was appropriate or collecting independent data.)

[1] All ESPC contracts are performed by ESCOs. A Utility Energy Service Contract (UESC) is a similar contractual arrangement with a utility performing work. Due to the nature of this sample, no UESC projects are included.

The Bonneville Power Administration (BPA), like many utilities, is focusing efforts on energy efficiency as the lowest cost resource for meeting load growth. As such, BPA provides incentives for projects that have verifiable energy savings. Many schools in BPA's Pacific Northwest service territory have installed energy upgrades, either through an ESPC or through a local contractor. From 2011 to 2015 BPA approved over 130 school (K-12) energy efficiency custom projects.[2] Over this time period, with the introduction of the BPA M&V Protocols (BPA 2012b), the measurement and verification philosophy for incentivizing commercial energy efficiency projects shifted to emphasize a whole building approach, similar to IPMVP Option C. This strategy was adopted in order to:

- Develop consistency in savings reporting across different ESCOs and customer utilities.
- Capture interactive effects of energy conservation measures
- Capture the energy usage and savings over the full range of independent variables
- Capture the persistence of energy savings over the first year of project performance

Under this approach, BPA engineers performed M&V unrelated to the contract mechanism in many cases. Because the shift was gradual, this yielded a large dataset of projects to examine. For this paper, submitted project documentation was reviewed to determine – as far as was available – what types of measures were implemented, how project savings were estimated, what baseline was used for the estimate (as compared to the facility baseline at project installation), M&V used for incentives, verified savings, project cost estimates, and project savings. It should be noted that analysis was necessarily limited to the data available; not all projects had all data available.

A Look at ESPC Projects

Out of the 128 projects in this analysis set, 99 were developed and implemented via an ESPC. Because of the guarantee included in the contract, it is often stated that ESCO projects report energy savings surpassing the estimate. In other words, their realization rate (RR), calculated by dividing verified savings by estimated savings, is over 100%. For example, a 2014 study of federal ESPC projects showed a self-reported RR of 102% for ESPC projects compared with a 67% RR for their non-ESPC counterparts (Coleman, Earni, and Williams 2014).

The overall verified energy performance distribution of ESCO projects compared to their estimated energy performance is shown in Figure 1, below.

[2] The initial data review identified 135 projects incentivized during this time period. However, several identified projects were missing too much information to be included in this analysis, reducing the set to 128 projects. Even among this reduced set, all information was not available for all projects.

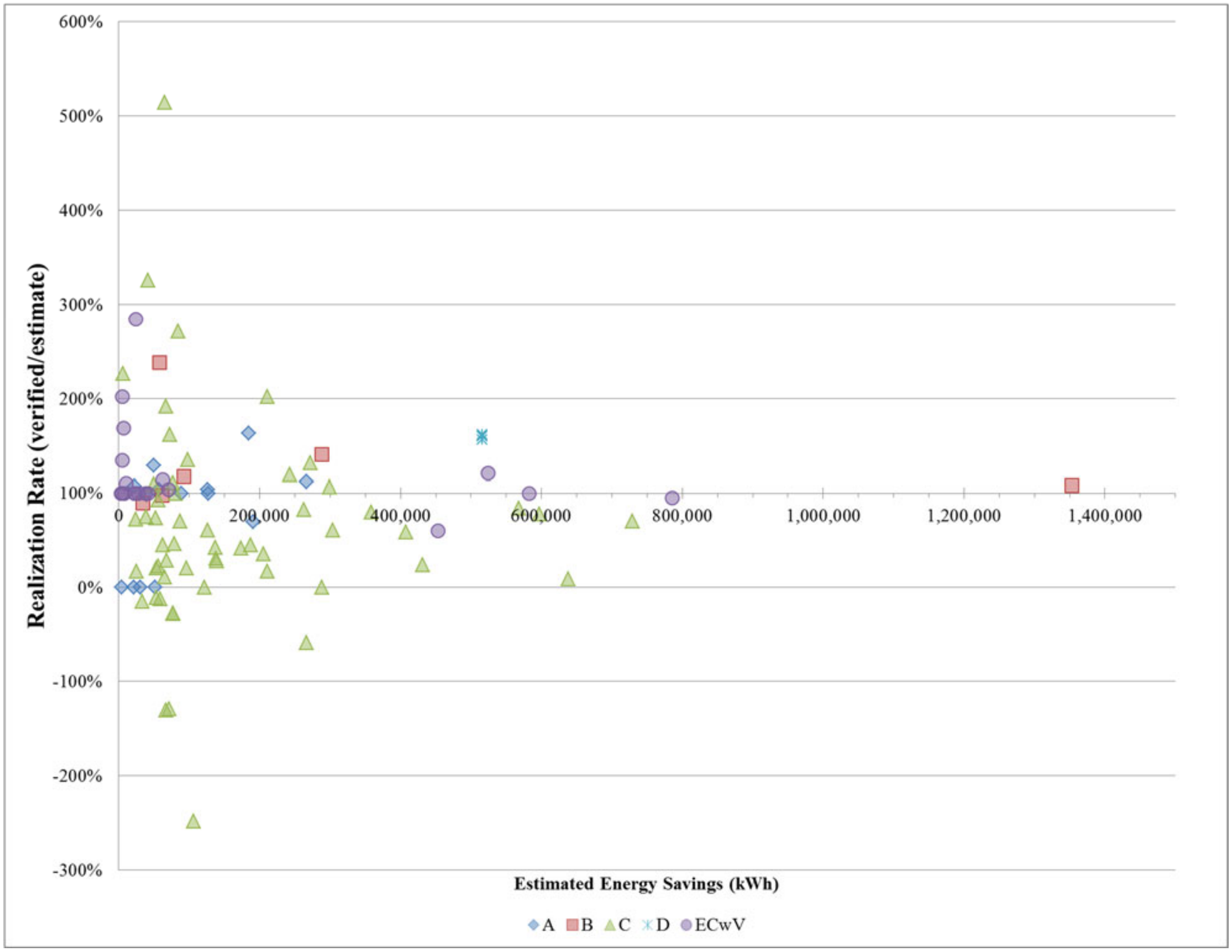

Figure 1: Project Performance

As shown, the verified performance of these projects is all over the map. Out of these 99 projects, 58 projects (59%) had a RR of less than 100%. 49 of the 99 projects (49%) had a RR significantly less (< 90%).

In an attempt to start to understand the verified performance variance, an investigation of M&V methods and project type was conducted. First, projects were broken down by M&V type. Of the 99 ESCO projects, the M&V methods implemented were broken down into the 5 following methods: IPMVP Option A=14, B=6, C=56, D=4, and IPMVP non-compliant ECwV, which are based on engineering calculations (no metering involved, also known as "stipulated savings") =19.[3]

IPMVP Options A and B are also known as retrofit isolation methods. Option A uses a single Key Parameter, and assumes other variables do not change. For example, in a parking garage lighting project where hours of operation are constant and can be reliably estimated based on schedule, the key performance parameter that would be metered is power draw. Option B meters "All Parameters". For example, in a fan variable frequency drive (VFD) the key performance parameters to be monitored are both power draw and operating schedule. Options C

[3] Combining A & stipulated leads to A – 33%, B – 6%, C – 56%, D – 4%. This is very different distribution from the project breakdown in Coleman 2014: A – 70%, B – 20%, C – 7%, and D – 3%

and D can be referred to as whole building methods. Option C is focused on measured building performance using utility grade meters, and is a good fit for an interactive, multiple measure project. Option D uses calibrated computer simulations, and could be used for a new construction project with multiple interactive measures, where there is no baseline energy consumption. (More detailed explanations are available from EVO and BPA.)

The M&V methods employed vary greatly in terms of performance testing length and detail. Figure 2, below, briefly summarizes some of these differences and includes some of the advantages and weaknesses associated with each method.

Table 1: Measurement and Verification Strategy Overview

M&V Strategy	Implementation Description	Advantages	Disadvantages
A	Short Term (typically < 2 weeks) Metering of Key Parameter	Low cost. Ease of implementation. Quick reporting/incentive payment	Measured performance is not over full range of independent variables. Long term performance persistence is unknown. High performance uncertainty.
B	Short Term (typically < 4 weeks) Metering of All Parameters	Low cost. Ease of implementation. Quick reporting/incentive payment	Measured performance is not over full range of independent variables. Long term performance persistence is unknown. High performance uncertainty.
C	Long Term (typically 9-12 months) of Utility Data	Low cost. Measured performance over full range of independent variables. Long term performance is monitored. High confidence in savings.	Lengthy reporting period/incentive payment. Savings by measure/ disaggregation unknown.
D	Long Term (12 months) Calibrated Simulation	Measured performance over full range of independent variables. Long term performance is monitored.	High cost/high complexity. Lengthy reporting period/incentive payment.
ECwV	No metering. Inspection and engineering calculations	Lowest cost. Ease of implementation. Quick reporting/incentive payment	No actual measurements. High uncertainty. Not IPMVP-adherent.

Interesting results emerge when comparing the verified savings compared to the estimated energy savings by M&V method (as shown in the figure below). The average realization rate is near or over one (i.e., the level at which the verified savings equal the estimated savings), except in those projects which utilized IPMVP Option C which show an average realization rate of 58%.

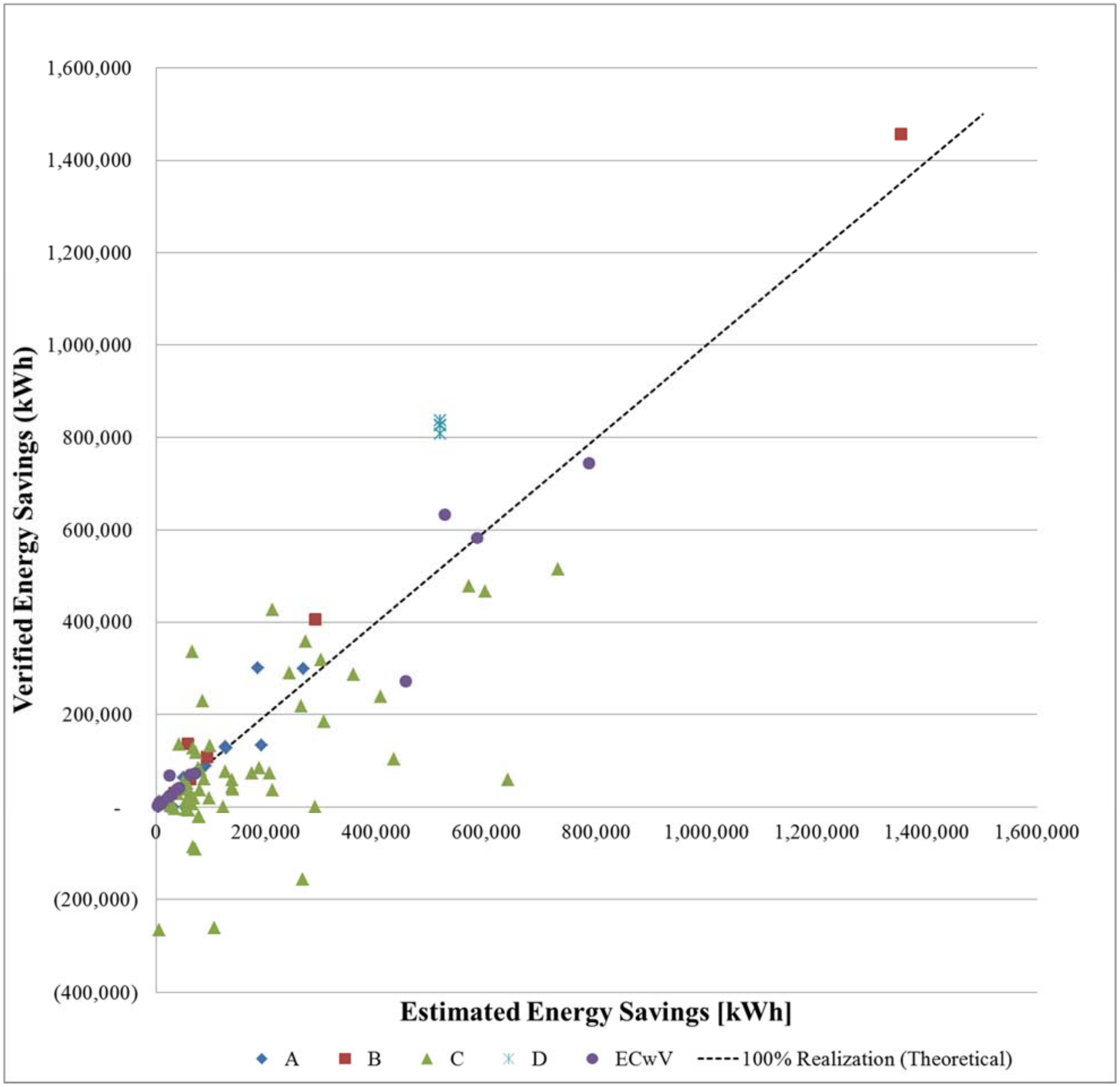

Figure 2: Project Performance

This information is displayed numerically in the table below. This shows some of the variations in projects that got each methodology – the projects that used Option A or ECwV were, on average, smaller than those verified using B or C. This is in line with the concept of balancing expected savings with M&V rigor and cost (see, for example, FEMP 5-2), i.e., expected smaller savings require less rigorous M&V. This also shows that on average, the projects verified with IPMVP Option C had significantly lower realization rates– 56% – than other M&V strategies.

Table 2: Realization Rates by M&V Strategy

M&V Option	Total # Projects	Avg Project Est Savings [kWh]	Total Est Savings [kWh]	Total Verified Savings [kWh]	Overall Avg RR
A	14	90,024	1,260,335	1,266,041	100%
B	6	314,508	1,887,050	2,199,559	117%
C	56	165,510	9,268,566	5,150,272	56%
D	4	516,404	2,065,616	3,298,015	160%
ECwV	19	142,124	2,700,363	2,655,006	98%
Total	99	1,228,571	17,181,930	14,568,894	85%

This large variance between projects utilizing IPMVP Options A, B and ECwV compared with Option C could have many potential causes.

One difference in project M&V selection and performance is in regards to M&V practitioner. Nearly all of the M&V using Options A, B, or ECwV was performed by the ESCO. All of the projects that had Options C or D M&V were performed by BPA engineers with a review from the ESCO.

Projects using Options A and B included short-term metering, typically 2 weeks (or less) for Option A and 4 weeks or less for Option B. These projects usually metered equipment amperage or equipment runtime and extrapolated annual energy performance. While most of these projects claimed to follow IPMVP protocols, many appear to not fully meet the current IPMVP requirements for these methodologies.

The primary driver of energy in these projects is weather, which can vary wildly over the course of a year. Extrapolating annual performance based on a short snapshot of operation may not be a sound practice, particularly for systems that operate seasonally such as air conditioning. In addition, these short measurement periods may not accurately capture measure persistence. This is particularly troublesome for HVAC controls projects, where energy savings can easily be reduced by building occupants or operators changing settings and setpoints.

Over half of the ESCO projects (57%) in this sample used Option C style M&V, performed by BPA engineers per BPA's M&V Protocols and ASHRAE Guideline 14. These projects used at least 12 months of utility billing data for baseline development and generally used 9-12 months of utility billing data for post-project analysis . In some cases, post-project data was reduced from the one year recommended by IPMVP, in line with industry best practices (see, for example, Urbatsch and Boyer 2014). This strategy inherently accounts for energy conservation measure (ECM) interactivity, captures the wide range of independent variables, and also captures the issue of persistence of energy savings.[4] This results in more confidence in overall project performance. One drawback of this method is that individual measure performance in a multi-measure project is not captured. Because this methodology has not historically been common, it is explored in further detail in the next section.

In an attempt to understand the effects of project type, the 99 ESCO projects are broken down into 4 categories: 1) Controls (Conservation) Only Projects- which are projects that save energy based on operational system improvements, e.g., installing DDC or VFD equipment to reduce runtime or load reduction (i.e. HVAC DDC, fan VFD, Retro-Commissioning, etc.); 2) Energy Efficiency (EE) Only Projects-which are projects which were replacing vintage

[4] At least persistence for the first year. Long term measure persistence is not addressed with one year of post data.

equipment with more efficient equipment (i.e. GSHP, Insulation, LED lighting, etc.); 3) Mixed Projects-which are a combination of controls and EE Projects; 4) New Construction.

The distribution of projects, average savings, and realization rate information is shown in the table below.

Table 3: Realization rate of projects by ECM type

Project Type	# of Projects	Avg Project Est Savings [kWh]	Overall Avg Realization Rate (Verified/Estimated)	RR Range
Controls	60	139,416	88%	-250% to 284%
EE	10	39,784	97%	74% to 107%
Mixed	25	254,141	55%	-129% to 326%
NC	4	516,404	160%	157% to 162%
Total	99	175,662	85%	

These results are further broken down by M&V method in Figure 3, below.

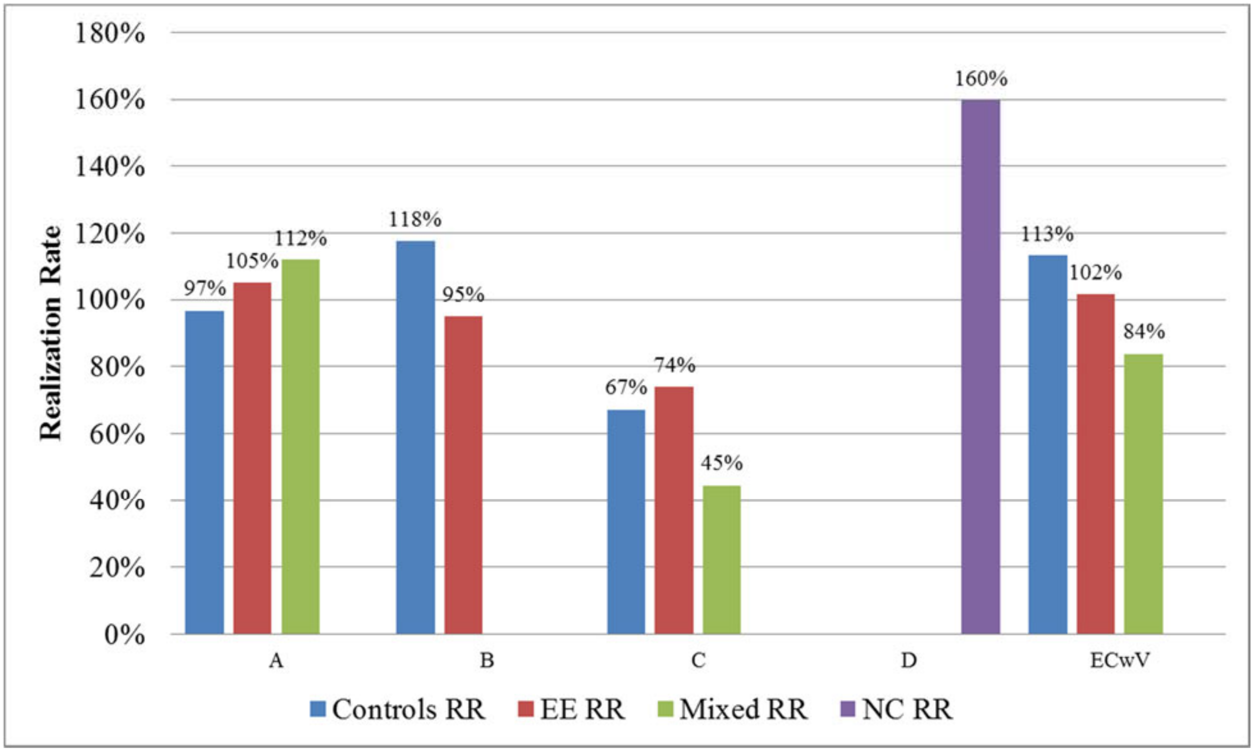

Figure 3: Realization Rate by Project Type and M&V Methodology

In general, the data seems to support the idea that project RR is not dependent on what type of ECMs are implemented, but rather is much more dependent on the type of M&V strategy used. It is possible that much of the ESPC activity is driven by a desire to upgrade failing infrastructure, rather than save energy. In this case the affected facilities may not care about the realization rates.

Non-ESPC projects may be performed by various entities utilizing various contractual methodologies, meaning their data is not collected in one central place. They are not required to follow FEMP guidelines, but M&V methodologies for these projects generally follow IPMVP guidelines (usually A or B, unless an outside entity requires a different strategy, for example for incentive payment). As with ESPC projects, implementation of the M&V strategies may not be done to official IPMVP standards.

Projects with Whole Building Analysis

Of the 128 projects in this sample – including both ESCO and non-ESCO projects – 6[5] were verified using whole building regression modeling. This is BPA's preferred method for large commercial[6] projects. The building's entire energy load is captured accurately at the utility meter, accounting for all interactive effects. Additionally it incorporates actual building operation, which may diverge significantly from the optimal operation projected by theoretical modeling/simulation. M&V for all buildings in this set was performed by BPA engineers for incentive calculations, which effectively served as third party analysis.

ESPC projects generally require M&V reports from the ESCO. Those reports were done independent of this analysis. ESCOs generally perform their own M&V, without independent oversight. While the ESCO M&V reports for the specific projects analyzed here were not generally available, the ones reviewed reported much higher savings than found by Option C analysis. In the few situations where it was available, the savings differential was due to the contractual M&V method used. For example, when the contractual M&V was stipulated savings or only required short-term measurement to prove that new equipment functioned.[7]

For these 61 facilities, regression was done to outdoor temperature, which is typically the major driver of variation in energy use for most commercial facilities. As temperature data is easily available for a wide range of project locations and historical periods, no extra metering is required. This makes the combination of billing meter and temperature data a simple, low-cost M&V strategy.

Occupancy in schools varies starkly over the course of the year, which clearly impacts energy usage. This may lead to the reasonable objection to the usage of temperature as the sole independent variable. Luckily, occupancy and temperature have a predictable (inverse) correlation. Since most schools in the Pacific Northwest have reduced occupancy in summer, occupancy decreases as temperature increases. This allows good models in many cases, even with monthly billing data.[8] In fact, while this varies widely, modeling uncertainty can be less than 1%. . As ASHRAE Guideline 14 suggests that savings should be more than double the modeling uncertainty (ASHRAE 2002), and model uncertainty varies widely, the 10% IPMVP savings threshold seems to be a rule of thumb more than mandate. A baseline model of a facility is suggested to determine whether the projected savings will be detected by whole building methodology.

Overall, projects verified with this whole building methodology saved a total of 6 million verified kWh. If the projects with negative savings– that is, where normalized whole building energy usage was higher after project implementation– were left out of the analysis, this number increases to 7 million kWh. The table below shows the breakdown by measure type. (In this

[5] The 61 projects included the 56 ESPC projects discussed in the previous section as Option C projects.
[6] As opposed to residential, industrial, or agricultural.
[7] It is assumed that these projects reported similar realization rates to those Coleman et al. found in 2014.
[8] In cases where the modeling uncertainty was too high, separate summer models were constructed as a proxy for occupancy.

section, Retro-commissioning (RetroCx) projects are treated as a separate category, and any project with more than 2/3 estimated savings for one measure is categorized with that measure.)

Table 4: Whole Building Realization Rates by ECM type

Project Category	Total projects	Projects that saved energy	% Projects w/energy savings	Estimated savings (kWh)	Verified savings (kWh)	RR
VFD	2	2	100%	95,326	64,177	67%
Mixed	8	8	100%	1,681,351	1,112,736	66%
Controls	27	24	89%	5,118,464	2,992,758	58%
RetroCx	15	9	60%	1,966,228	1,109,323	56%
Equipment	6	5	83%	1,338,669	746,290	56%
Other[9]	3	2	67%	91,426	47,033	51%
Total	61	50	82%	10,291,464	6,072,315	59%

Obviously, this realization rate is less than one would hope. While information about the circumstances of each project was limited, some information was available.

One hypothesis for the cause of this less than perfect realization rate was change in baseline. It is not uncommon, particularly in public facilities where contracts can move extremely slowly, for years to elapse between an initial project audit and project implementation. Buildings are not static entities, and it is not surprising to anyone familiar with facility operation that energy use can change dramatically from year to year. Fifty-five (of the 61 whole building projects) had an initial baseline estimate. As shown in the graph below, this sample supports the "baseline slip" hypothesis as a source of realization variance.[10] This issue strongly affected the retrocommissioning group, and impacted realization rates as reported in this sample. While details of the cause of these changes are unknown, fixing egregious building issues would both lower the baseline and reduce the savings, because that measure could no longer be counted towards the project.

[9] "Other" includes a transformer upgrade and engine block heaters.

[10] Unfortunately, the year of estimate was generally not available, so it was not possible to determine slip over time.

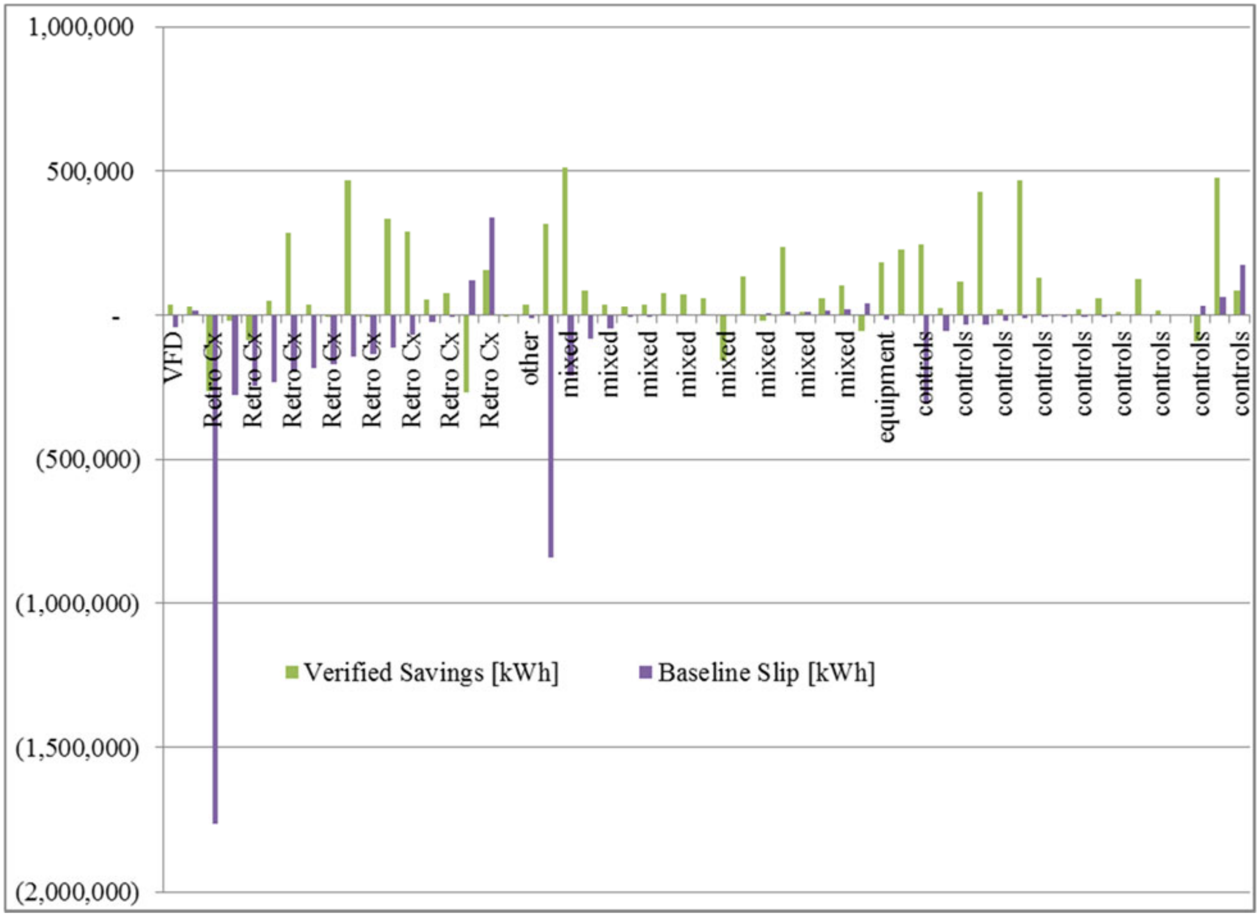

Figure 4: Savings vs Baseline Slip for Projects Verified Using Whole Building Methodology

Another hypothesis considered was that flawed estimation methods were used for the initial savings estimate. The surprising results seem to indicate that more detailed modeling does not produce better accuracy. (Estimation methods are ordered from best to worst by realization rate.)

Table 5: Realization rate by initial project estimation methodology

Project Category	Total projects	Projects that saved energy	% Projects w/energy savings	Estimated savings (kWh)	Verified savings (kWh)	RR
Arithmetic[11]	7	7	100%	1,168,743	1,236,990	106%
Some metering	7	7	100%	1,588,944	1,068,290	67%
Spreadsheet	7	6	86%	1,281,606	829,986	65%
Bin model	12	11	92%	2,412,220	1,332,779	55%
eQuest	5	4	80%	469,370	222,753	47%
Proprietary model	11	6	55%	1,359,579	566,215	42%

[11] These are simple percentage savings estimates, based either on a previous project result or engineering judgement.

Project Category	Total projects	Projects that saved energy	% Projects w/energy savings	Estimated savings (kWh)	Verified savings (kWh)	RR
Unknown	12	9	75%	2,011,002	815,302	41%
Total	**61**	**50**	**82%**	**10,291,464**	**6,072,315**	**59%**

A third hypothesis for this variation was that ESCOs who specialize in this type of project would be more accurate than local contractors, who lack the history or the experience of the more specialized companies. This hypothesis was not borne out by the data available (although it should be noted that the sample of non-ESCO projects was small).

Table 6: Realization rate by project implementer

	# Projects	**Estimated Savings (kWh)**	**Verified Savings (kWh)**	**RR**	**Verified Savings > 0 (kWh)**	**# of projects**	**RR**
ESCO	54	8,868,024	4,835,456	55%	5,813,750	43	66%
Non	7	1,423,440	1,236,859	87%	1,236,859	7	87%
Total		**10,291,464**	**6,072,315**	**59%**	**7,050,609**		**69%**

Discussion

These projects showed a large variance in energy savings realization rate depending on M&V methodology. Since Option C-type methods use real world utility data, its results should most accurately reflect actual building energy use over a variety of conditions. IPMVP says "Utility-meter data is considered 100% accurate for determining savings" (EVO 2012, p. 27). This raises the possibility that other verification methods may not accurately capture interactive effects and first year savings , as demonstrated by actual utility billing data. It is not clear whether this is due solely to M&V strategy, or whether having an outside party perform M&V analysis is the reason why these numbers were so different from each other and from the contractual self-reported savings numbers (or a combination of both). As a precaution, prospective program implementers and facility owners who want to ensure savings are realized may want to move towards the IPMVP Option C methodology for ESPC projects, at least for the first year, to make sure assumptions used for savings estimation were correct. This method will account for measure interactivity, capture the full range of independent variables, and if continued would ensure savings persistence.

Most current ex ante estimated methods seem to do a poor job of predicting savings associated with energy efficiency projects. It does not appear that firms who do energy projects exclusively have better savings estimation methodologies than firms who do a variety of projects. While project payback is often a driver in ranking projects for funding reasons, this evidence suggests that since projections are poor, making detailed savings estimates might be counter-productive. The delay between the initial audit and project implementation can have very deleterious effects on estimated project savings. Since most estimation methodologies seem to be poor predictors of project performance, the program might be more cost effective if less effort was spent on system modeling so that contracts could be awarded more quickly.

Conclusion

While this small sample may or may not be representative of broader trends within the industry, they certainly raise questions that challenge many common assumptions about energy efficiency projects. More study seems to be warranted in order to determine whether it is time for a paradigm shift in energy efficiency implementation.

References

ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers). 2002. *Guideline 14-2002: Measurement of Energy and Demand Savings*.

BPA (Bonneville Power Administration). 2012a. *Measurement &Verification (M&V) Protocol Selection Guide and Example M&V Plan.*

BPA (Bonneville Power Administration). 2012b. *Verification by Energy Modeling Protocol, Version 1.0.*

Coleman, P., Earni, S., and Williams, C. 2014. *Could What That ESCO Sales Rep Said Really Be True? Savings Realization Rates in ESPC versus Bid-to-Spec Projects.* ACEEE Summer Study 2014.

EVO (Efficiency Valuation Organization). 2012. *International Performance Measurement and Verification Protocol: Concepts and Options for Determining Energy and Water Savings Volume 1*. EVO 10000 – 1:2012.

FEMP (Federal Energy Management Program). 2015. *M&V Guidelines: Measurement and Verification for Performance-Based Contracts Version 4.0*.

Urbatsch, E., and Boyer, E. 2014. *How Much is Enough? Lessons Learned on Performance Periods for Monthly Whole Building Regression Modeling.* ACEEE Summer Study 2014.