Pay for Performance Case Study – 3 Years of Performance

Chris Smith, PE, CEM – Energy 350
Kathleen Belkhayat & Oliver Kesting – Energy Trust of Oregon

Introduction

A Pay for Performance (PfP) program structure has been an experimental new approach in program design. Rather than relying on measure level analysis, PfP measures energy savings at the meter and pays based on those savings, typically over a significant M&V period. This delivery structure provides a number of benefits, including:

- Delivers deeper savings, encouraging participants to take a holistic approach to energy efficiency that includes a mix of capital measures, operations & maintenance (O&M) and retrocommissioning (RCx).
- Improves realization rates for programs. Particularly for RCx measures, programs have been burdened by low realization rates. Since payments are only made after savings have been demonstrated, realization rates should approach 100%.
- Supplements energy efficiency programs with Strategic Energy Management (SEM) offerings. SEM is valuable in transforming the way an organization approaches energy efficiency and capturing the lower hanging O&M fruit cost-effectively. However, some customers are not ideal SEM candidates either because of their size or organizational readiness. By providing a path to bring in an external engineering firm, combining capital and O&M measures and offering significant incentives, PfP allows for a deep, comprehensive approach to improving building energy performance.
- Encourages scope growth to harvest additional energy savings. As additional opportunities are discovered during the implementation process, these can be implemented real-time with the knowledge that they will be incentivized through the additional savings at the meter.

Through our experience with 1000 Broadway, we'll explore the concept of Pay for Performance both programmatically and technically.

The Pilot

In 2014, Energy Trust of Oregon sought projects through a competitive solicitation in a Pay for Performance pilot offering. The pilot offered performance based, measure agnostic incentives for energy savings measured and verified at whole-building level. The only way in which Energy Trust distinguished measures is to delineate between capital and O&M measures. Since capital measures are more expensive and have a longer measure life, Energy Trust is able to pay more for projects comprised largely of capital measures.

The pilot was structured to not contract up front for a specific incentive, but rather an incentive rate ($/kWh). After project completion, year one measurement & verification (M&V) begins, with the first payment following a year of whole-building M&V. Additional payments are provided for years two and three M&V results.

The Building

1000 Broadway is a 1990 construction, 24-story, all electric office building in Portland, Oregon. Floors 2-8 are designed to look consistent with the rest of the building from the outside, though are parking garages with an exterior facade to match the rest of the building. Prior to the 2014 PfP implementation, the building was reasonably efficient and certified as an Energy Star building with a score of 80. 1000 Broadway had implemented the more easily identifiable energy efficiency measures including variable frequency drives (VFDs) on all large motors and LED lighting.

For HVAC, each floor has a water cooled DX VAV system with electric reheat. On the roof are (2) cooling towers and (2) condenser water pumps to circulate water through the towers and to each floor's DX cooling. They have a secondary condenser water loop to cool tenant owned, water-cooled data center HVAC. The primary and secondary condenser loops are connected with a plate and frame heat exchanger to allow the secondary loop to reject heat into the primary loop and ultimately, out through the cooling towers.

The HVAC and lighting are controlled by the original Trane direct digital control (DDC) system, which is still very functional. All HVAC and lighting are scheduled and lighting sweeps programmed, limiting the low hanging fruit that is available.

Measurement & Verification

Measurement and Verification (M&V) was done using the existing utility meters, with a regression model based approach to normalize for weather and any other building changes that may affect energy performance. The meters are not interval, so only monthly data was available, which we found sufficient to develop an accurate model. Of course, interval data would be preferred, but as this section demonstrates, monthly data is often sufficient to develop statistically defensible models. If the targeted customer base has monthly meters, we would advocate that the program work within that real-world constraint rather than exclude a major portion of customers from participation by requiring interval meters.

To support their O&M program offerings, Energy Trust has developed a comprehensive set of whole-building M&V guidelines, which were used to guide our model development. We tracked occupancy, though it was near 100% throughout the project measurement period. With consistent occupancy and no other significant changes to the building, weather and days in billing cycle were our only independent variables.

For weather, Energy 350 used Heating Degree Days (HDD) and Cooling Degree Days (CDD) rather than average temperature. The advantage of this approach over average temperature is that it captures fluctuations in temperature not reflected by the average. To test this, we compared competing models, one using HDDs and CDDs, the other using average temperature. All else remained the same. Using average temperature, we achieved an R^2 of only .67, whereas the HDD/CDD approach yielded an R^2 of .90. This indicates that the HDD/CDD approach is significantly more accurate, allowing the model to predict 90% of the fluctuations in energy use, compared to only 67% using the average temperature approach. This is a typical finding, which leads us to recommend using HDDs and CDDs rather than average temperature when only monthly data is available. If interval data is available, there is no need to calculate HDDs and CDDs.

An important step in using HDDs and CDDs is in selecting the reference temperature from which to calculate HDDs and CDDs. Reference temperature is intended to reflect the balance point of the building, which is the outside temperature at which the building requires minimal heating or cooling. This is typically in the range of 55˚F to 65˚F outside air temperature.

To select the most accurate reference temperature in building the model, Energy 350 ran the regression model iteratively using a range of reference temperatures until the model results identified the best fit reference temperature. We highly recommend this iterative approach to selecting the best fit reference temperature, as it has significant impact on model integrity. While this sounds tedious, it's relatively simple to program automated logic to efficiently iterate the model to select the most appropriate reference temperature. Below are the regression statistics and ANOVA tables.

Table 1 - Regression Statistics

Multiple R	0.95
R Square	0.90
Adjusted R Square	0.86
Standard Error	23,384.00
Observations	12.00

Table 2 - ANOVA Table

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	3.8096E+10	1.27E+10	23.22	0.000265313
Residual	8	4374491525	5.47E+08		
Total	11	4.2471E+10			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	86,092.51	161,960.92	0.5316	0.6095	(287,390.03)	459,575.06
Days in Billing Cycle	6,395.81	5,567.87	1.1487	0.2839	(6,443.72)	19,235.35
HDD	264.58	41.08	6.4399	0.0002	169.84	359.32
CDD	489.37	149.77	3.2675	0.0114	144.01	834.73

The high R^2 indicates that the model explains the majority of variation in energy use in the baseline data. While R^2 is useful when evaluating model fit, we also considered several significance and error metrics. The low p-values for the HDD and CDD independent variables illustrate that these variables are significant. While the HDD variable has the smallest coefficient, it has the largest variation in baseline observations. Therefore, the HDD variable has the largest effect on modeled energy use, indicating that it is the primary energy driver. This is expected because this building is electrically heated and is located in Portland, which has a heating dominated climate.

The ANOVA table also provides insight on model error, showing a standard error of 23,384 kWh, which translates to a 5.7% Coefficient of Variation of the Root Mean Square Error (CVRMSE). The CVRMSE illustrates that the model error is small relative to the mean baseline observation. We also consider fractional savings uncertainty (FSU) to interpret the validity of the result. This model achieved an FSU of 14% at a 68% confidence level. This low FSU inspires confidence in the reported savings and is a result of the large savings (~14%), low CVRMSE and uncorrelated residuals.

Contract Arrangement

The contract arrangement between the PfP Provider and the customer is critical in that a well-structured contract can overcome some common barriers to implementing energy efficiency. A common barrier to energy efficiency lies within typical lease and contract arrangements. Most commercial leases are triple net lease (NNN), under which tenants pay operational expenses, including energy. Since tenants pay utilities, they typically reap the benefit of energy savings through reduced NNN expenses while the owner bears capital expenses. This creates a split incentive where the project is funded by the owner and savings are reaped by the tenant, which can be a barrier to efficiency projects.

Another common barrier to energy efficiency projects lies in who owns the risk of potential underperformance. This is typically also borne by the owner. As a result, contractors are not incented to maximize real world performance of the energy project, which can often result in underperformance.

Energy 350 crafted a contract structure that avoids these common barriers. Energy 350 was the project implementer, performing some work in-house and subcontracting the rest to trades contractors. The contract arrangement with the customer was such that Energy 350 charged a performance based rate slightly less than the owner pays for energy. In addition, Energy Trust provided performance based payments through a contract with 1000 Broadway.

Through this approach, Energy 350 funded all the costs, accepted all the performance risk, but was also rewarded for maximizing energy savings. The owner classified Energy 350’s fee as an operational expense and billed it to the tenants through the NNN. However, since Energy 350’s fee was less than the value of the energy savings, the energy savings exceed the fee and the tenants saw a reduced NNN. The contract term was for three years, after which 1000 Broadway and their tenants own 100% of the energy savings. This arrangement essentially made 1000 Broadway the host site from which Energy 350 mined energy savings. Energy 350 mined energy savings for three years, then returned that revenue stream back to 1000 Broadway at the end of the three-year term.

Energy 350 owned the responsibility to implement measures, with a commitment from 1000 Broadway that they allow reasonable access to the building in order to make improvements, provided that they didn’t negatively impact the tenants. Through this arrangement, Energy 350 served as a general contractor and commissioning agent for the improvements. This allowed Energy 350 to manage trade contractors and ensure that their improvements were commissioned in a way that maximized energy savings. This control and accountability is extremely important. What we found is that typically when a contractor considers the project complete, it is only saving a portion of the energy it could. The quality control (QC) and commissioning process is critical in realizing the true energy savings potential of the building. In the case of every subcontractor and every measure, we issued multiple punch lists after the contractor considered their job complete. This commissioning process is key to realizing the full energy savings potential of each measure. Ironically, retrocommissioning measures have the greatest need for commissioning, since they tend to be complex and nuanced and the energy savings are realized only through attention to detail.

Energy Efficiency Measures

The Pay for Performance approach allows us the freedom to focus on optimizing the performance of the building as a whole, rather than parse out our activities into discrete Energy Efficiency Measures (EEMs). This is extremely valuable in allowing us to take a comprehensive approach and focus our time on achieving results rather than characterizing and quantifying discrete EEMs.

Energy 350 had previously done an ASHRAE level II study on the building, so had a good idea of the opportunity available. Based on the study, Energy 350 had initially identified the EEMs for Pay for Performance listed in **Table *3*** below.

Before diving into the measures, it is important to discuss some higher level conclusions related to them:

1) This building and its opportunity is not unique, these are the types of opportunities that we find on a daily basis. We feel that these measures are representative of opportunity that is prevalent in building stock throughout the US.
2) Notice that the majority of the savings are not capital, but rather operational. If 1000 Broadway is representative, as we believe it is, this indicates that the largest cost effective untapped resource potential within existing buildings is O&M based energy efficiency.

Table 3 - Initially Identified EEMs and Economics

EEM #	Description	Capital or O&M	Annual kWh Savings	Annual Energy Cost Savings	Trades Contractor Cost	E350 Costs	Total Cost
1	Economizer Tuning	O&M	76,411	$5,502	$9,950	$3,000	$12,950
2	SAT Reset	O&M	189,242	$13,625	$14,870	$6,000	$20,870
3	Duct SP Tuning	O&M	22,177	$1,597	$1,700	$1,000	$2,700
4	Modulate Flow through HXR	Capital	101,594	$7,315	$18,550	$8,000	$26,550
5	Secondary Pump VFDs	Capital	93,867	$6,758	$13,500	$4,000	$17,500
6	Cooling Tower Fan Staging	O&M	22,630	$1,629	$2,450	$1,000	$3,450
Total			**505,921**	**$36,426**	**$61,020**	**$23,000**	**$84,020**

EEM 1: Economizer Tuning – This EEM addresses (6) air handlers that are currently mechanically cooling when they should be fully economizing. Through adjusting the dampers and replacing failed hardware, all air handlers will be able to free cool when weather allows.

EEM 2: Add Supply Air Temperature (SAT) Reset – This EEM adds functionality to the control system to vary SAT. This limits the amount of excess reheat energy spent tempering zones that are not in cooling mode.

EEM 3: Adjust Duct Static Pressure Reset Strategy – This EEM further trims fan energy by tuning the duct static pressure reset strategy by reducing the minimum operating static pressure. While the system currently has a static pressure reset, most fans are running at maximum. This is because the reset is driven by the most extreme zone. Due to aging VAV boxes and reconfigured spaces, most floors have at least one zone that drives static pressure to maximum.

EEM 4: Modulate Flow through Plate and Frame Heat Exchanger– The heat exchanger that allows the secondary condenser loop to reject heat into the primary condenser loop is significantly oversized. This EEM uses a valve at the plate and frame heat exchanger to reduce excess flow. By reducing excess flow through the heat exchanger, pump energy is saved.

EEM 5: Retrofit Secondary Loop Pumps to VFD– This EEM adds VFDs to the secondary loop pumps and 2-way valves at all theater and lobby air handlers.

EEM 6: Adjust Cooling Tower Fan Staging– Currently, the two cooling tower fans operate independently at significantly different speeds. This EEM sequences the 40 hp cooling tower fans more efficiently.

We found that the more time we spent in the building, the more opportunity we found. Studies are typically budget-constrained and just don't allow for the amount of in-building time that we were able to spend with this project. Since our contracts for this project were performance based, we were incented to grow the scope as we found additional opportunity. By implementing additional measures we found during our time in the building, our first year energy savings exceeded our estimated energy savings by 35%.

Additional measures identified were numerous small actions, but included calibration of economizers, sequencing of condenser pumps, relocation of outdoor air temperature sensor, etc. Below is a description of some additional measures we found through our in-building time.

EEM 7: Condenser pump sequencing – Both condenser pumps were operating all of the time with a fairly steady speed of about 35 Hz (~60% speed). If pump efficiency were flat, this would indicate that two pumps are needed. However, in looking at the pump curve, we can see that at this low speed, the pumps are operating at significantly reduced efficiency. This indicates that we can transition to using one pump a majority of the time. We programmed the pumps to sequence up to two when needed and down to one as load allows. What we have found is that two pumps are needed only on the hottest days of the year.

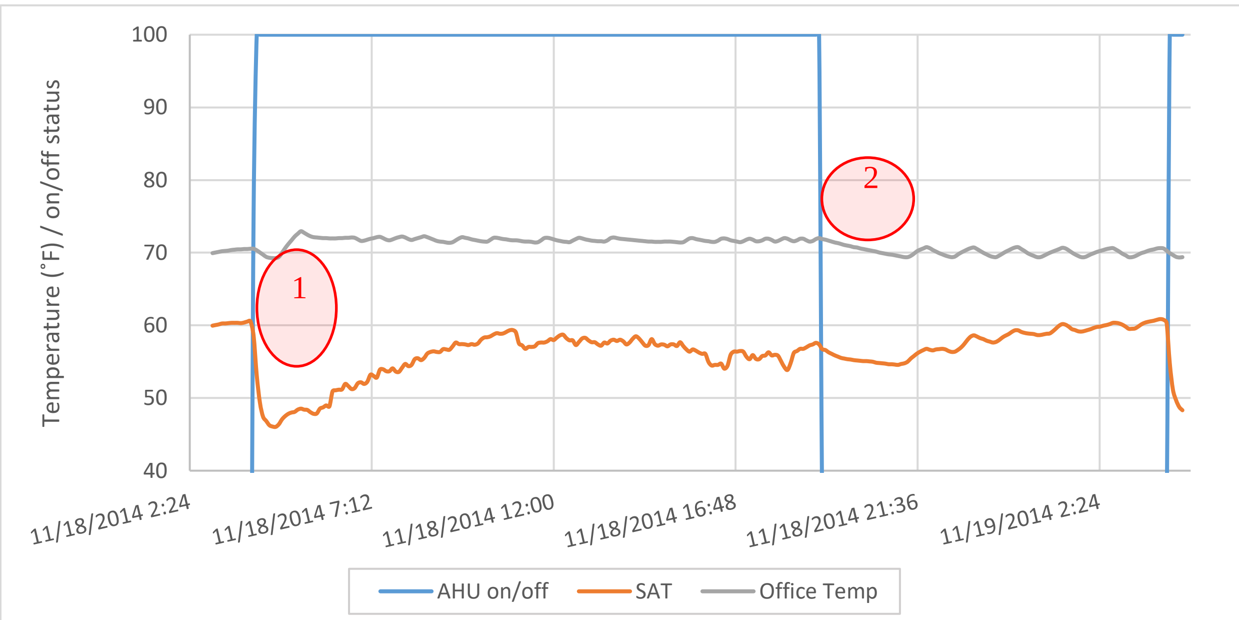
EEM 8: Relocation of outdoor air temperature sensor – During our work, we noticed that the outdoor air temperature was reading very high compared to airport data. This was causing the economizers to close during great economizer weather. We found that though the sensor was located out of the sun, it was done so by tucking it on the north side of an I-beam on the roof. The south side of the I-beam was in direct contact with the sun, heavily influencing the outdoor air temperature sensor on the other side of the beam. We relocated this to gain an accurate reading and properly control the economizers. For reference, Portland has 1,800 hours where outside air temperature is between 60˚F and

70˚F, many of which the economizers were closed due to the sun-affected temperature sensor.

EEM 9: Calibration of Economizers – While most of the economizers worked to some degree, for the most part, they didn't completely block return air or allow outside air to be restricted down to the minimum required for ventilation. As a result, on cold mornings, we would sometimes find supply air temperatures down in the 40s. Economizers were all calibrated back down to design levels of outside air at minimum and as close as possible to 100% outside air when commanded to full economizer position. As is typical with economizers, we were unable to achieve and maintain flawless operation, due to limitations of the dampers, linkages and actuators.

Figure *1* shows one of many examples of opportunities that Energy 350 identified through our in-building time implementing the measures previously identified in the study. This figure shows our use of data loggers to identify additional opportunities.

Figure 1 - Example Additional Measure Identification



1) Low Supply Air Temperature (SAT) during morning warmup is actually cooling the building, wasting significant reheat energy and slowing the morning recovery time of the building. This is caused by miscalibrated economizers that allow too much outdoor air in, even when commanded closed.

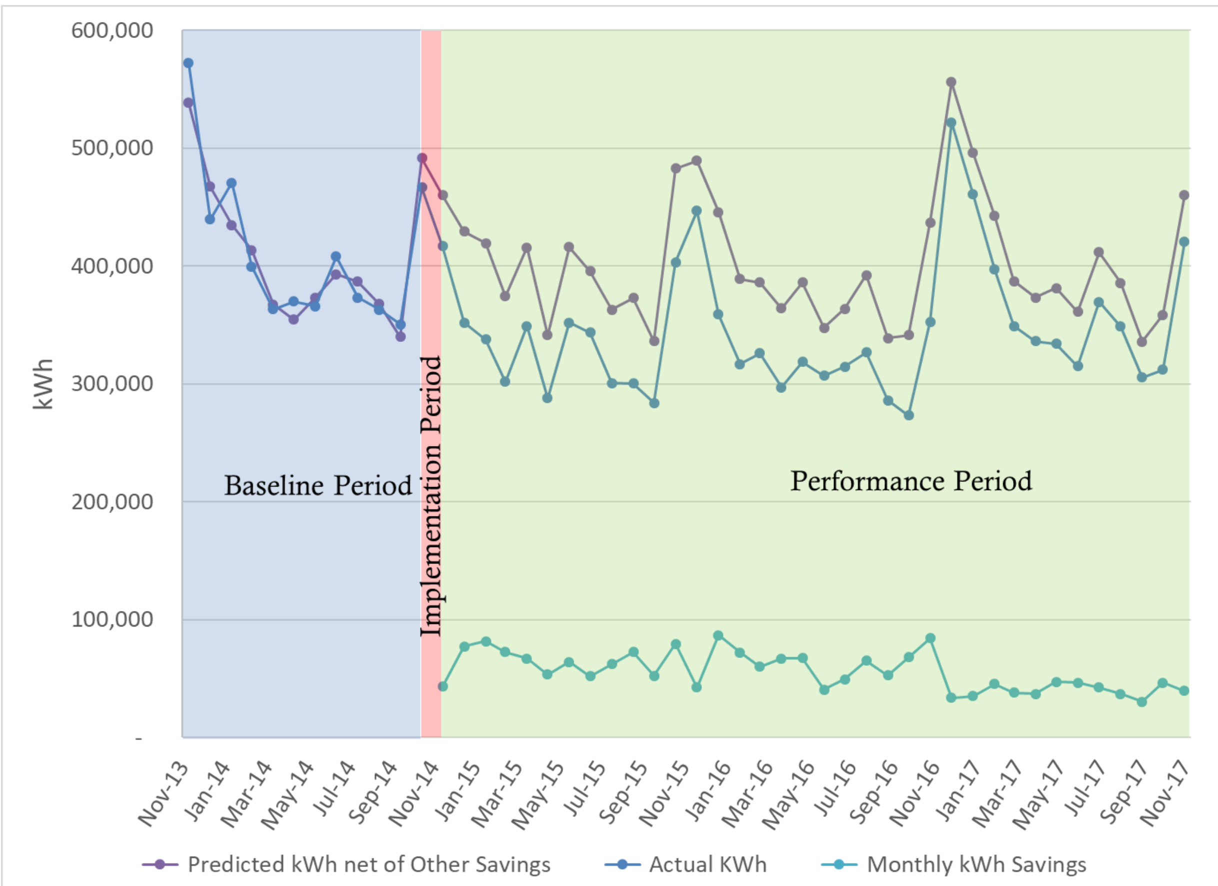
2) Air handling unit (AHU) shuts off at 7:00 PM to accommodate the occasional late workers. However, temperature logging shows that even in cold weather, temperature holds quite well after the AHU shuts off. It took nearly two hours for a perimeter office to cool from 72˚F to 70˚F. Based on this, we implemented "smart stop" at 6:00 PM. This means that starting at 6:00 PM, the control system evaluates the outside and inside temperatures and decides when it can turn off and maintain an acceptable temperature until 7:00 PM. This means that in mild weather, the AHU will shut off closer to 6:00 PM

and in more extreme weather, will run until closer to 7:00 PM. We also experimented with “smart start”, though had to limit its use after some cold morning complaints.

Results

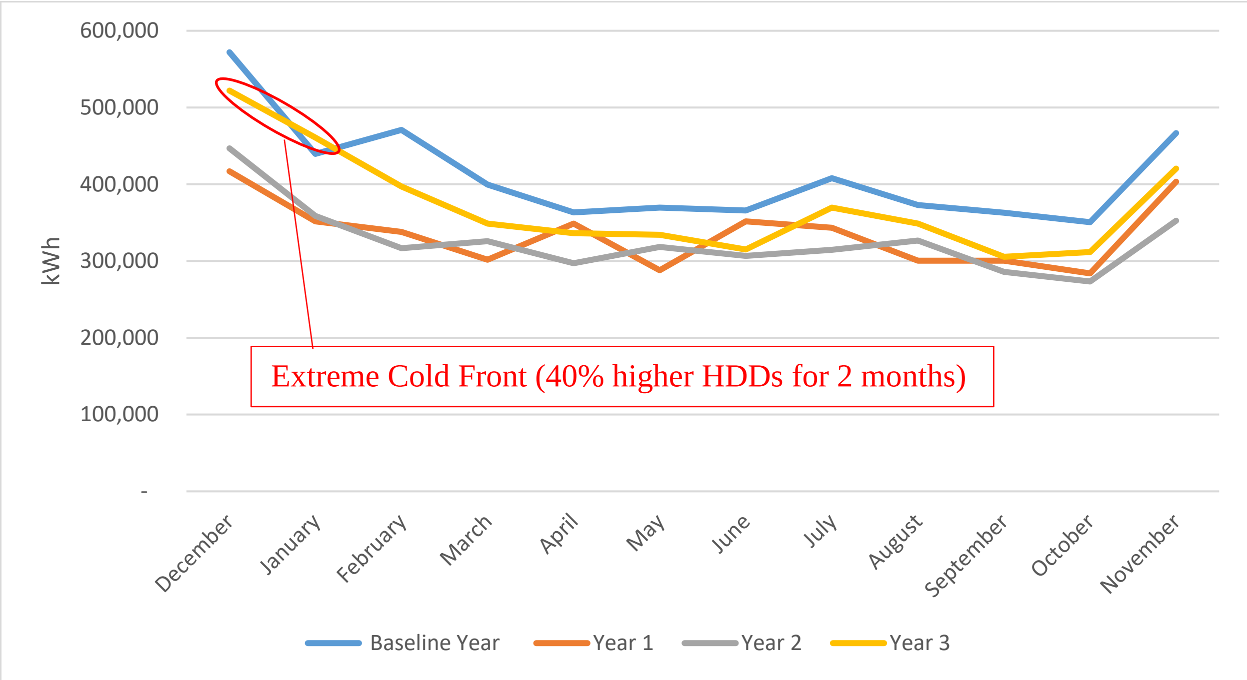
Results were highly positive, even on a building that was already efficient. Through significant in-building time and a mix of capital and O&M measures, we were able to save an average of 14% during the three-year performance period. **Figure *2*** shows performance results.

Figure 2 - 1000 Broadway Energy Performance



While not appropriate for analysis, it is often a helpful sanity check to view raw energy usage over time, unadjusted for weather or any other changes to the building. **Figure *3*** shows year-over-year monthly energy use during the entire engagement, starting with a baseline year. Aside from an extremely cold two months in year 3, this shows a clear trend in meaningful and sustained energy savings.

Figure 3 - Monthly Energy Use (Unadjusted)



Note that we did see some slip in savings in year 3, starting around the time of an extreme cold front in Portland. We suspect this was caused by operator-initiated changes to address potential comfort issues caused by the extreme weather. Several months passed before we noticed the slip in savings. By then, our engagement was ending and we were unable to determine the cause of the slip in energy savings. This is an important reminder of the need to be proactive to maintain energy savings throughout the performance period.

Advantages of Pay for Performance Approach

Pay for Performance has a number of advantages over traditional incentive mechanisms. A Pay for Performance program structure provides the following benefits:

- Reduces Risk for Program Administrators – Particularly when it comes to O&M/RCx measures, Program Administrators are often plagued by poor evaluation results. Since payment is not released until after performance is demonstrated, risk of underperformance to Program Administrators is essentially eliminated.
- Streamlines RCx Incentives – While RCx projects are highly cost effective, RCx can be a difficult fit for typical programs that operate by quantifying cost and savings on a measure level, prior to implementation. Since RCx measures are difficult to quantify, this energy engineering adds significant overhead and uncertainty to traditional RCx programs.
- Encourages a Whole-Building Approach to Efficiency – To truly realize a building’s energy savings potential requires a whole-building approach that combines capital and RCx measures. By simply paying for savings at the meter, participants are encouraged to take a whole-building, comprehensive approach to energy efficiency.

- Increased Accountability – Under traditional program models, incentives are largely based on calculated savings, sometimes with short term M&V or often only a verification. The Pay for Performance model holds participants and their contractors accountable to commission their EEMs to maximize energy savings.
- Encourages Scope Growth – The implementation process results in significant on-site analysis that will likely result in the identification of additional opportunity. Through traditional program approaches, customers are not incented for additional savings achieved. Additionally, new opportunities would have to be treated as a separate project, which introduces overhead and delays and may prevent the implementation of those additional opportunities. Through the Pay for Performance structure, savings achieved beyond the original scope can easily be implemented in real-time with the knowledge that they will increase savings at the meter, and therefore be incented without additional effort.

Challenges of Pay for Performance Approach

From a participant perspective, there are some aspects of Pay for Performance that could make traditional incentive mechanisms more desirable. Challenges of the Pay for Performance program structure for the customer include:

- Timeline of Payments – Traditional incentives are typically paid out within weeks of project completion in one lump sum.
- Risk of Underperformance – In traditional incentive structures, Program Administrators tend to own the risk of underperformance. While the shift in risk may be attractive to Program Administrators, participants would of course prefer that Program Administrators own the risk.
- Lack of Incentive Predictability – Since the incentive is performance based, it can be difficult to predict in advance, adding uncertainty to participants' investment decisions.

Additionally, this program structure can pose some challenges to Program Administrators, such as:

- For combined capital and O&M projects, Program Administrators face some uncertainty in parsing out savings between capital and O&M. Additionally, these combined savings can add uncertainty to measure life claims.
- Potential uncertainty around end of life verses early replacements. Since the savings are measured at the meter, the savings calculation treats all measures as early replacements.

Conclusion

Pay for Performance is an important program design to unlock energy savings potential from buildings. Pay for Performance is an especially attractive approach to RCx programs, which are historically burdened with high overhead and low realization rates. It is also an effective incentive mechanism to bundle capital and O&M measures for a single, comprehensive program approach to improving building efficiency.

To fully realize the operational efficiency potential of buildings takes a large time investment, significant expertise and significant commissioning of measures. It also requires a champion who is accountable for energy savings and diligent with every detail throughout the implementation and commissioning process. Pay for Performance creates a program structure that provides the required accountability to achieve results for Program Participants. It also creates a framework that lends itself to performance-based contracts. The M&V can serve as the mechanism for establishing energy savings for performance based contracts between the performance contractor and end-use customer.

It is our belief that much of the remaining cost-effective resource potential for energy efficiency in existing buildings lies in tuning buildings for maximum efficiency. These opportunities are difficult to capture through traditional program models. We believe that a Pay for Performance program structure is a sound approach to capturing some of the significant resource potential currently locked within nuances of how buildings operate.

Our experience at 1000 Broadway has demonstrated more than just the benefits of the PfP program model. Perhaps more importantly, it has demonstrated both the technical and economic potential for energy savings through O&M/RCx measures in existing buildings. It's important to point out that 1000 Broadway was not a cherry picked, inefficient building with lots of "low handing fruit". 1000 Broadway was an Energy Star certified building when we started, yet we cost effectively saved an additional 14% of energy use, bringing the Energy Star score from 80 to 92. Even efficient buildings have significant opportunity, largely through O&M/RCx measures.

Program Administrators should also recognize that the program design shifts some of the risk from the Program Administrator to the Program Participant as well as releases payments over an extended period of time, rather than as a lump sum. That being said, the design also creates opportunities to capture additional savings, and therefore, higher incentives. These factors need to be considered and addressed within program and incentive design to improve success in Pay for Performance offerings.