Realizing Measurable Savings in Multifamily Buildings: Results from NYSERDA's Multifamily Performance Program

Lindsay Robbins, New York State Energy Research and Development Authority
Betsy Parrington, Taitem Engineering

ABSTRACT

Despite a decades-long history of energy efficiency programs that target the multifamily residential sector, there is minimal data that includes the actual post-implementation energy consumption of the buildings participating in these programs. The achieved savings is critical to convince building owners and funding agencies that energy efficiency improvements are worthwhile investments. In 2010, NYSERDA presented "Results from NYSERDA's Multifamily Performance Program: Getting 20% Reduction in Multifamily Buildings" (Falk and Robbins, 2010). That paper analyzed the actual savings achieved by the first 17 projects to complete the program. Since then, 202 additional projects have completed the program, creating a total sample of more than 1,500 buildings with over 32,000 units of housing, representing more than 32 million built square feet. This paper expands upon the analysis conducted on the first 17 projects, to examine which factors contributed most to a project's ability to achieve projected savings. On average, projects achieved 23% savings, but realization rates (defined as the achieved percent savings divided by the projected percent savings) varied widely, and there is a high degree of both over- and under-prediction of savings. In order to better understand why some projects are able to accurately predict savings and others are not, this paper analyzes factors including energy conservation measures, the comprehensiveness of work-scopes, technical service provider experience, energy modeling software, and building characteristics.

Introduction

NYSERDA's Multifamily Performance Program (MPP) challenges building owners to reduce their whole-building energy consumption by 20%. Building owners work with a certified energy professional to select and install the most cost-effective work-scope to achieve or exceed the program's 20% target. One year after the work-scope is installed, another billing analysis is conducted to determine how much of the savings predicted by the energy model were achieved. MPP is relatively unique for its use of a performance-based approach in the multifamily sector. This approach provides a valuable data set that illuminates the challenges of achieving consistent savings results in multifamily retrofit projects. Only by tracking actual savings data can we hope to uncover what factors contribute to the successful achievement of savings and how to design programs and processes that improve results and increase consumer confidence in the value of investing in energy efficiency improvements.

Background

In May of 2007 NYSERDA launched the Multifamily Performance Program, which challenged all participating projects to reduce their total source energy consumption by 20%.

MPP serves both new construction and existing buildings, but for the purposes of this paper only existing buildings will be discussed.

MPP has evolved over time based on experience; however, the fundamental structure remains the same. Between 2007 and 2009, three updated versions of the program were released, each improving program processes and technical documentation. In 2009 Version 4 reduced the savings target from 20% to 15%, and in 2012 Version 5, the most recent version, introduced a streamlined participation option for smaller buildings (<50 units). Almost all of the 217 projects discussed in this paper participated in one of the first three versions of the program; only two participated in one of newer versions with the reduced 15% savings target.

MPP employs a market-based approach to providing technical services. Buildings are free to work with whichever service provider they choose so long as the providers hold "Partnership Agreements" with NYSERDA qualifying them as "Multifamily Performance Partners". Service providers are able to join the program's "Partner Network" on a rolling basis. MPP Partners shepherd projects through the program from beginning to end. Services performed by Partners include benchmarking and billing analysis, conducting a whole building energy audit and developing an Energy Reduction Plan, inspecting the installation of the work-scope contained in the audit, and conducting a final billing analysis one year post construction. Owners can choose whoever they like to install their work-scope, but Partners are expected to ensure that all measures are properly installed.

MPP allows buildings to choose the energy measures they wish to pursue in order to achieve the 20% energy performance target, but requires that all measures to be part of a cost effective work-scope. Cost effectiveness is defined through the application of a savings-to-investment ratio (a net present value calculation that compares the installed cost of an ECM to the present value of the future stream of cash flow resulting from the measure over the course of its depreciable life). Rather than trying to provide a one-size-fits-all solution to different building types, the flexibility to install any cost effective measure enables each building to address its own unique issues.

The Existing Building Component of MPP was designed with the recognition that all successful comprehensive energy efficiency projects must follow a similar process: plan, install, and measure. That is to say, each project needs to undergo sufficient pre-retrofit energy analysis and energy auditing to inform the development of an effective work-scope; improvements must be properly installed to achieve the anticipated savings; and finally, a post-retrofit energy analysis needs to be conducted to verify the achievement of the source energy reduction target.

The planning phase of MPP entails a detailed energy analysis and benchmarking of the building. The Benchmarking Tool (BT) used by MPP was developed by Oak Ridge National Laboratory, with funding from the US EPA. The dataset underlying the BT is the physical characteristics and energy usage information for 500 HUD properties from across the country. Use of the tool requires at least one continuous twelve-month set of all energy bills associated with the building to establish a usage baseline and benchmarking score. MPP requires the collection of apartment-level energy use information. Where whole-building data is available from master-metered buildings or for buildings where aggregated utility information is available, such whole-building data is used. For direct-metered properties a sampling protocol is utilized to extrapolate whole-building consumption. Therefore all of the energy use information discussed in this paper represents whole-building energy usage rather than just common area usage.

The BT serves three primary functions. First, at the outset of the project it performs a pre-retrofit analysis- resulting in an initial benchmarking score. Second, the tool performs a site/source conversion for all energy inputs where applicable- and uses that calculation to determine total source energy use intensity (EUI) expressed as kBtu/sqft/year. Finally, after the project is completed and twelve months of whole building post-retrofit data are entered into the BT, it calculates the post-construction source EUI and provides the achieved percent source energy reduction. MPP uses the post-retrofit percent source energy reduction number from the benchmarking tool to determine achievement of MPP's energy reduction target.

After benchmarking, all projects are required to perform a comprehensive ASHRAE Level II energy audit. MPP provides strict guidance to Partners to receive audit approval, including a standardized document template called the Energy Reduction Plan (ERP) that must contain the results of the audit. In addition to programmatic guidance (such as the provision of a list of measures that must be evaluated), MPP has developed a series of technical documents that guide work-scope development and energy simulation. The MPP Simulation Guidelines guide the development of energy model inputs for both the base model and the proposed energy conservations measures (ECMs). The program provides a set of "Minimum Performance Standards" which recommended ECMs must comply.

After the planning phase concludes with the approval of the ERP, installation of measures begins. MPP requires two inspections to be performed by the MPP Partner and a NYSERDA inspector, one at 50% construction completion, and one at 100% construction completion. Partners are required to supply cut sheets, invoices, and photographs documenting the installation of ECMs with each inspection request.

Finally, one year after the installation of the work-scope is completed, the post-construction analysis of energy performance is performed by the Partner.

Every deliverable from every project is subjected to in-depth quality control procedures implemented by either NYSERDA project managers, the program's implementation contractor (TRC Solutions), or the program's quality assurance contractor (Taitem Engineering). These procedures include a rigorous review of all ERPs and models as well as quality control inspections of ECM installations and the post-construction billing analysis.

Weather Normalization

It is important to note that while the MPP Benchmarking Tool does provide a partial correction for weather conditions to determine actual savings, it does not follow industry-accepted methodology for weather normalization. This can significantly impact the reported savings for individual projects, for example when the post-retrofit weather differs substantially from the baseline weather. NYSERDA is aware of this issue and is currently in the process of considering options for the development of a new tool that would meet industry-accepted standards for weather normalization.

In order to ensure that the data presented in this paper was adequately robust from a weather-normalization perspective, an 11% sample of all projects in the data set was extracted, and their percent source energy reduction at typical weather conditions was calculated using ASHRAE Guideline 14 protocols. We found that the results from the Benchmarking Tool differed from the weather-normalized results, on average, by 0.5% of total percent savings per every 1% change in heating degree days (HDD) between the pre-retrofit and post-retrofit year. We applied this 0.5% per 1% change as an adjustment factor to the entire group of buildings in the larger dataset to come up with an adjusted percent source energy reduction to see whether the Benchmarking Tool's shortcomings caused a systematic skewing of the findings reported here.

Because the total group of all projects is evenly balanced between warmer and colder post-retrofit years, applying the adjustment produced almost no change in the sum-total measured percent savings for the entire data set of buildings analyzed. By applying the adjustment factor, we found that the sum-total measured percent savings achieved by the entire group of buildings differed by less than one percentage point when compared to the original Benchmarking Tool results.

Data Set

The data set analyzed for this paper includes 219 projects that participated in MPP. The 219 projects include 1,562 buildings, 32,955 units, and 32 million square feet of space. The range of project sizes, locations, and building types represented in the data set is very broad:

- The data set includes everything from historic single-family homes converted into multifamily housing, to 500+ unit high-rise complexes.
- 33% of the projects are located within New York City (NYC), while the other 67% are scattered throughout the rest of New York State. While only a third of the projects are located in NYC, close to 50% of the units and square footage are located there.
- 84% of the projects in the data set qualify as affordable housing according to MPP's guidelines.
- 6% of the projects are publicly-owned rental housing, 13% are condos or co-ops, and the remaining 81% are privately owned rental housing.
- 61% of the projects are direct-metered or sub-metered for electricity with the residents paying for their own electricity usage. 35% of the projects have in-unit electric costs paid for by the owner either because they are master-metered or because they are direct-metered and the owner covers the cost. The remaining 4% had a variety of metering configurations within the same project. While we do not have complete data on the metering systems for heating, cooling, or DHW, we do know that in the majority of these projects, the building owner pays for heating and DHW.
- 40% of projects are heated with steam, 38% with hot water boilers, 8% with electric resistance, and 5% with furnaces. The remaining 8% of projects had multiple system types included in the project.
- 8% of projects were built before 1900, 25% are pre-war (1900-1945), 27% are post-war (1946-1969), 31% were built between 1970 and 1994, and 3% were built within the last 20 years. 6% of projects included buildings from more than one era.
- 47% of projects are low-rise (1-3 stories), 33% are mid-rise (4-10 stories), and 15% are high-rise (11+ stories). 5% of projects had various building heights.
- All but seven of the projects in the dataset examined in this paper used the energy simulation software TREAT to model building energy consumption. Other MPP-approved modeling software utilized by projects included eQUEST and EA-quip.

Unfortunately, at this time the program does not have access to complete data on several important building characteristics including heating and DHW controls, whether a project has a mechanical ventilation system, and what the configuration of that ventilation system is. That information is generally included in project records, but for projects that entered the program prior to July 2012, those records are written reports where data extraction requires significant time and effort.

Findings

Average delivered energy savings for the program are relatively strong with 73% of the projects reaching the program's required savings target. While the program requires that projects develop a work-scope that will deliver at least 20% savings (or 15% for the two V4 projects in the dataset), the majority of projects had work-scopes that projected significantly more savings. The average predicted energy savings per project for this data set was 27%, and the average actual savings achieved per project was 23%. Therefore, the average realization rate (i.e. the percent of the predicted savings that the project actually achieved) was 87% with a standard deviation of 45%. These figures include five projects that had projected savings of less than 20%, one of which was a V4 project with the 15% savings target and the remainder of which had reduced projected savings due to changes in their work-scopes during the construction process.

While the program's average savings are relatively strong, this average does not tell the whole story. One of the goals of MPP is to create demand for energy efficiency services in multifamily buildings. In order to achieve that goal, it is important that multifamily building owners investing in energy efficiency, and any potential lenders providing the capital for that investment, have confidence in the savings that the investment is predicted to achieve.

Figure 1 shows achieved versus predicted savings for all of the projects in the data set. The dotted red line represents the program's savings target of 20%. Projects falling above the dotted red line met the program's savings target and those below it did not. The dotted black line, which is not a trend line, represents perfect accuracy of saving predications. The further away from the line a project falls, the more savings were under- or over-predicted.

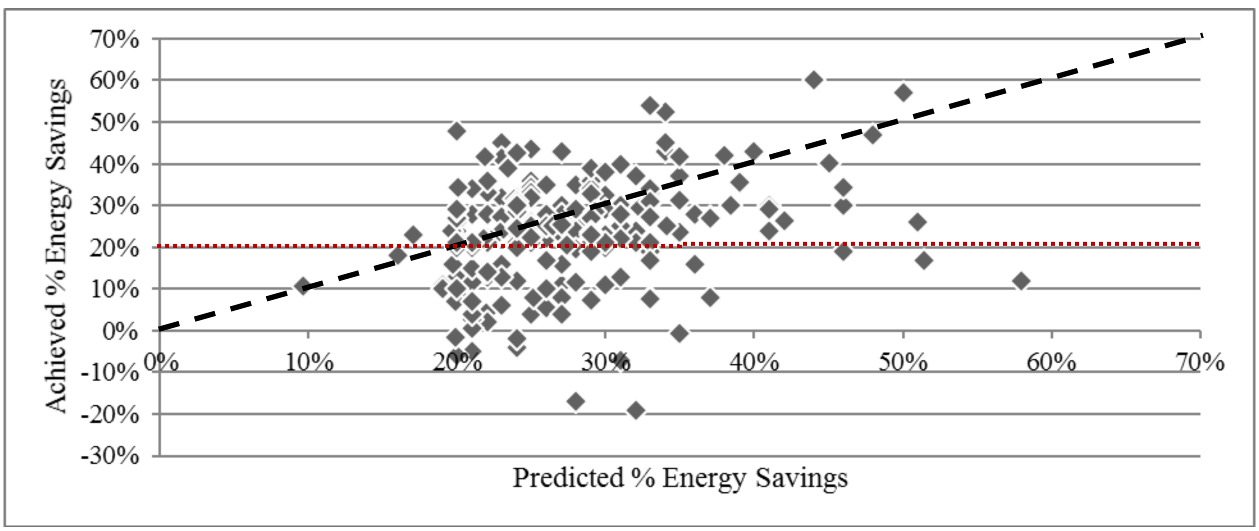

Figure 1. Achieved versus predicted percent energy savings. The dotted red line represents the program target. The dotted black line represents perfect accuracy of saving predictions.

It is clear from this scatter plot that the accuracy of predicted savings is not robust. Only 27% of projects came within 10% of the savings they predicted and achieved a realization rate of 90-110%. Those are the projects clustered along the dotted black line in Figure 1. The remaining 73% of projects over- or under-predicted savings, many substantially. The realization rates for this data are as low as negative 61% (meaning that the project increased their energy usage by

61% of what they planned to reduce it by) and as high as 240% (meaning that the project achieved more than twice as much savings as they predicted they would).

Project Characteristic Analysis

The wide range of realization rates shown in Figure 1 is the critical issue this paper attempts to explain. All the projects in this dataset went through a similarly robust program process, and all were subjected to relatively high levels of quality review. Yet some saved more than twice as much as projected, and some actually increased their energy consumption. To tease out the reasons behind this variation, we compared several different project characteristics to realization rates. Those characteristics included building age, project size, Partner experience level, projected savings, pre-retrofit source EUI, and project location. We sought to evaluate if any strong correlations existed between any of those characteristics and a project's success at achieving its predicted energy savings.

No strong correlations were found based on those characteristics. The strongest correlations (R^2) were a negative trend line for projected percent energy savings (0.0023), a positive trend line for pre-retrofit source EUI (0.0026), and a positive trend line for project location as determined by average heating degree days (HDD) (0.0029). Any correlation less that 0.03 is considered to be weak. Therefore, these factors cannot be considered to have had a meaningful impact on project performance, but they may indicate trends. Other project characteristics were examined as well, but the impact of non-quantifiable factors such as HVAC system type is difficult to judge.

Electricity Savings versus Fuel Savings

The program does not have access at this time to weather-corrected data separated between electricity and fuel, but we do have the actual billing data. We analyzed this data to gain a better understanding of how projects are performing on the achievement of electricity savings versus fuel savings.

Electricity Savings

The average predicted reduction in electricity usage for projects was 23%, and the average achieved reduction in electricity usage was 17%; the average realization rate was 91%. However only 11% of projects had an electricity realization rate of 90-110%, and the standard deviation for the realization rate was 165%.

Figure 2 shows predicted vs achieved percent savings for electricity consumption. Projects that were electrically heated achieved a high degree of accuracy in their electricity savings predictions, while projects heated with fossil fuels were significantly less accurate. Electrically heated projects could address heating and DHW improvements as part of their electric work-scope. This suggests it may be more difficult to accurately predict savings for lighting and plug load measures than it is for those addressing heating or DHW systems.

Heating Fuel Savings

The average predicted reduction in fuel usage (including gas, oil, and district steam) was 32% and the average achieved reduction was 28%. The average realization rate was 100%, however only 18% of projects had a fuel realization rate of 90-110%; the standard deviation for the realization rate was 104%.

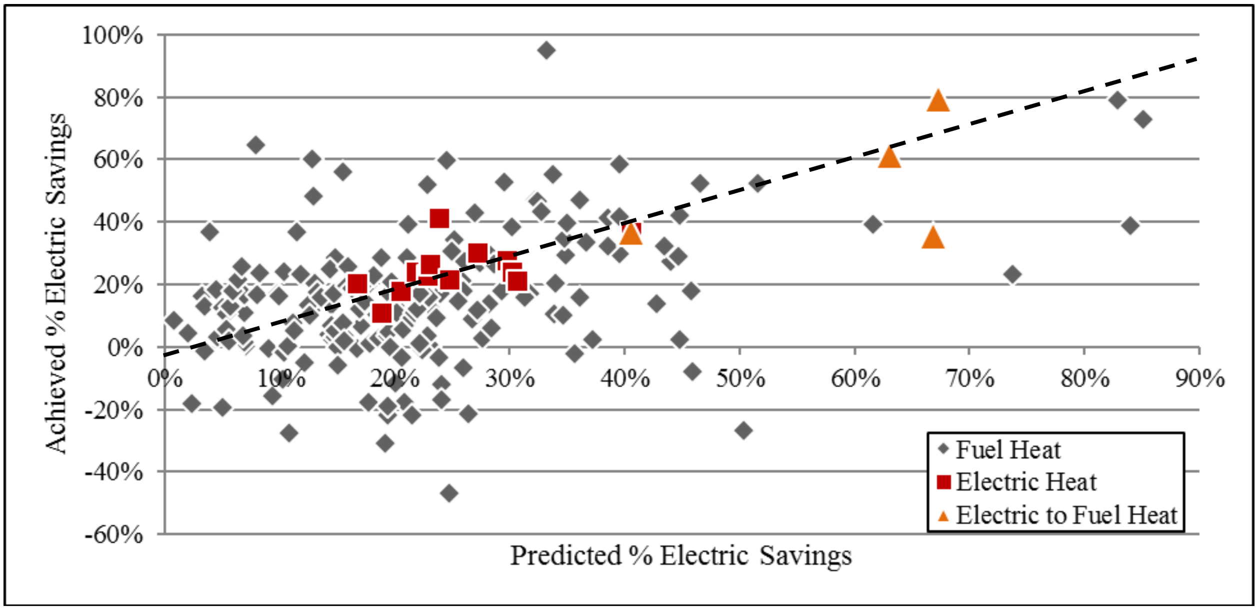

Figure 2. Electricity savings: achieved versus predicted. The dotted black line represents perfect accuracy of saving predictions.

These results, together with the very accurate results for electrically heated projects, imply that it is easier to accurately predict fuel savings than to accurately predict electricity savings. This may indicate fuel savings predictions are more accurate is because they predominantly deal with envelope and heating system improvements, and those measures may deliver more reliable savings. However, the lack of weather normalization means that no definitive conclusions should be drawn from this data.

Energy Factor

Energy factor (EF) is a weather-normalized metric that measures the efficiency of a building's heating system based on the energy content of the fuel used for heating, the square footage of the building, and the HDD for the time period being measured. Due to a lack of detailed billing data we were unable to calculate the EF for eight of the projects, but the following analysis does contain pre- and post-retrofit EFs for the remaining 211 projects.

The program-wide average pre-retrofit EF was 10.7 btu/sq.ft./HDD, and the average post-retrofit EF was 7.1 btu/sq.ft./HDD. The average reduction was 24% (with a standard deviation of 34%). MPP does not require a prediction of EF reduction, but only 13% of projects failed to see a reduction in their EF, and 58% of projects saw an improvement of 25% or more, which indicates that projects were relatively successful at achieving heating efficiency improvements.

Measure Analysis

We next analyzed the project work-scopes to try to determine the impact of ECMs on achieved savings. Because MPP only collects data on how much savings the whole building achieved, we were unable to disaggregate savings by ECM and could only draw conclusions indirectly. The projects in the dataset had between 2 and 18 unique ECMs, with an average of 8.2 measures per project. There is no correlation between the number of ECMs and the success of a project at achieving its predicted savings.

Table 1 shows the measures that occurred most frequently and predicted to save the most energy. We focused our analysis on these ECMs since they likely impacted savings the most. In past analyses with smaller datasets, we had seen a significant difference between the performance of projects located in NYC and projects located outside NYC. This difference is less pronounced now that the dataset includes more projects, but to be thorough, we looked at the ECM data using the aggregated data from all the projects, and also using the data from NYC and non-NYC projects separately. Where significant differences were found by project location, they are noted in the table.

Correlations for Predicted Savings of Specific ECMs

We compared the achieved whole-project realization rate to the predicted percent source energy reduction for each ECM. Seven ECMs showed moderate (0.3-0.5) or strong (>0.5) correlations (R^2), as shown in Table 1. Nearly all ECMs had negatively-sloped trend lines. That is, as the predicted savings for that ECM increased, the whole-project achieved realization rate decreased. We interpret the negative slope as an indication that the savings for these ECMs is being overestimated. It is unclear from our data whether the overestimation is an indication of systematic overestimation by specific Partners, or if these ECMs are drivers of the overall likelihood of success of a project. In either case, high estimations of savings for these ECMs should raise red flags in future projects.

For the two ECMs where trend lines had positive slopes – atmospheric to condensing boiler replacements and roof insulation (both for NYC projects only) – conclusions are harder to draw. We feel that the positive slopes are not sufficient rational to justify any encouragement of deeper savings predictions in the Simulation Guidelines. The positive slopes may indicate that these measures are critical measures when they appear in a project's work-scope, and that they can drive the whole project to success. They may also be a fluke of our data (e.g. there are only 5 NYC projects with atmospheric to condensing boiler replacements in our dataset), and as more projects are added to the dataset, the correlations may disappear.

Maximum Recommended Predicted Savings

For many of the ECMs shown in Table 1, our scatter plots for a specific ECM showed clear cutoffs for reasonable predicted savings that we list as recommended maximums. Most (81%) of the projects in this dataset were from program Versions 1 or 2. The Simulation Guidelines document that was released with V3 of the program makes recommendations for how to conservatively estimate savings by defining the inputs that should be used in representing the ECM in the modeling tool. It is hard to directly compare the Simulation Guidelines that were developed by NYSERDA's experienced energy modelers to our recommendations below that are based on actual savings data collected by the program. However, some encouraging trends are evident:

First, for seven of the ECMs where we make a recommendation for maximum savings, the average percent source energy reduction decreased between projects submitted before and after the Simulation Guidelines went into effect. Second, the upper end of the range of projected savings seen in Versions 3 and 4 aligns almost exactly with the maximum savings recommendations for those seven ECMs based on this dataset. We will take both trends into consideration when future revisions of the Simulation Guidelines are released, especially for the three ECMs whose averages did not decrease in this dataset.

Table 1. Energy conservation measures

Measure	% of projects with ECM	Average predicted % source energy reduction	% of projects with a realization rate > 90%	Average realization rate of projects w/ECM	Correlation[1,2] (r)	Recommended maximum % source energy reduction
Air Sealing	44%	4.3%	51%	90%	-0.14	
Apartment Lighting Upgrade	79%	2.6%	53%	88%	-0.39 (NYC only)	3%
Attic Insulation	31%	3.8%	64%	100%	-0.06	
Boiler Replacement - Atmospheric to Condensing	18%	11.5%	59%	101%	0.83 (NYC only) -0.42 (non-NYC only)	15%
Boiler Replacement – Same to Same	16%	7.2%	51%	91%	-0.06	10%
Common Area Lighting Upgrade	78%	2.0%	52%	86%	-0.12	6%
DHW Replacement - Atmospheric to Condensing	18%	3.0%	56%	97%	-0.43	5%
Energy Management System	16%	6.3%	33%	64%	-0.37(NYC only) -0.62 (non-NYC only)	6%
Motor Improvement	18%	1.3%	41%	73%	-0.48	2%
Pipe Insulation	29%	1.6%	54%	85%	-0.23	3.5%
Refrigerator Replacement	64%	2.4%	50%	84%	-0.03	
Roof Insulation	22%	2.9%	52%	83%	0.36 (NYC only)	
Thermostatic Radiator Valves	16%	3.9%	46%	84%	-0.11	
Wall Insulation	16%	5.2%	62%	99%	-0.20	
Windows	46%	5.9%	55%	88%	-0.35 (NYC only)	12%
All Projects			53%	87%		

[1]This is the correlation between the predicted percent source energy reduction for the ECM and the whole-building achieved realization rate.
[2]Where only one correlation is listed, it is the correlation for all the projects regardless of location.

Outlier Analysis

Since much of our preliminary analysis was inconclusive, we also conducted an analysis of a sample of the projects that significantly over- or under-predicted savings to see if there were any patterns in what caused the inaccurate energy savings predictions. A total of 28 projects were selected: 6 projects that significantly under estimated savings (realization rates of 150% or higher), and 22 projects that significantly over estimated savings (realization rates of 50% or less). Each project was impacted by several different factors that affected their realization rate, and those factors differed significantly from project to project. However, for each project, we were able to identify the factor that had the greatest impact on their realization rate. Those factors fell into four different categories.

Under-achievers: Over-Estimated Savings (15 projects)

The most common factor negatively impacting realization rate in our outlier sample was over-estimated savings. It was classified as the greatest impact factor in 15 projects and appeared as a secondary factor in all but two of the other under-achieving projects in the sample.

Of the projects that fell into this outlier category, 13 of the 15 were V1 or V2 projects that participated prior to the release of the Simulation Guidelines. The measures in the V3 projects that were the most egregiously overestimated were a steam-to-steam boiler replacement that studies have shown rarely achieve any significant savings (Shapiro 2010), and an oversized Combined Heat and Power (CHP) system. Neither of these measures is addressed in the Simulation Guidelines. Some of the measures with the most drastically over-predicted savings in the V1 and V2 projects were window replacements, EMS installations, TRVs, pipe insulation, aerators, and air sealing, all of which are addressed by the Simulation Guidelines.

Encouragingly, the measure analysis on EMS installations shows a steep reduction in the over-prediction of savings in later Versions of MPP: the average predicted savings for EMSs in V1 and V2 projects was 7.1%, but it was only 3.9% in V3 and V4 projects. While we have not yet seen a significant improvement in overall realization rate in the V3 and V4 projects in this paper's data set, we hope that as data continues to come in, an improvement becomes apparent.

Under-achievers: Added Load (5 projects)

These projects either made load-increasing capital improvements during the same timeframe as the efficiency scope was installed or during the monitoring period, or MPP work-scope added load that was not accounted for in the modeling of the ECMs. Examples included:

- An existing heating system reportedly had significant down time during the pre-retrofit billing analysis year, and provided inadequate heat to the building even when operating. As a result, the boiler replacement measure likely increased energy usage.
- The addition of new laundry rooms, security lighting and cameras, a new computer lab, and upgraded basement lighting (left on 24/7) increased electricity consumption.
- New power-vented DHW heaters use more electricity than the old atmospherically-vented DHW heaters; the fans on the new condensing furnaces use more electricity than fans in the old furnaces; and the new bathroom exhaust fans also use more electricity. None of these increased electric loads were accounted for in the model.

Some of the issues uncovered could have been caught in inspections, while others could have been addressed by better energy modeling, but some of the issues were outside the MPP work-scope and therefore are more difficult to address.

Mixed Results: Issues With Billing Analysis (4 projects)

Two of the projects in this outlier category had less than a 50% realization rate and the other two had a realization rate of 150% or more. Examples of issues included:

- Oil usage was missing from the pre-retrofit analysis. With the missing account included, overall energy savings jumps from 8% to 16% and the realization rate increases from 32% to 64%.
- The building was reported to be approximately 75% occupied pre-retrofit, but post-retrofit occupancy was closer to 100%. This was not taken into account in the post-retrofit analysis. Adjusting the pre-retrofit usage to a 100% occupancy rate increases the savings from 4% to 15.6% and the realization rate from 15% to 58%.
- The post-retrofit analysis of a building that served mainly as military housing used apartment accounts that showed significant periods of vacancy, likely from soldiers being deployed. When corrected for vacancy, the building saved 26% rather than 43%, much closer to the projected savings of 27%. The realization rate decreased from 159% to 96%.

The program relies on Partners to identify all relevant utility accounts and to flag any significant changes in occupancy so that they can be appropriately incorporated into the billing analysis. These are issues that are difficult to detect during inspections and Partners have little incentive to seek out issues that have a negative impact on savings and the level of incentive their client is eligible to receive, so these are difficult issues to address. Hopefully, the more rigorous billing analysis protocols initiated by the program in Versions 4 and 5 will address some of these billing analysis issues.

Over Achievers: Additional or Enhanced Measures (4 projects)

These projects installed more ECMs than reported to the program, or the improvements made were better than reported. These types of issues are very challenging to address from the perspective of a program administrator since we have little control over what a participant chooses to include or not include in their MPP work-scope. We hope that the Partners work with participants to understand the full scope of the improvements being installed on the property so that even if those improvements are not reflected in the MPP work-scope, they can be taken into consideration when the participant is analyzing predicted and actual savings.

Other Outlier Issues

While the issues identified above were classified as the main causes of over- or under-prediction of savings in a project, every project was impacted by multiple factors. Other common issues included anecdotal evidence of increased plug load, and the removal by tenants of unpopular in-unit measures like aerators, lighting controls, and CFLs after installation.

Conclusion

This analysis was unable to explain the high degree of variation in predicted versus actual energy savings for the projects in this dataset, but it does highlight many of the factors that have an impact on savings achievement. Some factors are not surprising, such as over-predicted savings for ECMs, which can be addressed with better-trained modelers and more robust program (or industry) guidelines for modeling. Other factors are less intuitive and more difficult to address, including trends showing that savings from improvements to heating systems appear to be easier to accurately predict than savings from improvements to electrical systems, and trends that show differences in performance between NYC and non-NYC projects.

The analysis does clearly illustrate what most industry practitioners already know: multifamily retrofit projects are complex and challenging. The success of a project depends not only on the technical skills and experience of those conducting audits, creating models, and installing ECMs, but also on the behavior of a multitude of stakeholders, including owners, residents, and building operators. Many of the issues raised in the outlier analysis cannot be addressed with program rules or technical guidance, but might have been addressed by better project management by the technical service providers. Those types of non-technical skills need to be emphasized in the training of service providers because they play such a critical role in complex projects like these.

While this data highlights the difficulty of accurately predicting savings on a project-by-project basis, it does show that robust savings can be achieved on a portfolio-wide basis. MPP's program-wide averages are relatively strong. Those projects that drastically over-predicted savings are countered by those that drastically under-predicted, and while there are outliers that did not achieve any savings, the vast majority of projects achieved a reasonable level of savings, with many achieving far more than they predicted. Based on this data, owners of large portfolios should have confidence that investing in efficiency across their portfolio will yield positive results. A separate cash flow analysis conducted on the program found that to cover debt service, the required average breakeven realization rate 80%, assuming that projects borrowed at an interest rate of 6% and a loan term of 10 years to cover all project costs not covered by program incentives. Furthermore, if the loan term is lengthened to match the weighted lifetime of the work-scope, the required realization rate drops to 56%. Even at the higher 80% realization rate level, 63% of the projects in this data set would have broken even on a cash basis, even if they took out loans to cover all of their out-of-pocket costs for the project.

It is critical to the growth of the energy efficiency market that we improve the accuracy of savings predictions to decrease the risk involved with investing in efficiency. The first step in doing so is to track and analyze actual savings data to discover changes that practitioners or program administrators can make to improve the accuracy of savings predictions and to discover which factors cannot be changed, so that building owners and investors better understand the inherent risks and the likelihood of project success.

References

Falk, L. and L. Robbins. 2010. "Results from NYSERDA's Multifamily Performance Program: Getting 20% Reduction in Multifamily Buildings" In *Proceedings from the American Council for an Energy Efficient Economy 2010 Summer Study on Energy Efficiency in Buildings,* 2:60-75. Washington, DC: ACEEE.

Shapiro, I. 2010. "Water & Energy Use in Steam-Heated Buildings." *ASHRAE Journal* May 2010:14-18.