Results from NYSERDA's Multifamily Performance Programs: Getting 20% Reduction in Multifamily Buildings

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ABSTRACT

For decades both electric and fuel-based energy efficiency programs targeting the multifamily residential sector have been deployed across the country. Despite the long history of programs and their evaluations, there is a dearth of multifamily post-construction billing analysis available. As cash flows from energy savings are beginning to play a crucial role in the development of financing mechanisms (including PACE, on bill recovery) and underwriting criteria, post-construction billing data is of paramount importance. This paper examines a billing analysis conducted on all of the projects that completed NYSERDA's Multifamily Performance Program as of the writing of this paper. The sample includes 93 buildings with over 3,600 units of housing, representing more than 3.4 Million square feet of space. The common process and strict quality control shared by each of these projects, coupled with the billing analysis, give insight into the accuracy of modeled savings and the impact of heating system type and building height on savings realization. An examination of the outliers contained in this dataset gives rise to important lessons regarding the negative impact of take-back and unanticipated load growth on the success of efficiency projects, which all underwriters and administrators should understand when relying on predicted savings to guide financial decision making. The Multifamily Performance Program challenged buildings owners to reduce their buildings' consumption by 20%. The observed average energy savings per project was 19.7%, which the authors interpret as a successful program outcome. Projects in MPP tended to over-predict electric savings and under-predict fuel savings.

Introduction

In May of 2007 NYSERDA launched the market transformation-focused Multifamily Performance Program (MPP), which challenged all participating projects to reduce their total source energy consumption by 20% and awarded a "New York Energy $mart Building" performance indicator (in the form of a plaque) to each successful existing building project. In order to evidence achievement of the performance target, projects are required to enter twelve months of pre and post retrofit energy usage into a benchmarking tool developed by Oak Ridge National Laboratory. The benchmarking tool converts this consumption data to source energy values using different factors for all fuel types, and then applies a regression analysis to it. The result is a weather-normalized total source energy reduction value, which is expressed as a percentage of the baseline year's use. Projects that achieve or exceed 20% reductions receive additional incentives from NYSERDA.

This paper examines the preliminary results of MPP by looking at the initial portfolio of projects that have completed construction and performed the post-retrofit billing analysis required by the program. The dataset is comprised of 17 projects, all of which participated in MPPs "Existing Buildings Component." The 17 projects represent 93 buildings with over 3,600 units of housing, and 3.4 Million square feet of space. The value proposition of this dataset lies in the uniformity of the process shared by all participants and the highly quality-controlled documentation associated therewith. Through billing analysis, examination of project work-scopes, inspection reports, and interviews with owners and their energy consultants, information emerged about the accuracy of whole building energy modeling, the efficacy of a performance-based approach to program design in the multifamily sector, and important lessons from the outliers.

Background

In May of 2007 NYSERDA launched the Multifamily Performance Program (MPP), which challenged all participating projects to reduce their total source energy consumption by 20%. The program represented the culmination of knowledge acquired through the deployment of several disparate multifamily energy efficiency programs by NYSERDA since the late 1990's. NYSERDA seized upon the opportunity of a renewed Systems Benefits Charge allocation in 2006 (commonly referred to as SBC III) to consolidate these efforts into a single soup-to-nuts program, which offered New York State's diverse multifamily market a single point of entry, a standardized process for all projects, varying schedules of incentives, and a market-based approach to technical service provision.

MPP is relatively novel for its use of a performance-based approach in the multifamily sector. In addition to focusing participants' attention on measured energy performance rather than simply the installation of energy conservation measures (ECMs), the program attempts to be user friendly through the use of a fixed incentive schedule based on building size, which all building owners can easily understand prior to entering the program.

MPP employs a market-based approach to technical service provision. 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. This enables participating building owners to have the flexibility to work with service providers of their choosing. MPP Partners shepherd projects through the program from beginning to end. Minimum technical service requirements 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 re-benchmarking and conducting a final billing analysis one year post construction,

In an effort to tailor the program to the diverse multifamily marketplace, MPP allows buildings to choose the energy measures they wish to pursue in order to achieve the 20% energy performance target. Through July 2009[1i] MPP required all measures to be part of a cost effective work-scope. Cost effectiveness was defined through the application of a savings-to-investment ratio (a net present value calculation, which compares the installed cost of an ECM to the present value of the future stream of cash flows 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 enabled each building to address and correct the unique issues it faced. It also enabled a whole-building approach because even costly

[1] After July 2009, in accordance with New York State Public Service Commission's "Order On Rehearing Denying In Part And Granting In Part Petition For Rehearing" in Case 08-E-1132, dated December 23, 2009 MPP will require each ECM to be cost effective as defined by the application of the Total Resource Cost test at the measure level.

and sometimes non-cost effective measures such as windows and large boiler retrofits could be wrapped into a cost effective whole-building package. The market responded well to this approach, and participation in MPP is robust.

Multifamily Performance Program Pipeline[2]		
	Existing Buildings	New Construction
Active Projects	549	240
Active Buildings	3,421	271
Active Dwelling Units	95,771	13,441
Active Square Footage	100,294,204	15,822,262

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; that work-scope needs to be properly installed to achieve the anticipated savings; and finally, energy analysis needs to be conducted ex post-facto to establish the achievement of the 20% source energy reduction target.

The planning phase of MPP entails a detailed energy analysis of the building. Benchmarking is required of all projects. The benchmarking tool used in MPP was developed by Oak Ridge National Laboratory with funding from US EPA under the auspices of a national working group seeking to develop an ENERGY STAR performance indicator for Multifamily High-rise Buildings. The dataset underlying the Benchmarking Tool is comprised of physical characteristics and energy usage information for 500 HUD properties from across the country. Use of the tool requires at least one contiguous 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, and uses a sampling protocol to extrapolate whole-building consumption. When energy use information is discussed here it is not simply common area use; it is our best approximation of whole building data.

In order to understand how we derived the data contained in this paper it is important to understand some technical aspects of the program. The benchmarking tool offers three primary functions. First, at the outset of the project it performs a pre-retrofit regression 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 a total source energy use intensity value expressed as kBtu/sqft/year. The source/site conversion factor for electricity is 3.34[3] (there are no conversion factors for oil and gas as these fuels are burned on site). Finally, after the project is completed and twelve months of post-retrofit data are fed into the tool, it provides a post-retrofit, weather-normalized, total source energy reduction value expressed as

[2] As of March, 2010.

[3] This value will be changed in July 2010 at the request of New York State Department of Public Service staff to 2.98, in order to better reflect the electric generation mix of New York State.

percentage. The regression analyses performed by the tool use total source energy intensity as an independent variable and other factors such as energy use, weather data, building size, the presence of laundry hook ups, and percentage of cooled floor area as dependant variables. To restate, it is the post-retrofit, weather-normalized source energy reduction which is determinative of achievement of the 20% source energy reduction target established by the program.

In addition to benchmarking, all projects are required to perform a comprehensive, ASHRAE Level II energy audit. Along with a standardized document template called an "Energy Reduction Plan" within which the results of the audit must be contained, MPP provides strict guidance to which the MPP Partners must adhere in order to receive audit approval. In addition to programmatic guidance (such as the provision of a list of measures that must be evaluated), contained in a "Program Guidelines"[ii] document), MPP has developed a series of technical documents that guide work-scope development and energy simulation. The MPP "Simulation Guidelines" provide equations to which existing building conditions can be applied, and which result in the development of energy modeling inputs. The program provides a set of "Minimum Performance Standards"[iii] with which all recommended ECMs must comply.

All of the projects in the dataset examined in this paper used the energy simulation software TREAT. TREAT was developed, in part, with funding from NYSERDA. It utilizes a simulation engine called SUNREL®. SUNREL, an hourly building simulation program, is an upgrade of SERI-RES, which was released in the early 1980s by the Solar Energy Research Institute (SERI) that has since been incorporated into the National Renewable Energy Laboratory.[iv] Other MPP-approved modeling software includes eQUEST and EA-quip.

After the planning phase concludes with the approval of the Energy Reduction Plan, installation of measures begins. MPP requires two inspections to be performed by the MPP Partner, one at 50% construction complete, and one at construction completion. Templates for the inspection reports are auto-generated from the Benchmarking Tool, which houses a table outlining the detailed list of recommended measures. These inspection templates are supplemented with cut sheets, invoices, and photographs documenting the installation of ECMs.

One year after measures are installed, post-construction analysis of energy performance can begin. For MPP, this entails the collection of energy bills and going through the process of re-benchmarking the project to determine the total, post-retrofit, weather-normalized, source energy use reduction. If a project meets or exceeds the 20% energy performance target, it receives a plaque indicating its accomplishment and is designated a New York Energy $mart Building.

NYSERDA uses an implementation contractor (currently TRC Solutions) in conjunction with NYSERDA project managers to perform quality control on all deliverables submitted through the program. This includes a rigorous multi-layered third-party review of all Energy Reduction Plans and models as well as quality control inspections of ECM installations,

Whole Building Energy Analysis: Methods & Results

Multifamily whole-building energy retrofits are large capital improvement projects that typically take years to complete. MPP provides up to 34 months for projects to reach completion (this includes time for preparation of the Energy Reduction Plan, installation of measures, a year for consumption data to accrue post construction and time to analyze that data). Due to the long timeline of the program only 17 projects reached completion in time to be analyzed for this paper.

Although 17 projects is a small sample size, an examination of their outcomes can begin to provide an informative preview of trends that apply to the greater multifamily market. Also, the trend in energy efficiency policy nationally seems to be the development of financial products (including PACE, on-bill recovery) and energy underwriting criteria that rely on cash flows from energy savings to satisfy debt service. The authors feel that any relevant information, even preliminary data that can be brought to bear to better inform the activity of stakeholders involved in this effort should be shared publicly.

The table below contains basic information on the 17 projects that make up the dataset. The projects represent a wide variety of building sizes and configurations from locations throughout New York State.

Project	SF	Bldgs	Units	Floors	Heating System	Market Type	County
135 Broadway	7,500	1	13	4	Hydronic	Affordable	FRANKLIN
16 Oakland	11,973	1	12	3	Electric Baseboard Heat	Affordable	ORLEANS
268 Alexander	23,232	1	38	3	Hydronic	Affordable	MONROE
2911 West 36th Street	227,355	1	259	20	Two-Pipe Steam	Affordable	KINGS
3601 Surf Avenue	175,025	1	197	19	Hydronic	Affordable	KINGS
525 East 82nd Street	109,000	1	94	13	Hydronic, Absorption Chiller	Market Rate	NEW YORK
921 Columbia	3,924	1	5	3	Hydronic	Affordable	COLUMBIA
Chelsea Ridge	816,904	39	835	3	Hydronic	Market Rate	DUTCHESS
Mercer's Mill	72,592	10	80	2	Electric Baseboard Heat	Affordable	ONONDAGA
NYCHA	618,000	7	413	3-17	Steam	Affordable	BRONX
Peace Bridge	63,156	1	125	2	Steam	Affordable	ERIE
Plaza, The	333,030	2	385	6	Steam	Affordable	KINGS
Scotch Grove	34,866	2	38	2-3	Electric Baseboard Heat	Affordable	OSWEGO
Skyline Apartments	343,148	1	361	12	Steam	Affordable	ONONDAGA
Spring Creek Gardens	430,352	3	582	4-7	Hydronic	Affordable	KINGS
Tri-Light Court	27,507	4	32	3	Hydronic	Affordable	BROOME
Wilna Housing Authority	113,340	15	100	2	Furnace	Affordable	JEFFERSON

While the program requires that projects develop a work-scope that will deliver at least 20% savings, the majority of projects develop work-scopes that are projected to save significantly more. On average, when all of the approved Energy Reduction Plans for existing buildings in MPP are considered, the average energy savings prediction per project is 28%. These 17 projects predicted an average savings of 30%. The chart below shows each project’s energy savings target and the actual weather-normalized percentage of source energy savings achieved. Projects above the line met the program’s savings target of 20% and projects below the line did not.

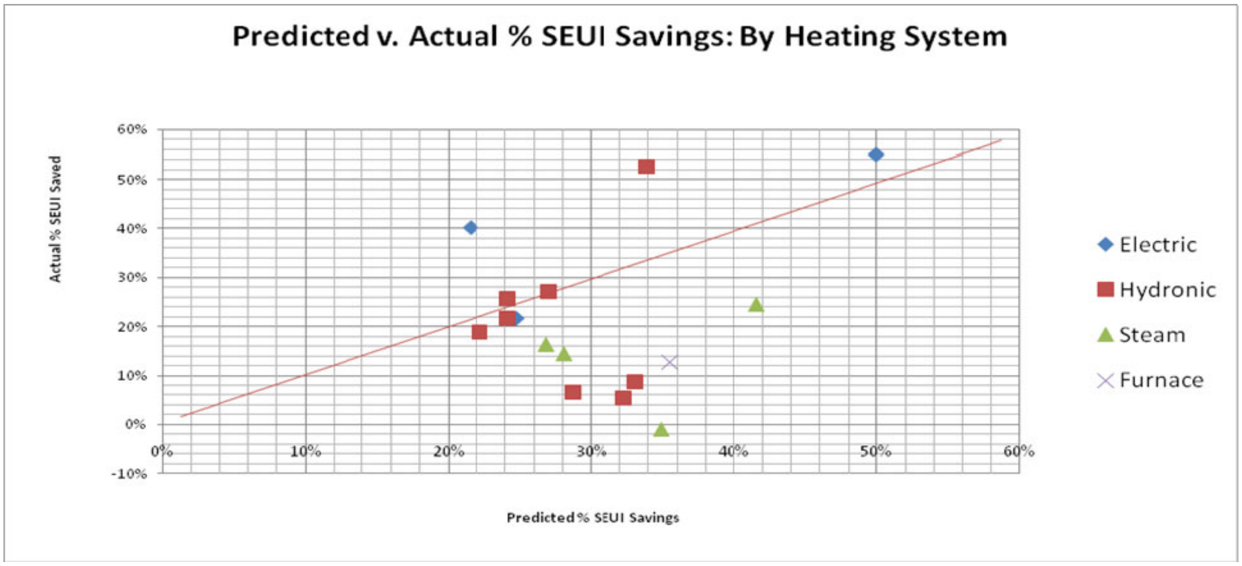
The Multifamily Performance Program challenged projects to reduce their SEUI by 20%. Remarkably, the average per-project observed SEUI savings is from this dataset is 19.7%. The total SEUI savings across the program (total baseline SEUI across all project compared to total SEUI savings for all projects) is 22%. We consider this data-point to be evidence of MPP’s success.

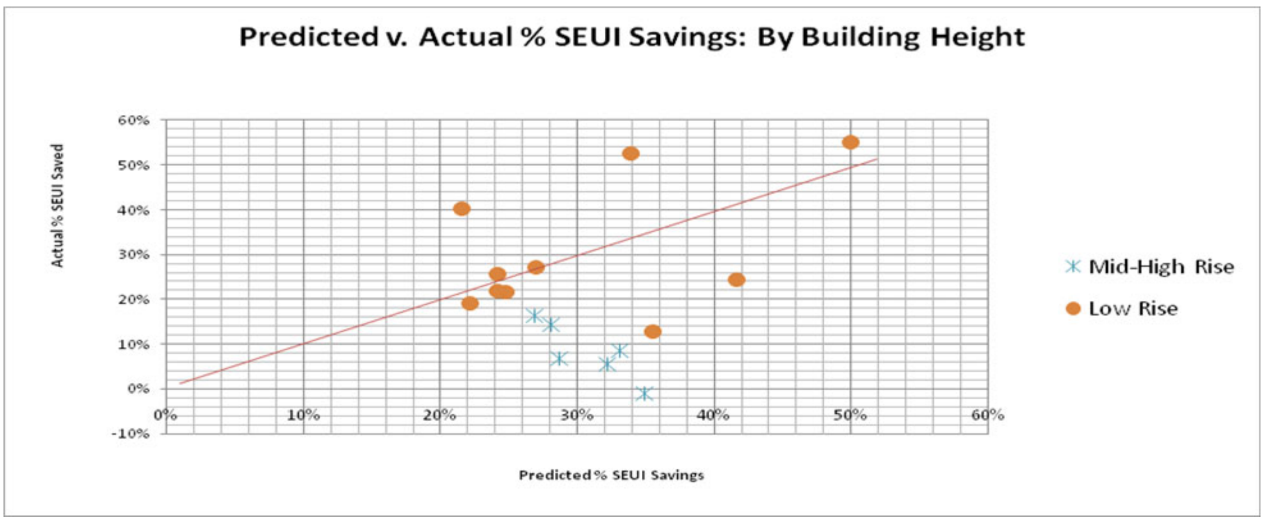
59% of the projects reached the program's required 20% savings target. The projects that did meet the program target achieved an average savings of 30% while the projects that did not achieve a 20% reduction missed the target by an average of 11%. Unsuccessful projects' average savings was 8.7%.

Project	Savings Target	Savings Achieved	Rise	Upstate/Downstate	Units
16 Oakland	50%	57%	Low	Upstate	12
921 Columbia	34%	52%	Low	Upstate	5
Scotch Grove	22%	39%	Low	Upstate	38
268 Alexander	27%	29%	Low	Upstate	38
135 Broadway	24%	27%	Low	Upstate	13
Skyline Apartments	33%	27%	Mid-High	Upstate	361
Peace Bridge	42%	26%	Low	Upstate	125
Mercer's Mill	25%	22%	Low	Upstate	80
Chelsea Ridge	22%	21%	Low	Upstate	835
Tri-Light Court	24%	20%	Low	Upstate	32
NYCHA	27%	14%	Mid-High	Downstate	413
Plaza, The	28%	14%	Mid-High	Downstate	385
Wilna Housing Authority	36%	14%	Low	Upstate	100
Spring Creek Gardens	33%	8%	Mid-High	Downstate	582
3601 Surf Avenue	29%	7%	Mid-High	Downstate	197
525 East 82nd Street	26%	5%	Mid-High	Downstate	94
2911 West 36th Street	35%	-1%	Mid-High	Downstate	259

The chart above clearly illustrates a difference in the success rate of upstate and downstate projects. It should be noted, however, that these buildings' location in New York City is not necessarily the driving factor at play. There is an unmistakable correlation between building height and the frequency with which buildings met the program savings target; only one tall building, Skyline, a twelve-story building, achieved the target, whereas only one low-rise project did not. Because the distribution of taller buildings in this dataset is almost entirely concentrated downstate, it is difficult to determine the extent to which each characteristic, building height or location, is more responsible for this outcome without additional information.

In order to illuminate other trends across projects regarding the achievement of predicted savings, we created a series of scatter-plots through which predicted Source Energy Use Intensity (SEUI) savings are compared to observed SEUI savings. Each scatter-plot applied a different filter, such as building market type, location, heating system type, and, building height. Below, we have reproduced two of the scatter plots for Heating System Type and Building Height. The diagonal line on these charts is not a trend line. Instead, it represents perfect accuracy of saving predications. The further above the line, the more savings were under-predicted. The further under the line, the more savings were over-predicted. It is important to note that these scatter plots only reflect the accuracy of modeled savings, and do not examine those savings as a function of the achievement of the MPP 20% energy reduction target.



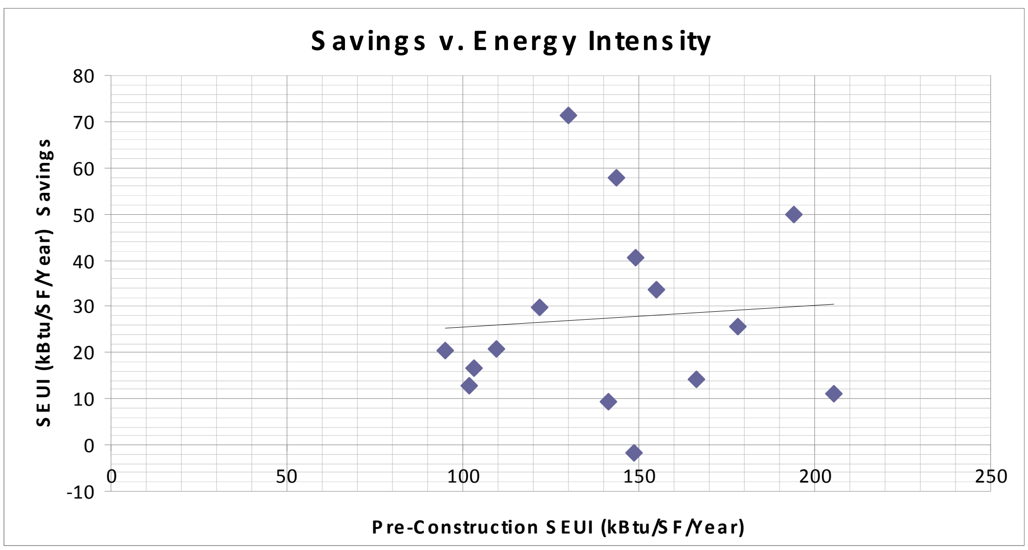


The results are instructive. First, it is clear that most projects over-predicted savings. That finding will be examined in greater detail later in the paper. In the heating system scatter-plot it is easy to recognize that electrically heated buildings tended to approach and exceed their predictions, while each steam-heated building over-predicted its savings.

The second scatter-plot, which expresses the accuracy of modeled savings as a function of building height gives rise to an interesting discussion. All of the mid- and high-rise projects over-predicted savings. Although, as was stated earlier, we cannot conclusively distinguish a causal relationship between location, building height, and savings realization, we can speculate as to the potential drivers of the observed trends with this additional data in mind. Considering building height as a primary driver of energy performance immediately calls to mind the question of stack pressures. There is wide consensus that stack pressures are an important driver of energy performance in buildings.[v] From a building science perspective, it makes sense that low-rise buildings would achieve savings targets more frequently than mid- and high-rise buildings. Diminished stack effect in low-rise buildings makes it easier to control energy losses associated with infiltration and exfiltration. The proceeding scatter plot shows a clear correlation between building height and over prediction of savings, which would seem to reinforce the consensus view that stack pressures can have a significant impact on building performance.

However, as will be discussed in greater detail later in the paper, predictions of fuel savings in this dataset tended to be more accurate than electric savings (which were significantly over-predicted). While one might draw the conclusion from the scatter plot that stack pressure is the primary cause behind savings over-prediction in taller buildings, the fuel savings data does not support that conclusion. For example, the NYCHA project, contained a high rise building, but under predicted its fuel savings. Likewise, the Skyline Apartments project is a high-rise that accurately predicted fuel savings. In fact, the data seem to suggest that there is a more pronounced correlation between building height and over-prediction of electric savings than fuel savings. Whether that is due to modeling software or an aspect of MPP program design (such as inadequate inspection enforcement, which the authors do not believe to be the case), or other factors remains unclear. What is clear is that each of the mid- and high rise buildings over-predicted electric savings. All of the electrically heated buildings in the dataset were low-rise, and, as can be seen in the first scatter plot, two of the three projects under-predicted electric savings, while the third was accurately predicted.

The scatter plot below compares projects' pre-construction Source EUI to the amount of Source EUI savings they were able to achieve. It is a commonly held belief that projects with higher baseline energy intensities have a greater potential to save energy, but the trend-line on this chart suggests that is not the case with the projects in this sample. The trend-line shows only a slight correlation between buildings' pre-construction SEUI and their ability to save energy.



Energy Analysis by Fuel Type: Methods & Results

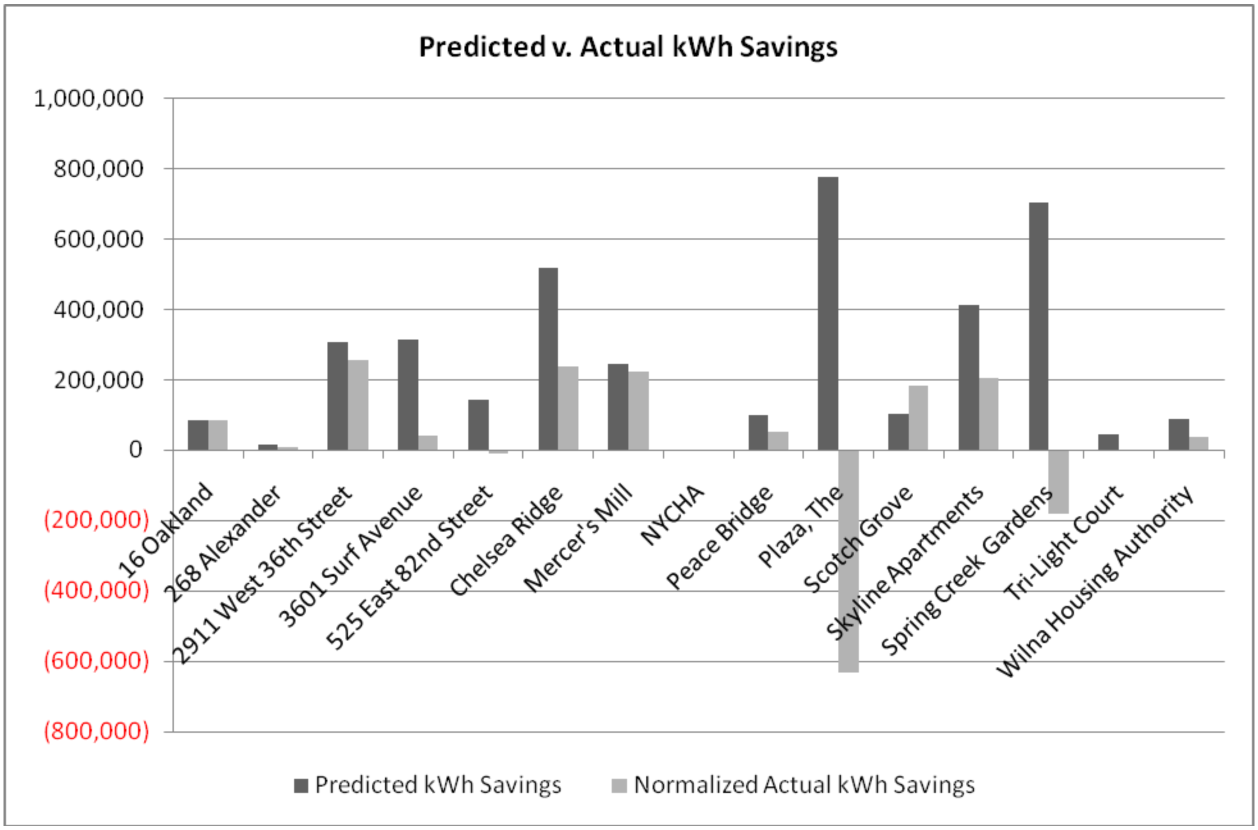
The percentage of source energy savings and the Source EUI values expressed by the benchmarking tool allow us to measure the success or failure of a project relative to the achievement of our performance target, but, as was highlighted in the building height discussion earlier, these values do not provide sufficient detail to illuminate energy savings by fuel type, nor do they begin to answer questions as to which types of energy saving measures contributed to projects' successes and failures.

Pre and post-construction energy bills have the potential to show realized energy savings over the course of the year by fuel type. These bills must be normalized for weather severity in order to facilitate differentiation of weather-dependent changes in energy use from observed savings. In order to dig deeper into the data we utilized two different analysis methods to normalize post-construction energy usage data to pre-construction baselines.

First we used ASHRAE's Inverse Modeling Toolkit (IMT). IMT is an application that weather normalizes pre-construction energy usage to post-construction energy usage in order to calculate normalized electric and fuel savings. It also enables a month-to-month comparison of pre and post-retrofit energy use information. IMT was developed by the University of Dayton in Texas A&M University under ASHRAE TRP-1050 in order to support ASHRAE's GPC-14 protocol, which establishes a standardized process for measuring retrofit savings in buildings. [vi] The tool uses monthly energy data and Heating Degree Days from both the pre and post-retro periods to develop an algorithm that projects what the energy usage would have been in the post-retrofit year if energy usage remained constant from the pre-retrofit year. It then normalizes that projection to the actual Heating and Cooling Degree Days from the post-retrofit year. This makes it possible to subtract the actual energy usage of the post-retrofit year from the projection in order to determine weather-normalized energy savings.

Two of the 17 projects did not have detailed enough energy data available to be able to run them through the IMT. One project (921 Columbia) entailed a retrofit where the number of dwelling units changed during the construction period. This renders the preconstruction data unusable. In order to arrive at the benchmarking score and the SEUI, the MPP Partner used TREAT to "reverse model" the baseline year. For this reason, it was not examined in a more detailed manner. The other project was excluded from this part of the analysis because our team received its post-retrofit billing data during the writing of this paper and could not include it in the analysis.

Another flaw in the data is that several other projects' pre to post-retrofit billing periods did not match. This impacted our ability to conduct a true month-to-month comparison of usage. When comparing non-aligned billing periods (for example, when the pre-retrofit bills begin on the first day of the month and the post-retrofit bills begin on the 15th day of the month) it becomes impossible to accurately compare weather severity between the usage datasets. While this impacted the accuracy of the monthly results, we were still able to obtain annual, normalized savings by fuel type for the post-retrofit period, which allowed us to compare annual predicted savings to annual, actual savings by fuel type. The results for kWh savings are depicted in the graph below.



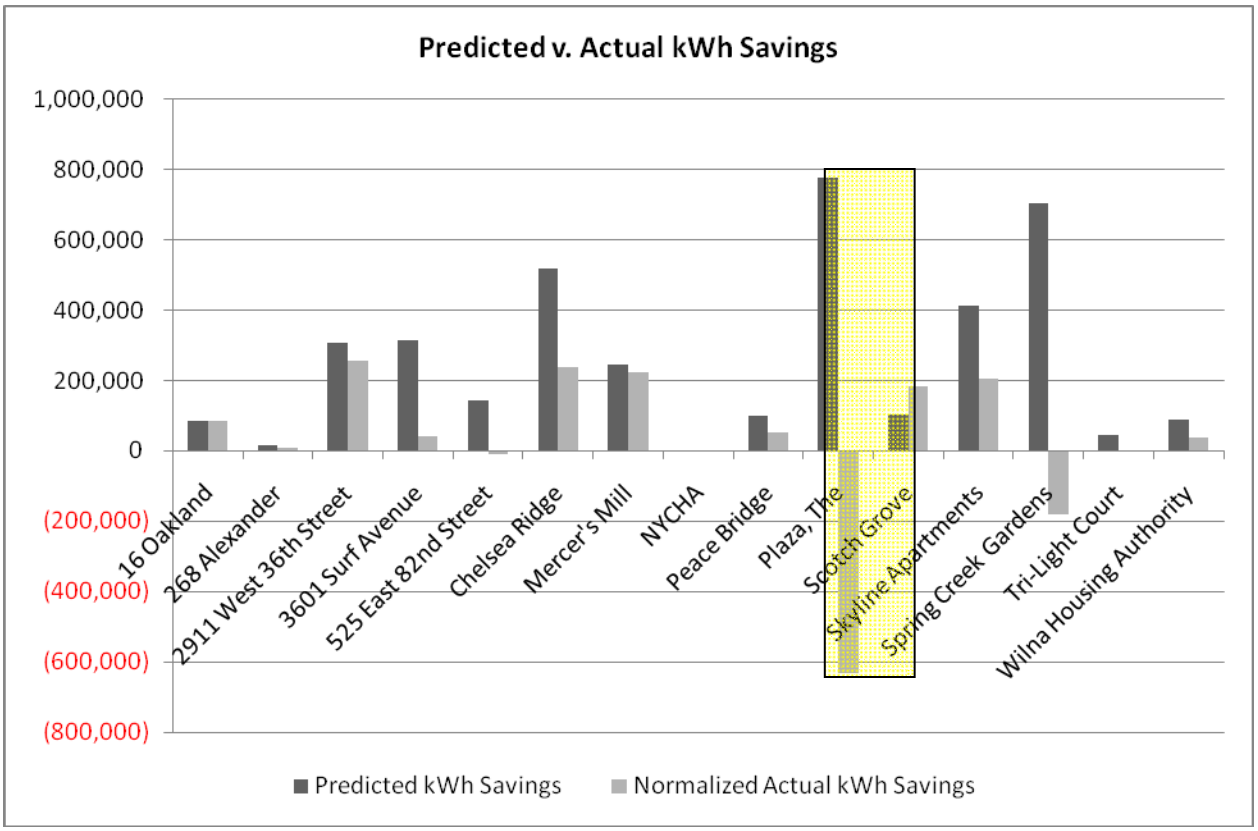
This chart compares predicted or modeled kWh savings to realized kWh savings. The chart illustrates the significant discrepancy between predicted and actual kWh savings in the program. The 15 projects measured in this analysis over predicted kWh savings by an average of 54%. More dramatically, when predicted and actual kWh savings are aggregated between all 15 projects the total kWh savings predicted were 87% greater than what was realized.[4] This finding requires further examination to determine its cause.

As was stated earlier in the paper, all projects used TREAT to model savings. All of the projects also received rigorous, multi-layered, third-party quality control reviews from MPP's implementation contractor and NYSERDA project managers. Through a different analysis conducted on NYSERDA's previous multifamily program, the Assisted Multifamily Program, it was discovered that electric savings were over-predicted by an average of 35%[5]. When considered from this context, the obvious question that emerges is the cause of this consistent over-prediction of electric savings. Is it something related to the SUNREL simulation engine? Is it the manner in which the measures are depicted in the model (often lighting systems are entered in aggregate)? Is it the modeling assumptions regarding occupancy and use? It is important to note that MPP's Simulation Guidelines document, which offers guidance on acceptable ranges of modeling input values, was developed after these projects were analyzed and implemented. It will be important to re-examine results from future projects to ascertain the impact of the Simulation Guidelines on modeling accuracy. That inquiry will help determine if the observed trend in electric savings over-prediction in our projects is the result of modeling inputs.

[4] Both this number and the previous number exclude the NYCHA project, which predicted kWh savings but did not install any of the electric measures specified in their work-scope.
[5] This analysis was performed by NYSERDA's implementation contractor. The results were never published.

It is important to note that three of the projects represented in this dataset were all-electric buildings so the kWh usage data in the above chart reflects the *total* predicted and actual savings for those projects. These three projects (16 Oakland, Mercer's Mill and Scotch Grove) were the most successful at hitting their energy reduction targets.

While kWh savings were over predicted across the board, there are several clear outliers that not only did not save kWh but drastically increased kWh usage. After finding that The Plaza, a 6 story, 385 unit affordable housing development in the East New York neighborhood of Brooklyn, over-predicted electric savings by 181%, we engaged in the forensic exercise of trying to determine what caused the project to add load despite anticipating electric reduction. By revisiting the project's Energy Reduction Plan, and holding separate interviews with the building owner and the project's MPP Partner a narrative emerged.



The owner claims that one of the measures, a CFL distribution to every apartment, was unsuccessful. Despite the fact that NYSERDA's inspectors observed these bulbs installed and working in the apartments they sampled, the owner maintains that the residents ultimately discarded them. The Energy Reduction Plan anticipated that this measure would save 135,167kWh, which represents 17% of the total 776,332 kWh savings predicted. The owner also shared with the authors a change order that was filed during the capital improvement project of which the energy work was a part. The change order was not reflected in the Energy Reduction Plan because it was never discussed with the MPP Partner. It calls for the addition of 81,000 annual kWh of outdoor security lighting. This represented 10.4% of the anticipated kWh savings.

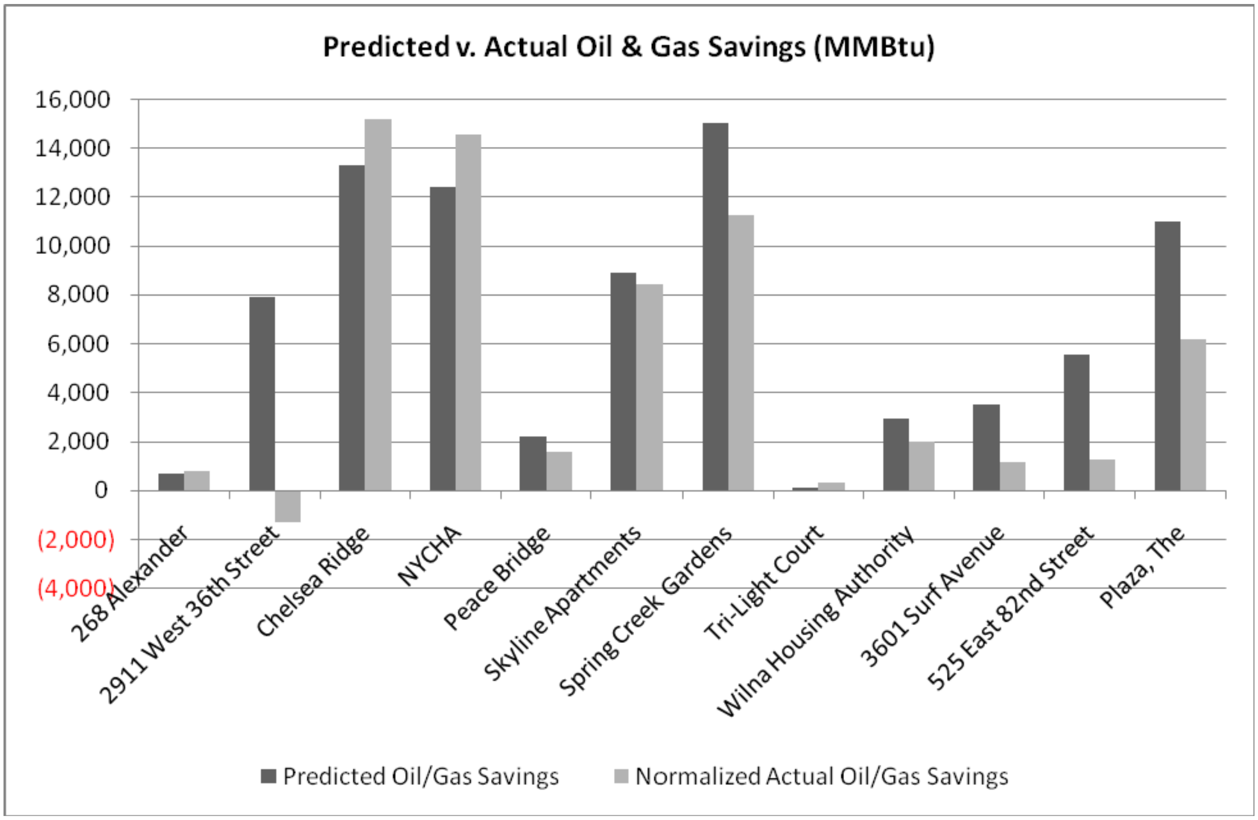
Security was a serious concern for the owner of this project, who also reported during an interview that the building installed "about" 2,000 security cameras in and around the building. If we assume the cameras use 20 watts/hour and operate 8,760 hours per year, they represent an added base-load of 350,400 kWh, or ~45% of the project's projected kWh savings. Through the interview we also learned that the owner added laundry facilities to the buildings, which represents added load relative to the baseline use.

The Plaza tells a story of the impact of load growth and exogenous factors such as tenant behavior on an energy retrofit. By addressing security, providing additional amenities, and relying on tenant acceptance of CFLs this project appears to have subverted its energy savings endgame. As financial stakeholders and policy makers develop underwriting standards and debt instruments based on energy savings it is important that program administrators develop protocols for minimizing uncertainly presented by factors exogenous to the energy retrofit that have the potential to adversely impact energy saving realization. This project raises the question of how owners, program administrators and underwriters can learn to anticipate these exogenous factors and take them into account. More often than not, NYSERDA's experience with whole-building energy retrofits indicates that these projects tend to be part of larger, building-wide capital improvements. Quantifying the energy impact of the rest of those improvements is essential to accurately quantifying savings realization. It is important to note that this project would have had an even more dramatic increase in kWh use had in not been for the efficiency work-scope installed.

Another outlier is 525 East 82nd Street; it over-predicted kWh savings by 108%. Looking back over the oil usage data and the audit, it became clear that this 94 unit, 13-story market-rate building on the Upper East Side of Manhattan had an indirect, oil-fired absorption chiller providing cooling to the whole building. The Energy Reduction Plan anticipated significant oil savings resulting from the increased efficiency of the chiller itself, but it also anticipated ~22,000 kWh in savings resulting from the improved efficiency of the pumps and motors in the cooling tower.

Those savings never materialized in the bills, but not because the cooling tower was not efficient. According to interviews with both the Partner and the building's board president, once the building had a functional chiller management ran the new system constantly, whereas the previous system was chronically in need of repair and often could not be used. Although the new system was more efficient, it was used significantly more often. That is a phenomenon known as takeback or snapback. And although it appears not to have saved energy, this project's takeback begs the question of what an observed "energy savings" really is. Again, stakeholders involved in decision-making predicated on energy savings projections need to be aware of this potentiality.

The data on program-wide fuel savings tells a different and somewhat surprising story.



The chart above shows actual oil and gas savings compared to modeled oil and gas savings. The 12 projects measured in this analysis over-predicted fuel savings by an average of 6%. When predicted fuel savings and actual fuel savings are aggregated between all 12 projects the total fuel savings achieved is 26% less than what was predicted. While this is still a significant discrepancy between predicted and achieved savings, fuel savings were predicted more accurately in these projects than kWh savings, and the majority of projects come close to achieving or exceeded their savings goals. This analysis also includes outlier projects such as 525 East 82nd Street, which was discussed earlier for its takeback, and The Plaza, which entailed an oil to gas conversion of the heating system. With these project removed, from the analysis, project fuel savings were under-predicted by 5% on average.

The most surprising trend discovered through this analysis was the accuracy of the fuel predictions. From a building science perspective, it seems counterintuitive. The stack effect and the complexity of the relationship between building envelopes and heating systems would seem to breed more uncertainty than the relatively more straight forward kWh saving ECMs.

There is one outlier building in the fuel dataset that warrants consideration. 2911 West 36th Street is a 259 unit, 20 Story building in Coney Island, Brooklyn. It is the project that, despite achieving the majority of its predicted electric savings (it predicted 1100 MMBtus of electric savings and realized 900) it increased its fuel consumption and achieved a -1% SEUI savings, the worst performer of the set. When we examined the building's energy factor (the energy it uses to provide heat – expressed in Btus/sqft/HDD). We observed a decrease from 13 Btu/sqft/HDD to 12 Btu/sqft/HDD – in other words, the building's heating efficiency increased relative to the baseline year. The increase in total fuel use was caused by added DHW load; the DHW base-load increased from 4,621 to 7,220 therms. We are uncertain as to the cause of the

DHW increase; this building may have experienced a change in occupancy or there may have been a leak in the DHW piping.

Energy Factor (Btu/ Square Foot/Heating Degree Day) for each project was calculated using actual energy usage data from project energy bills and Heating Degree Days from the National Weather Service's Global Summary of the Day[vii] The Energy Factor allows for a comparison of heating system performance from the pre-construction to post-construction period. The Energy Factor is calculated by establishing the baseline fuel usage that is constant from month to month and not weather dependent. This is the buildings' DHW baseload. Once the DHW baseload is determined, it is subtracted from the total fuel use during the heating months in order to isolate the energy that was utilized to service the heating load of the building. The analysis method is the same for electrically-heated and cooled buildings, but determining electric DHW baseload in the presence of electric summer cooling is challenging. For the all-electric buildings in this dataset, we utilized the fuel bill analysis capability of TREAT, which uses a regression analysis to derive a heating slope based on weather data and extrapolates heating and cooling load. The table below depicts pre and post-retrofit energy factors.[6]

Project	Pre-Construction Energy Factor	Post-Construction Energy Factor	Units	Floors	Heating System
135 Broadway	9	7	13	4	Hydronic
268 Alexander	10	6	38	3	Hydronic
2911 West 36th Street	13	12	259	20	Two-Pipe Steam
3601 Surf Avenue	10	7	197	19	Hydronic
Chelsea Ridge	7	4	835	3	Hydronic
Mercer's Mill	3	2	80	2	Electric Baseboard Heat
NYCHA	10	7	413	3-17	Steam
Peace Bridge	10	5	125	2	Steam
Plaza, The	16	12	385	6	Steam
Scotch Grove	3	2	38	2-3	Electric Baseboard Heat
Skyline Apartments	8	5	361	12	Steam
Spring Creek Gardens	14	10	582	4-7	Hydronic
Tri-Light Court	4	3	32	3	Hydronic
Wilna Housing Authority	7	5	100	2	Furnace

Every project realized efficiency gains in their heating energy usage. On average, the efficiency with which projects provided heat improved by 31%. Even projects that failed to meet the program's overall 20% savings target still improved their heating system performance by an average of 25%. None of the projects exceeded an energy factor of 12 Btu/sqft/HDD.

In addition to our analysis of energy performance, we also examined several other variables from our project data set, including project work-scopes and installation costs, in order to determine if there were any patterns apparent between projects that met the program's savings target and those that did not. We compared ECMs installed by successful and unsuccessful projects by calculating the frequency with which measures were recommended within each group. The work-scopes from each group were similar, and exhibited no clear correlation between recommended ECMs and projects' ability to meet the program's 20% performance

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[6] It was difficult to determine, with certainty, the baseload of 585 East 82nd Street, which contains an indirect, oil-fired absorption chiller. Therefore, it was excluded from this part of the analysis.

target. Although we anticipated this measure-level examination to produce some of the most interesting results from the study, results were inconclusive.

Finally, we looked at overall monetary investment as a variable. Successful projects spent an average of $4,618/unit and unsuccessful projects spent an average of $6,801. This discrepancy between the level of investment and a project's ability to meet its savings target appears to be extreme, but is likely due to the fact that all but one of the unsuccessful projects was located in the downstate area where costs are significantly higher. For example, research within the MPP program has shown that audit costs are on average 55% higher downstate. This point of inquiry exposed a gap in our data and we are now analyzing our pipeline's measure costs normalized for geographic distribution in an effort to be able to quantify the relationship between financial investment, ECMs, and energy performance.

Conclusions

NYSERDA's Multifamily Performance Program employs a performance-based approach to deploying whole-building multifamily energy efficiency. It challenges buildings to achieve a 20% reduction in source energy consumption. 20% appears to be a well placed target for the program as a whole. The observed average energy savings per project was 19.7%, which the authors interpret as a successful program outcome.

While 59% of the projects in the dataset achieved the 20% performance target, those that missed it, missed it by a significant margin. Because the Multifamily Performance Program was always conceived to be a market transformation initiative, accurate savings predictions on a project-by-project basis are crucial. The provision of reliable energy savings predictions is a task central to the establishment of a robust market for energy efficiency retrofits. The responsibility for the execution of that task will reside with a group of professional energy firms that can deliver those services. If those firms lack the technical guidance to accurately predict savings, the development of cost effective work scopes is called into question, making the recruitment of potential participants difficult. Without confidence in savings projections, project underwriters will continue to question the idea that investing in energy efficiency is a fiscally sound decision. Ultimately, if we are to realize market transformation in this sector, the financial underwriters must gain comfort with energy savings predictions, as government programs are not sufficiently funded to solve the problem in isolation of a functioning market solution.

This preliminary analysis of the first 17 project to complete the Multifamily Performance Program is a small snapshot of the data that will eventually be generated by the program, but it illuminates some key trends - the uniform over-prediction of energy savings of mid-high rise buildings in the New York City area, the consistently strong performance of low-rise buildings located upstate, and the overall trend across building types and locations of over-prediction of electric savings. The over-prediction of electric savings is significant and warrants further inquiry, especially in light of the results of NYSERDA's previous multifamily program, AMP, which also observed significant over-prediction of electric savings.

It is important to keep in mind that these 17 projects are the first projects to complete MPP. Many of these projects were transitioned from previous NYSERDA programs, and did not have the benefit of tools such as the Simulation Guidelines that have been developed to provide technical guidance based on lessons learned from projects like these. This technical guidance, coupled with NYSERDA's quality control and quality assurance efforts seek to further empower

MPP Partners to generate and successfully implement what we hope to be increasingly accurate Energy Reduction Plans in buildings.

This analysis illuminates a need for in-depth investigation into the underlying causes behind of the deviation from modeled savings. Zeroing in on these issues will allow program administrators and underwriters across the country to create better protocols for achieving predicted energy savings in their retrofits.

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