Lessons Learned: Performing QC on Energy Models

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ABSTRACT

Six years into NYSERDA's Multifamily Performance Program - New Construction component, Program staff decided to make a philosophical shift in the way the reviews were being performed: to stop being coaches and start being umpires, thereby allowing the energy modelers to be the experts of their own models. The reviewers now focus their efforts in identifying outliers in project-level energy intensity by end use and in measure-level savings, based on a detailed project description, model outputs, and a historic database of over 200 projects previously brought through the Program. The modelers are then tasked with determining the causes of these outliers, and either resolve them or explain why they are justified. While this new approach works well for expert energy modelers, due to the recent growth and relative youth of the energy modeling industry, many modelers are not yet adequately equipped. To address this issue, Program staff developed a guidance document to assist modelers in this process.

This paper focuses largely on a summary of that guidance document, which is based on the lessons learned by our reviewers in performing hundreds of energy model reviews. These lessons are applicable to residential and commercial efficiency Programs that require energy modeling. The guidance can be given to energy modelers working in the Programs to assist them in submitting higher quality models, as well as to help expedite any necessary corrections. It can also be used by Program staff to perform model reviews more effectively and efficiently.

Introduction

The Program

The New York State Energy Research and Development Authority (NYSERDA) launched the Multifamily Performance Program (MPP) in early 2007, with the goal of assisting multifamily building developers, owners and management companies in improving the energy efficiency of their buildings through the use of incentive funds and technical services. This paper focuses on the New Construction component of MPP (MPP-NC, the Program), which aligns with the ENERGY STAR Multifamily High Rise Program (MFHR). Specifically, it focuses on the Performance Path of MPP-NC, and does not refer to the Prescriptive Paths available.

The New Construction component of MPP was greeted with unprecedented enthusiasm from multifamily owners and developers. As of the writing of this paper, 111 projects totaling over 6,600 units have completed the Program and have earned over $13M in incentives. There are another 199 active projects totaling over 15,500 apartments in the Program with a total incentive pool of over $22M available to these projects. Just under 90% of all new construction projects were affordable housing, partially due to the strong support of state regulatory agencies.

The Program Requirements

The New Construction component of MPP relies on the modeling protocols described in ASHRAE's Standard 90.1 Appendix G, Performance Rating Method. Based on that modeling protocol, the projects are required to achieve a 15% performance target, which equates to 15% lower energy cost for the proposed design compared to the baseline that minimally complies with ASHRAE 90.1-2007. The Program supplements ASHRAE 90.1 requirements with the ENERGY STAR MFHR Simulation Guidelines, which provides multifamily-specific guidance as well as guidance on assumptions used to ensure consistency from project-to-project. Additionally, the Program mandates specific Minimum Performance Standards be met on all systems. These requirements limit the efficiency trade-offs allowed by ASHRAE 90.1 for certain systems. For example, the Minimum Performance Standards require that all in-unit lighting must meet or exceed ENERGY STAR specifications.

The submittal requirements for the Program include not only an ASHRAE-compliant model, but also several other template documents. The primary submittal document is the Energy Reduction Plan Tables (ERP Tables) spreadsheet, which captures detailed project-specific information to expedite the technical review of the submittal. The Program also requires the submittal of Testing and Verification Worksheets, as well as a Photo Template, to verify compliance with construction-phase requirements.

This information required in the ERP Tables include the following: basic information, such as number of units and square footage of spaces; model inputs, which includes everything from the heating system type and size to the number of dishwashers; and detailed measure information, which captures the costs and savings of every energy-savings measure included in the building in order to perform the cost-effectiveness calculations mandated by NYSERDA's funding source. Lastly, the ERP Tables spreadsheet includes multiple tabs designed to assist the modeler in performing calculations necessary to massage building data into the form needed to input into the energy model.

The Partner Network

In order to participate in MPP-NC, the developer is required to hire an energy-efficiency firm approved to work in the Program. These approved firms, called Partners, serve as the developer's agent to facilitate participation in the Program. They are involved with the project from design through project completion. Their tasks include working with the design team to develop an energy-efficient design, modeling the building following Program requirements, completing and submitting all Program submittal documentation, and overseeing installation of energy-efficient measures throughout the entire construction phase.

The individual Partner firms that are approved to work in the Program vary significantly. They include small companies with a handful of employees, as well as multi-national companies. Some primarily serve large commercial buildings and some are primarily home performance contractors. Some of the Partners' strengths lie in modeling, though many lie instead in installations, design or financing. The variety of Partners does allow for great diversity of the building types served. However, it also significantly complicates the quality control process, as some Partners have very little modeling experience and others are true modeling experts.

Quality Control Process

Previous Processes

The quality control process for reviewing MPP-NC submittals has evolved since the inception of the Program in 2007. In the beginning, projects mainly were modeled using TREAT software. The technical review process involved checking all model inputs to verify that they matched the building description and demonstrated understanding of the modeling protocol. When an inconsistency was discovered, the reviewer provided detailed instructions on how to fix the issue.

This first major change to this process occurred when the Program decided to disallow TREAT software in the MPP-NC component, as it is not ASHRAE 90.1 Appendix G compliant in several areas deemed significant in new construction projects. Instead, only compliant software was allowed to be used. Therefore, Partners started using more complex, input-rich software tools, most commonly eQUEST, to model their buildings. It became quickly apparent that reviewing all model inputs was not feasible anymore, as there are thousands of inputs. At this point, a metric-driven quality control process was developed.[1]

This metric-driven quality control process focused on model outputs instead of model inputs. Also, the focus shifted from identifying all errors in the model to identifying all significant errors in the model. This review process had five main steps. First, the reviewer familiarized themselves with the project by reviewing the detailed project description submitted. Next, the reviewer evaluated the general quality of the model by investigating output reports for red flags such as excessive unmet load hours or unexpectedly high simultaneous heating and cooling load hours. Third, the reviewer would compare the energy use intensity by end use (e.g., space heating) to similar previously submitted projects. This step required the use of an Output Verification Tool, which will be described later in this paper. Next, the reviewer would determine whether or not the projected savings by end use were reasonable given the project description and experience with similar previously approved projects. Lastly, the reviewer would open the model to attempt to determine the source of error of any issues identified in the four previous steps.

Challenges Faced

The metric-driven quality control process described above was a big step towards streamlining and expediting the review process when compared to the previous process of attempting to review all model inputs. However, Program staff felt that there were further improvements that could be realized in the following areas.

Submittal review efforts. Focusing on the model outputs to identify all significant errors in the model did reduce the submittal review efforts as compared to the previous method. However, the technical review process was still a very time-consuming effort for both Program staff as well as the Partners. Typically, model submittals require multiple revisions prior to obtaining a report which the Program was willing to approve. Each revision requires both time from the Partners in responding to the comments and making any necessary revisions, as well as time

[1] To learn more about the metric-drive quality control process, refer to *Modeling Energy Use of Green Buildings: Metric-Driven Quality Control* (Beaulieu, Rooney, and Karpman 2010).

from the technical reviewers to review the new submittal. Moving to the metric-driven QC process, along with a few other tweaks to the Program process, halved the average number of revisions from 2.8 to 1.4. 60% of the projects were approved with only 1 revision iteration, 37% were approved after 2 review iterations, and 3% were approved after 3 review iterations.

Based on a survey of our active Partners, the average estimated time they spend working on revisions for each project to get to an approved submittal is 24 hours. The technical reviewers estimated that they spend an average of 14 hours reviewing revisions per project. This translated into significant implementation costs to the Program, as well as increased project cost to the developer, as the Partner typically factors these additional labor costs into the fees.

Catering to a diverse set of Partners. As previously mentioned, the modeling experience of the Partner network varies significantly. A recent Partner survey showed that roughly one-third of the Partners have worked on 1-6 energy models, one-third have worked on 7-15, and one-third have worked on more than 16 energy models. This variability creates difficulty in developing a single technical review process to cater to all experience-levels. Ideally, such a process would provide enough guidance to the inexperienced modeler to avoid excessive effort on their part, but to also allow the experienced Partner to be the modeling experts for their own projects by not specifically identifying how to fix the issue. Transforming the market by increasing technical sophistication of energy consultants was viewed as an important program goal, and the submittal reviews were used as a vehicle for disseminating energy modeling expertise and knowledge of energy code and ASHRAE Standard 90.1. To support this vision, the Program staff routinely provided technical support to Partners who struggled with addressing review comments, as opposed to taking administrative actions such as rejecting projects or expelling companies from the Partner network.

New Process

The technical review team set out to revise the quality control process to address these challenges with the main goal of finding a way to expedite the process without undermining the quality control standards necessary to confidently approve a project as being worthy of receiving Program incentives. The resulting decision was a philosophical shift in how reviews had historically been performed. Previously, the technical reviewers had acted as coaches – not only identifying issues, but also assisting the Partners in correcting the issues. It was decided that the technical reviewers should now act as umpires – focusing their efforts on identifying significant issues in the model and then expecting the Partners to correct the models on their own.

One benefit to this approach was that it allowed the Partners to be the experts of their own models. The rationale was that since the Partners had designed the models, they would be the most familiar with the models, and would best be suited to being able to locate the source of the issues or recognize that the identified outliers were justifiable. The Partners should be able to navigate the model more quickly and address the issues in less time, thereby reducing the overall time required to complete each revision.

The downside of this new approach is that some of our Partner firms do not have the experience necessary to easily find and fix these errors. To address this downside, it was decided to develop a comprehensive guidance document to assist those Partners in this effort that was a compilation of troubleshooting methods that the technical reviewers had developed and employed over the previous seven years of performing these reviews. Additionally, if a Partner encounters difficulties in identifying issues after following this guidance document, the Program staff is available to assist the Partner in reviewing the model and identifying the source of the errors. The Partner's use of the additional technical support is tracked, and excessive reliance on it could negatively affect their Partner status and their ability to bring new projects into the Program.

That resulting document is the focus of the majority of the remainder of this paper. First, however, as this guidance document explains how to locate the sources of the errors identified in the technical review process, it is important to understand what errors are identified by the technical reviewers, and how those errors are identified. The following tools are used to identify significant errors within the models and submittals.

QC checklist. The master tool used in this new review process is a checklist used to guide and focus the review process. The reviewers are instructed not to deviate from this checklist, to ensure consistency between reviewers. The checklist was based heavily on the U.S. Green Building Council's *Advanced Energy Modeling for LEED Technical Manual* (USGBC 2011). This manual includes, among other things, a detailed review of the requirements of ASHRAE 90.1 Appendix G for a typical building's baseline and proposed models. Additionally, it covers how to use the modeling software's output reports to perform quality control on these models.

The content of this manual was modified, based on experience of reviewing over 200 energy models, to apply to multifamily projects in New York State, and put in checklist form. Additionally, there were some Program-specific questions added to ensure complete and reasonable documentation was submitted, and to ensure that the project met all Program requirements.

Lastly, this checklist includes reference to various comparison tools developed to assist in identifying outliers in model output data. In order to be able to identify significant issues in the model without investing significant time in reviewing the model itself, it was determined that two different metrics should be compared between each new model and the database of other similar projects in the pipeline. These metrics are measure-level savings and project-level energy use intensity by end use.

Measure cost and savings comparison tool. It was found that one of the most important metrics that points to whether or not the output of a model was reasonable was measure-by-measure savings. Additionally, it was determined that measure-by-measure incremental cost was important both to the developer, to assist in selecting which measures to pursue, as well as to the Program, to ensure the measures meet the Program's cost-effectiveness requirements. To meet these needs, a tool was developed to compare these parameters of the project under review to all other previously submitted projects. This comparison tool compares each measure, based on the identified measure type (e.g., indirect domestic hot water system or above-grade wall insulation), to a database of the same measure in similar previously submitted models. Specifically, it compares the incremental costs and savings per "quantity" (e.g., Btu/h or square feet of above grade wall) to normalize for size. The tool then flags any measure cost or savings that falls outside a statistically-determined range of values.

Output verification tool. The other metrics that were deemed important to ensure that the output of a model was reasonable was the total energy use intensity (Btu/sqft) by end use of both the baseline and proposed models. The end uses investigated are heating, cooling, lighting, domestic hot water, appliances, fans and pumps. Similar to the Measure Cost and Savings Tool, the Output Verification Tool uses a database of metrics from all similar previously submitted models to establish statistically-determined anticipated ranges of energy use intensities. The tool then flags any end use that fall significantly outside of these ranges.

To ensure consistency in comparing the project metrics, the Output Verification and the Measure Cost and Savings Comparison Tools filter project data into peer groups, such as new construction projects versus major renovation projects, and the program version number. (Program rules evolved significantly since inception, including but not limited to the baseline change from Standard 90.1 2004 to 90.1 2007.) Early versions of the Output Verification Tool flagged projects with energy use intensities and savings that differed by more than one standard deviation from the corresponding mean values of the filtered sample. The resulting ranges were later validated by reviewing a sample of flagged projects, and the algorithms used to establish the acceptable ranges were enhanced based on the findings of these validation efforts. Further fine-tuning of the peer groups proved to be unproductive because it resulted in small sample sizes making statistical ranges unreliable. Instead, building characteristics that were observed to cause significant variations in building performance compared to typical project were addressed in the Partner Guidance document. Examples of such characteristics are provided in Table 1 in the following section. Interestingly, the project location within the state (New York State covers three climate zones) was not found to be statistically significant, as its influence was overpowered by factors such as the size of common space, number of bedrooms per apartment, etc.

Partner Guidance Document

In order to avoid overburdening inexperienced energy modelers in identifying and addressing issues in their model, a guidance document was compiled using lessons learned by our reviewers as a result of performing hundreds of energy model reviews. The document is intended to assist the energy modeler throughout the entire submittal process – from initial submittal to final revisions.[2]

Common mistakes that were often identified during reviews on energy models were used as the foundation in compiling the guidance document. The document demonstrates how these common mistakes may be identified in the simulation output reports, discusses how they impact the model results, and explains steps to address or prevent these mistakes. Specific guidance is provided for models developed in eQUEST; however, many of the topics apply to other software programs as well. The guidance document discusses a mix of general best practices and Program-specific best practices. The following sections will focus on the general best practices within the document.

Developing and Implementing an Internal Quality Control Process

Based on the Program staff's experience, it has been found that the quality of submittals vary drastically across our pipeline. Performing quality control prior to submitting a model for review can alleviate the number of necessary revisions per submittal as well as decrease the review turnaround time, saving overall time and effort. It is recommended that a company-wide quality control checklist be developed to ensure that the process is performed consistently.

[2] To learn more about the New Construction Partner Guidance for Technical Review Process document, refer to http://www.trcsolutions.com/Services/EnergyEfficiency/Pages/default.aspx

There are readily available QC checklists that can be used as a reference. These include the "10 Minute" DOE2 Output QC Checklist, the "30 Minute" DOE2 Output QC Checklist (Hirsch 2009), and, for multifamily projects, the ENERGY STAR Multifamily High Rise Energy Modeling Quality Control Checklist (EPA 2013). This section also covers Program-specific commonly found errors to incorporate into the company-wide QC checklist.

Evaluating the General Quality of the Simulation

This section covers several of the common mistakes related to the general quality of the energy model. The mistakes discussed were chosen based on the experience of the technical reviewers and are mistakes identified as typically resulting in significant errors in the model output. Specifically, it addresses the following errors: an excessive number of unmet load hours, incorrectly modeled square footage of the building, unexplained substantial hours of coincident heating and cooling, and incorrectly modeling interactive measure savings.

In addition to explaining how to determine whether or not these errors exist in a given model, the document also explains how to dig deeper into the problem to identify the underlying mistake, and then provides details on how to fix the more common causes of these errors.

Comparing Model Outputs to Similar Projects

Rather than focusing on an unwieldy number of model inputs, the Partner Guidance document recommends analyzing a few select model outputs to identify significant errors in the model. Energy modelers in the Program are provided with the End Use Intensity Comparison Tool, which is based on the Output Verification Tool previously discussed in this paper. The End Use Comparison Tool allows the energy modeler to compare the annual consumption by end use (Btu/sqft) produced by the current model to the annual end use of similar approved projects in the MPP pipeline. The end uses captured are heating, cooling, lighting, domestic hot water, appliances, ventilation fans, and pumps. Results outside the typical range are flagged for further investigation. If the simulation outputs do not display any statistically significant anomalies when compared to the metric database, then there is no need to look further into those related model inputs.

Guidance in the document is then broken down into each end use category included in the End Use Comparison Tool. Each section lists the possible modeling errors that may cause the end uses to fall above or below the typical range. For example, if the baseline annual heating end use intensity falls above the typical range, the energy modeler should investigate the following:

- Are the internal heat gains from lighting, appliances, or plug loads too low?
- Are appropriate ventilation rates modeled?
- Are there months that show heating energy consumption that shouldn't?

In addition to the possible modeling errors, each section lists possible justifications that may explain why the end use is below or above the typical range. So, for the example above, possible justifications for the baseline heating use falling above the typical range found in this Program include:

- Is this building a gut rehab project?

- Is this building comprised of very small apartments (<400 square foot average)?
- Are there large common spaces with high occupancy density that require mechanical ventilation?

This section also covers some known building characteristics that will likely cause certain end use data to fall outside the typical range. Table 1 below provides examples of atypical building characteristics for this Program and the expected trends that may result in the model when compared to the typical multifamily new construction projects that participate in the Program. Additionally, this section covers atypical HVAC systems and presents the expected effect on impacted end uses. For example, if the baseline and proposed models have 100% electric-source heating systems, it would be expected that the baseline and proposed heating end use intensities would be significantly lower than in a typical MPP project. Additionally, if in this case the baseline heating falls within the typical range, this may indicate that the model has excessive heat pump supplemental energy, which should trigger further investigation.

Table 1. Atypical building characteristics and expected trends

Building Characteristics	Expected Trends
Gut Rehabilitation Projects	• Baseline heating and cooling end uses will be higher than average. • Proposed heating and cooling end uses could be higher than average, depending on the envelope components that are upgraded. • Cost savings for heating and cooling may be higher than the average project. • Cost savings for envelope measures may be higher than the average project.
Very Small Apartments <400 SqFt Average (Found in buildings with 100% studios or supportive housing)	• Baseline and Proposed appliance and DHW end uses will be higher than average (more appliances and low flow fixtures per SqFt). • Appliance and DHW contribution to performance target may be higher than average. • Baseline and Proposed heating and cooling end uses could be affected due to higher allowances for apartment ventilation per SqFt.
Larger Apartments >1500 SqFt Average	• Baseline and Proposed appliance and DHW end uses will be lower than average (less appliances and low flow fixtures per SqFt). • Appliance and DHW contribution to performance target may be lower than average. • Baseline and Proposed heating and cooling end uses could be affected due to lower allowances for apartment ventilation per SqFt.

Reviewing Measure-Level Savings

The guidance document provides methods to verify if the projected savings are reasonable based on the measure details, as well as how to identify common errors with modeling measures. The methods discussed in the guidance document, and below, encourage the energy modeler, or better yet their peers, to quantitatively and qualitatively review the simulated energy savings by end use and by measure to ensure that results are consistent with the design. In addition to the suggestion below, the document recommends maintaining company-wide databases of measure-level metrics to compare to the results of active projects as a means of measure-level savings validation.

Verify that affected end uses are reasonable. This section explains the importance of qualitatively checking which end uses are affected by a particular measure. For example, exterior lighting measures should affect lighting end uses, but should have no effect on heating or cooling end uses. Interior lighting, on the other hand, should affect lighting, heating and cooling, but should not have an effect on domestic hot water usage.

Most modeling software packages include tools to identify which end uses are affected on a measure-by-measure basis. For example, if using eQUEST, you can refer to the eQUEST report, Annual Energy by End Use, shown in Figure 1 below. This report demonstrates how the end uses are affected for a proposed window measure in the model. The window measure in the figure (gray bar) results in reduced heating and increased cooling consumption relative to the Baseline run (blue bar). The other end uses are not affected by this run in the example.

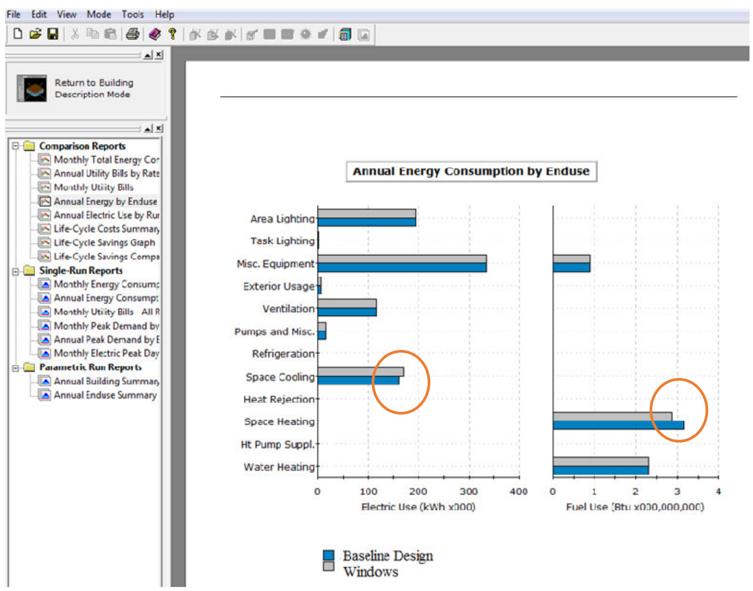

Figure 1. Screenshot of eQUEST report - Annual Energy by End Use.

Verify measure inputs and savings. Another suggested method of measure-level quality control is to verify that only the inputs identified in the submittal vary between the baseline and the proposed model. For example, if using eQUEST, the grid view of eQUEST Parametric Run Tool can be used as shown in Figure 2 below. The word processor 'File Compare' function can also be used to compare eQUEST's .inp files to verify the changes in the model inputs. Figure 2 shows an example of the model inputs for a window measure. The blue box on the left identifies the baseline window properties and the red box on the right identifies the window properties in the proposed design that were set by the 'Windows' parametric run in the model.

Once the inputs are verified, simple estimation techniques can be used on many measure types to determine if the model results are reasonable. For example, the kWh savings reported for appliance measures can be compared to the baseline and proposed consumption included in the measure description to determine if the energy savings predicted by the model are reasonable.

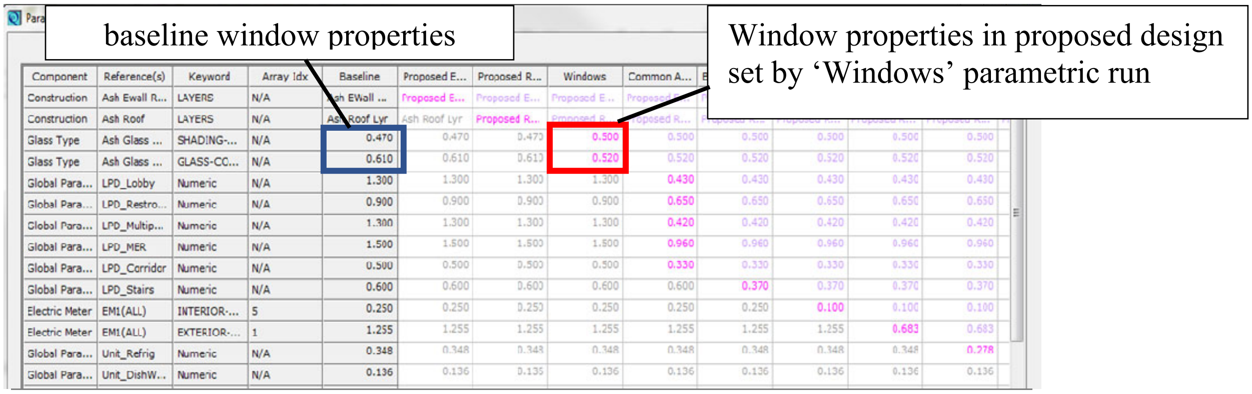

Figure 2. Parametric run tool, grid view.

Verify key inputs that stayed unchanged but affect savings. There are model inputs that remain unchanged between the baseline and proposed models but that can affect measure savings. In addition to verifying the model inputs associated with measures, these unchanged inputs should also be verified when looking at the savings. For example, savings from a lighting measure depend on the lighting power density in the baseline and proposed models, but also on the lighting runtime hours. Another example is savings from an insulation measure; while it depends on the baseline and proposed U-values, it also depends on the area of the insulated surface.

Next Steps

The recent updates to the review process including the QC checklist and review guidance document represented a marked improvement compared to earlier practice; however there are many opportunities for further optimization. This optimization is critical for improving the Program effectiveness, as submittal review continues to require significant effort. A few ideas currently under consideration are included here.

Fine-Tune the Tools and Guidance Provided

Based on a recent survey, Partners are using the guidance document to perform internal quality control as well as for assistance in troubleshooting their models. They found the guidance valuable, and have asked to have it expanded to include additional items that they continue to struggle with. For example, they would like to see guidance on why measure costs or savings may differ from the typical project in the Program.

In addition to ensuring consistency of reviews from project to project and reviewer to reviewer, analyzing the completed QC checklists offers opportunity to identify frequent modeling and Program-related errors. This information can be used to fine-tune the trainings that are routinely delivered to the Partners during monthly webinars to address the areas that most often trigger review comments.

Defining What Constitutes an "Approvable" Submittal

Some of the issues identified in a review may impact a project's eligibility, incentive amounts, or represent significant deviation from Appendix G modeling protocols. Such problems clearly warrant further revisions before the project is approved. On the other hand, smaller discrepancies that are unlikely to affect the key results to a significant extent may be noted in reviews, but should not prevent the project from approval. The review team has been using "Approved with Comments" review outcome to differentiate critical from non-critical issues, however developing a more structured policy in this area may help reduce the number of review iterations.

Scaling the Review Effort Based on Project Size

The fundamental M&V principle articulated in International Performance Measurement and Verification Protocols (2012) suggests that "M&V costs should normally be small relative to the monetary value of the savings being evaluated. M&V expenditures should also be consistent with the financial implications of over- or under-reporting of a project's performance. Accuracy tradeoffs should be accompanied by increased conservativeness in any estimates and judgments."

This principal of finding a balance between accuracy and cost may be applied to both the modeling work performed by Partners as well as model reviews performed by the Program staff. Following this principal, definition of "approvable submittal" should vary depending on the project's scale, to ensure that modeling and review efforts are appropriate for the "the monetary value of the savings being evaluated", aka project incentive. With this approach, smaller projects with less incentive at stake should be subjected to less scrutiny compared to large projects.

Adopting this approach would represent a shift in the current process, in which reviewers are instructed not to deviate from the standard checklist when performing reviews, to ensure consistency between projects. It is well recognized that modeling effort is not proportional to project size, and developing an equally detailed model costs more per unit floor area for the smaller buildings compared to the larger ones. Subjecting the smaller projects to lower review scrutiny would reduce this inequality to some degree, making the Program more accessible to such projects, since the Program incentive *is* proportional to project size.

Strategies for adjusting review rigor based on project size may be incorporated into the QC checklist, directing reviewers to skip certain steps on smaller projects. Alternatively, only a random sample of small projects may be subject to the normal level of QC scrutiny.

Identifying Impactful Review Comments

The QC checklist currently includes verifying 100+ items on each project. Analysis of the QC checklists filled out for completed projects may help identify comments that typically result in critical changes such as incentive adjustment, compared to those that are commonly "explained away" without affecting results. These historic patterns will help differentiate between comments that warrant submittal rejection versus those that may result in "Approved with Comments" review outcome. Furthermore, some checks that never or only rarely result in impactful changes to submittals may be eliminated from the checklist altogether, simplifying the review process. This insight may also be incorporated into the guidance document, allowing Partners to prioritize their modeling and trouble-shooting efforts.

Determine If Gaming Results From New Process

One potential outcome of presenting the modelers with detailed information on the review process is gaming of the system. For example, by providing the modelers with the acceptable ranges of end use intensities, it is possible that the modelers will manipulate their models to fall within those ranges. This is something that should be investigated by performing in-depth review of a random sampling of projects to determine if modelers are indeed gaming the process.

Conclusion

The review process used by the Program has changed dramatically since program inception seven years ago. It started as an ad-hoc review of simulation inputs with no consistency between reviewers and projects. The current process is highly structured and well documented, with all reviewers following the same steps and using standardized Excel-based tools including the QC Checklist, Output Verification Tool and the Measure Savings and Cost Comparison Tool. The process optimization resulted in measurable improvements in turnaround time, and reduction in the average number of revisions required before projects are approved.

The review guidance document allowed transferring valuable experience gained by the review team through their exposure to numerous submitted models to Partners, to inform the Partners about the prominence of internal model QC and to help them troubleshoot the models. This document facilitates market transformation by helping the Partners train new staff, and also allows the Program to expand the review team to accommodate the growing pipeline of projects without negative impact on quality.

Even though the MPP review process and the review guidance document were developed to perform quality control of modeling-based submittals for New York State multifamily projects, the same approach and many of the same tools can be successfully used by any simulation-based program.

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