Performance Based Approaches to Energy Codes and BPS – Results of Jurisdiction Pilots

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ABSTRACT

To achieve net zero energy and emissions performance and put new construction on a path to compliance with building performance standards (BPS), energy codes will need to transition towards performance-based approaches. Concerns expressed by stakeholders at this shift away from traditional prescriptive approaches include added complexity and cost, lack of confidence in modeling results, gamesmanship on the part of applicants, lack of qualified reviewers, challenges in promoting decarbonization, and the inequity of trading long lived envelope efficiency for measures such as building controls. This paper will discuss multiple performance-based approaches being piloted in two US jurisdictions to improve the usability for both code compliance and beyond code programs. The authors will additionally share a methodology and results that test the alignment of energy code compliance for new construction and future BPS energy targets, including whether alignment varies depending on selected performance path. The results of these pilot programs will help to inform and refine tools, trainings, and enable the advancement and implementation of performance-based code solutions at scale.

Introduction and Background

Current energy codes provide users with two primary compliance paths: a prescriptive compliance path that is based on component efficiency requirements such as the R-value of insulation or the SEER of an air conditioner, and a performance path based on whole building simulation. Each successive version of the energy code results in an improvement over the previous version. The past few code cycles have seen diminishing returns relative to prescriptive requirements. Additionally, research has shown that when design parameters are varied the annual energy use of minimally code compliant building designs varies, resulting in a ratio of up to 2:1 between the highest energy use designs and the lowest energy use designs (Curtz et al. 2024). Figure 1 shows the modeled results of all possible variations and combinations of minimally prescriptive code compliant design parameters including envelope characteristics, heating, ventilation and air conditioning system types, and service water heating system types in a medium office building in climate zone 5B as prescribed by IECC 2018. For these reasons performance-based codes that treat the building as a system and encourages creative solutions more likely to lead to deep savings than the prescriptive alternative (Rosenberg et al. 2015). [1]

[1] Performance-based codes are not synonymous with outcome-based codes. Performance-based codes set standards based on design features, similar to the performance path, but do not necessarily require whole building energy simulations. Outcome based codes look at actual building energy use at operation.

Additionally, a performance-based code allows developers to set and track progress toward clearly defined targets. Replacing the prescriptive compliance path with a performance-based code that includes both whole-building performance and system level performance options makes it easier to establish a performance threshold for all projects.

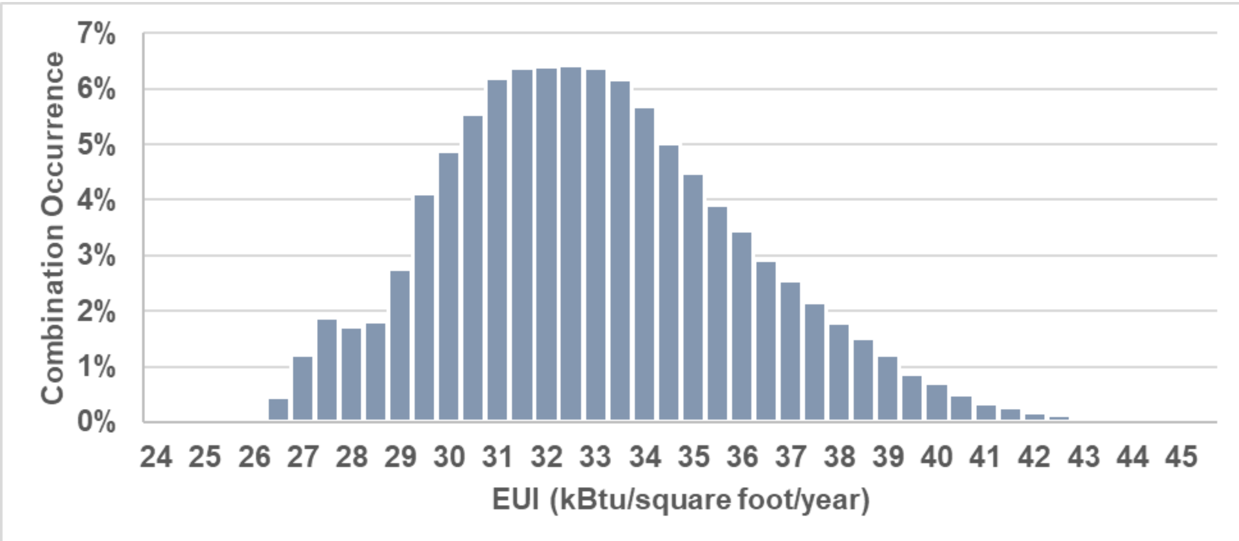

Figure 1. Distribution of Energy Use Intensity (EUI) for Medium Office Building Designs in Climate Zone 5B that Are Minimally Compliant with Prescriptive Requirements of IECC 2018

The traditional performance-compliance path in energy code requires the use of energy modeling to estimate the energy use of the proposed building design, which is compared against a baseline defined based on code requirements. Including a system level performance option in an energy code provides two advantages. First, it is much less resource intensive than whole building performance, making it an attractive option for smaller or simple projects with limited budgets. Second, system efficiency minimums are established, eliminating trade-offs between systems with varying lifecycles and longer-term performance impacts, a valid criticism of the whole building simulation method (Goel et al. 2021).

Alongside the decreasing savings potential and exploration of the limitations of prescriptive based compliance, a growing number of states and jurisdictions are developing and implementing building performance standards (BPS). Building performance standards are a policy tool used to track the actual measured performance of existing buildings and hold them to a performance metric or target (ASHRAE 2023). With long term performance goals on the minds of many designers, there is a growing interest in understanding how energy code compliance pathways may support or limit the ability of a building to comply with future BPS targets, spurring additional interest in the development and application of performance-based compliance pathways.

To support the goal of developing a 100% performance-based energy code, Pacific Northwest National Lab (PNNL) worked with stakeholders to develop and implement a performance-based energy code pilot program that would test performance methods on real buildings, receive critical feedback on tools and methods, and use data from each pilot to refine an approach to the development and support of such an energy code.

Proposed Approaches to Performance Based Energy Codes in Pilot Studies

To pilot performance-based approaches to energy codes, PNNL looked at a combination of whole building and system level approaches under development to understand the impact and implications of each in a real-world application. One important aspect in the development of a performance-based code is the ability to utilize different compliance metrics to meet specific policy goals across jurisdictions. For example, the State of Washington adopted a carbon dioxide equivalent metric for performance-based compliance in their new energy code (WSEC 2021), while the State of New York's NYStretch added a site energy metric (NYSERDA 2023). The most recent edition of ASHRAE 90.1, which traditionally used energy cost as the metric, has introduced an informative appendix providing approaches for using site energy, source energy, or emissions, as desired by a jurisdiction to help meet their policy objectives (ASHRAE 2022). Through pilot studies, PNNL has developed and evaluated code formats that include the performance-based approaches discussed.

The early pilot programs tested performance-based compliance pathways including an HVAC, Lighting and Envelope System Performance approach; Simplified Performance Rating Method (S-PRM); Performance Rating Method (Appendix G); and Building Performance Standard (BPS) alignment. The vision for a fully performance-based energy code eliminates the prescriptive path, replacing it with options to address performance either by system (envelope, lighting, and HVAC system performance) or through a simplified modeling approach. The whole building performance approach that exists now is maintained (Figure 2). Each approach and basic methodology as applied to the studies is explained below.

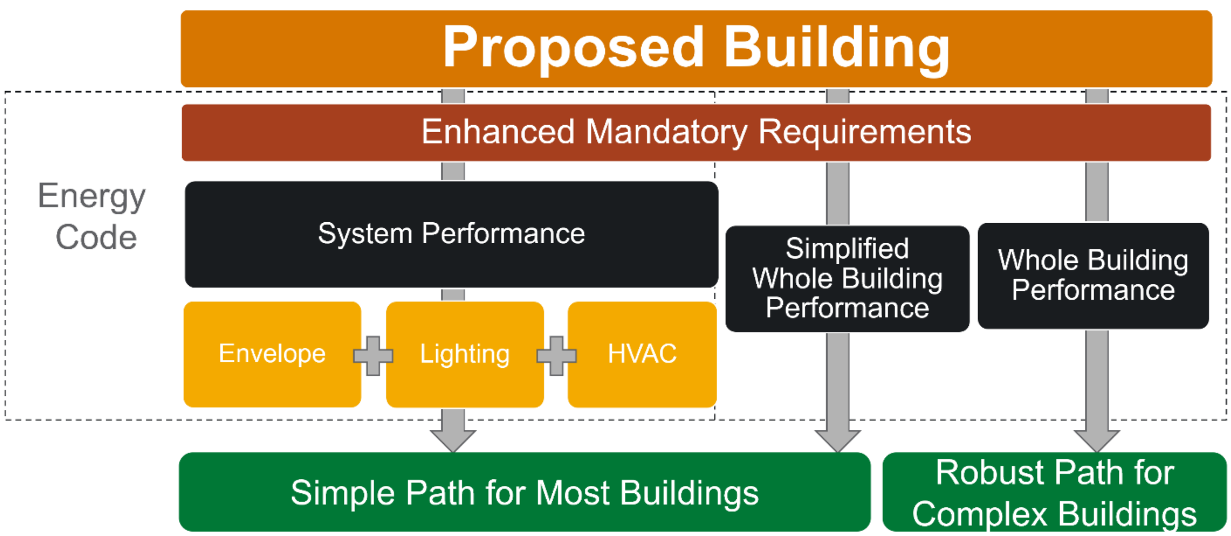

Figure 2: Vision for a 100% Performance Based Code Approach

HVAC, Lighting and Envelope System Performance Approach

The HVAC, Lighting and Envelope System Performance Approach was evaluated through the testing of the three different systems as its own pilot pathway. Both envelope and lighting build on the familiar COMcheck tool for comparison of selected performance of those systems to a designated baseline. The HVAC approach, Total System Performance Ratio (TSPR) uses a new tool designed by PNNL to evaluate the comparison of performance of HVAC systems.

Total System Performance Ratio (TSPR). Total System Performance Ratio (TSPR) is a ratio that compares a building's annual heating and cooling load to the annual energy consumption of or carbon emissions associated with its HVAC systems.

The first performance pilot version of TSPR was developed using an approach similar to what has been adopted by the State of Washington for its 2018 and 2021 energy code (Jonlin, Thornton, and Rosenberg 2018). The Washington State Energy Code (WSEC) uses an HVAC reference system design that is aligned with the current energy code prescriptive requirements (WSEC 2018, WSEC 2021). There are variations in the reference systems dependent on building type, but they all include cycling heat pumps combined with a dedicated outdoor air system with high efficiency energy recovery and low fan power. The TSPR of the proposed building is required to be equivalent to or better than that of the baseline building.

Figure 3. TSPR User Interface. *Source*: US DOE.

The Phase 1 Pilot, conducted in collaboration with the New York City Department of Buildings, evaluated three different compliance metrics: source energy, site energy and carbon emissions. Typical HVAC configurations in NYC, such as district heating, perimeter baseboard heating and through-the-wall air conditioning / baseboard heating system configurations, were not originally included in the TSPR tool and needed to be added to accommodate the pilot. In addition to the broader set of systems, the Phase 2 HVAC TSPR pilot was based on the Mechanical System performance approach in Appendix L of Standard ASHRAE 90.1-2022 (ASHRAE 2022). Standard 90.1-2022 defines the reference systems at the level of efficiency of the 90.1-2004 code and specifies 'mechanical performance factors' based on a set of target systems, which the proposed design must meet or exceed. Standard 90.1-2022 uses energy cost as the compliance metric, though New York City Energy Conservation Code (NYCECC) uses site energy as the metric.

By evaluating the energy efficiency of a select group of buildings, the NYC pilots were designed to evaluate feasibility of making these tools available for compliance with future versions of the NYCECC.

Simplified Performance Rating Method (S-PRM)

In addition to developing a performance-based compliance path for individual systems to replace the prescriptive path, PNNL developed a methodology for simplified whole building energy modeling. This compliance pathway is the Simplified Performance Rating Method, or S-PRM. S-PRM uses traditional energy modeling software used for the PRM of ASHRAE 90.1, but simplifies modeling guidelines and key aspects of inputs including building geometry, defaults for schedules and loads, lighting and HVAC controls to reduce modeling time.

The S-PRM approach for commercial buildings has the potential to expand the use of energy modeling for small and simple buildings that would have had difficulty justifying the cost for whole building simulation under the traditional energy code performance path (Tillou, Goel and Rosenberg 2020).

The S-PRM approach was developed through extensive stakeholder input and the ruleset is now being discussed by the Standard 90.1 committee for inclusion in a future edition of Standard 90.1. Through the pilot with NYC, participants were asked to evaluate the new S-PRM modeling methodology for simple buildings and provide feedback on the methodology.

Building Performance Standard (BPS) Alignment

Jurisdictions with or developing BPS are interested in assessing ways to better plan for code compliance to translate into BPS compliance, including assessing the potential of performance-based codes. For this reason, PNNL developed a methodology for BPS integration into the performance pilot with the following:

- Analysis of benchmarking data to understand previous code likelihood of compliance (Boyce, Cheslak and Edelson 2022) (backwards-looking),
- A methodology to incorporate outputs from pilot participants completing building modeling using Appendix G or S-PRM pathways (current-code), and
- Simulation analysis work on prescriptive variability of the model codes and how it might impact future BPS compliance (future-looking)

Participants were asked to share information on how they are designing and planning for future compliance with a BPS based on the BPS within the pilot jurisdiction. Data from all three data sets (backward-looking, current-code and forward-looking) shows the differing levels of performance and extrapolates data sets to three future compliance periods. PNNL planned to compare the data from each data set to the BPS performance targets for the buildings and understand performance outcomes for newly constructed buildings following different energy code compliance paths, and the implications for compliance with BPS.

Overview of Jurisdiction Pilots

PNNL engaged with two jurisdictions during the course of the pilots, tailoring approaches to each jurisdiction's goals and needs to ensure that the outcomes are locally and more immediately applicable, as well as able to inform development and implementation at a national level. Context and application of different methods for each jurisdiction is explained below.

New York City

In 2018, New York City (NYC) passed Local Law 32 (LL32), requiring that by January 1, 2025, the energy code include performance-based or predictive energy use targets for buildings (City of New York 2018). Considering that buildings generate about 68% of NYC's greenhouse gas emissions, adopting performance-based codes—and replacing prescriptive codes—helps to move NYC toward achieving its goal of carbon neutrality by 2050.

Working in collaboration with the NYC Department of Buildings (DOB), PNNL developed a pilot using HVAC, Lighting and Envelope System Performance compliance pathways as an alternative to the Prescriptive and the Whole Building Performance compliance pathways. Phase 1 of the pilot was introduced to the design community in NYC via webinar in August 2021. Almost 100 projects applied to be part of the Phase 1 Pilot and a total of 12 projects were selected. Phase 1 focused on using the System Performance compliance pathways and a range of projects were selected that covered multifamily, office and educational property use types. PNNL prepared and delivered a series of training webinars for each System Performance pathway prior to the start of the Pilot. NYC DOB was not allowed to use the pilot as an alternate method of code compliance, as such participants in the pilot were volunteering their time to complete the work.

The results of the Phase 1 Pilot were used to develop a Phase 2 Pilot that looked at modifying the TSPR approach in response to Phase 1 comments, adding in piloting of changes to Appendix G, seeking input on the Simplified Performance Rating Method (S-PRM) approach developed by PNNL, and investigating the alignment between performance options and NYC's BPS, Local Law 97 (LL97) (City of New York 2019). In collaboration with NYC DOB, a group of designers and energy practitioners was selected for participation in the Phase 2 Pilot. The Phase 2 Pilot was introduced via webinar in June 2023. PNNL prepared and delivered a series of training webinars for each pathway prior to the start of the Pilot and provided dedicated office hours for each pathway over a five-week period to support projects completing the pilots. This phase of the study was developed to align with the proposed version of NY Stretch under development at the time.

Both phases of the pilot focused on new buildings with one or more of the following occupancy types: multifamily, office, retail, and/or school. Additions and/or alterations of these occupancy types were considered on a case-by-case basis.

Participants were asked to submit alternate energy analysis forms documenting a new or existing project and provide feedback on the process itself. For system-based approaches the level of effort was estimated to be similar to using COMcheck compliance software, with a typical 25,000 square foot office building taking about 4-6 hours to complete for each of the reporting tools. For modeling-based approaches (S-PRM and Appendix G), the level of effort was estimated to be 8-16 hours to complete.

Results of Performance-Based Code Compliance Approaches

Envelope System Performance

Tool and Documentation Feedback. Pilot participants were very receptive to using the familiar COMcheck software tool for the envelope system performance.

Reporting the reference baseline criteria alongside the proposed design criteria was a challenge given the way the COMcheck reports are programmed. Several participants commented that it is important for designers to be able to know what the reference baseline performance criteria is for purposes of knowing what to adjust when the envelope doesn't comply.

The modifications that added new functionality for curtain wall spandrel were very well received by both NYC DOB and the pilot participants. A similar approach for incorporating thermal bridging elements and other opaque wall adjustments (i.e. louvers) was recommended to be incorporated into the current envelope performance tradeoff methodology.

Results. The projects that completed the Envelope System Performance had all previously completed envelope COMcheck and the results showed that the independent baseline was about 1% more stringent than the dependent baseline case. This is likely due to the reduced window to wall ratio of the independent baseline based on the building types tested as part of the Pilot. Unfortunately, none of the Pilot participants had the extra time to look at how they could improve the envelope design to achieve compliance, though it is anticipated that only minor modifications to the design would have achieved compliance with the independent baseline.

HVAC TSPR System Performance

Tool and Documentation Feedback. In Phase 1, the users of the TSPR tool had very positive things to say about the usability of the tool. The majority of the user feedback stated the tool was very intuitive to use. Where users seemed to struggle the most was understanding and setting up more complicated HVAC systems and their control configurations. In Phase 2, users found the tool to be less intuitive and had a more difficult time getting started with the block geometry and setup of the systems. Users in Phase 2 attempted to include "less simple" buildings in their TSPR analysis, resulting in usability issues for the tool. Primary issues included inputting building geometry and HVAC system types into the TSPR tool.

Pilot participants in both phases felt that the time to build and run the TSPR analysis was reasonable and could be done in about eight hours, only slightly more than the original estimate of 4-6 hours and would be expected to decrease with increased familiarity with the tool.

The original TSPR code language, as adopted by WA, was written to exclude systems that used purchased heating and cooling (i.e. district heating and cooling) and HVAC zones that utilize perimeter baseboard heating systems. Hence these systems were not supported through the tool for the Phase 1 pilot. However, in NYC both of these HVAC system configurations are, in contrast, quite popular choices for HVAC system designers. Many of the NYC Phase 1 Pilot projects selected for testing were unable to complete the TSPR analysis because they utilized district heating (purchased steam) or baseboard heating systems. To support the applicability and increased adoption of TSPR in colder climate zones, the tool was further developed to include these system configurations and included in the NYC Phase 2 Pilot.

Participants noted that increased training and a clearer step-by-step guide on how to build the model would have saved time. TSPR outcomes could be improved with better technical support documents to help explain the proper setup of different HVAC system configurations. It was not always obvious to new users of TSPR how to configure the HVAC systems and control settings in the software.

Phase 1 Results. The NYC Pilot adopted an all-electric HVAC reference case for the Phase 1 Pilot. The electrification goals being pursued by NYC and New York State were the primary consideration for selecting the reference system. None of the projects that completed the TSPR calculations were able to demonstrate compliance against the reference design criteria because of the building systems used. Pilot participants expressed frustration that their designs were unable to achieve the level of performance of the reference system. One project that included areas served by all electric VRF systems was able to meet the target TSPR for just those areas, but the remaining portion of the building served by systems with direct-expansion cooling and gas furnaces did not comply.

Phase 2 Results. The NYC Phase 2 Pilot adopted the ASHRAE 90.1-2022 version of TSPR in order to align with changes being developed for the next New York State energy code. Most buildings that were able to complete the TSPR calculation were able to demonstrate compliance with the reference design, due to the adjustments from Phase 1 to include district heating and baseboard systems, and the adjustment from the all-electric baseline. One project showed non-compliance, and one project was unable to complete the calculation. The project that was unable to complete the TSPR calculation included a central system air to water heat pump, a system that was unavailable in the TSPR tool.

Lighting System Performance

Tool and Documentation Feedback. Generally Pilot participants were receptive to the idea of having the flexibility to trade-off between lighting power and lighting controls. However, they were discouraged by the level of detail they were required to enter. All of the participants gave feedback that the data entry was very time consuming and took much longer than they had anticipated. Pilot participants did acknowledge that the tool was intuitive to use and were able to provide lots of good feedback on how to improve the user experience. Pilot participants, comprised of electrical engineers and designers, made clear that the current design fees they receive from building owners would not allow them to provide the required level of documentation for this approach.

Lighting designers are not accustomed to documenting their designs on the scale being asked for using the Lighting System Performance approach. It was evident that lighting designers are only used to documenting lighting fixture counts on building basis or in some cases a room-by-room basis but certainly not at the lighting circuit level. Proper accounting of trade-offs between lighting controls and lighting power requires this more rigorous documentation.

Completing the Lighting System Performance calculations was incredibly time consuming for the participants, well over the estimated time commitment. This methodology was the most time consuming of the three System Performance pathways. In most cases pilot participants ended up only entering a subset of data for the entire building because they ran out of time to complete documentation for the entire building. Participants provided feedback that the data entry process needs to be better streamlined to reduce time entering data.

Results. Participants that completed the Lighting System Performance were able to show that their designs met the current NYCECC code requirements. None of the participants were interested in spending additional time to explore how their design could be different had they taken advantage of the ability to trade-off lighting controls and lighting power.

Simplified Performance Rating Method (S-PRM)

None of the pilot participants opted to evaluate buildings using the S-PRM approach. One likely reason for this is the absence of software tools which implement the ruleset, provide a simple interface for a user to define the proposed building design and automatically generate the baseline. Through other pilot studies (for utility incentive programs), PNNL has received positive feedback on the ease of analysis following the S-PRM ruleset and hopes that inclusion in a future edition of Standard 90.1 will spur the development of software tools that support the ruleset for code compliance evaluation.

Results of BPS Analyses

PNNL planned to assess how newly constructed buildings would perform compared to the LL97 targets using three different data sources for this assessment: data from the Performance Pilot, benchmarking data, and data from energy modeling simulations of prototypical buildings for future buildings. Because of the lack of participation in the S-PRM and Appendix G approaches in the NYC pilot, there was no data from the pilot participants to evaluate.

PNNL evaluated recently constructed buildings for compliance with the first 3 rounds of LL97, using publicly available energy benchmarking data. The NYC benchmarking data from calendar years 2017 through 2021 was used in this analysis (City of New York 2018-2022), roughly approximating the term of the previous energy code. The building data was cleaned for data quality issues and filtered to use only one record for each property ID (building) using the most recent year of data if valid data was available for more than one reporting year. PNNL calculated the greenhouse gas intensity (GHGI) compliance targets for each building using area-weighted averaging of all the reported property use types for each building, following the methodology in the NYC LL97 rulemaking (City of New York 2022). Figure 4 shows the results for office properties, over the three compliance cycles. Because the energy emissions coefficients for the third compliance period are not yet determined, PNNL used the energy emissions coefficient values for the second compliance period to calculate emissions for both the second and third compliance periods. Comparing the graphs for the second and third compliance periods in Figure 4, it is apparent that the buildings' emissions are unchanged for the two periods (due to the unknown coefficients for period three), while the targets are more stringent in compliance period three.

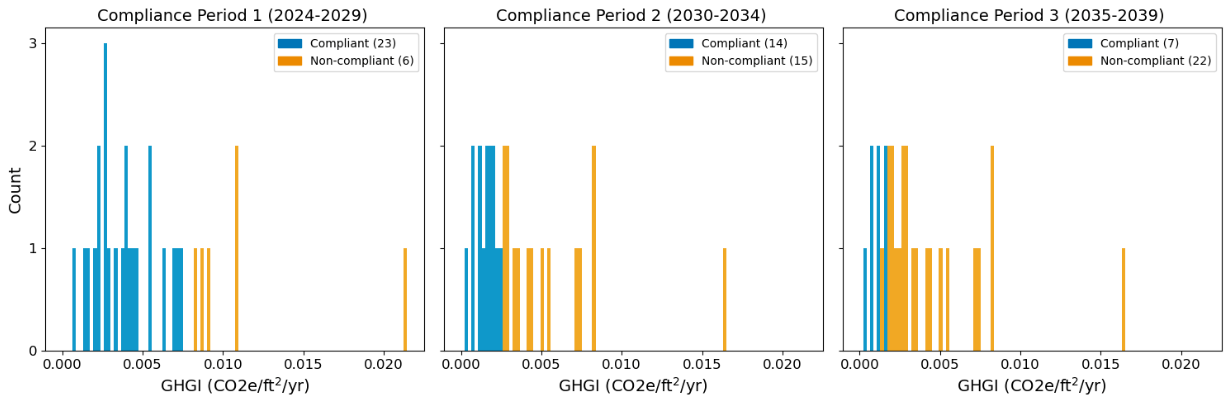

Figure 4. Greenhouse gas emissions intensity for office buildings in recent NYC benchmarking data (2017-2021). Data from 29 unique buildings is shown over three LL97 compliance periods. Note that energy emissions coefficients for compliance period 3 are yet to be determined, so the results shown for period 3 use the period 2 energy emissions coefficients.

The results in Figure 4 show that for the first compliance period, a large majority of building in the filtered data set comply with their GHGI targets, whereas by the third compliance period the opposite occurs: a large majority of buildings are non-compliant at their current level of performance. In compliance period two, the buildings are evenly split between compliant and non-compliant. In the near term, only a small fraction of buildings need to make adjustments to achieve compliance. In the longer term, most of these recently constructed office buildings will need to take action to maintain compliance.

The Pilot also examined a simulation-based analysis to assess the range of performance outcomes that may be obtained when following the prescriptive compliance path of ASHRAE 90.1-2022 to compare those as designed simulation outcomes with the LL97 targets. This analysis includes many building energy model runs of prototypical buildings to represent different options allowed by the prescriptive energy code, resulting in a large data set of potential performance outcomes similar to the data presented in Figure 1, above. For NYC, analysis was complete using Climate Zone 4A compliant systems. PNNL converted the simulation energy outputs to the GHGI compliance targets for each building type following the methodology in the NYC LL97 rulemaking. Figure 5 shows the results for office properties, over the three compliance periods.

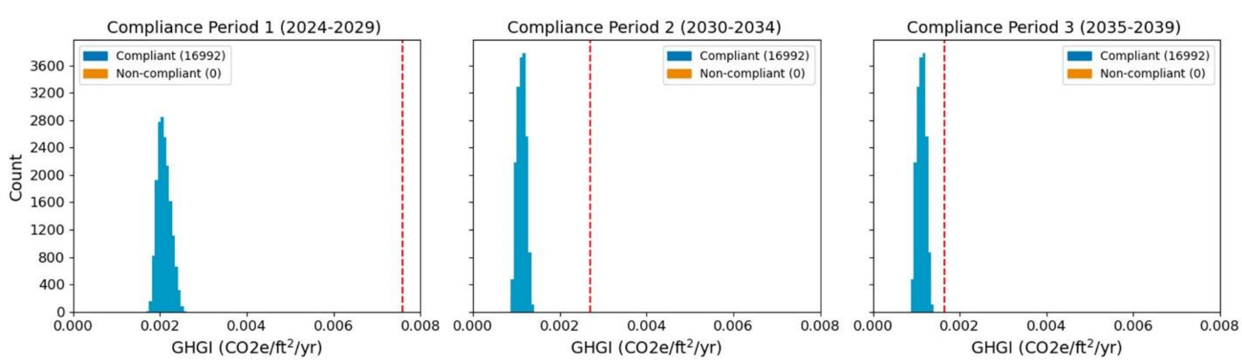

Figure 5. Greenhouse gas emissions intensity for office buildings based on 90.1-2022 prescriptive code design models (16,992 models) is shown over three LL97 compliance periods with emissions target.

The office prototype projection shows a very high likelihood of prescriptive buildings being able to be compliant with LL97 based on the information known for the first three compliance periods. Based on design simulation, all prescriptively compliant office model variants would be compliant with LL97 for the first three periods. As previously stated, because the energy emissions coefficient values in the third compliance period have not yet been established, the buildings are showing the same emissions profile, while the LL97 target is decreasing. Once the emissions coefficient values are established, the third compliance period may begin to show non-compliant model variants.

Finally, PNNL reviewed the backward- and forward-looking data sets together. Figure 6 shows data for office buildings from the simulation analysis (Figure 5) overlaid with benchmarking data (Figure 4) and the LL97 GHG target for three compliance periods.[2]

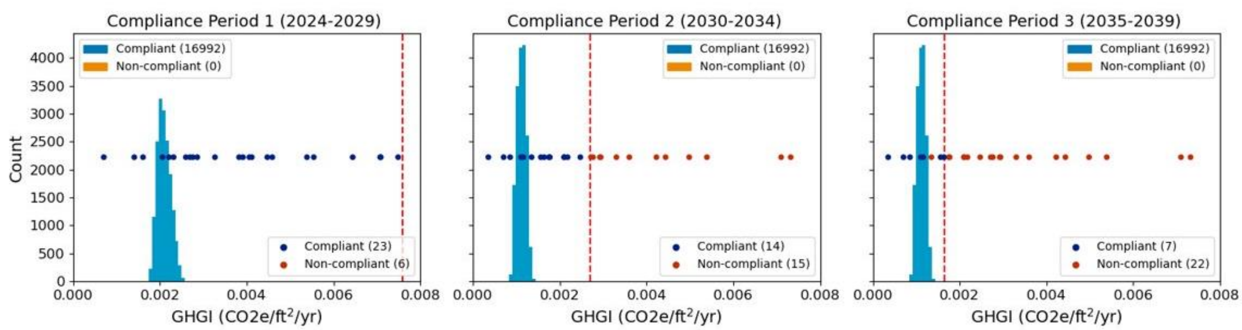

Figure 6. Greenhouse gas emissions intensity for office buildings based on 90.1-2022 prescriptive code design models (16,992 models), with data from 29 benchmarking buildings overlayed is shown over three LL97 compliance periods.

This final review of data indicates that there are a number of buildings built to the previous NYC energy code that are performing in the expected range of a future energy code. Additional analysis is needed to understand if characteristics of these high-performing buildings are similar in a way that could support performance-based code development.

Continued Development of Performance Based Approaches and Tools

HVAC TSPR System Performance

Broader adoption of TSPR, especially in heating dominated climates will need to address the current limitations on HVAC system configurations. While TSPR is primarily designed to address building designs with less complicated HVAC system configurations, it was very frustrating for users to not be able to use the TSPR approach for their designs. The system limitations also open the door for designers to avoid using TSPR by including excluded systems in their designs. While the current TSPR methodology supports the most common HVAC system types, additional system configurations may be needed to support a national application of TSPR in model energy codes.

Additionally, the design community's desire for application of TSPR to increasingly complex buildings and systems needs to be better understood. While the tool could be developed

[2] Some data points to the far right of the charts shown in Figure 6 have been omitted for clarity of the graphic.

to support complex building geometry and systems, its original intent was not to replace whole building energy simulations, which can easily accommodate those.

COMcheck

Envelope Performance. Additional functionality is needed to support reporting the reference baseline criteria alongside the proposed design criteria as well as to develop additional specific assembly types to derate the clear-field performance of the wall. Louvers were specifically mentioned in the NYC Phase 1 Pilot, but other common assemblies should be reviewed for inclusion as well. Feedback from the NYC pilots is currently being incorporated into the latest version of Comcheck to facilitate the documentation of envelope assemblies and components including louvers and thermal bridging.

Lighting Calculator. Future consideration needs to review options to improve ease of data entry including being able to use multipliers to reduce repetitive data entry and utilize direct connections to design tools where lighting system data can be directly extracted for Lighting System Performance calculations.

As this new, more detailed approach is currently being implemented in COMcheck for all projects, it will be important for DOE to provide concurrent education, both on how to use the new approach as well as why it is important to provide documentation at this level. Consideration should be given to improving the tool so that it is easier for lighting designers to complete this calculation.

Based on the feedback from pilot participants the continued development of Comcheck seeks to include a data schema allowing designers to directly import lighting system design details directly into COMcheck from a number of existing design tools**.**

S-PRM

There was very limited engagement on the S-PRM side during the pilots and the predominant reason for this was the unavailability of any tools which can support the simplifications of the proposed building and automatically generate the baseline building. Since industry is incentivized to develop software to support policies and programs which require the use of specific approaches, the PNNL team is focusing on incorporating S-PRM in ASHRAE Standard 90.1, to facilitate the adoption of the same and incentivize the development of software to support compliance evaluation.

A pilot conducted with a utility program, in support of their new construction incentive program, provided positive feedback of the S-PRM approach and identified over 30%-time savings in the creation of an energy model compared to a standard PRM model. This pilot involved manual generation of the baseline model, and the time savings is expected to be higher when the baseline is automatically generated, as required by the S-PRM approach.

Expanded pilot testing through either a code-based approach or additional utility incentive programs would continue to add value to the understanding of necessary tools or guidance needed to support S-PRM on a broader scale.

Inclusion in Model, State and Local Energy Codes

There is already progress toward the inclusion of performance-based energy methods into model, state and local energy codes. Washington State's energy code was an early leader in performance-based compliance paths, including TSPR and the use of site energy and emissions as options for Appendix G compliance since 2021. This section highlights the current development of performance compliance pathways in ASHRAE 90.1 and the IECC, as well as in the next version of NY Stretch.

ASHRAE 90.1

- TSPR was adopted into ASHRAE 90.1-2022. The version adopted into ASHRAE uses a 2004 baseline reference system similar to Appendix G and in Phase 2 of the pilot.
- S-PRM is being discussed for inclusion in a future edition.
- Appendix G in ASHRAE 90.1-2022 includes informative Addendum l with guidance for jurisdictions to calculate and adopt building performance factors (BPF) based on local energy tariffs, site energy, source energy or greenhouse gas emissions.
- An Envelope System Performance methodology using an independent baseline is being developed as part of work to develop a net-zero operational energy emissions pathway.
- A Lighting System Performance methodology is continuing to be worked on to address stakeholder concerns.

IECC

- TSPR was approved for inclusion in the IECC 2024. The adopted version of TSPR is based on the methodology adopted into ASHRAE 90.1-2022.
- S-PRM, Envelope System Performance and Lighting System Performance are not currently being considered for inclusion in the IECC.

NY Stretch. The experience from Pilot Phase 1, which used an all-electric TSPR baseline, helped inform discussions about the application of TSPR for the development of NYStretch 2023. At the conclusion of the Phase 1 Pilot, concerns were expressed about using an all-electric baseline for TSPR. The initial discussions with NY Stretch stakeholder groups had similar concerns and pushed for a more "typical" target design using both electric and natural gas. However, because the recent electrification laws passed in both NYC and New York State, the NY Stretch development team has proposed adoption of the ASHRAE 90.1-2022 TSPR methodology with all electric HVAC Target systems that align with the goals of the new code, but which also gives high efficiency mixed-fuel systems the opportunity to comply.

Expansion of Performance Pilot: Montgomery County, MD

To better understand the opportunity and application of performance-based compliance to different building stocks (NYC being unique even among large cities with similar building typologies), climate zones, and stakeholder pools, PNNL identified jurisdictions to expand the pilot. Jurisdictions that met the following general criteria were prioritized: expressed interest in performance based codes, have sufficient building stock to provide sample of 10-12 buildings, and have staff capacity and interest to engage with PNNL to pursue a pilot study. Montgomery County, Maryland provides a more replicable application of the performance compliance paths with its varied building stock across the county from more urban to suburban, providing a counterpoint to the predominantly urban, high density NYC building stock. Montgomery County (MoCo) also recently passed a BPS – so a focus on performance-based outcomes is on the minds of designers and engineers practicing in the region.

To develop the pilot, PNNL is actively engaging with the Montgomery County Department of Permitting Services (DPS) to review options for the pilot that were completed in NYC and discuss the County's goals around energy codes and performance-based compliance pathways to develop its pilot. The next version of the energy code proposed in MoCo is based on 90.1-2022 and with a modified Appendix G based on addendum l, estimated to result in an 11% increase in efficiency (ASHRAE 2024). All new construction over 20,000 sqft will be required to comply with the energy code using Appendix G, and therefore be required to complete an energy model. In 2022, MoCo passed Bill 16-21, Environmental Sustainability - Building Energy Use Benchmarking and Performance Standards, locally referred to as BEPS (Montgomery County Council 2022). The MoCo BEPS applies to buildings over 25,000 sqft and requires site energy use reductions by set dates. Final performance targets are under review and are expected to be finalized later this year.

Because of the changes in its base code that will require approximately half of all commercial new construction in MoCo to complete a building energy model, the MoCo pilot is planned be focused on the use of enhanced energy credits (including system-based performance options) for buildings over 20,000 sqft, to compare those design outcomes with Appendix G modeling analysis. This Phase 3 of the performance pilot has a goal of understanding if simpler buildings could achieve the same design EUI without the requirement for full building energy simulation. The pilot will also explore the code designed EUI compared to MoCo BEPS targets through a similar structure that was used in the NY Phase 2 pilot. Early results are anticipated in 2025.

Conclusion

Performance pilots have been successful in providing an opportunity for direct stakeholder feedback on proposed performance-based compliance pathways. This feedback has informed future development of code language, tools, and methodologies necessary to improvements in usability and expansion of pathways to fully support the inclusion of performance based-code pathways into national model codes.

As these pathways continue to be refined, additional small-scale testing through an expanded number of jurisdictions may be necessary to fill gaps in application to additional climate zones, common HVAC configurations, and building types to ensure application and usability of these paths is ready to replace the prescriptive compliance path.

Additional coordination will be needed between performance-based codes and the long-term compliance of buildings with BPS to understand relationships of design-based target setting with building operations and performance.

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