Bridging the Gap: Aligning Building Energy Codes with Existing Building Performance Standards

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ABSTRACT

The U.S. building sector is seeing unprecedented levels of investment in policies that improve energy performance in both new construction and existing buildings. The higher uptake in advanced, innovative energy codes as well as building performance standards (BPS), policies which seek to establish a specific level of performance for new and existing buildings, is beginning to change the lens through which we view building design and operation. As buildings transition from design and construction to operation, many of them become subject to BPS requirements as existing buildings, highlighting the need for bridging the performance gap between these two policies early on. This paper explores challenges that can arise from conventional code compliance processes as newly constructed commercial and multifamily buildings transition to BPS compliance, and potential strategies for policymakers and practitioners to address them. The authors will discuss the limitations of the prescriptive code compliance path as well as the role of performance-based design, simulation, enhanced commissioning, metering, and operation and maintenance strategies in aligning energy codes and BPS.

Introduction

Building energy codes for new construction and building performance standards (BPS) for existing buildings are two separate but related regulatory policies. While the main goals appear to be in alignment – energy efficiency and low operational carbon emissions – there are important differences in approach that require further alignment if those goals are to be realized throughout a building's life.

Building energy codes focus on building design and construction and offer the best opportunity to reduce energy use over the life of a building (Nelson 2012). While other factors affect energy use in buildings, including operation, maintenance, and the level of services provided, if a building does not start with an energy efficient design as required by an energy code, it will have a much more difficult time achieving its full energy efficiency potential. Initial construction is the best time to significantly influence building energy efficiency; otherwise, the opportunity could be lost since it is rarely as cost-effective to retrofit a building later (Nelson 2012). Most jurisdictions have energy codes based on ASHRAE Standard 90.1 (Standard 90.1) and the International Energy Conservation Code (IECC) (ASHRAE 2022, ICC 2021). Compliance options available in these model energy codes include a **prescriptive path**, **whole building performance paths**, and **system specific performance paths** for envelope and heating, ventilation, and air-conditioning systems.

The **prescriptive path** requires compliance with efficiency metrics for individual systems and components, such as the R-value of wall insulation, combustion efficiency of heating equipment, and maximum lighting power allowance. While easy to use and understand, the prescriptive path limits design flexibility and fails to acknowledge individual building characteristics as well as the interactive considerations that can optimize a building's energy performance with integrated solutions. Prescriptive requirements are typically established at an individual component level based on cost-effectiveness considerations and not by targeting any specific level of performance, hence the performance of two similar buildings complying with the same energy code may be different. Despite known performance limitations, the prescriptive path is used by the majority of projects in most jurisdictions (Rosenberg, Karpman 2021).

A **whole building performance path** considers holistic building design through the use of building energy simulation. It allows a design team to demonstrate, using energy models, that their proposed building design achieves equivalent energy performance to a building design that just meets the prescriptive path. Design flexibility is the main advantage of this path. It allows for the optimization of the design for a particular building's climate, operations, system interactions, and utility rate structure. The whole building performance compliance options in the model energy codes are the IECC Total Building Performance (TBP), the Standard 90.1 Energy Cost Budget Method (ECB), and the Standard 90.1 Performance Rating Method (PRM). All of these options require development of two energy models: one proposed design model that reflects the specified systems and components, and one baseline model that is primarily based on specified minimum requirements and is used as a point of reference. Compliance is determined based on the predicted annual performance of the proposed model matching (or exceeding by a specified amount) the annual performance of the baseline model.

For the TBP path, the modeled building performance used to determine compliance may be expressed as either annual energy cost or annual site energy consumption. The ECB and PRM paths require annual energy cost as the metric, but an informative appendix included in Standard 90.1-2022 provides language that jurisdictions may adopt to require the use of site energy, source energy, or greenhouse gas (GHG) emissions instead of cost. Some states have already adopted metrics other than energy cost; for example, Washington State uses site energy and GHG emissions; New York and Massachusetts 2023 stretch codes use site energy (WSEC 2024, NYSERDA 2019, Mass 2023).

System performance paths are conceptually similar to whole building performance paths but they allow tradeoffs only within a given system type (HVAC, lighting, envelope) and have simpler calculation procedures. System performance paths in Standard 90.1 include the Appendix C Envelope Tradeoff Method and the Appendix L Mechanical System Performance Rating Method introduced in the 2022 version of the standard. System performance paths for lighting and service water heating are under development for possible inclusion in Standard 90.1. Both the Envelope Tradeoff Method and the Mechanical System Performance Rating Method in Standard 90.1 use energy cost as the metric for compliance. The Mechanical System PRM includes informative sections about using alternative compliance metrics, including site energy, source energy, and GHG emissions.

Building performance standard policies are an emerging policy tool used by jurisdictions to reduce the operational energy use or GHG emissions of the existing commercial and larger multifamily residential building stock. BPS policies vary widely between jurisdictions and are tailored to each location's climate and energy goals, but they generally prescribe performance levels or targets that limit a building's energy use or emissions.

Figure 1 shows jurisdictions where BPS policies have been adopted or are being considered for adoption and the selected BPS compliance metrics as of March 2024. Table 1 summarizes key characteristics for three existing BPS policies to showcase the variation in the type of metric(s) used, type of buildings covered, the implementation timeframe, and the allowed alternative compliance pathways.

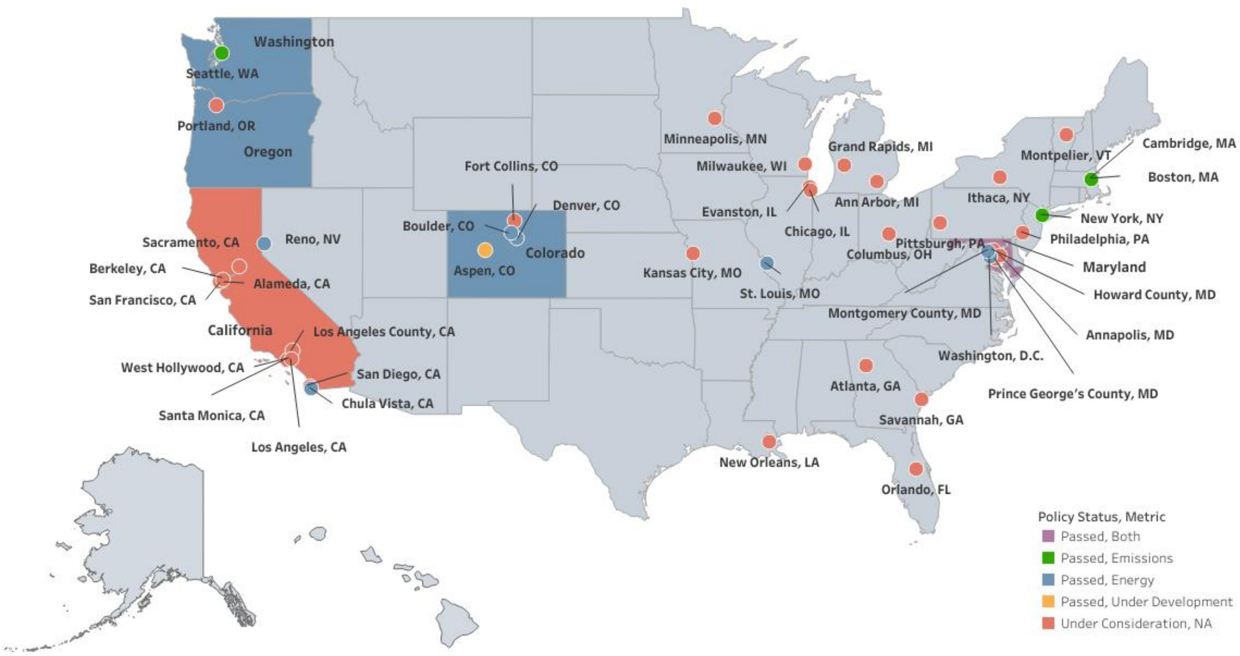

Figure 1. State and local building performance standards adoption[1] (March 2024)

[1] https://www.energycodes.gov/BPS

Table 1. Key characteristics of existing BPS policies

Jurisdiction	Type(s) of metric(s)	Covered building types	Initial compliance year	Alternative compliance pathways
New York	Greenhouse Gas Emissions Intensity (GHGI)	Commercial, Industrial (except for power generation) and Multifamily	2024 for buildings ≥ 25,000 square feet	Renewable Energy Credits (RECs), Greenhouse Gas Emissions Offsets, Alternative Compliance Payments
Washington, D.C.	Site Weather-normalized Energy Use Intensity (EUI) or ENERGY STAR score	Commercial, Multifamily, and Municipal	2025 for buildings ≥ 50,000 square feet and municipal buildings ≥ 10,000 square feet. The commercial size threshold drops to 10,000 square feet in 2030.	Performance Pathway: improve performance by a specified percentage. Prescriptive Pathway: Implement cost-effective energy efficiency measures as determined by a professional.
Washington State	Site EUI	Commercial and Multifamily	2026 for buildings > 220,000 square feet. The threshold drops to 50,000 square feet in 2028.	Investment Criteria Pathway: conduct an ASHRAE Level 2 energy audit and implement measures that meet cost-effectiveness criteria

Why New Buildings that Meet the Energy Code May Not Meet a Future BPS Target

Building energy codes and BPS policies have inherent differences in focus, scope, and compliance approaches that may result in a building complying with a jurisdiction's energy code but not with its BPS. In terms of focus and scope, an energy code regulates the design and construction of a building's systems, components, and controls, ensuring that they are capable and configured to operate efficiently when a building is initially occupied. BPS focuses on the holistic performance of the building once it's occupied, impacted by variables such as occupancy, operation, and maintenance. In addition, building energy codes do not regulate the energy use of the many different types of equipment and plug loads provided by occupants, such as consumer electronics and appliances in multifamily buildings, computers in offices, and medical equipment in hospitals. These account for a substantial and increasing share of building energy use, and their use can significantly change a building's overall performance. A comparison of items influencing building performance that are considered by energy codes and BPS policies is summarized in Table 2.

Table 2. Differences in the aspect of performance considered by energy codes versus BPS

Factors affecting post-occupancy building performance	BPS	Energy Code
Inherent efficiency of building design (envelope insulation; heating, cooling and service water heating system efficiencies; lighting and HVAC controls; etc.)	Yes	Yes
Ongoing proper operation and maintenance of building systems and controls as specified in design	Yes	No
Building use by occupants (operating hours, occupant density, plug-in equipment, temperature setpoints, etc.)	Yes	No

The stringency of prescriptive requirements is typically driven by a life-cycle cost analysis applied to each new prescriptive provision of Standard 90.1 and the IECC. The analysis involves evaluating the energy and energy cost savings and the related incremental construction and replacement costs to determine the cost-effectiveness of energy code changes over time (Rosenberg, et al. 2015). The requirements are not developed with a goal of establishing an overall performance requirement for a building, but rather about optimizing the efficiency of the individual components of a given design solution. For example, a design incorporating wood framed walls is required to include the most cost-effective level of insulation for that design as specified by the energy code, while the same building using steel framed walls has a different insulation requirement (and resulting heat transfer). Thus, the energy performance of the two similar buildings will be different even if both are minimally compliant with the code.

A similar situation exists with other design choices, including the choice of HVAC system type. For example, Project A with a minimally compliant geothermal heat pump and Project B with a minimally compliant packaged rooftop unit both comply with the prescriptive path, even though Project A will use less energy and have an easier time complying with the BPS than Project B. A study by Pacific Northwest National Laboratory used prototype building energy simulation to evaluate the energy impact of variations in 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 4A with no parameters exceeding prescriptive minimum efficiency levels as prescribed by Standard 90.1-2022 (Curtz, et al. 2024). As shown in Figure 2, design variations allowable using the prescriptive code resulted in a 60 percent variation in the annual energy use intensity.

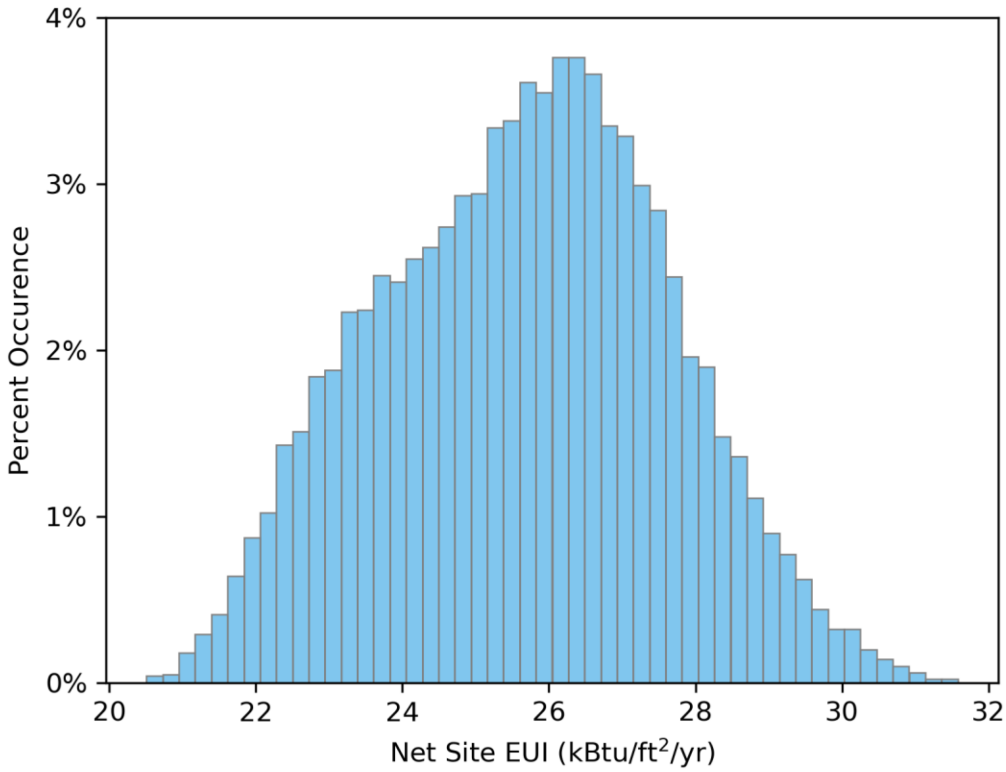

Figure 2. Distribution of Energy Use Intensity (EUI) for medium office building designs in climate zone 4A that are minimally compliant with prescriptive requirements of Standard 90.1-2022.

BPS policies and energy codes also differ in how they consider other aspects of compliance:

- **Compliance Metrics**: Performance-based energy code compliance pathways frequently use energy cost as the compliance metric, while BPS policies commonly use energy consumption or GHG emissions. Using different metrics for both policies may result in design solutions that are favorable for energy code compliance but are unfavorable for future compliance with the BPS. For example, when energy cost is the metric for code compliance, in jurisdictions where electricity is significantly more expensive than fossil fuels, compliance will be more easily achieved with fossil fuel heating compared to electric heat pumps. However, in most cases electric heat pump heating systems will have lower site energy consumption than fossil fuel systems. If the BPS targets in that jurisdiction are based on energy consumption, it is possible to envision a scenario where a building that complied with a cost-based energy code may not comply with the BPS.
- **Building Amenities**: BPS targets typically do not account for building amenities. For example, School A that offers summer programs has a swimming pool and kitchen facilities that will use more energy than School B that does not have these features, even when both schools have equally efficient envelope, lighting, and HVAC. As a result,

complying with the BPS may be more challenging for School A unless the BPS performance target can be adjusted to account for additional services or if the associated loads are allowed to be subtracted from the energy use subject to BPS. Model energy codes account for some of these factors. For example, if the swimming pool in School A met the relevant swimming pool prescriptive requirements (pool heater, pool cover, and controls) it would comply with the code just like School B, even though it uses significantly more energy. Similarly, in the performance path, the existence of the pool (or not) is carried over to the baseline design, and both schools would comply equally.

- **Renewable Energy**: Energy codes such as Standard 90.1 set the minimum renewable energy generation requirements for prescriptive compliance and allow renewable energy to contribute to the building performance calculation up to a set limit under the whole building performance path. In contrast, renewable energy can influence BPS compliance in different ways depending on the BPS metric. For example, BPS policies based on site or source energy targets typically focus on the total energy consumed at the building site (gross site energy), regardless of whether renewable energy generation is in use. When a BPS policy uses source energy or GHG emissions as the metric, renewable energy has a more significant effect on a building's ability to meet the target since it lowers the overall source energy and GHG conversion factors for the building. Some BPS policies also allow the use of a limited amount of renewable energy credits for off-site renewable energy as a compliance mechanism.

Strategies for Aligning the Energy Code with a Building Performance Standard

Although there are strategies that can be implemented within the BPS policy itself to support alignment with the local energy code, this paper focuses on changes that can be made to the energy code to improve a new building's likelihood of complying with BPS targets throughout its lifetime. Each suggested strategy described below is an optional addition to a jurisdiction's energy code and can be adopted individually or in combination with other strategies. This flexibility in strategy adoption is provided in recognition that there is no single energy code or BPS policy that fits all jurisdictions, hence policymakers and practitioners should consider the strategies that best serve their particular scenario. The strategies are described generically here, but PNNL has developed detailed model code language in the form of an overlay to ASHRAE Standard 90.1-2022 that can be adopted by a jurisdiction wishing to better align their energy code with their BPS (Karpman, et. al 2024).

1. Require a Predictive Model to Assess Future BPS Compliance. Code compliance options in the model energy codes do not set performance targets analogous to the BPS. Prescriptive-based code compliance does not establish whole-building performance, and performance-based compliance pathways determine a building's compliance based not on the modeled building's absolute energy use, but instead, on the modeled performance compared to a reference or baseline building with prescribed characteristics.

The advent of BPS offers a new opportunity for incorporating the modeled energy use of the proposed design into energy code framework. The energy model of the proposed design may be used to estimate post-occupancy energy performance relative to the BPS target. For example, if BPS compliance is based on site energy use, projects can compare the energy use of the predictive model to the BPS target. If the BPS is based on GHG emission intensity and excludes certain end uses, the exempt end uses may be similarly subtracted from the results of the predictive model, and performance expressed using the site energy to GHG conversion factors prescribed by the BPS to determine the expected BPS compliance outcome. If BPS compliance is based on an ENERGY STAR score, projects may enter the energy use of the predictive model into the U.S. Environmental Protection Agency's Target Finder tool to confirm the expected compliance outcome. The predictive model may also be used to inform design to select low-energy design alternatives that help projects comply with the BPS.

While building energy modeling is the best available tool for assessing the future performance of new building designs, it does present challenges. Developing a predictive model requires substantial additional effort for projects that do not use the whole building performance path. In addition, experience has shown that post-occupancy energy use often deviates significantly from model projections. To fully realize the predictive potential of energy modeling, the reasons for misalignment between modeled and measured energy use should be recognized and mitigated (Karpman, et al, 2024; CSA 2023). By addressing the following aspects of the code compliance energy modeling process towards a more predictive approach it may be possible to demonstrate code compliance while better estimating a building's post-occupancy performance relative to a BPS:

- Modeling rules should support the goal of making the model more predictive as described in guidelines such as the CSA/ANSI Z5020:23 Building Energy Modeling Standard. The metric used for the code compliance model should be the same as specified in the BPS. At the very least, the software used to develop the code compliance model should be capable of generating results using the same metric used by the BPS to demonstrate that the building is capable of meeting the BPS target to which it will be subjected. Modeling rules should be updated to eliminate provisions that require deviating from as-designed conditions.[2]
- Add reporting requirements to isolate end uses that are exempt from the BPS requirements. The added requirements could include energy use of electric vehicle charging stations, industrial equipment, or commercial kitchen equipment in schools.
- Add modeler qualification requirements. The requirements could include the relevant professional certifications and experience.[3]
- Update modeling software testing requirements. The requirements could include demonstrating compliance with the acceptance ranges incorporated into ASHRAE Standard 140 (ASHRAE 2023).

2. Enhance Commissioning Requirements. Commissioning can support compliance with a BPS by helping to ensure that building systems and components are properly controlled and configured to operate as intended in design documents. Standard 90.1-2022 includes mandatory verification and testing requirements and commissioning requirements. It also

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[2] For example, Standard 90.1-2022 Table G3.1 #1, Proposed Building Performance column item 1b requires modeling all conditioned spaces as both heated and cooled even if no heating or cooling system is to be installed.
[3] As part of a suite of tools to support performance-based code compliance (https://www.energycodes.gov/performance_based_compliance), DOE has developed recommended minimum qualifications for energy modelers documenting code compliance. https://www.energycodes.gov/sites/default/files/2022-07/2_Modeler_Quals_FINAL.pdf

includes Informative Appendix H, which provides additional guidance on best practices for verification, testing, and commissioning that can enhance the commissioning process. Future BPS compliance can be strengthened by expanding the current commissioning requirements to include guidance from the following sections as new normative requirements:

- Section H2: Recommended Minimum Qualifications and Independence of Commissioning Providers and Functional Performance Testing Providers
- Section H4: Standard 90.1 Items to Include in Verification, Testing or Commissioning
- Section H5: Commissioning documentation

3. Enhance Metering Requirements. Energy use monitoring, recording, and reporting play an important role in identifying building performance issues and informing future retrofits. The relevant existing energy code requirements include submetering the key electric end uses including HVAC, interior lighting, exterior lighting, receptacle circuits and refrigeration and whole building metering for other fuels, such as natural gas. However, energy codes for buildings that will be subject to a BPS should include enhanced metering of end uses (such as service water heating) served by other fuels as well as requirements for submetering of additional building end uses that may relate to BPS compliance, such as on-site renewable energy generation or loads that are specifically exempt from a BPS.

4. Enhance Operation and Maintenance (O&M) Plan Requirements. Similar to commissioning, O&M documentation helps ensure that building systems realize their performance potential. Standard 90.1-2022 requires that an O&M manual be provided to the building owner. Additional O&M requirements pertinent to the key building systems, including building envelope, HVAC, service water heating, power distribution systems and equipment, lighting, and other equipment, are provided in the corresponding sections of the standard. However, that content lacks specific details, pointing instead to the Informative Appendix E that includes more than 50 references to various standards, guidelines, and research projects.

A better approach is to require buildings to comply with ASHRAE Standard 100, Energy Efficiency in Existing Buildings, Section 6, Operations and Maintenance Requirements (ASHRAE 2024). The section requires establishing and implementing an O&M program tailored to the individual building to ensure that the building energy-using systems achieve their intended energy efficiency throughout their service life. The Normative Annex C referenced in Section 6 provides additional details about the required scope of the O&M plan, including an inventory of items to be inspected and maintained, performance objectives, condition indicators, inspection and maintenance tasks and their frequency, and documentation requirements. Informative Annex I provides specific O&M requirements for building systems and elements, including building envelope, domestic hot water systems, HVAC, refrigeration, lighting, controls, electric power distribution, and on-site generation systems.

5. Make PRM the only allowed path of energy code compliance for buildings that will be subject to a future BPS. As described above, the prescriptive path of compliance with the energy code allows significant variability in actual performance of minimally compliant designs. The IECC's TBP and Standard 90.1's ECB Method whole building compliance options share this shortcoming, since the baseline in these performance paths is dependent on the proposed design. A dependent baseline matches the proposed design, but its efficiency is adjusted to meet prescriptive code values. For example, under ECB or TBP, if a small office building in climate zone 4A is designed with an air source heat pump, the baseline will have an air source heat pump with efficiency and other regulated parameters just meeting the prescriptive code. If the same building is served by a gas furnace and direct expansion cooling system, the baseline will be a gas furnace with direct expansion cooling, thus the compliance target varies between the two designs. The PRM on the other hand uses an independent baseline design that depends only on building location, size, and occupancy type and both of the examples above will have a gas furnace with direct expansion cooling in the baseline, so the compliance target is consistent.

Similar to the PRM, the BPS performance targets are typically independent of the specifics of the building design, such as the type of walls, fenestration area, HVAC and service water heating system type and fuel source. Unlike any other energy code compliance pathway, the independent baseline methodology in the PRM offers the best opportunity for alignment with BPS performance targets.

The key disadvantage of making the PRM the only allowed path for energy code compliance, is the increased effort that would be required by design teams to document compliance and by jurisdictions to enforce compliance. However, if a predictive model is also required, the added work is limited to adjusting the predictive model to reflect the Appendix G rules and creating the PRM baseline model. Some building energy modeling tools automatically generate the baseline model based on the user-created model of the proposed design, and others are in the process of developing that capability. ASHRAE Standard 229P, Protocols for Evaluating Ruleset Application in Building Performance Models, aims to automate submittal reviews of modeling-based code compliance options, and a Ruleset Checking Tool for automating Standard 90.1 PRM submittal reviews following Standard 229P requirements is being developed by PNNL (ASHRAE 2024a). Several jurisdictions such as Washington State; Seattle, WA; Denver, CO; Boulder, CO; Aspen, CO; and New York City have recognized these advantages and made the PRM the only allowable whole building performance path (WSEC 2024, Denver 2022, Boulder 2020, Aspen 2021, NYSERDA 2023).

6. As-Designed Energy Performance Documentation. It is recommended that energy codes in jurisdictions with a BPS include requirements for submission of an energy performance report in conjunction with the predictive model discussed above. Information in this report along with the energy models can be used by building owners and operators after a building is occupied to help inform operation strategies and potential retrofits to support BPS compliance through the life of the building. The report should document the results of the model relative to the BPS performance target and include the following:

- Modeled energy use broken out by end use and energy source to allow direct comparison to the metered and submetered energy uses.
- Modeled energy savings associated with on-site renewable energy including energy consumed by the building and exported.
- In cases where a predictive model is required, the whole building performance expressed using the BPS metric (and any BPS prescribed metric conversion factors) and following all applicable BPS reporting rules, such as with respect to renewable energy and excluded loads.

- The current and, where applicable and known at the time of design, future BPS performance targets that projects will be required to meet.
- Determination of whether the project is expected to comply with the BPS based on the energy model.
- Supporting documentation including modeling files, weather files, and supporting calculations.

Conclusions

Building performance standard policies are an emerging tool used by jurisdictions to reduce the operational energy use or GHG emissions of the existing building stock by targeting a specific level of energy performance. Because of the variability in energy outcomes allowed by new building energy codes, there is justified concern that newly constructed buildings may have difficulty complying with an existing BPS policy soon after they are occupied. The results of a PNNL analysis of the energy variability of code compliant buildings shows this concern to be justified. To reduce this risk, jurisdictions can make modifications described in this paper to better align their energy code to produce outcomes required by their BPS. The most fundamental of these changes is to require that new buildings that will be subject to a BPS produce a predictive energy model of their proposed building design demonstrating that it will be capable of meeting the BPS. Other recommended changes to the code include enhanced commissioning, improved energy metering, development of an O&M plan during construction, and limiting code compliance options to the PRM.

As far as the authors are aware, no jurisdiction developing a BPS has in parallel made changes to their energy code to achieve better alignment. However, several jurisdictions that are currently in the process of implementing a BPS are now questioning whether some alignment is necessary. Because of the significant lag between code development and code implementation, jurisdictions should consider the energy code changes recommended in this paper at the same time they are developing a BPS or related statutory emissions limits.

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