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Building Performance Standards and Energy Code Alignment

Technical Brief

April 2024

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U.S. DEPARTMENT OF ENERGY

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Richland, Washington 99354

Preamble

The U.S. Department of Energy (DOE) and Pacific Northwest National Laboratory (PNNL) are developing a series of technical briefs supporting national, state, and local initiatives to update and advance building energy codes. These technical briefs represent specific technologies, measures, or practices that can be incorporated as module-based “plug-ins” via the national model energy codes, such as the International Energy Conservation Code (IECC) or ASHRAE Standard 90.1, or can be adopted directly by state and local governments pursuing advanced energy savings and greenhouse gas emissions reductions. The collection of briefs is part of a larger effort to provide technical assistance supporting states and local governments and help them realize their policy goals.

This technical brief presents recommendations for changes that may be incorporated into energy codes to facilitate future compliance with the building performance standard (BPS) policies that a newly constructed building has to meet once it is occupied. It provides background on the basis and benefits of the proposed changes and model code language that can be inserted into ASHRAE Standard 90.1 or adapted into other energy codes.

Additional assistance may be available from DOE and PNNL to support states and local governments interested in harmonizing their energy code and BPS policies. Forms of assistance include technical guidance, customized analysis of expected impacts (e.g., based on state-specific building stock, climate considerations, or utility prices), and further tailored code language to overlay state building codes or other standards. DOE provides this assistance in response to the Energy Conservation and Production Act, which directs the Secretary of Energy to provide technical assistance “to support implementation of state residential and commercial building energy efficiency codes” (42 USC6833). PNNL supports this mission by evaluating concepts for future code updates, conducting technical reviews and analysis of potential code changes, and assisting states and local jurisdictions that strive to adopt, comply with, and enforce energy codes. This helps assure successful implementation of building energy codes, as well as a range of advanced technologies and construction practices, and encourages building standards that are proven to be practical, affordable, and efficient.

DOE Building Energy Codes Program

DOE supports the advancement of building energy codes. Modern building codes and standards offer cost-effective solutions, contributing to lower utility bills for homes and businesses and helping mitigate the impacts of climate change. Learn more at energycodes.gov.

Executive Summary

Building energy codes focus on building design, construction and renovation and have significantly increased building efficiency since the first national energy code was published in 1975. Most jurisdictions have energy codes based on ANSI/ASHRAE/IES Standard 90.1 (hereto referred to as Standard 90.1) and the International Energy Conservation Code (IECC). Compliance options available in these model energy codes include a prescriptive path, whole building performance paths – including IECC Total Building Performance (TBP), Standard 90.1 Energy Cost Budget (ECB) method and Performance Rating Method (PRM) – and system performance paths for envelope and heating, ventilation, and air-conditioning systems[1].

Building performance standard (BPS) policies are an emerging policy tool used by jurisdictions to reduce the operational energy use or greenhouse gas (GHG) emissions of the existing commercial building stock. BPS policies vary widely between jurisdictions and are tailored to each location's climate and energy goals. Intuitively, projects that met a recent edition of the energy code should comply with the BPS targets. However, some new buildings may struggle with meeting the BPS for the following reasons:

1. Energy codes focus on the design of the building and its projected ability to perform efficiently, while BPS compliance is dependent on the actual ongoing performance of the building, considering variables like occupancy, operation, and maintenance.

2. There are significant differences in the methodologies used to determine BPS compliance versus code compliance, including how each handles compliance metrics, handling of building amenities, and renewable energy generation.

3. The prescriptive compliance path in the energy code is based on performance of individual building components, as opposed to the performance compliance path which accounts for holistic building design strategies and interdependent building systems. This can result in a significant variability in post-occupancy performance for buildings built using the prescriptive path. Designs on the lower end of the permitted efficiency range may struggle with meeting the BPS.

Although there are strategies that can be implemented within the BPS policy itself to support alignment with the local energy code, this technical brief focuses on changes that can be made to the energy code[2]. The strategies and associated sample code language presented in this brief may be optionally adopted individually or as a package by jurisdictions seeking to align their energy code with a BPS. The following strategies are included:

1. **Use a predictive model to assess future BPS compliance.**

   Future compliance with the BPS for a new construction project may be gauged by applying BPS rules to the modeled energy use of the proposed design. Predictive modeling requires substantial additional effort for projects that do not use the whole building performance path

[1] System performance paths for lighting and service water heating are under development and are being proposed for inclusion in Standard 90.1.

[2] Actions for aligning a BPS policy with code can include leveraging performance data from recently constructed buildings in target-setting, encouraging collaboration between BPS and code compliance officials, creating alternative compliance pathways for new buildings in the transition period from code to BPS compliance, and educating building owners, designers, and operators on the requirements of BPS (EERE 2023)

but may help avoid costly retrofits or fines soon after construction completion in order for the building to comply with the BPS. The proposed code change language requires using a predictive model to evaluate future BPS compliance. The provided modeling rules are based on the PRM requirements for the proposed design model updated to eliminate the rules that require deviation from as-built conditions and leveraging a new U.S./Canada energy modeling standard that includes the methodology for developing predictive models (CSA 2023). The language also includes modeler qualification requirements and expanded simulation tool testing requirements based on the recent additions to ASHRAE Standard 140 (ASHRAE 2020).

2. **Align metrics used for performance-based compliance with the BPS metric.**

   The proposed new language leverages the informative sections in Standard 90.1 that describe how to use the PRM and Mechanical System Performance Rating Method in conjunction with metrics other than energy cost. The language for using alternative metrics for other performance-based compliance options is also included.

3. **Require or encourage the use of the PRM energy code compliance path.**

   The prescriptive path of compliance with the energy code allows significant variability in performance of minimally compliant designs. The TBP and ECB whole building compliance options have similar shortcomings. The PRM independent baseline methodology offers the best alignment with the BPS performance target. Making PRM the only permitted compliance option increases the likelihood of future BPS compliance. While this approach makes modeling mandatory for all projects, if a predictive model is also required, the added effort for the modelers is limited to adjusting the predictive model to reflect the ASHRAE Standard 90.1 Appendix G rules and creating the PRM baseline model, which some modeling tools generate automatically.

4. **Add enhanced metering requirements**

   The proposed expanded metering requirements facilitate isolation of the loads and energy uses that are subject to BPS to support the documentation of BPS compliance.

5. **Add enhanced commissioning requirements**

   Commissioning ensures that building systems and components operate as intended in design documents. The new language enhances commissioning requirements.

6. **Add enhanced operation and maintenance requirements**

   Similar to commissioning, operation and maintenance (O&M) documentation helps ensure that building systems realize their efficiency potential. The proposed new language leverages ANSI/ASHRAE/IES Standard 100-2024, Energy Efficiency in Existing Buildings, to add specificity to the existing O&M requirements in the model energy codes.

7. **Require energy performance documentation**

   The proposed new language requires submitting an Energy Performance Report showing the results of the predictive model relative to the BPS performance targets.

Sample code language for Standard 90.1 2022 is provided for three options representing groups of changes that include different combinations of the strategies listed above.

Acronyms and Abbreviations

ANSI	American National Standards Institute
ASHRAE	American Society of Heating Ventilation and Air-Conditioning
BEM	building energy modeling
BPS	Building Performance Standard
BPF	building performance factor
CSA	Canadian Standards Association
CX	commissioning
DOE	U.S. Department of Energy
ECB	energy cost budget method
EUI	energy use intensity
GHG	greenhouse gas
HVAC	heating, ventilation, and air conditioning
IES	Illuminating Engineering Society
IECC	International Energy Conservation Code
O&M	operation and maintenance
PCI	performance cost index
PNNL	Pacific Northwest National Laboratory
PRM	performance rating method
PTAC	packaged terminal air conditioner
REC	renewable energy credit
TBP	total building performance
WSHP	water source heat pump

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1.0 Introduction

Building energy codes set requirements that must be met during building design and construction, and they have significantly increased building efficiency since the first national energy code was published in 1975 (Rosenberg, et al. 2015). Building performance standard (BPS) policies are emerging policy tools used by jurisdictions across the U.S. and beyond to reduce the operational energy use or greenhouse gas (GHG) emissions of their existing building stock and to meet their climate commitments for the building sector. As new buildings finish construction and become occupied, they transition to existing buildings that have to comply with any BPS policy in place.

The primary target audience for this technical brief is the policymakers involved in developing local energy codes. Because a jurisdiction's building energy code and BPS are in most cases developed and enforced by different departments, policymakers have to make a concerted effort to create alignment between the two policies and implement strategies that ease a building's transition from new construction to BPS compliance. Although there are strategies that can be implemented within the BPS policy itself to support alignment with the local energy code, this technical brief focuses on changes that can be made to the energy code and provides sample language that jurisdictions can consider for adoption[1]. In addition, the brief also provides background information on the reasons why buildings constructed to meet an energy code may not automatically comply with a future BPS.

[1]Actions for aligning a BPS policy with code can include leveraging performance data from recently constructed buildings in target-setting, encouraging collaboration between BPS and code compliance officials, creating alternative compliance pathways for new buildings in the transition period from code to BPS compliance, and educating building owners, designers, and operators on the requirements of BPS (EERE 2023)

2.0 Background

2.1 Building Energy Code Overview

Energy codes set minimum efficiency requirements for the design, construction and renovation of commercial buildings, offering the best opportunity to reduce energy use over the life of a building at the outset of the project (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 ANSI/ASHRAE/IES Standard 90.1 (hereto referred to as Standard 90.1) and the International Energy Conservation Code (IECC) with local amendments. Compliance options in these model energy codes include prescriptive path, whole building performance path, and system performance path.

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. It is used by the majority of projects in most jurisdictions (PNNL 2021).

A **whole building performance** path considers holistic building design through the use of building energy simulation. 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 generally reflects the specified systems and components, and one baseline model that reflects all code minimum requirements and is used as a point of reference. Compliance is determined based on the 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[1] included in Standard 90.1-2022 provides language that jurisdictions may adopt to require using PRM in conjunction with site energy, source energy, or 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.

The Standard 90.1 ECB and IECC TBP methods are favored by designers for code compliance (PNNL 2021) because historically they were often less stringent for documenting minimum code compliance than the Standard 90.1 PRM (Pillai et al, 2021). The 2022 edition of Standard 90.1 includes several impactful updates to better align its stringency with other compliance options,

[1] An Informative Appendix I included in Standard 90.1-2022 provides instruction for using the PRM in conjunction with site energy, source energy, and GHG emissions metrics.

such as a new methodology for determining the Building Performance Factors (BPFs) and improved support of retrofit projects. The PRM is the only allowed whole building performance path in some jurisdictions such as Washington State and Denver, Colorado, and is slated to become the only whole building compliance path in NYStretch Energy 2023 and NYC 2023 Energy Code. It is also widely used in beyond-code applications, such as LEED certifications.[1] .

System performance paths are conceptually similar to the whole building performance paths but they allow tradeoffs only within a given system type (i.e., 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 and are being proposed for possible inclusion in Standard 90.1.

The Envelope Tradeoff Method establishes compliance based on the relative annual energy use of a model reflecting the specified building envelope and a model for which the envelope is minimally compliant with the prescriptive requirements. All other systems including lighting and heating, ventilation, and air-conditioning (HVAC) are the same between the two models. For example, a project may use this compliance path to trade more insulation in one area for less in another, or trade higher fenestration area for opaque envelope and fenestration properties that perform better than prescriptive requirements.

The Mechanical System Performance Rating Method uses a similar approach for mechanical systems, evaluating the performance of the specified HVAC design relative to a prescribed reference HVAC design with all other model inputs such as envelope and lighting aligned between the two models. This approach allows the HVAC system to be evaluated in its entirety, accounting for the impact of heating, cooling and fan efficiency, energy recovery, outside air economizers, and the impact of efficient control strategies. While the Mechanical System Performance Rating Method was new in Standard 90.1 in 2022, it has been in place in the Washington State Energy Code since the 2018 edition. It is also slated for including in the 2024 IECC.

Both the Envelope Tradeoff and Mechanical System Performance Rating Method in Standard 90.1 use energy cost as the metric for compliance, but like the whole building PRM, the Mechanical System Performance Rating method includes informative sections about using alternative compliance metric including site energy, source energy, and GHG emissions.

2.2 Building Performance Standards Overview

BPS policies typically apply to commercial and multifamily buildings and prescribe performance levels or targets that limit a building's energy use or emissions over its lifetime. The BPS policies adopted to date use a variety of approaches tailored to the policy goals of each jurisdiction. They differ in the occupancy type and size of buildings that are covered, the metrics used to measure performance, performance normalization methodology, loads that may be excluded when determining BPS compliance, handling of renewable energy, the methodology

[1] Examples of beyond-code programs that use PRM include utility incentive programs, the Section 179D Energy Efficiency Tax Deduction, the U.S. Environmental Protection Agency ENERGY STAR Multifamily Program, and the U.S. Green Building Council's LEED® [Leadership in Energy and Environmental Design] Rating System.

used for establishing performance targets, the compliance time frame, and implementation mechanisms (ASHRAE 2023). Figure 1 shows jurisdictions where BPS policies have been adopted or are being considered for adoption and the selected metrics as of May 2023. Table 1 summarizes key characteristics for three existing BPS policies to showcase the variation in the types of buildings covered, the type of metric(s) used, the implementation timeframe, and the allowed alternative compliance pathways.

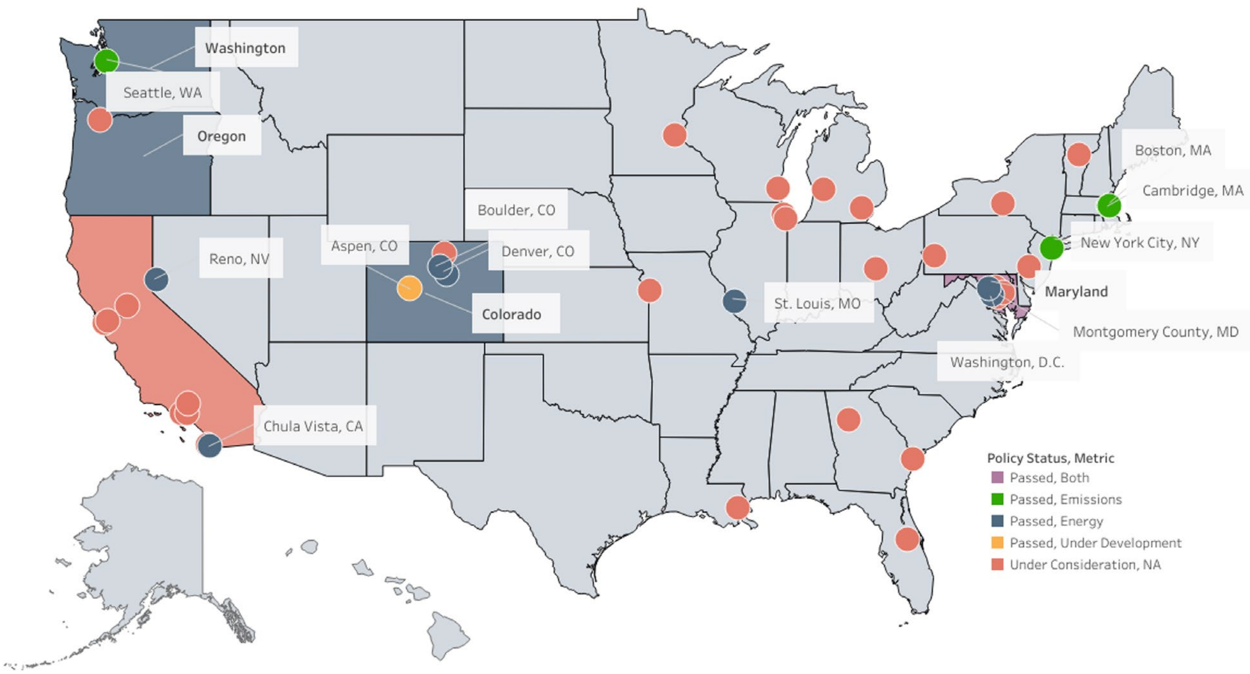

Figure 1. State and Local Building Performance Standards Adoption[1] (April 2024)

[1] Building Performance Standards | Building Energy Codes Program

Table 1. Key Characteristics of Existing BPS Policies

Jurisdiction	Type(s) of Metric(s)	Covered Building Types	Initial Implementation 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 sq. ft. The commercial size threshold drops to 10,000 square feet in 2030.	• Performance Pathway: improve performance by a specific 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

2.3 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 types of systems account for a substantial and increasing share of building energy use, and their use can significantly change a building's overall performance[1]. A comparison of the building performance factors considered by energy codes and BPS policies are summarized in Table 2.

Table 2. Building Performance Factors Considered by Energy Code and 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 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). 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 PNNL used prototype building energy simulation to evaluate the energy impact of

[1] On average, the contribution of unregulated energy use toward the total site energy use increased from 16 percent in buildings minimally compliant with Standard 90.1-2004 to 24 percent in the designs minimally compliant with ASHRAE Standard 90.1-2019. https://public.tableau.com/app/profile/doebecp/viz/2019EndUseAnalysisViz-Copy/Introduction

variations in design parameters including envelope characteristics, heating, ventilation and air conditioning systems, and water heating systems 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 70 percent variation in annual energy use intensity.

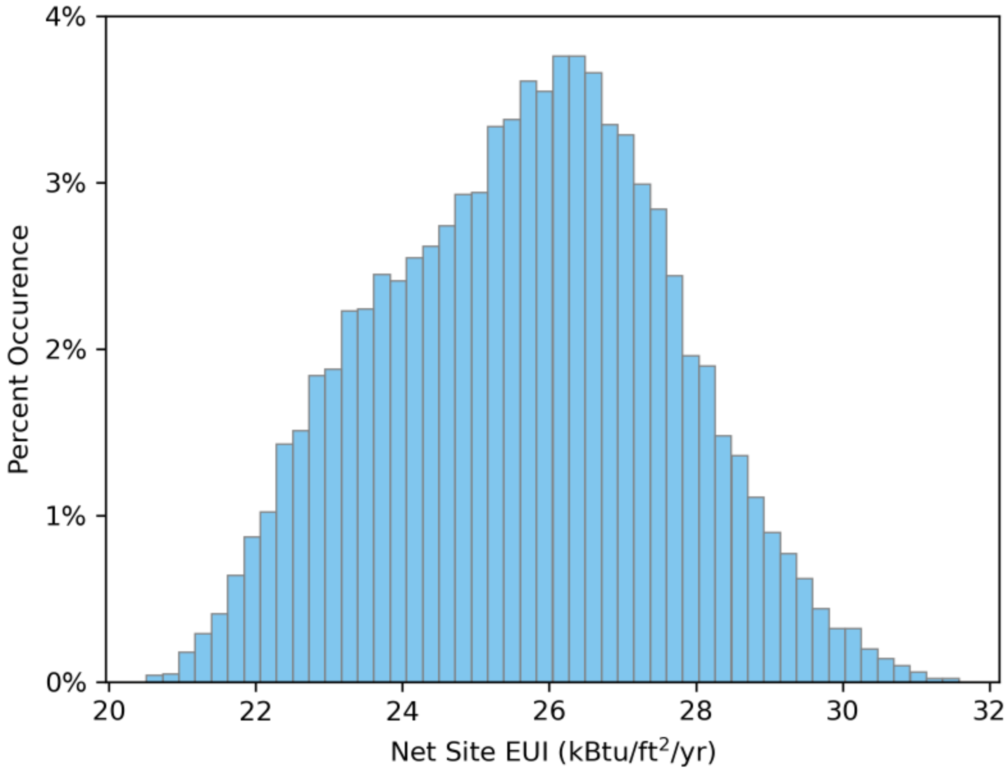

Figure 2. Distribution of Energy Use Intensity (EUI) for medium office building designs in climate zone 4A that are minimally compliant with prescriptive requirements of Standard 90.1-2022.

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

- Compliance Metrics: Performance-based energy code compliance pathways frequently use energy cost as the compliance metric, while BPS policies commonly use energy consumption or greenhouse gas 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 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 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 (RECs) for off-site renewable energy as a compliance mechanism.

3.0 Strategies for Aligning the Energy Code with a Building Performance Standard

The section describes possible changes to the energy code that have the potential to address differences between the focus and scope of energy codes and BPS, and improve a new building's likelihood to comply with BPS targets throughout its lifetime. Each suggested strategy is an optional addition to a jurisdiction's energy code and can be adopted individually or in combination with other strategies.

3.1 Use 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 the 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 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 Target Finder 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.[1] To fully realize the predictive potential of energy modeling, the reasons for misalignment between modeled and measured energy use should be recognized and mitigated. Table 3 summarizes the main areas for misalignment between modeled and measured energy use and highlights recommended mitigation strategies that are discussed in more detail later in this report.

[1] In a sample of LEED-certified buildings, the measured energy use deviated by more than 25 percent from the design projections for more than half of the projects, with 30 percent performing significantly better and 25 percent significantly worse (NBI 2018).

Table 3. Factors Causing Misalignment between Modeled and Measured Energy Use

Factor	Description	Mitigation Strategy
Differences between Ideal and Actual Operation	Models typically assume that building systems and controls operate as specified, but this is rarely the case. One example is building controls, which are frequently not fully commissioned and not configured to operate as intended by the code (PNNL 2017). For instance, economizers may reduce cooling energy use by 6 percent to 32 percent depending on climate, but without proper commissioning and ongoing maintenance tend to malfunction over time (Battelle, n.d.). Since that study was completed, model codes have added requirements for economizer commissioning and automatic fault detection diagnostics. Still, models reflecting correct economizer operation may underestimate cooling energy use.	Require enhanced commissioning, metering, and Operation and Maintenance documentation.
Impacts of Occupant Behavior, Weather, and Occupant-installed Equipment	Building occupants can operate a building in a variety of ways. Temperature setpoints, hours of occupancy, opening and closing windows and shades all affect energy use. One study showed service hot water use differing by a factor of four or more depending on whether an apartment is occupied by seniors or a family with kids (ASHRAE 2019). Energy use of systems and equipment installed by occupants such as office computers, kitchen appliances, task lighting, and industrial equipment, is another factor that strongly affects building energy use but is difficult to accurately predict.	Additional requirements to help make models more predictive, as described in CSA/ANSI Z5020:23 Section 6.2. Enhanced metering to better identify when use usage is misaligned with modeled assumptions (for example, lights being left on or setpoints overridden).
Limitations of Building Energy Modeling (BEM) Tools	Buildings are complex mechanical systems with many interacting components. Different energy modeling tools may give differing results. In addition, BEM tools do not always support the specified systems and controls, requiring modelers to use workarounds. The skill of the modeler can have a big impact on the accuracy of these workarounds.	Enhanced simulation program testing and acceptance criteria in accordance with ASHRAE Standard 140 - Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs. Enhanced qualifications for energy modelers.
Inconsistencies in Modeler Expertise and Results	The Building Energy Modeling Innovation Summit[1] cited inconsistencies in the results obtained by different modelers simulating the same building in the same tool as one of the top issues affecting BEM credibility. Compliance models are often developed by professionals who	Enhanced qualifications for energy modelers. Additional requirements to help make models more predictive, as described in

[1] Building Energy Modeling Innovation Summit, Rocky Mountain Institute.

Factor	Description	Mitigation Strategy
	have insufficient background and experience. In addition, modelers are often disconnected from the design team and are not fully aware of changes made to the building design, resulting in models that do not reflect the as-built systems.	CSA/ANSI Z5020:23 Section 6.2.

By refocusing 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. The sample code language shown in Section 4.0 covers the following areas:

1. **Require developing a predictive model for projects subject to BPS requirements.**

   Projects may be required to demonstrate that the energy use of the predictive model complies with the current or future BPS targets to which the building will be subjected. Alternatively, the requirements may be limited to submitting a report showing the expected BPS compliance based on the predictive model to raise the owner's awareness of the expected future energy use with respect to the BPS targets.

2. **Provide modeling rules for the predictive model.**

   The rules are based on the PRM proposed design model requirements updated to eliminate provisions that require deviating from as-designed conditions.[1] In addition, the language leverages a new Canada/U.S. energy modeling standard (CSA 2023)[2] that describes the methodology for developing a predictive model.

3. **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.

4. **Add modeler qualification requirements.**

   The requirements could include the relevant professional certifications and experience. [3]

5. **Update BEM software testing requirements.**

   The requirements could include demonstrating compliance with the acceptance ranges incorporated into ASHRAE Standard 140.

[1] 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.
[2] CSA/ANSI Standard Z5020:23 defines a predictive modeling use case and prescribes methodology for establishing modeling inputs for predictive models, including techniques for identifying the impactful parameters that require special attention.
[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

3.2 Align Metrics Used for Performance-based Compliance with the Metric Used for the BPS.

Using different metrics for energy code and BPS compliance may send a conflicting signal about design options that should be favored. To eliminate this disconnect, the same metric should be used for both. For example, if the BPS is based on GHG emissions with prescribed site energy to GHG emissions conversion factors, then the same metric and conversion factors should be used for establishing performance-based compliance in the energy code.

Standard 90.1-2022 includes a framework for using the PRM[1] and the Mechanical System Performance Rating Method[2] with metrics other than energy cost. Jurisdictions may use this framework to amend the model energy code to use the same metric as prescribed for the BPS. Other allowed performance-based paths of compliance with the energy code may be similarly amended to modify the compliance metric.

3.3 Require or Encourage the use of PRM Energy Code Compliance Path

The prescriptive path for compliance with the energy code allows significant variability in performance of compliant designs, as illustrated in Figure 2. The Standard 90.1's ECB and the IECC's TBP whole building compliance options share this shortcoming because the virtual design they use as the point of reference essentially reflects a version of the proposed design that is compliant with prescriptive requirements. The PRM eliminates this variability by using a baseline design that depends only on building location, size and occupancy type to disallow lower-performing designs that comply prescriptively. 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. Thus, PRM compliance outcomes are better aligned with the BPS than the compliance outcome of any other energy code compliance path. If the PRM is the only permitted compliance path and the compliance metrics are aligned, the new designs are more likely to meet the BPS once buildings are occupied.

While some jurisdictions[3] already require energy modeling for most new commercial designs, doing so will represent a significant change to the standard practice for most. The key disadvantage of disallowing all compliance options other than the PRM, including the prescriptive path, is the increased effort 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 BEM 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-

[1] Standard 90.1-2022 Informative Appendix I: Using Other Metrics in Conjunction with Appendix G Performance Rating Method When Approved by The Rating Authority

[2] Standard 90.1-2022 Normative Appendix L Informative Tables L5-2 through L5-5, which include values for alternate energy input metrics that may be adopted by a jurisdiction including site energy, source energy and GHG emissions.

[3] 225 Cmr 23: Massachusetts Commercial Stretch Energy Code and Municipal Opt-In Specialized Code 2023

based code compliance options,[1] and a Ruleset Checking Tool for automating Standard 90.1-2019 Appendix G submittal reviews following Standard 229P requirements is being developed by PNNL.

Another consideration is that COMcheck,[2] which is commonly used by projects complying prescriptively, does not support whole building performance compliance options. However, projects can use DOE/PNNL Standard 90.1 Section 11 and the Appendix G Compliance Form instead which, similar to COMcheck, are maintained to support new editions of Standard 90.1 and state amendments using DOE funding.

3.4 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 Standard 90.1-2022 requirements[3] include submetering the key end uses including HVAC, interior lighting, exterior lighting, receptacle circuits and refrigeration; recording the usage data at 15-minute intervals; reporting energy use at hourly, daily, monthly, and annual intervals; and storing information for a minimum of 3 years. In addition, most air-handling systems, chilled and hot water plants, and the associated coils and terminal units must be equipped with Direct Digital Control systems with certain diagnostic capabilities and reporting and recording abilities similar to those required for the whole building submeters. Metering and monitoring systems help building operators more easily identify performance issues that could adversely affect a building's compliance with the BPS. The sample language in Section 4.0 proposes enhanced metering requirements for tracking additional building end uses that may relate to BPS compliance, such as on-site renewable energy generation or loads that are exempt from a BPS.

3.5 Enhance Commissioning Requirements

Commissioning ensures that buildings 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 (Section 4.2.5.1) and commissioning requirements (Section 4.2.5.2). The standard's Informative Appendix H provides additional guidance on best practices for verification, testing, and commissioning that may be used to help meet the mandatory requirements. The sample code language in Section 4.0 builds on those requirements and provides updated language for section 4.2.5.2. The requirements added to the sample code language also leverage ASHRAE Standard 202 – 2018, Commissioning Process for Building and Systems.

3.6 Enhance Operations and Maintenance Plan Requirements

Similar to commissioning, O&M documentation helps ensure that building systems realize their performance potential. Standard 90.1-2022 Section 4.2.2.3 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

[1] The public comment draft of the standard is expected to be published in early 2024.
[2] DOE's commercial energy code compliance software.
[3] Standard 90.1 Sections 8.4.3 and 10.4.7.

Appendix E that includes more than 50 references to various standards, guidelines, and research projects.

The sample code language in Section 4.0 references ANSI/ASHRAE/IES Standard 100-2024, Energy Efficiency in Existing Buildings, Section 6, Operations and Maintenance Requirements. 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 Appendix C referenced in the section 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 Appendix I provides specific O&M requirements for building systems and elements, including building envelope, domestic hot water systems, HVAC, refrigeration, lighting, controls and electric power distribution, and on-site generation systems.

3.7 Energy Performance Documentation

The sample language in Section 4.0 requires submitting an Energy Performance Report documenting the results of an energy model (whether for code compliance or predictive, as needed) relative to the BPS performance targets, including the following:

- Modeled energy use broken out by end use and energy source to allow direct comparison to the metered and sub-metered 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.

4.0 Sample Code Language

This section provides sample code language designed to amend Standard 90.1 2022 to integrate the strategies described in the previous sections and support new construction, additions, and major renovation projects in their transition to BPS compliance.

4.1 Code Requirements Architecture Options

While most of the recommended strategies can be adopted individually, a multi-prong approach will achieve a better alignment between a BPS and energy code. To illustrate how different strategies can be combined, code language is provided for three policy options representing groups of recommendations that could be adopted. These policy options are described below and summarized in Table 4. The Standard 90.1 language overlays included in the following sections indicate the policy option(s) to which each amendment applies in the subsection titles.

- **Option 1:** Predictive model must meet the BPS performance target(s) + PRM is amended to use the BPS metric and is the only allowed compliance path + must submit Energy Performance Report + enhanced metering, commissioning, and O&M requirements.
- **Option 2:** Predictive model must meet the BPS performance target(s) + all compliance options are allowed + all performance-based performance compliance options must use the BPS metric + must submit Energy Performance Report + enhanced metering, commissioning, and O&M requirements.
- **Option 3:** Predictive model is required but is informative (i.e., is not required to meet the BPS performance targets) + all compliance options are allowed + all performance-based performance options amended to use the BPS metric + must submit Energy Performance Report + enhanced metering, commissioning, and O&M requirements.

Table 4. Code Architecture Options

Strategy	Policy Option #		
	1	2	3
Predictive model must meet the BPS performance target	Y	Y	N
Predictive model is required but is informative	N	N	Y
PRM is the Only Allowed Compliance Path (prescriptive path, ECB and TBP not permitted)	Y	N	N
All appliable performance-based compliance options are amended to use the same metric(s) as the BPS	Y	Y	Y
Must submit Energy Performance Report with the estimated BPS compliance based on the predictive model	Y	Y	Y
Enhanced Metering, Commissioning, and O&M Plan Requirements	Y	Y	Y

4.2 Standard 90.1-2022 Language Overlay

The following sections show proposed changes to Standard 90.1-2022 for each policy option. Each section describes in either the title or the subtitle which option from Table 4 the proposed language applies to (i.e., Option 1, Option 2, Option 3 or All Options). Instructions are provided to describe the changes. The following summarizes the changes required for each option:

Option 1: When adopting Option 1 include the changes in Section 4.2.2.1 in addition to the changes listed for All Options below.

Option 2: When adopting Option 2 include the changes in Sections 4.2.2.2, and 4.2.7.1 through 4.2.7.4 in addition to the changes listed for All Options below.

Option 3: When adopting Option 3 include the changes in Sections 4.2.2.3 and 4.2.7.1 through 4.2.7.4 in addition to the changes listed for All Options below.

All Options: The changes in Sections 4.2.1.1, 4.2.2.4, 4.2.3, 4.2.4, 4.2.5, 4.2.6 and 4.2.8 apply to all 3 options.

4.2.1 Section 3, Definitions

4.2.1.1 All Options

Instructions:

a. Amend Sections 3 to replace references to "annual energy cost" with the BPS performance metric in the definitions of "baseline building performance" and "proposed building performance".
b. Add the following definitions to Section 3:

Building performance standard (*BPS*): a policy that establishes performance targets for *existing buildings*, verified by measured *building energy* use.

predictive model: a computer representation of the actual proposed *building* design, or portion thereof, developed for the purpose of estimating measured *energy* use of the *building* after it is occupied.

BPS performance metric: unit of measurement used to express performance of the *building* either during the design phase or during operation that is used to express the targets in the *building performance standard* that the *building* will be subject to once put into operation.

predicted performance: estimated post-occupancy *energy* performance of a *building* and the associated *building site*.

BPS predicted performance: estimated post-occupancy *energy* performance of a *building* and the associated *building site* based on the results of the *predictive model* excluding *energy* use of *systems* and components exempt from the *BPS* compliance, accounting for *BPS* renewable energy requirements, expressed using the *BPS performance metric* and normalized as required by the *BPS*.

4.2.2 Section 4, Administration and Enforcement

4.2.2.1 Option 1

Instructions:

a. Amend Section 4.2.1.1 (without changing the rest of the 4.2 section) as follows:

4.2.1.1 New Buildings. New *buildings* shall comply with Section 4.2.2 through 4.2.5 and ~~either~~ the provisions of

~~a. Sections 5, “Building Envelope”; 6, “Heating, Ventilating, and Air Conditioning”; 7, “Service Water Heating”; 8, “Power”; 9, “Lighting”; 10, “Other Equipment”; and 11, “Additional Efficiency Requirements,” or~~
~~b. Section 12, “Energy Cost Budget Method,” or~~
~~c.~~ Normative Appendix G, “Performance Rating Method” and Normative Appendix X, “Assessing Expected Building and Site Energy Performance”.

When following Normative Appendix X, the *BPS predicted performance* of new *buildings*, *additions* to *existing buildings*, and/or *alterations* to *existing buildings*, determined in accordance with Section X3.3, shall be less than or equal to the *building performance standard* target as determined by the *authority having jurisdiction*.

When using Normative Appendix G, the Performance Cost Index (PCI) of new buildings, additions to existing buildings, and/or alterations to existing buildings shall be less than or equal to the Performance Cost Index Target (PCIt) when calculated in accordance with the following:

b. Amend Section 4.2.1.2 as follows:

4.2.1.2 Additions to Existing Buildings. *Additions* that increase the *gross conditioned floor area* of *existing buildings* by greater than or equal to 50% shall comply with Section 4.2.1.2.1, all other *additions* to *existing buildings* shall comply with the provisions of Section 4.2.2 through 4.2.5, and one of the following:

a. Sections 5, “Building Envelope”; 6, “Heating, Ventilating, and Air Conditioning”; 7, “Service Water Heating”; 8, “Power”; 9, “Lighting”; 10, “Other Equipment”; and 11, “Additional Efficiency Requirements,” or
b. Section 12, “Energy Cost Budget Method,” or
c. Normative Appendix G, “Performance Rating Method,” and Normative Appendix X, “Assessing Expected Building and Site Energy Performance”, both in accordance with Section 4.2.1.1.

4.2.1.2.1 Large Additions to Existing Buildings: *An addition* that increases the *gross conditioned floor area* of an *existing building* by greater than or equal to 50% or has a gross conditioned floor area greater than 10,000 square feet, whichever is smaller, shall comply with the provisions of Section 4.2.2 through 4.2.5, and Normative Appendix G, “Performance Rating Method,” and Normative Appendix X, “Assessing Expected Building and Site Energy Performance”, both in accordance with Section 4.2.1.1.

c. Amend Section 4.2.1.3 as follows:

4.2.1.3 Alterations of Existing Building Assemblies, Systems, and Equipment. *Alterations* to *existing building* assemblies, *systems*, and *equipment*, that meet the criteria of two or more items in Section G3.1.4(a), shall comply with the provisions of Section 4.2.2 through 4.2.5, and both Normative Appendix G, "Performance Rating Method," and Normative Appendix X, "Assessing Expected and Site Building Energy Performance", both in accordance with Section 4.2.1.1. The Performance Cost Index Target (PCIt) shall be calculated using the applicable BPF from Table 4.2.1.1 multiplied by 1.05.

All other ~~*A*~~*alterations* of *existing building* assemblies, *systems*, and *equipment* shall comply with the provisions of Section 4.2.2 through 4.2.5 and one of the following:

a. Sections 5, "Building Envelope"; 6, "Heating, Ventilating, and Air Conditioning"; 7, "Service Water Heating"; 8, "Power"; 9, "Lighting"; 10, "Other Equipment"; and 11, "Additional Efficiency Requirements," or
b. Section 12, "Energy Cost Budget Method," or
c. Normative Appendix G, "Performance Rating Method," in accordance with Section G3.3 and Section 4.2.1.1. The Performance Cost Index Target (PCIt) shall be calculated using a BPF equal to 1.0~~. with the following modifications:~~
   ~~1. *Alterations* that meet the criteria in Section G3.1.4(a) shall use the BPF from Table 4.2.1.1 multiplied by 1.05.~~
   ~~2. All other *alterations* modeled following Section G3.3 shall use BPF = 1.~~

4.2.2.2 Option 2

Instructions:
a. Amend Section 4.2.1.1 as follows:

4.2.1.1 New Buildings. New *buildings* shall comply with Section 4.2.2 through 4.2.5, Normative Appendix X, "Assessing Expected Building and Site Energy Performance", and either the provisions of

a. Sections 5, "Building Envelope"; 6, "Heating, Ventilating, and Air Conditioning"; 7, "Service Water Heating"; 8, "Power"; 9, "Lighting"; 10, "Other Equipment"; and 11, "Additional Efficiency Requirements," or
b. Section 12, "Energy Cost Budget Method," or
c. Normative Appendix G, "Performance Rating Method."

When using Normative Appendix X, the *BPS predicted performance* of new *buildings*, *additions* to *existing buildings*, and/or *alterations* to *existing buildings*, determined in accordance with Section X3.3, shall be less than or equal to the *building performance standard* target as determined by the *authority having jurisdiction*.

When using Normative Appendix G, the Performance Cost Index (PCI) of new buildings, additions to existing buildings, and/or alterations to existing buildings shall be less than or equal to the Performance Cost Index Target (PCIt) when calculated in accordance with the following:

b. Amend Section 4.2.1.2 as follows:

4.2.1.2 Additions to Existing Buildings. *Additions* to *existing buildings* shall comply with the provisions of Section 4.2.2 through 4.2.5, and one of the following:

a. Sections 5, “Building Envelope”; 6, “Heating, Ventilating, and Air Conditioning”; 7, “Service Water Heating”; 8, “Power”; 9, “Lighting”; 10, “Other Equipment”; and 11, “Additional Efficiency Requirements,” or
b. Section 12, “Energy Cost Budget Method,” or
c. Normative Appendix G, “Performance Rating Method,” and Normative Appendix X, “Assessing Expected Building and Site Energy Performance,” both in accordance with Section 4.2.1.1.

An *addition* that increases the *gross conditioned floor area* of an *existing building* by greater than or equal to 50%, or has a gross conditioned floor area greater than 10,000 square feet shall comply with Normative Appendix X, “Assessing Expected Building and Site Energy Performance,” in accordance with Section 4.2.1.1.

c. Amend Section 4.2.1.3 as follows:

4.2.1.3 Alterations of Existing Building Assemblies, Systems, and Equipment. *Alterations* of *existing building* assemblies, *systems*, and *equipment* shall comply with the provisions of Section 4.2.2 through 4.2.5 and one of the following:

a. Sections 5, “Building Envelope”; 6, “Heating, Ventilating, and Air Conditioning”; 7, “Service Water Heating”; 8, “Power”; 9, “Lighting”; 10, “Other Equipment”; and 11, “Additional Efficiency Requirements,” or
b. Section 12, “Energy Cost Budget Method,” or
c. Normative Appendix G, “Performance Rating Method,” in accordance with Section 4.2.1.1. with the following modifications:
   1. *Alterations* that meet the criteria in Section G3.1.4(a) shall use the BPF from Table 4.2.1.1 multiplied by 1.05.
   2. All other *alterations* modeled following Section G3.3 shall use BPF = 1.

Where an *alteration* meets two or more of the criteria in Section G3.1.4(a), the alteration shall comply with Normative Appendix X, “Assessing Expected Building and Site Energy Performance,” in accordance with Section 4.2.1.1

4.2.2.3 Option 3

Instructions:
a. Amend Section 4.2.1.1 as follows:

4.2.1.1 New Buildings. New *buildings* shall comply with Section 4.2.2 through 4.2.5, Normative Appendix X, “Assessing Expected Building and Site Energy Performance”, and either the provisions of

a. Sections 5, “Building Envelope”; 6, “Heating, Ventilating, and Air Conditioning”; 7, “Service Water Heating”; 8, “Power”; 9, “Lighting”; 10, “Other Equipment”; and 11, “Additional Efficiency Requirements,” or
b. Section 12, “Energy Cost Budget Method,” or

c. Normative Appendix G, “Performance Rating Method.”

Informative Note: Using Normative Appendix X to calculate the *BPS predicted performance* of new *buildings*, *additions* to *existing buildings*, and/or *alterations* to *existing buildings,* determined in accordance with Section X3.3, is to assess the risk of whether a proposed design will meet the future *building performance standard* target as determined by the *authority having jurisdiction*.

b. Amend Section 4.2.1.2 as follows:

4.2.1.2 Additions to Existing Buildings. *Additions* to *existing buildings* shall comply with the provisions of Section 4.2.2 through 4.2.5, and one of the following:

a. Sections 5, “Building Envelope”; 6, “Heating, Ventilating, and Air Conditioning”; 7, “Service Water Heating”; 8, “Power”; 9, “Lighting”; 10, “Other Equipment”; and 11, “Additional Efficiency Requirements,” or
b. Section 12, “Energy Cost Budget Method,” or
c. Normative Appendix G, “Performance Rating Method,” in accordance with Section 4.2.1.1. and Normative Appendix X, “Assessing Expected Building and Site Energy Performance,”.

An *addition* that increases the *gross conditioned floor area* of an *existing building* by greater than or equal to 50%, or has a *gross conditioned floor area* greater than 10,000 square feet shall comply with Normative Appendix X, “Assessing Expected Building and Site Energy Performance,”.

c. Amend Section 4.2.1.3 as follows:

4.2.1.3 Alterations of Existing Building Assemblies, Systems, and Equipment. *Alterations* of *existing building* assemblies, *systems*, and *equipment* shall comply with the provisions of Section 4.2.2 through 4.2.5 and one of the following:

a. Sections 5, “Building Envelope”; 6, “Heating, Ventilating, and Air Conditioning”; 7, “Service Water Heating”; 8, “Power”; 9, “Lighting”; 10, “Other Equipment”; and 11, “Additional Efficiency Requirements,” or
b. Section 12, “Energy Cost Budget Method,” or
c. Normative Appendix G, “Performance Rating Method,” in accordance with Section 4.2.1.1. with the following modifications:
   1. *Alterations* that meet the criteria in Section G3.1.4(a) shall use the BPF from Table 4.2.1.1 multiplied by 1.05.
   2. All other *alterations* modeled following Section G3.3 shall use BPF = 1.

Where an *alteration* meets two or more of the criteria in Section G3.1.4(a), the alteration shall comply with Normative Appendix X, “Assessing Expected Building and Site Energy Performance”.

4.2.2.4 All Options

Instructions:

a. Amend Sections 4 as described in the Standard 90.1 Informative Appendix I Section I3 to replace energy cost with the performance metric used in the BPS.

b. Amend Section 4.2.2.3 as follows:

4.2.2.3 Manuals. Operating and maintenance information shall be provided to the *building* owner. This information shall include but not be limited to the information specified in Sections 5.7.3.2, 6.7.3.2, 7.7.3.2, 8.7.3.2, 9.7.3.2 ~~and~~ , 10.7.3.2, and ASHRAE Standard 100 Section 6 and Normative Appendix C.

Informative Note: It is recommended that the operating and maintenance plan meets requirements of the ASHRAE Standard 100 Informative Appendix I which provides the operations and maintenance requirements for building envelope, domestic hot water systems, heating, ventilating and air-conditioning systems, refrigeration systems, lighting systems, controls systems and electric power distribution and on-site generation systems.

c. Add new section 4.2.2.4 as follows:

4.2.2.4 Energy Performance Documentation.
The Energy Performance Report meeting requirements of Section X2.1 shall be provided to the *building* owner. In addition, the input files of the *predictive model* and the weather file used to determine *building energy* performance following Normative Appendix X shall be provided.

Exception: Alterations meeting less than two of the criteria in Section G3.1.4(a).

d. Amend Sections 4.2.5.2, 4.2.5.2.1, and 4.2.5.2.2 as follows:

4.2.5.2 Building Commissioning Requirements. *Commissioning* shall be performed in accordance with this section and Sections 5.9.2, 6.9.2, 7.9.2, 8.9.2, 9.9.2, 10.9.2, 12.2(e), and G1.2.1(f). *Commissioning* shall use ASHRAE/IES Standard 202. *FPT* and verification requirements for *commissioning* are as stated in Section 4.2.5.1. *Commissioning* shall also document in sufficient detail compliance of the *building systems*, controls, and *building envelope* with required provisions of this standard. *Commissioning* requirements shall be incorporated into the *construction documents*.

The *commissioning provider* shall have the necessary training, experience, and *FPT equipment*. The *commissioning* team shall include *V&T providers*. The *commissioning provider* shall be ~~(a) a~~ an independent third-party entity not associated with the *building* project ~~, (b) owner's qualified employees, or (c) an individual associated with the design firm or contractor but not directly associated with design or installation of the *building systems*, controls, or *building envelope* being commissioned~~.

Exceptions to 4.2.5.2:

1. *Buildings*, *additions*, or *alterations* with less than 10,000 ft^2 of *conditioned space* and combined heating, cooling, and *service water heating equipment* totaling less than 960,000 Btu/h in capacity.
2. *Buildings* or portions of *buildings* that use the simplified approach building compliance path for HVAC systems in Section 6.3.

3. *Dwelling units*.
4. Nonrefrigerated warehouses.

4.2.5.2.1 Commissioning Activities Prior to Building Permit Issuance. The following activities shall be completed prior to issuance of a *building* permit:

a. A copy of the *commissioning* plan shall be submitted to the owner. A copy of the *commissioning* plan shall be submitted with the *building* permit application if requested by the *building official*.
b. A *commissioning provider* shall be designated by the owner to manage *commissioning* activities prior to completion of *construction documents*. The *construction documents* shall identify the *commissioning provider*.
c. The *commissioning provider* shall submit the design review report to the owner.
d. *Construction* phase *commissioning* requirements shall be incorporated into *construction documents*.

4.2.5.2.2 Project System Manual ~~Commissioning Documents~~. The system manual shall provide the information needed to understand, operate and maintain the building's systems and assemblies and shall include the required *commissioning* documents in accordance with this section. The System Manual and all ~~P~~project *commissioning* documents shall comply with ASHRAE/IES Standard 202 ~~or other *generally accepted engineering standards* acceptable to the building official~~. The *commissioning provider* shall certify completion of the required *commissioning process* and provide a System Manual that includes the following *commissioning* documents to the owner and design teams:

a. **Owner's Project Requirements**. Identify project goals, measurable performance criteria, cost considerations, benchmarks, and success criteria.

b. **Basis of Design**. Document and record the concepts, calculations, decisions and product selections used to meet both the Owners Project Requirements and applicable regulatory requirements, standards and guidelines.

c. **Commissioning Plan.** Identify *FPT* or verification procedures for all *systems* to be verified, commissioned, or tested.
d. **Design Review Report.** Detail compliance of the design with the Owner's Project Requirements and provisions of this standard. This *commissioning* design review shall not be considered a design peer review or a code or regulatory review.
e. **Preliminary Commissioning Report.** The preliminary *commissioning* report shall include the following:
    1. Required performance of commissioned *equipment*, *systems*, and assemblies, and results of *FPT* and verification.
    2. Summary of compliance of the *building* and its components, assemblies, controls, and *systems* with required provisions of this standard.
    3. Issues and resolution logs, including itemization of deficiencies found during verification, testing, and *commissioning* that have not been corrected at the time of report preparation.
    4. Deferred tests that cannot be performed at the time of report preparation.
    5. Documentation of the training of operating personnel and *building*

occupants on commissioned *systems*, and a plan for the completion of any deferred trainings not completed at the time of report preparation.

6. A plan for the completion of *commissioning* and training, including climatic and other conditions required for performance of the deferred tests.

f. **Final Commissioning Report.** The *construction documents* shall require the *commissioning provider* to provide a final *commissioning* report to the owner before completion of the contractor's general warranty period.

g. **Operation and Maintenance Manuals.** Operating and maintenance information shall be provided in accordance with Section 4.2.2.3 of this Standard.

h. **Training Plan**. A written document that details the expectations, schedule, duration, and deliverables for CX Activities related to training of project operations and maintenance personnel, users and occupants. The *construction documents* shall require the *commissioning provider* to provide a Training Plan to the owner prior to occupancy.

4.2.3 Section 8.4.3 Electrical Energy Monitoring (All Options)

Instructions:

a. Amend Section 8.4.3.1 as follows:

8.4.3.1 Monitoring. Measurement devices shall be installed in new *buildings* to monitor the electrical *energy* use for each of the following separately:

a. Total electrical *energy.*
b. *HVAC systems* including heating, cooling and ventilation, including but not limited to fans, pumps, boilers, chillers, and heat rejection.
c. Interior lighting.
d. Exterior lighting.
e. Receptacle circuits.
f. Refrigeration *systems.*
g. Service water heating systems.
h. Plug and Process equipment, including any single equipment category that is not included in an HVAC, lighting or plug load category and that exceeds 5 percent of the peak connected load of the whole building, including but not limited to data centers, manufacturing equipment and commercial kitchens.
i. Electric vehicle charging serving vehicles used on-*site*, off-*site* or both.
j. The production, consumption, and export of on-*site electricity generation system* production.
k. Other systems or components that the *building performance standard* permits to be excluded from the reported *building* energy.

Informative Note: For example, if a school includes a commercial kitchen that is exempt from meeting the *building performance standard* target, energy use of exempt systems and equipment in the commercial kitchen would be separately monitored to comply with 8.4.3.1(i).

For *buildings* with tenants, these *systems* shall be separately monitored for the total *building* and (excluding shared *systems*) for each individual tenant.

Exception to 8.4.3.1: Where the design load of any of the categories (b) through ~~(f)~~ (g) are less than 10% of the whole-building load, these categories shall be allowed to be combined with other categories.

b. Amend Exceptions to 8.4.3.1 and 8.4.3.2 as follows:

Exceptions to 8.4.3.1 and 8.4.3.2:
1. *Buildings* less than 25,000 ft2 and exempt from a *building performance standard*.
2. Individual tenant *spaces,* less than 10,000 ft2., with separately metered electric service..
3. *Dwelling units*.
4. *Residential buildings* with less than 10,000 ft2 of common area.
5. Critical *equipment* and life-safety branches of NFPA 70, Article 517.

***Informative Note**:* The exceptions to 8.4.3.1 and 8.4.3.2 are intended for building areas and systems exempt from a *building performance standard*. When adopting provisions to align 90.1 with a *building performance standard* exclude any exceptions describing *building* areas or *systems* that are not exempt.

4.2.4 Section 10.4.7 Whole Building Energy Monitoring (All Options)

Instructions:

a. Amend Section 10.4.7.1 as follows:

10.4.7 Whole-Building Energy Monitoring. Measurement devices shall be installed at the *building site* to monitor the *energy* use of each new *building*.
10.4.7.1 Monitoring. Measurement devices shall be installed to separately monitor the *energy* consumption of each fuel type ~~the following types of *energy*~~ supplied by a utility, *energy* provider, or plant that is not within the *building*~~:~~ including the following:

a. Natural gas
b. *Fuel* oil
c. Propane
d. Steam
e. Chilled water
f. Hot water
g. Other unique energy sources (specify)

Informative Note: Examples of other unique energy sources include but are not limited to coal, hog fuel and gasoline.

Additional measurement devices shall be installed, as necessary, to monitor the *energy* consumption, regardless of fuel type, of all systems or components that the *building performance standard* permits to be excluded from the reported *building* energy consumption.

b. Amend Exceptions to 10.4.7.1 and 10.4.7.2 as follows:

Exceptions to 10.4.7.1 and 10.4.7.2:
Unless required to be included as part of a BPS, the following areas are exempt from requirements in 10.4.7.1 and 10.4.7.2.

1. *Buildings* or *additions* less than 25,000 ft2.
2. Individual tenant *spaces* less than 10,000 ft2 with their own utility service and meter.
3. *Dwelling units*.
4. *Residential buildings* with less than 10,000 ft2 of common area.
5. *Fuel* used for on-*site* emergency *equipment*.

***Informative Note**:* The exceptions to 10.4.7.1 and 10.4.7.2 are intended for building areas and systems exempt from a *building performance standard*. When adopting provisions to align 90.1 with a *building performance standard*, exclude any of the above exceptions describing *building* areas or *systems* that are not exempt.

4.2.5 Section 13 Normative References (All Options)

Instructions:

a. Add the following references to Section 13:

ANSE/ASHRAE/IES Standard 100-2024, Energy Efficiency in Existing Buildings, Section 6, Operations and Maintenance Requirements, Normative Appendix C, Operations and Maintenance Implementation, and Informative Appendix I, Operations and Maintenance Requirements for Building Systems and Elements

CSA/ANSI Z5020:23 Building Energy Modelling, Section 6.2, Absolute Models and Section 8.3, Building Energy Performance Verification

4.2.6 Appendix G Performance Rating Method (All Options)

Instructions:

a. Amend Normative Appendix G, as described in Informative Appendix I Section I4, to replace energy cost with the BPS performance metric.

4.2.7 Amending ASHRAE 90.1 compliance metric with the BPS performance metric for Option 2 and Option 3

For jurisdictions adopting code change Option 2 or Option 3, this section provides instructions for amending the compliance metric in the ASHRAE 90.1 performance-based compliance pathways.

4.2.7.1 Section 12, Energy Cost Budget Method (Options 2 and 3)

Instructions:

a. Make the following changes to Section 3:
   1. In the definitions of “energy cost budget” and “design energy cost” replace the reference to “annual energy cost” with a reference to the BPS performance metric.
   2. In the definition names “energy cost budget” and “design energy cost” replace the word “cost” with a term representative of the selected compliance metric. For example, where site energy is selected as the rename the terms to “site energy budget” and “design site energy”.

b. Amend Section 12 to replace the defined terms “energy cost budget” and “design energy cost” with the re-named terms, as described in instruction a.2.

4.2.7.2 Normative Appendix C, Methodology for Building Envelope Trade-off Option in Section 5.6 (Options 2 and 3)

Instructions:

a. Amend Section 3 to replace the reference to “annual energy cost” with a reference to the BPS performance metric in the definition “envelope performance factor”.

b. Amend Normative Appendix C as follows:
   1. Delete Section C3.3 in its entirety.
   2. Delete “*purchased energy rates*” and replace with “BPS performance metrics” in Section C3.4 item c.

4.2.7.3 Normative Appendix L, Mechanical System Performance Rating Method (Options 2 and 3)

Instructions:

a. Follow Section L5 Informative Note 2 to replace the energy cost metric with the applicable BPS performance metric. Replace conversion factors in Table L5-2 with the applicable site energy to BPS performance metric conversion factors.

4.2.8 Normative Appendix X: Assessing Expected Building and Site Energy Performance (All Options)

Instructions:

a. Add a new normative appendix. The Appendix letter should be consistent with the version of 90.1 being amended. For example, when amending ASHRAE 90.1-2022 the Appendix should be added as Appendix M. Note that all text that follows is new and should be added; to enhance readability, it is not underlined.

X1 Scope

This appendix provides requirements for assessing expected energy performance of new buildings, additions and alterations for the purpose of evaluating their ability to comply with a *building performance standard* that they will be subjected to once operational.

X2 Submittals

An Energy Performance Report shall be submitted to the *building official*.

X2.1 Energy Performance Report

The Energy Performance Report shall include the following sections.

1. **Executive Summary** section shall include the use types in the *building* (e.g., office, cafeteria, retail, parking, etc.), gross floor area, project scope (new construction, addition or alteration), and the *building performance standard target* determined following Section 3 alongside the projected energy performance determined following Section 4.

2. **Project Overview** section shall include a list of *building* area types, the *gross area* of each, whether each area is heated and/or cooled, whether it is a new construction or alteration, and the number of *stories* above and below *grade.*

3. **Building Performance Standard Target** section shall summarize the *BPS* requirements applicable to the *building* based on the adopted policies including the *building* occupancy type(s), site to *BPS performance metric* conversion factors, rules for handling the renewable energy and systems exempt from the *BPS* compliance.

In addition, the section shall include the *BPS* reporting period and all future periods.

4. **Energy Performance** section including the following:
   a. Projected *building energy* consumption by end use and *energy* source broken out as required in Section 8.4.3.1 and 10.4.7 including separate reporting of *energy* used by *systems* and components exempt from the *building performance standard*.
   b. Summary of the annual energy generated by each *on-site electricity generation system*.
   c. Summary of the gross *predicted performance* and *BPS predicted performance* determined in accordance with Section X3.3.
   d. The applicable *building performance standard* target(s) as determined by the *authority having jurisdiction.*

5. **Description of the *Energy*-related features**

6. **Operating Conditions Assumptions** section shall describe the key operating assumptions used in the analysis for each applicable *predictive model* shall meet the requirements for a *proposed design* in accordance with Section G3, Calculation of the Proposed Design and Baseline Building Performance and the additional requirements in this section.

X3.2.1 Simulation Program Requirements

The following ASHRAE Standard 140 test results, input files, and modeler reports for each tested version of a *simulation program* shall be posted on a publicly available website:

1. Test results demonstrating the *simulation program* was tested in accordance with ASHRAE Standard 140 Annex A3 and that meet or exceed the values for "The Minimum Number of Range Cases within the Test Group to Pass" for all test groups in ASHRAE Standard 140, Table A3-14.
2. Test results of the *simulation program* and input files used for generating the ASHRAE Standard 140 test cases along with the results of the other *simulation programs* included in ASHRAE Standard 140, Annexes B8 and B16.
3. The modeler report in ASHRAE Standard 140, Annex A2, Attachment A2.7. Report Blocks A and G shall be completed for results exceeding the maximum or falling below the minimum of the reference values shown in ASHRAE Standard 140 Table A3-1 through Table A3-13, and Report Blocks A and E shall be completed for any omitted results.

X3.2.2 Energy Modeler Qualifications

The predictive model shall be created by persons qualified by education and training to perform such work. The submitted modeling documentation shall be signed either by a registered design professional with a minimum of two years of experience in modeling buildings of similar size and complexity or an individual with an active certification from ASHARE as a Building Energy Modeling Professional (BEMP).

Informative Note: Additional details and recommendations for minimum more qualifications are found at 2_Modeler_Quals_FINAL.pdf (energycodes.gov)

https://www.energycodes.gov/sites/default/files/2022-07/2_Modeler_Quals_FINAL.pdf

X3.2.3 Lighting

Where a complete *lighting system* is designed and submitted with design document, the actual lighting power for each *thermal block* shall be modeled.

Informative Note: A multifamily building may be designed with no cooling in apartments, but the future tenants will likely install window air-conditioners, thus modeling apartments as cooled will help capture the future load.

X3.2.4 HVAC Systems

a. Where heating or cooling *system* was not submitted with design documents for the spaces that are expected to be conditioned once occupied, heating and/or cooling *system* shall be modeled. *System* type shall be selected based on the local standard practice. *System* efficiency, controls and ancillary features shall comply with but not exceed the requirements of Section 6.

    Informative Note: A multifamily building may be designed with no cooling in apartments, but the future tenants will likely install window air-conditioners, thus modeling apartments as cooled will help capture the future load.

b. Distribution system losses shall be accounted for.

X3.2.5 Other Modeling Inputs

Modeling inputs not prescribed in Normative Appendix G, or Section X3, including but not limited to operating schedules, miscellaneous equipment and process loads, shall be established in accordance with the absolute predictive use case requirements in CSA/ANSI Z5020:23 Section 6.2 .

X3.3 Projected Building Energy Performance

BPS predicted performance shall be determined using simulation results of the *predictive model* developed in accordance with Section X3.2 with the following adjustments:

a. Exclude *energy* use of *systems* and components that are exempt from compliance with the *building performance standard.*
b. Exclude contribution of renewable energy if renewable energy is included in simulation results but is not allowed to contribute toward compliance with the *building performance standard*.
c. Convert to the applicable *building performance metric* using conversion factors consistent with those required by the building performance standard, where applicable and approved by *authority having jurisdiction*.
d. Normalize the result as required for compliance with the *building performance standard*.

Informative Note: Note to *authority having jurisdiction on Section X3.3(c)*. The prescribed conversion factors should align with the conversions required for the BPS.

5.0 References

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