# The Technical Basis of Building Performance Standards

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## ABSTRACT

*As leading cities and states seek to meet their aggressive climate, energy, and decarbonization goals, they are turning increasingly to mandatory policies that require improved energy and emissions performance across their existing building stock. The most comprehensive of these policies is the building performance standard (BPS), in which performance thresholds are set that building owners must meet at a specified time or when a triggering event occurs. A BPS can address a range of emissions, energy and grid-related goals. This paper examines technical approaches used to set the key metrics for both buildings and fuels in performance standard legislation. Some of these metrics include emissions levels per square foot, energy use per square foot, and pounds of greenhouse gases per kilowatt-hour consumed. The paper will consider how standards for existing buildings, including ASHRAE Standard 100 and ASHRAE Standard 105, are being referenced in setting these parameters. The methodology and level of these metrics in a BPS directly impacts which actions will be taken by building owners to meet its technical requirements. Nuanced relationships between metrics, compliance periods, and equipment replacement cycles can greatly influence the degree to which a BPS is aligned with a jurisdiction's climate policy goals The paper also analyzes and explains how performance levels in standards for new construction, including ASHRAE Standard 90.1 and ASHRAE Standard 189.1, relate to the metrics and performance levels of BPS - with an eye to ensuring that newly constructed buildings will be positioned to meet a proposed BPS. Following concluding summaries on the technical issues involved in BPS standard-setting, the paper provides a range of recommendations for data collection, analysis of building stock data, and scenario planning in the preparation of BPS language.*

## INTRODUCTION

As jurisdictions seek to meet aggressive climate goals, they are turning increasingly to mandatory policies that require improved energy and emissions performance across their building stock. The most comprehensive of these policies is the building performance standard (BPS), which set performance thresholds that buildings must meet on a specified schedule, or must meet upon the occurrence of a triggering event, such as equipment replacement or building sale. Mandatory requirements for action based on that performance differentiates a BPS from past policies, such as benchmarking, which provide information to the market but do not directly improve building performance.

Beyond its mandatory aspect, the power of a BPS derives from its ability to reach across the standing building stock of a city or state. The US Green Building Council estimates that the portion of the total building stock newly constructed or majorly renovated each year has historically been about 2% of building square footage in any given year (Davis, 2012). Thus, it is clear that any policy addressing carbon reductions in the building sector must focus strongly on existing buildings. A BPS also can be developed to improve upon multiple criteria for performance in buildings simultaneously, including carbon reduction, building electrification, energy efficiency and peak demand reduction through load shifting and storage. For most jurisdictions, however, the BPS is new territory as they have historically considered regulation only of the design and construction of new buildings, and major renovations of existing buildings, through the energy codes.

Washington DC, New York City, Washington State, and St. Louis, MO have passed versions of a BPS, though they have not yet entered the enforcement phase. Many other jurisdictions are in earlier phases of writing their own BPS. Each of these policies appear to be applying a slightly different metric, and to be applying variations on

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implementation mechanisms.

## ALIGNMENT OF TECHNICAL COMPONENTS WITH POLICY GOALS

Setting a policy goal for the existing building stock establishes the city's priorities and puts them on an absolute timeline for achieving climate objectives in the building sector. The BPS design should align with the jurisdiction's building-related goals laid out in existing sustainability, clean energy, climate action or other similar plans. Selecting the appropriate performance metrics, electricity conversion factors, performance thresholds, and normalization factors are critical to developing clear and enforceable regulations that align with climate and other policies. The effective implementation of reporting and enforcement are critical to ensure the jurisdictions actions then meet the policy goal.

### What metrics are being used in performance standards?

Several metrics are being applied in the development of BPS, and those are summarized in Table 1, adapted from the Regulatory Assistance Project (Sunderland and Santini, 2020) and the primary metrics are discussed below.

**Table 1. Building Performance Standards in the United States**

| Where | Introduced | Enforced | Building Stock | Metric | Standard |
|---|---|---|---|---|---|
| Boulder, CO | 2010 | 2019 | Privately rented homes | Points (based on energy and carbon) | Points threshold |
| Washington, DC | 2018 | 2026 | Commercial >50,000 sf (down to 10k over time) | ENERGY STAR score | Exceed Median Energy Star score by building type |
| Reno, NV | 2019 | 2026 | Commercial >30,000 sf | Energy Star score OR energy and water use intensity | Multiple options |
| New York, NY | 2019 | 2024 | Commercial >25,000 sf | Carbon intensity (CO2/sf) | 40% reduction by 2030, 80% by 2050 |
| Washington State | 2019 | 2026 | Commercial >50,000 sf | Energy use intensity (kBtu/sf) | Exceed Median Energy use intensity by building type |
| St Louis, MO | 2020 | 2025 | Commercial >50,000 sf | Energy use intensity (kBtu/sf) | Exceed $65^{th}$ percentile of local buildings by type |

**ENERGY STAR Score.** Washington DC uses an ENERGY STAR score as its metric. ENERGY STAR is potentially the least understood metric. The score is generated from a combination of actual energy use on site, regional grid emissions, worker density, hours of operation, and a comparison of a single building to a national peer group to place the building on a bell curve from 1-100 (US EPA, 2018). DC has selected local medians for its first compliance cycle, but the impact of the national peer group and worker density on the scores have the potential to change the scores overtime in unexpected ways.

**Carbon Emissions.** New York City uses an emissions metric based on the actual energy use on site multiplied by a carbon equivalent conversion factor. New York City has set its standards through 2034, but changes to the grid over the next 14 years may not align with the projections that created the conversion factors. A carbon emission metric will be best used when a jurisdiction has a carbon reduction policy goal but will need to carefully account for a cleaning electric grid. As electric generation (or renewable natural gas) approaches 100% clean, carbon metrics may need to be supplemented in order to ensure buildings are required to become more energy efficient over time.

**Energy Use Intensity.** Both Washington State and St Louis, MO are using "site energy use intensity" as their metric. Energy metrics are best paired with energy efficiency policy goals, but on their own may not be able to address other jurisdiction goals like clean energy, and carbon emissions reductions. Energy metrics can be paired with electrification and renewable energy standards to meet multiple goals, though this has not yet been done in an existing

BPS policy.

## Performance Data Collection and Reporting

Reporting for BPS is primarily built on the existing reporting structures used for benchmarking and disclosure ordinances. In many jurisdictions this will take the form of using ENERGY STAR's Portfolio Manager (PM). PM reporting has many benefits including potential automation to collect utility bills, sharing capability with the jurisdiction, and an online platform. PM will report a variety of data including actual energy use, site EUI, source EUI, ENERGY STAR Score, and captures basic information about the buildings from construction year to number of workers. While most jurisdictions use PM to report annual data, the platform can also report monthly data. PM also has limitations it cannot capture or report the data on equipment type and other construction information (see Using Disclosure Data below) or hourly energy use. PM also uses a regional annual average to convert energy to carbon, which does not capture an accurate picture of the true carbon footprint of a building.

Where PM is not the reporting mechanism, jurisdictions will need to establish a method of data transfer and sharing that attempts to minimize time needed on both the side of the jurisdiction and building owners to report, as well as minimize potential for missing or incomplete reporting.

The available data for a jurisdiction will depend largely upon the reporting mechanism used. Building owners and facility managers should have access to all of their utility bills, which create the basis of the energy consumption data. Depending on what types of fuel may be used in a building, complete reporting may be a challenge, even with an established tool like PM. Buildings in cold climates that rely on fuel oil, propane, and biomass for heating and water heating face specific challenges in reporting due to delivery and use cycles that may not be as cleanly documented as a monthly electric or gas bill.

## Using Disclosure Data and Other Data Sets

Building data is the foundation of all building performance standards. Jurisdictions need data both during development of an ordinance to analyze the building stock and set its standards, and during implementation to determine compliance and enforce the policy. Whatever metrics a jurisdiction uses, determining building compliance will require collection of data in the same units as the metric from all covered buildings over time.

For jurisdictions with a current benchmarking and transparency policy, basic data should be available for the larger (usually >50k square feet) building stock. Compliance with the benchmarking law should be examined prior to creating a BPS. If compliance is low, either overall or for specific building types, the data may not provide a statistically sound basis for setting a standard. If this is the case, at a minimum, the local data should be compared to regional data available from the Commercial Buildings Energy Consumption Survey (CBECS) to identify large discrepancies.

While benchmarking data can be very valuable, it should be thought of as a beginning rather than an end as it provides only the most basic information on energy use and the building itself. As noted above, the more building-specific data that is available, the more targeted a BPS can be and the more effective it will be in reaching the city's goals.

In the absence of any jurisdiction specific dataset, national or regional level data, such as CBECS, can be used to set the performance level. This has potential significant drawbacks. Because it will not be specific to the jurisdiction's building stock, there is a legitimate concern that standards based on national or regional data will be inappropriate for local buildings, making potentially unrealistic demands on owners. An equally likely possibility is that non-city-specific building data would result in standards that are too lax, minimizing the impact of the policy.

All BPS should require that specific data be collected from all buildings and that resources be allocated to create and maintain a data infrastructure and analyze data on a regular basis. In addition to the actual performance data to determine compliance with the standard, information on system types, equipment sizes and vintages and building construction characteristics should be collected and reported. As more data become available, both the interim and final standards can be further refined to meet the jurisdiction's policy goals.

## Accounting for electricity use in building performance

One of the key technical questions in developing a BPS is determining what a consumed kWh, and an exported kWh, means for performance. This is important with regards to the current grid emissions factors for a building, and also for the grid emissions factors in future compliance periods for decades to come. Future source and emission characteristics of grid electricity are expected to change dramatically over the next three decades because of policy and market changes that will increase the share of renewable generation.

The treatment of electricity consumption, and of the export of surplus onsite generation, are perhaps the most critical technical components for fairly measuring and accurately determining a building's performance. The challenge to BPS development arises because electricity is a derivative fuel – it is produced from another source of energy, or primary fuel. This derivative nature of electricity means there must be consideration of the conversion from primary fuel to the electricity consumed onsite, or there must be explicit omission from the measurement (as in site energy).

A site energy metric for electricity (or site EUI as was selected by the State of Washington for their BPS) only considers how much electrical energy is consumed by the building at the meter. This measures consumption at the site that is most fully controlled by the building owner and occupants. But some argue that source energy, or primary energy, that includes the energy in the fuels used to generate the electricity and then transmit it to the building, should be the correct metric for electricity in a building performance. Source energy is used to evaluate energy consumption when different types of energy sources need to be accounted for equitably, such as in buildings (e.g. electricity, natural gas, steam, fuel oil) or large sectors of the economy (e.g. coal, natural gas, petroleum). Using source energy allows all of these energy types to be evaluated on a common energy metric. Source energy is used in a variety of Department of Energy and EPA products, publications, tools, and reports, including Energy Star. Others, including ASHRAE 90.1, argue that the cost of the electricity, and other energy sources, should be the factor that measures electricity and other energy consumption in buildings.

Because the variances between the site, source and cost metrics are much larger for electricity than they are for natural gas or other fuels, the calculation framework for electricity consumption in a BPS becomes a major policy driver in the development of a BPS. The choice of a metric for BPS will impact whether, and to what extent, the regulation encourages the electrification of building energy uses as the electricity supplied to the building gets cleaner.

## Greenhouse gas impacts and the tale of two jurisdictions

Using carbon as the performance metric aligns BPS efforts most closely with the climate goals at the heart of most BPS, but energy metrics are more familiar to the market, particularly because Energy Star Portfolio Manager, a source energy-based tool, has been the mainstay of benchmarking policies across the country. And the complexity of arriving at agreed-upon carbon coefficients for the existing grid, let alone for the next 30 years, makes the carbon metric path challenging. The main outstanding question boils down to whether current and forecast carbon coefficients for electricity can be relied upon for investment decisions made today about electrifying new and retrofit building systems in order to plan to meet the BPS requirements.

Both Washington State and New York City explicitly recognize carbon reductions as a primary purpose for the enactment of a BPS, but each has taken a very different tack for incorporating carbon into BPS development. The BPS enacting legislation, Washington HB1257 Section (3) 1 (b) states, "In developing energy performance standards, the department shall seek to maximize reductions of greenhouse gas emissions from the building sector". But because the definitions section of HB 1257 is specific, Washington is thus developing a BPS metric solely based on a site energy EUI measurement for the first cycle of regulations and applying this definition.

**"Energy Use Intensity** means a measurement that normalizes a building's site energy use relative to its size."

On the other hand, New York City Local Law 97(LL97) both states the goal of carbon reduction for its BPS and follows through with a definition that is consistent with the goal. Because of this alignment, the NYC Division of

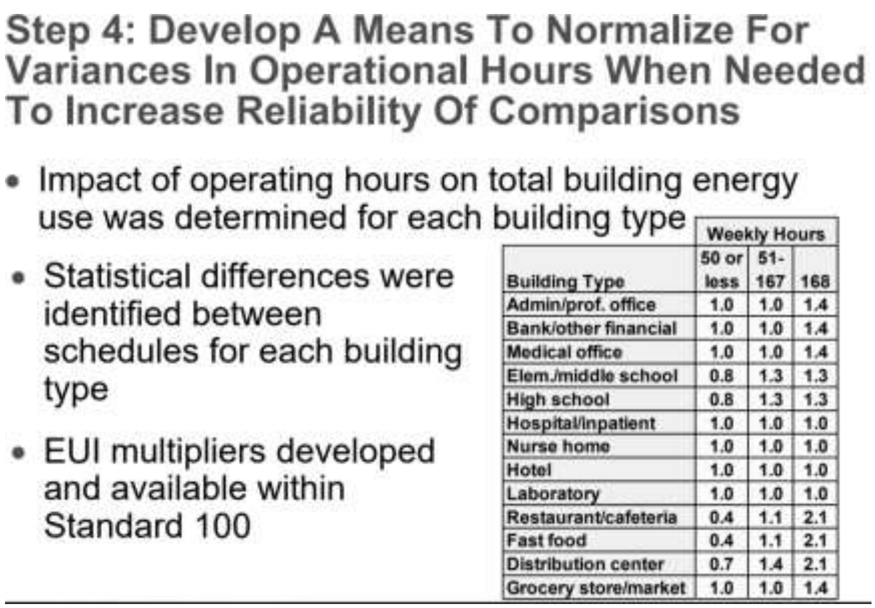
Buildings is undertaking a public process for "carbon accounting" that will execute upon this language in LL 97.

**"Building Emission Intensity** means, for a covered building, the number obtained by dividing the building emissions by the gross floor area for such building, expressed in metric tons of carbon dioxide equivalent per square foot per year."

Even though New York City's metric will be using CO2 per square foot while Washington will be using kBTU per square foot, both will be using annual reporting data. Fortunately, much work is underway to determine practical and accurate application of greenhouse gas emission factors based on an hourly time-of-use scale. This time-of-use approach, generally based on the 8760 operating hours within a year, becomes increasingly important for measuring carbon impacts as the grid becomes more dependent on variable renewable generation. The most comprehensive effort to standardize and provide this data is underway at the National Renewable Energy Lab as part of their Cambium Project (Hale, 2019). The CEC is also undertaking work to produce hourly source energy factors as a surrogate for carbon emissions on the California electricity grid. These Time Dependent Source (TDS) factors are contemplated for use in future version of Title 24 (Fernstrom, et al).

### Normalizing for actual operations

One critical technical dimension of BPS compliance is whether to adjust the performance thresholds for actual energy use, or emissions, if the operating conditions during the compliance deviates from the expected or average conditions upon which the thresholds were set. St Louis has stated that annual energy use will be weather normalized, meaning a particularly hot or cold season will not on its own adversely impact a building's score. Washington has explored through its open rulemaking process that it may use normalizations based on operating hours. There are arguments for and against normalization of scores – the primary being that normalizations should be limited to using local data, and reliance on any national data will not be appropriate to an individual jurisdiction. Figure 1 illustrates how operation hours normalization routines were derived by Oak Ridge National Lab and published in ASHRAE Standard 100 under Table 7-3 Building Operating Shifts Normalization Factor and are being contemplated for the Washington rule (Sharp, 2015).




| | Weekly Hours | | |
|---|---|---|---|
| Building Type | 50 or less | 51-167 | 168 |
| Admin/prof. office | 1.0 | 1.0 | 1.4 |
| Bank/other financial | 1.0 | 1.0 | 1.4 |
| Medical office | 1.0 | 1.0 | 1.4 |
| Elem./middle school | 0.8 | 1.3 | 1.3 |
| High school | 0.8 | 1.3 | 1.3 |
| Hospital/inpatient | 1.0 | 1.0 | 1.0 |
| Nurse home | 1.0 | 1.0 | 1.0 |
| Hotel | 1.0 | 1.0 | 1.0 |
| Laboratory | 1.0 | 1.0 | 1.0 |
| Restaurant/cafeteria | 0.4 | 1.1 | 2.1 |
| Fast food | 0.4 | 1.1 | 2.1 |
| Distribution center | 0.7 | 1.4 | 2.1 |
| Grocery store/market | 1.0 | 1.0 | 1.4 |

Figure 1. Oak Ridge National Lab presentation on normalizing operating hours for ASHRAE Standard 100.

There are only three hourly bins in the table, and one is applied to buildings that operate 24 hours per day, seven day per week. This is a non-granular approach to normalization and does permit up to 50% in additional energy use. Standard 100 states only that "S is the building operating shifts normalization factor in Table 7-3", without further guidance definition or documentation of 24/7 operations, thus creating an enforcement challenge. In addition, these factors have not been revised in more than 5 years. If normalization factors are to be applied in BPS, the factors should have a reasonable level of granularity in the bins, and should use data that reflects current not past operational trends. The effects of the pandemic on ordinary uses of public and private spaces will exacerbate these changes in building operations.

### Enforcement of building performance

Jurisdictions will need to establish two key enforcement timelines for their buildings for a BPS to be successful: a compliance cycle and a reporting period. The compliance cycle is the period where the end date is when compliance with a standard is measured. A reporting period is the frequency with which a covered building is required to submit compliance documentation and may be more frequent than a compliance cycle. Compliance cycles in proposed or enacted BPS range from 5-6 years with reporting periods typically being annual.

Performance is then measured based on the metric selected, and the standard, or threshold, set for compliance. Buildings that meet the standard are considered compliant, often referred to as direct compliance. Buildings that miss the mark, may be offered additional compliance paths including performance or prescriptive upgrades that must be completed within the compliance cycle, or may be offered exemptions, extensions or possibly even payments or fines for a given compliance cycle.

The enforcement agency within a jurisdiction must be set up to handle all types of compliance that are available to buildings through legislation or rulemaking. For most jurisdictions this will mean new, dedicated staff to BPS enforcement.

## ALIGNMENT OF BUILDING PERFORMANCE STANDARDS AND NEW CONSTRUCTION CODES

Outside of Washington, the current BPS structures only take into consideration existing buildings performance and leaves new construction requirements in the scope of new construction energy codes. A potential conflict can arise from siloing these two policies because new construction becomes an existing building the moment it is occupied. Jurisdictions should explicitly address new construction in their BPS policies for two reasons: to ensure that new buildings built to a future code will be prepared to meet their first BPS compliance standard, and to address the higher potential savings that new construction can achieve where existing buildings may not.

Washington in its rule making has included proposals for different targets for more recently constructed buildings. In both WA climate zones (4C and 5B), new construction targets based on current best technologies available generate standards that average 39% better than potential BPS targets, and 63% better than the mean Washington building today (WA Dept of Commerce, 2020). Realizing this additional savings potential from the BPS is critical to meeting the intent of Washington's statutory codes requirement to be near zero by 2031 (Frankel and Edelson, 2015).

Based on analysis by NBI (Carbonnier, 2019) and Steven Winter Associates (Steven Winter Associates, 2020), the EUI targets at "net-zero ready" levels across three ASHRAE climate zones show significant differences between new construction (NC) and existing buildings (EB) in all building types except apartments, as shown in Figure 2. Because of this large margin of performance, jurisdictions may want to consider market segmentation analysis based on year of building construction to ensure that the existing building BPS threshold is both forgiving, while aggressive where necessary, in setting targets for BPS.

Addressing new construction should still fall to the energy code. But changes to target setting by adding consideration of BPS in the modeled performance paths for ASHRAE 90.1 Appendix G, or zEPI targets in ASHRAE 189.1, may be helpful in getting designers and developers on the right path toward long term BPS compliance as they become more commonplace

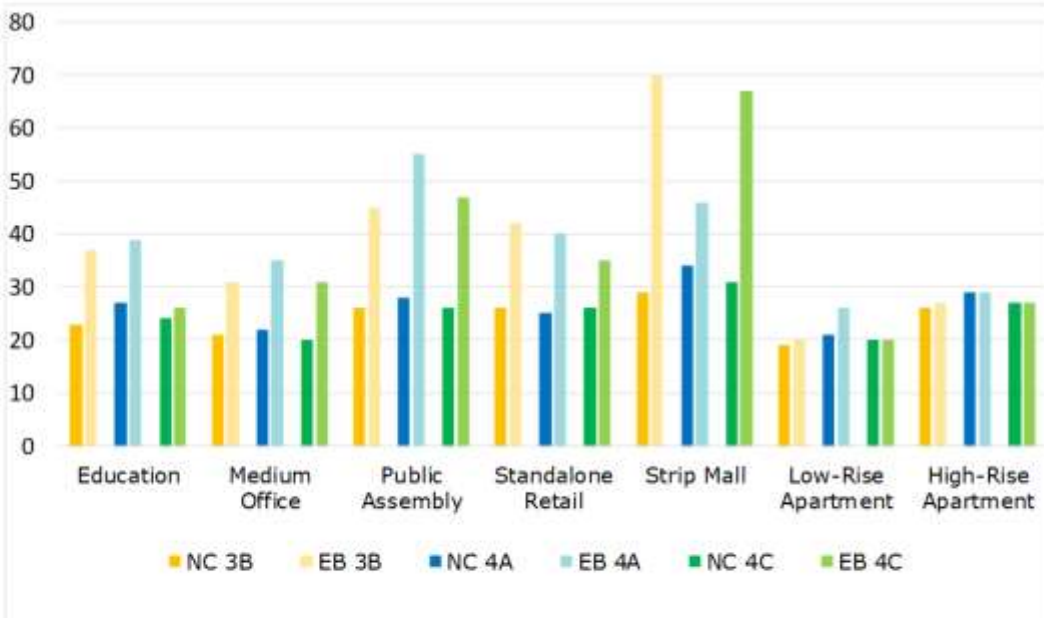



Figure 2. Comparison of New Construction and Existing Building EUIs.

## CONCLUSION

As climate change increasingly drives existing building performance policy around the world, many jurisdictions are turning to BPS. As the BPS policy emerges from theory to practice, many lessons can be learned from experience to date on how to get the technical details right. First, the development of the rule or the regulation should align with and support the jurisdiction's policy goals as much as possible. Second, the rules should be transparent, clear to understand, and straightforward both for compliance and enforcement.

It is becoming clear that there is a range of key technical details that must be addressed in the course of implementing a BPS. Some technical details, especially around using the data from energy bills or energy metering devices to align with an emissions reduction goal, present additional complexity and also highlight the need for additional technical investigation. This will become increasingly critical to BPS implementation efforts as the electric grid becomes more dependent on renewable energy, and eventually moves to, or close to, 100% renewable in many areas of the world.

We have learned that it is not too early to consider how to embed GHG performance into the implementation of the BPS. We are encouraged that the National Labs, the California Energy Commission, and jurisdictions like New York City are leading the way towards practical and effective applications of technical insights to this challenge. Buildings are the largest user of electricity in the United States, and most of the buildings that will be standing in 2050 exist today – so reducing the GHG impacts of existing buildings is an urgent task. Establishing the technical groundwork for Building Performance Standards will enable wider adoption across the nation, and will help make the BPS a key policy lever for limiting greenhouse gas emissions from the building sector.

## REFERENCES


Carbonnier, K., PhD. 2019. “Zero Energy Commercial Building Targets”. https://newbuildings.org/wp-content/uploads/2019/09/ZeroEnergyCommercialBuildingTargets.pdf

Fernstrom, G., Eilert, P., Mahone, D., McHugh, J., Horii, B., Price, S., and D. Engel. 2000. “Energy Codes and Standards: Time Dependent Valuation, a New Source Energy Bias”. https://www.eceee.org/static/media/uploads/site-2/library/conference_proceedings/ACEEE_buildings/2000/Panel_8/p8_9/paper.pdf

Frankel, M. and J. Edelson. 2015. “Washington State Energy Code Roadmap”. https://newbuildings.org/wp-content/uploads/2015/11/WashingtonEnergyCodeRoadmap2015091.pdf

Hale, E.T., PhD. 2019. “The Evolving Nature of Grid Energy”. https://www.nrel.gov/docs/fy20osti/75219.pdf

Sharp, T. 2015. “Developing Building Energy Performance Targets for ASHRAE Standard 100”. https://www.iea-ebc.org/Data/Sites/4/media/events/2016-09/1st_sharp_std_100_targets_development_september_12.pdf

Steven Winter Associates. 2020. “Performance Standards for Existing Buildings Performance Targets and Metrics Final Report; Carbon Neutral Cities Alliance”. http://carbonneutralcities.org/wp-content/uploads/2020/03/CNCA-Existing-Building-Perf-Standards-Targets-and-Metrics-Memo-Final-March2020.pdf

Sunderland, L. and M. Santini. June, 2020. “Filling the Policy Gap: Minimum Energy Performance Standards for European Buildings”. https://www.raponline.org/wp-content/uploads/2020/06/rap-sunderland-santini-mini6mum-energy-performance-standards-june-2020-final.pdf

US Environmental Protection Agency. 2018. “ENERGY STAR Portfolio Manager Technical Reference: ENERGY STAR Score”. https://portfoliomanager.energystar.gov/pdf/reference/ENERGY%20STAR%20Score.pdf

Washington State Department of Commerce. 2020. “WA-Targets”. https://www.commerce.wa.gov/wp-content/uploads/2020/06/WA-Targets-2.xlsx