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Leading by Example: Building Performance Standards for Decarbonizing Federal Buildings

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1. Introduction

In February 2021, the United States rejoined the Paris Climate Accord, and President Biden announced the new US commitment to reducing economy-wide greenhouse emissions by 50 percent relative to 2005 levels by 2030. Given the political infeasibility of economy-wide carbon pricing, achieving this ambitious goal will likely require a collection of policies that target specific sectors (National Academies of Sciences, Engineering, and Medicine 2021). Although decarbonizing electricity is typically the lowest-cost option and thus most likely path for achieving reductions in the near term, reductions in other sectors, including buildings, will be required to achieve this ambitious target.

Commercial and residential buildings are responsible for about 12.5 percent of total US greenhouse gas emissions but more than 30 percent of emissions when indirect emissions from electricity use are included (EPA 2019). Ongoing efforts to decarbonize electricity supply are reducing the electricity-related emissions attributable to buildings, but they do not address the fuel-related portion. Thus, decarbonizing buildings requires a combination of reducing on-site fuel consumption and a switch to cleaner energy, like electricity.

Existing policies aimed at reducing emissions from the building sector have predominantly targeted energy efficiency improvements through the use of incentives, minimum efficiency standards for new buildings and their appliances and equipment, and information programs that help consumers and businesses factor future energy costs into leasing or purchasing decisions for structures and appliances. For example, building energy codes in many US states (no federal building code exists) typically require new or renovated buildings to contain certain design features intended to reduce energy use.

The results of policies like those are difficult to estimate because the level of energy use in the absence of the intervention is unknown. Some studies rely on engineering models to estimate savings ex ante, but these models can overestimate savings due to other factors, such as the rebound effect (the tendency for consumers to use more energy as consumption becomes cheaper with efficiency improvements). Few studies validate ex ante savings estimates with observations about outcomes in commercial buildings. Some studies have estimated the effectiveness of certain interventions ex post, but empirical studies are rare (Gillingham et al. 2018).

Buildings' emissions intensity has fallen, but progress has been gradual relative to what is now required to achieve deep decarbonization. Between 1999 and 2018, commercial building floor space in the United States increased by 44 percent (EIA 2020a) while commercial building emissions declined by 8 percent (EPA 2019). Much of the decline in buildings' emissions intensity during this time can be attributed to improvements in electricity emissions factors and lower indirect emissions tied to electricity consumption. In fact, the emissions associated with buildings' direct fuel consumption increased by 12 percent over that same period (EIA 2020a). When measured in greenhouse gas emissions per square foot of commercial building space and excluding the gains in electricity emissions rates, the emissions intensity of fuel use in buildings has improved by only 1 percent per year over the past 20 years.[1]

The extent to which improvements in building performance experienced to date are due to policy is unclear, but the fact that existing policies tend to focus on the adoption of more efficient technologies or practices and not on specific emissions outcomes limits their ability to achieve significant emissions reductions in the sector. Few current policies offer incentives to encourage building occupants to adjust behavior to save energy after the efficiency improvements have been made.[2]

Given the limitations of existing building energy efficiency policies in meeting future emissions reduction goals, several cities here and abroad have started to implement building performance standards (BPS). This approach, which focuses on outcomes rather than mandated upgrades or efficiency subsidies, requires covered buildings to achieve certain energy or emissions performance goals, which become more ambitious over time. Cities with BPS programs include New York, Washington, DC, and Tokyo.

Several institutions have looked at design options for a citywide BPS. A report by the American Council for an Energy Efficiency Economy (Nadel and Hinge 2020) summarizes and evaluates BPS programs of some current and proposed city programs, focusing on such criteria as metrics, stringency of standards, allowing for trading, and other considerations. A report from the Urban Green Council (2020) focuses on designing a BPS with trading for New York City and also includes suggestions about incorporating environmental justice into policy design, options for allocating and pricing credits, and options for tracking compliance. The Institute for Market Transformation (2021b) published a model BPS ordinance that explores design considerations applicable to any city looking to adopt a BPS.

Although research has addressed how to design a BPS program for a particular city, designing a program that spans multiple regions or an entire nation can be more complicated. This paper considers the options for implementing a building performance standard across a broader scope of buildings and geography: federally owned or leased buildings, which comprise 1 billion square feet across the country (excluding the Department of Defense) and represent roughly 1 percent of the total commercial building stock.[3]

In May 2021, the Biden administration announced that the Council on Environmental Quality would launch an interagency effort with the General Services Administration

1 Author's calculations based on data from EIA (2020a).

2 An important exception to this could be the cost of energy use, as long as building occupants face those costs directly, which may not be the case for leasing arrangements if occupants' energy use is not separately metered.

3 According to the most recent Commercial Buildings Energy Consumption Survey, conducted by the Energy Information Administration (EIA 2020a), total US commercial building stock in 2018 consisted of roughly 5.9 million buildings with a total of 97 billion square feet.

(GSA), Department of Energy, and Environmental Protection Agency (EPA) to develop building performance standards for federal buildings (White House 2021b). By focusing on outcomes, a BPS can ensure that reductions in energy use are achieved cost-effectively and has the potential to drastically lower the carbon footprint of the US federal building stock. Additionally, a well-designed federal BPS can serve as a blueprint for BPS policies in other cities, for corporations with large building portfolios, and for a broad-based national policy. In developing the BPS, the agencies will need to consider data availability and metrics, options for flexibility, and enforcement mechanisms that will determine its ability to deliver. Potential interactions with other decarbonization policies and regional energy mixes could also be important considerations for policy design.

The rest of the paper is organized as follows. Section 2 looks at the existing federal building stock and current and past federal policies aimed at reducing its energy use. Section 3 presents BPS design options and looks at types of standards, metrics, and flexibility mechanisms. Section 4 considers issues unique to designing a BPS for the federal government. Lastly, Section 5 concludes.

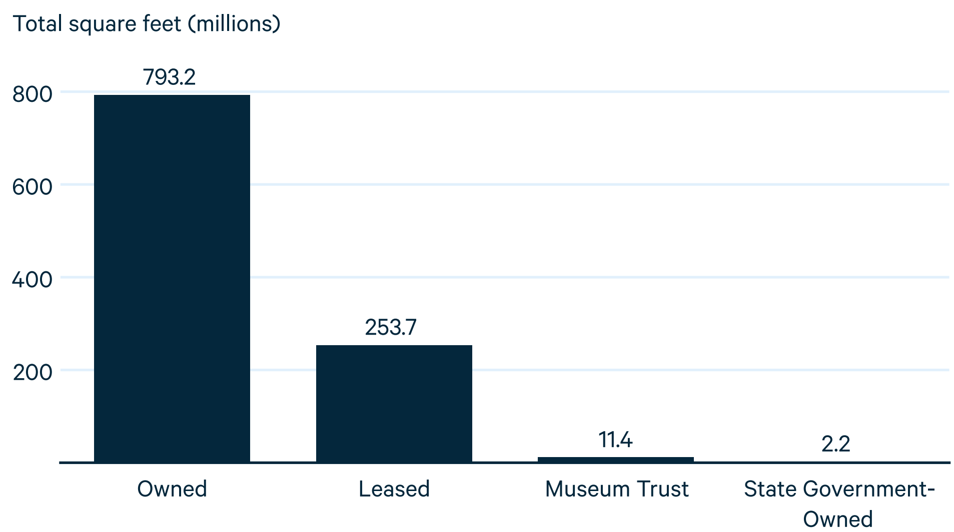
2. The Federal Building Stock

The first step in designing a building performance standard for federal government buildings is to characterize the population of buildings, their locations, and their current energy-related requirements. In this section, we assume that a federal BPS would be limited to the nonmilitary building stock, mostly because of the sensitivities to reporting energy data for military buildings, particularly if data transparency is a policy requirement.

2.1. Description

The US government (excluding the Department of Defense) manages about 100,000 civilian buildings comprising more than 1 billion square feet across all 50 states plus the District of Columbia.[4] Although most (75 percent) of the square footage is owned by the US government, the rest is leased (nearly 24 percent), and a small portion is owned by state governments or in a museum trust (Figure 1).

Figure 1. US Government-Controlled Domestic Buildings by Legal Status

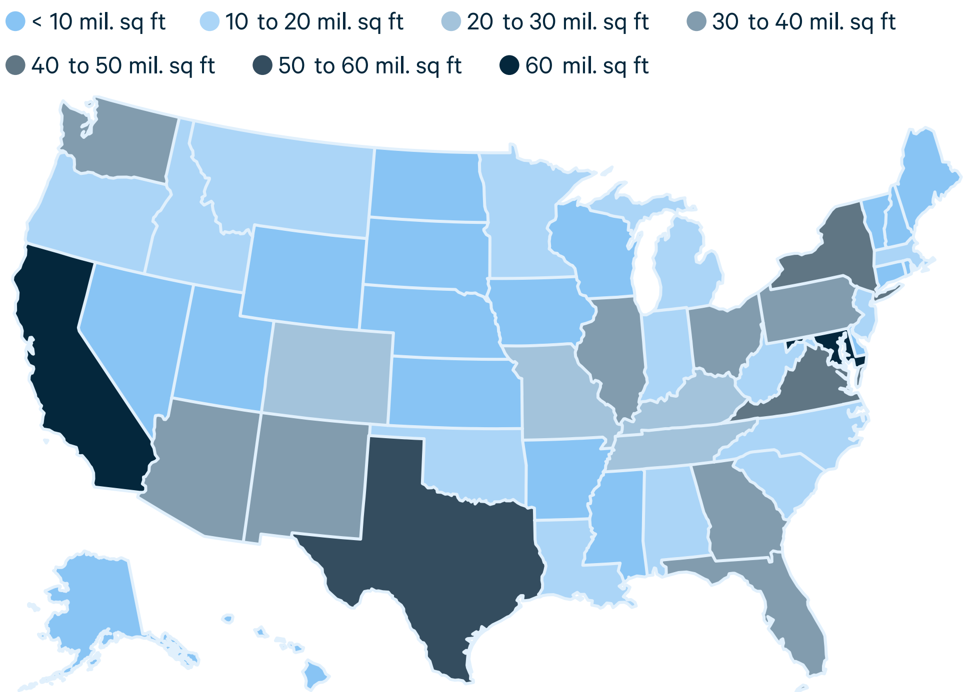


Source: GSA FY 2019 Federal Real Property Profile Data for Civilian Agencies

Some federal buildings (about 8,000 buildings) are managed by GSA, but the majority are managed by the agencies themselves.

4 For context, many of these are small buildings. For example, about 35,000 buildings are post offices.

Figure 2. Location of Federal Buildings (by square footage)



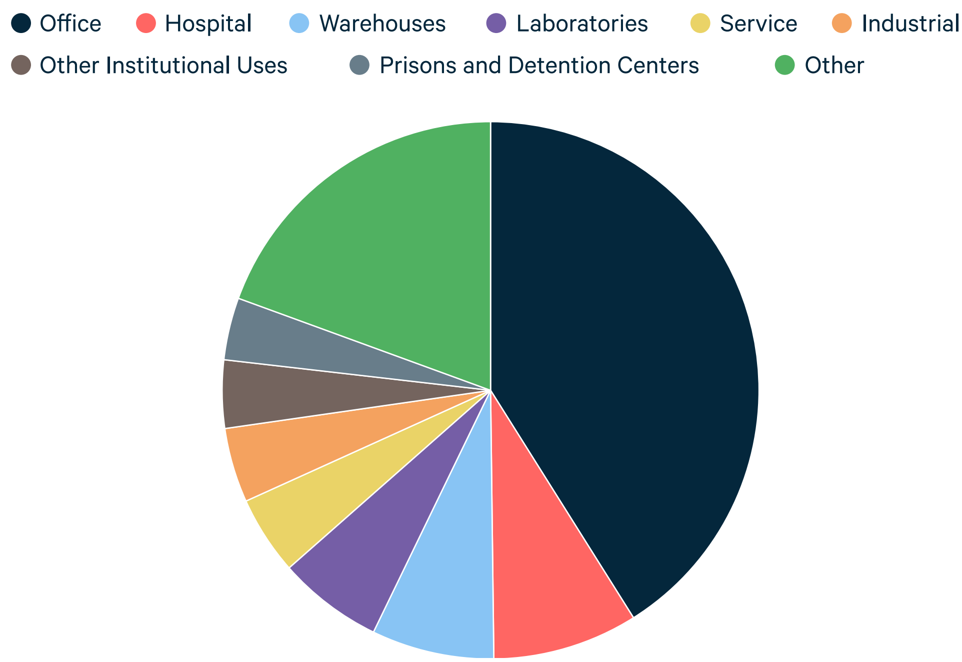
Source: GSA FY 2019 Federal Real Property Profile Data for Civilian Agencies

Figure 2 shows how federal buildings are distributed across the states. Federally controlled buildings are located in all states, but California, Maryland, and Washington, DC, in particular have a much higher concentration of federal buildings relative to the rest of the country. These three jurisdictions account for 60 million square feet of federal buildings, as much as six times higher than other states.

Figure 3 shows that the plurality of the federal building stock is office space, with other major uses being hospitals, warehouses, and laboratories. The federal building stock is fairly old, with an average age of more than 50 years.

Those differences in location and building type present some challenges for designing a federal BPS. In particular, developing an appropriate and transparent standard or set of standards that all covered buildings can achieve requires careful thought and consideration. We discuss this challenge in Section 3.

Figure 3. Federal Building Floorspace by Use (by square footage)



Source: GSA FY 2019 Federal Real Property Profile Data for Civilian Agencies

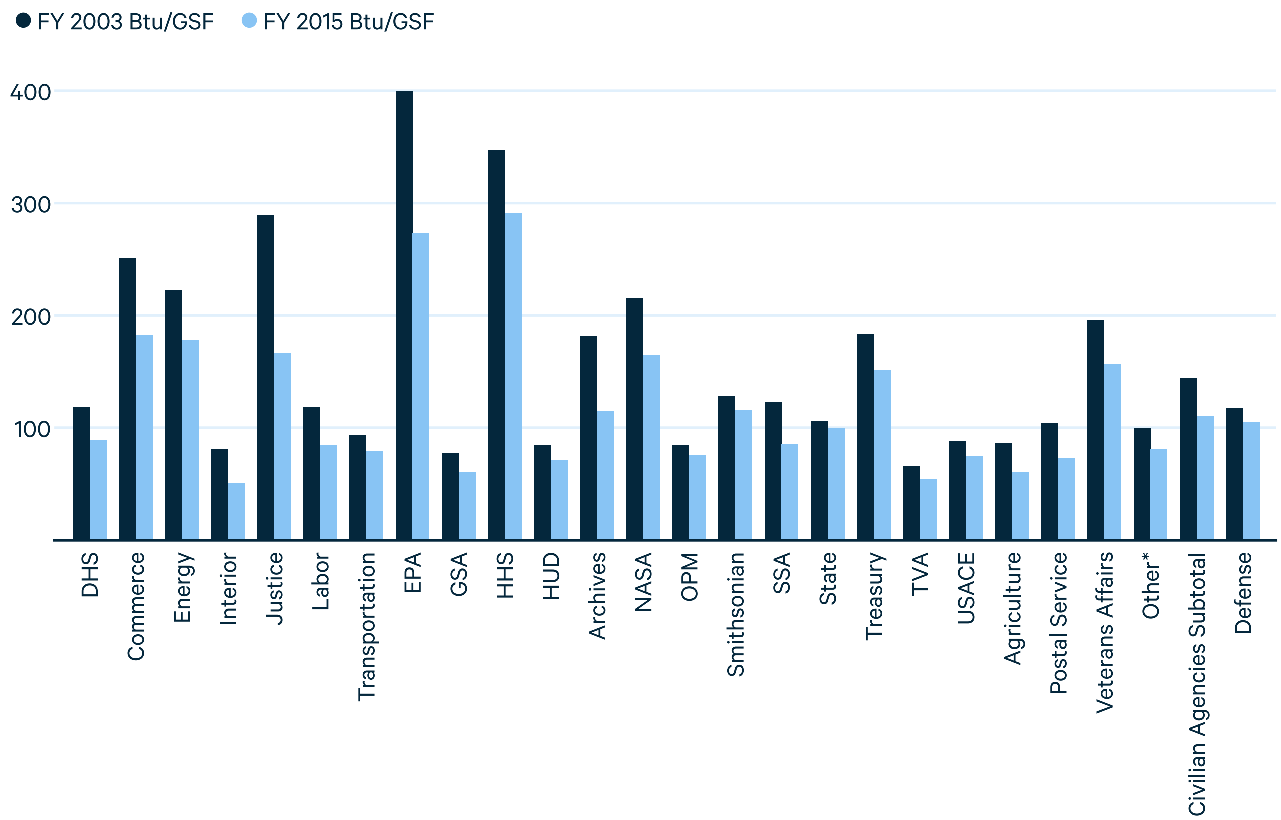
2.2. Current Standards

Several legally mandated standards address energy use in federal buildings. Some are specific to new or significantly modified buildings, while others apply to all buildings.

Efforts to reduce energy usage in buildings have been ongoing for quite some time. The Federal Energy Management Program (FEMP) was created in 1973 to cut costs for taxpayers by reducing energy use in federal buildings. Since then, FEMP has worked to promote energy and water conservation in federal buildings by providing financing for projects, technical assistance, and outreach. As of 2006, federal building energy use per square foot had decreased by 25 percent since 1985 (FEMP 2006), in large part because of this effort.

Since the creation of FEMP, several pieces of legislation have required reductions in federal buildings. The energy performance requirement standards (42 USC 8253 (a)), which have been in place since 2006, mandated that every agency cut annual energy use intensity by a certain percentage in each fiscal year through 2015, relative to a FY 2003 baseline. The final reduction requirement, for 2015, was 30 percent below the 2003 baseline intensities. Additional regulations were expected for fiscal years 2016 through 2025, but Congress has not taken any action to extend these goals, and Executive Order 13693, which was signed in March 2015 and required a 2.5 percent annual reduction in energy use intensity relative to FY 2015 through FY 2025, was revoked by the Trump administration in 2018 when it issued Executive Order 13834.

Figure 4. Energy Use Intensity Across Federal Agencies in FY 2003 and FY 2015



Source: Department of Energy, Comprehensive Annual Energy Data and Sustainability Performance

Based on the data that we were able to collect, most federal agencies fell short of achieving the 30 percent reduction targets, though energy use intensity did fall for all agencies from 2003 to 2015. For civilian agencies, energy use intensity fell by nearly 25 percent, indicating some success.

New federal buildings are also subject to efficiency requirements. If it is deemed cost-effective over the building's life cycle,[5] new buildings must be designed to achieve energy use levels that are 30 percent below a baseline level from either the ASHRAE Standard or the International Energy Conservation Code from 2005 and include sustainable design principles (42 USC 6834 (a)). Sustainable design principles are evaluated according to the LEED green building certification system (GSA 2021).

Additionally, new federal buildings and those undergoing major renovations are required to reduce energy consumption specifically from fossil fuels. The Federal Building Energy Efficiency Standards (42 USC 6834) require that their energy consumption from fossil fuels be reduced relative to a similar building's baseline (from

5 That is, the energy cost savings associated with efficiency improvements will outweigh the upfront investment over their lifetime.

the Commercial Buildings Energy Consumption Survey) from FY 2003. The standard started at a 55 percent reduction in 2010 and eventually rises to a 100 percent reduction by 2030.

Lastly, under 42 USC 8253 (f), included as part of the Energy Independence and Security Act of 2007 (EISA 432), federal agencies are required to designate buildings in their portfolio that together account for 75 percent of the agency's total energy use. These "covered" facilities are subject to annual benchmarking and disclosure requirements and energy and water efficiency evaluations every four years. Agencies are then required to implement any conservation measures identified and must track savings for those projects.

3. Policy Design Options

Building performance standards can be designed to target reductions in building energy consumption or building emissions or to set goals for improvements in derived metrics, such as Energy Star scores. They can also seek to enforce energy code compliance or require implementation of efficiency measures. Each design has its merits and drawbacks, which are evaluated here in the context of a federal design. For example, concerns about different climate zones would have no bearing on the design of a local program and are relevant only for programs that encompass multiple cities or cover wide geographic regions. Conversely, various approaches to the allocation of program allowances, discussed by Urban Green Council (2020), are unlikely to be a consideration in a federal building design.

Here we focus on three primary design features: types of standards, policy metrics, and flexibility mechanisms.

3.1. Types of Standards

Structuring consumption and emissions targets could take either a uniform approach or a building-specific approach.[6]

3.1.1. Uniform Approach

A uniform intensity-based approach in consumption or emissions per square foot applies the same target to all buildings in the program or all buildings in the same category (e.g., all health care buildings). The intensity target is progressively lowered in subsequent years to meet the final policy objective. In Figure 5, the markers represent emissions intensity targets for a hypothetical group of five buildings, each with different starting emissions intensities. The lines represent possible compliance pathways. Initially, only the buildings with emissions intensities above the threshold must undergo improvements. As the targets get more stringent, all buildings must improve their efficiency.

Applying the same standard to similar buildings has an element of fairness and administrative simplicity but doesn't reflect differences in building use: a half-empty office building would have to meet the same target as a fully occupied building of the same size. The approach does, however, put buildings that are designed to higher efficiency standards or have gone through substantial energy upgrades at an advantage, rewarding early action. This is the approach used in St. Louis, Washington State, Boston, and Washington, DC.

6 By definition, a program based on Energy Star or other derived metrics will be a uniform approach, since buildings in a particular category are compared with each other in the construction of the Energy Star score.

3.1.2. Building-Specific Approach

A building-specific intensity or absolute target forces buildings to reduce consumption or emissions relative to a starting baseline, which is calculated from historical consumption or emissions in the baseline years. The baseline should be selected to be fair to participants, averaging out extreme weather effects and avoiding outliers, such as Covid effects in 2020 and 2021. This is the approach used in the pioneering Tokyo BPS and proposed in Montgomery County, Maryland (Montgomery County, 2021), and Cambridge, Massachusetts.

This approach flips the pros and cons discussed above. Because all buildings have a tailored goal, even the most efficient buildings would have to show consumption or emissions reductions, meaning that early action is not rewarded. To ensure fairness, one approach is to exempt the most efficient buildings from compliance for the first compliance period(s). Figure 6 illustrates compliance pathways for five hypothetical buildings subject to a building-specific target: the buildings start at individual efficiency levels and gradually improve their performance. One issue with this approach is that because each building has its own targets, both setting goals and tracking compliance with multiple targets raise data and administrative challenges.

Figure 5. Uniform Target: Energy Use Intensity Pathway for Five Buildings with Different Starting Intensities

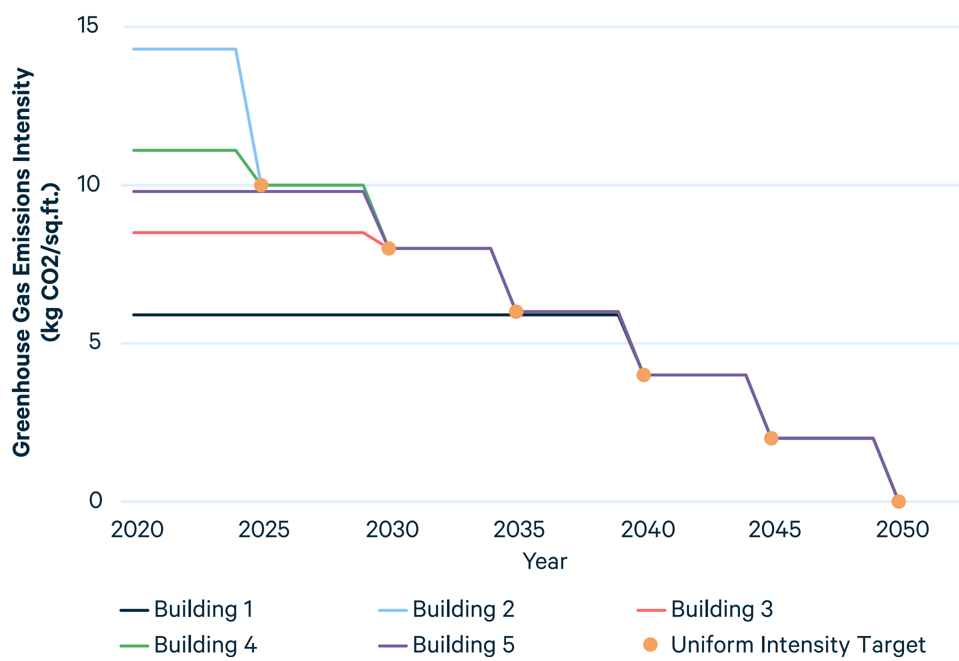
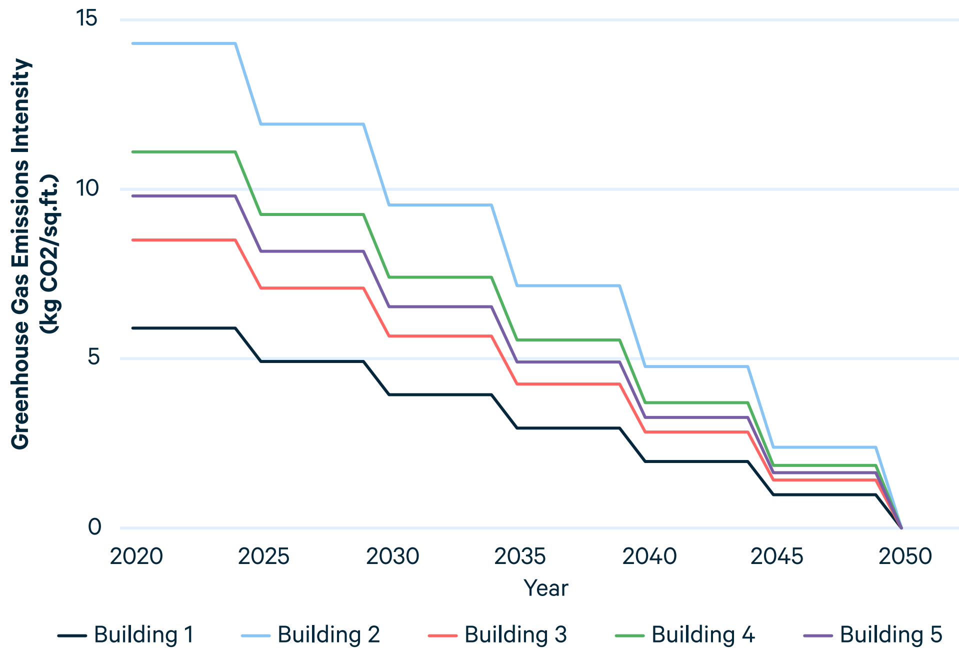


Figure 6. Building-Specific Target: Energy Use Intensity Pathway for Five Buildings with Different Starting Intensities



3.2. Metrics

3.2.1. Consumption Standards

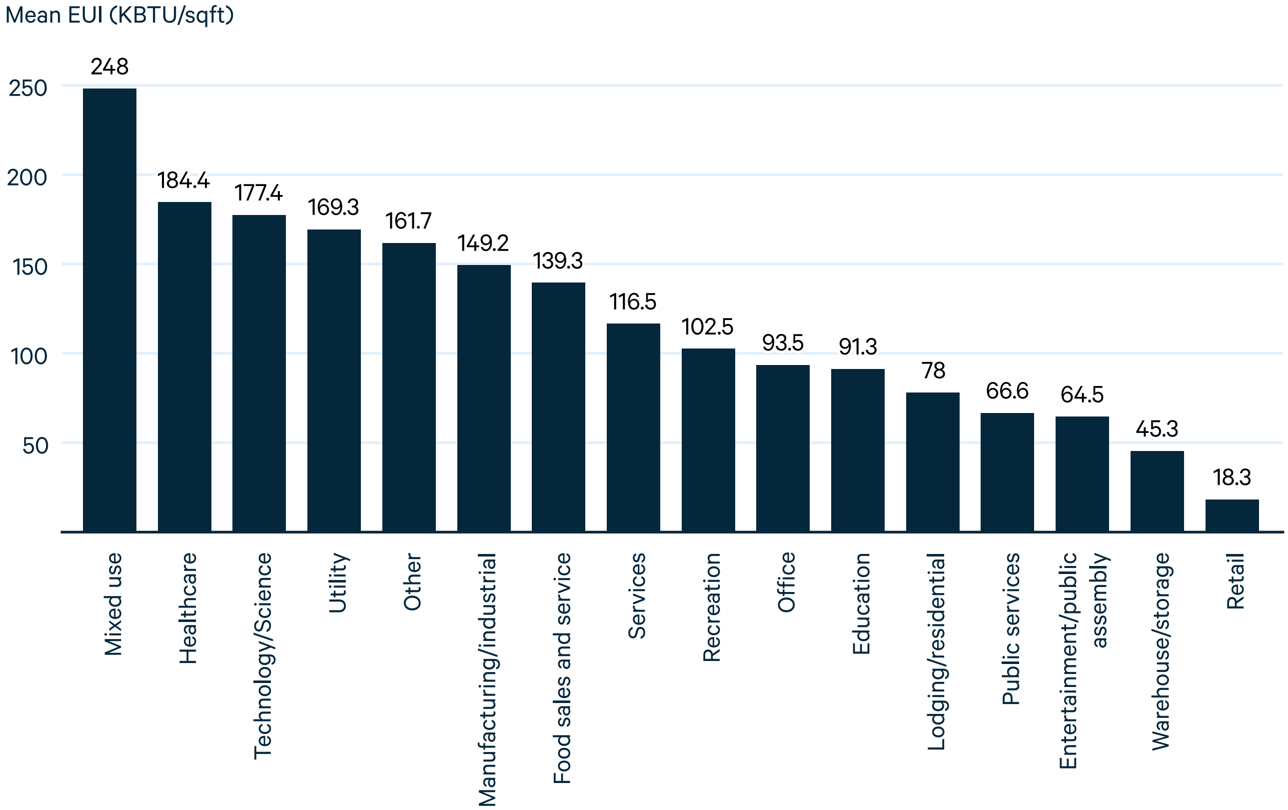
A consumption-based target requires buildings to reduce energy use by improving efficiency.[7] Some programs allow netting out externally purchased renewable electricity credits. A program that targets consumption creates an incentive for building owners to start with the most cost-effective efficiency measures and gradually work their way to items with lower efficiency returns on investment as needed to meet policy goals or when replacing failing equipment.

As noted by EPA (2021b), compliance with site-based consumption metrics is "within control of the building owner." The piecemeal approach to pursuing building energy improvements is validated by a study of commercial building energy upgrades (Regnier et al. 2020) across 12,000[8] utility and energy service company projects and federal

7 The municipal program in Reno, Nevada, has requirements for reductions in both energy consumption and water consumption. In addition, several cities that have benchmarking and disclosure programs require reporting of both energy and water consumption by covered buildings. Concerns about drought may grow with a changing climate, and including water conservation considerations in certain locations could help to make the federal building stock more resilient to water shortages.

8 Of the 12,255 projects tracked, 2,234 came from the Federal Energy Management

Figure 7. Mean Energy Use Intensity by Federal Building Type (kBTU/sqft)



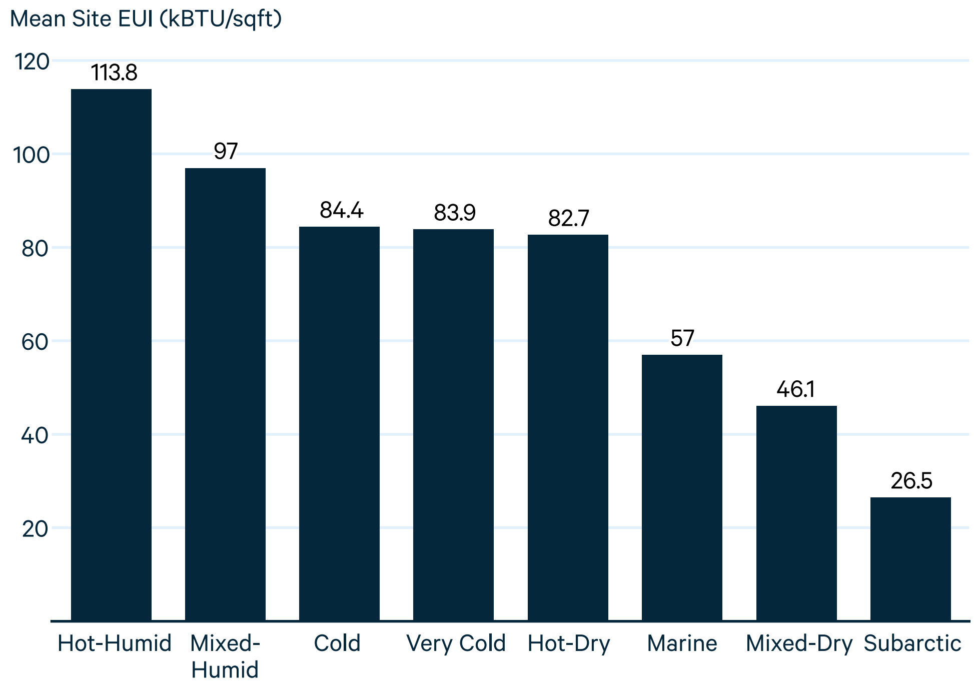
Source: FEMP EISA 432 Compliance Tracking System for FY 2019

government retrofits. Only 20 percent of projects took a systems approach to energy efficiency, with 80 percent being single-measure projects. More than 70 percent of single-measure projects were lighting upgrades; heating, cooling, and ventilation upgrades each represented approximately 10 percent of projects. Those numbers confirm the propensity to start with the projects with the shortest payback periods: as the opportunities for low-cost efficiency gains from lighting changes dwindle, building owners seek deeper retrofits and operational gains. Buildings' operational performance can be improved by optimizing temperature management, optimizing airflow, and using smart sensors to adapt lighting and temperature to occupancy (Fernandez et al. 2017).

Designing a uniform consumption-based standard for the federal building stock could be challenging because of variation in the types of buildings and their distribution across different climate zones. Energy consumption in federal buildings varies dramatically by end-use type, with healthcare and technology spaces consuming up to twice the energy per square foot as office, lodging, or education buildings (Figure 7).

Program database and 41 directly from the GSA deep retrofit program.

Figure 8. Mean Energy Use Intensity for Federal Office Buildings by Climate Zone (kBTU/sqft)



Source: FEMP EISA 432 Compliance Tracking System for FY 2019

The differences justify segmenting uniform consumption-based targets by building type. However, because of the influence of weather on building energy consumption, consumption per square foot of office building space also varies greatly across the country (Figure 8): energy use intensity is much higher in the warmer and more humid regions than it is in drier and cooler regions.

Federal Buildings' Energy Use Data

Obtaining data on federal buildings' energy usage is difficult, for many reasons. Data on energy use are not available for all federal buildings, and for those that do have data, the information is subject to errors and requires substantial data cleaning, which limits the data set.

To develop some summary measures of current energy use intensities (circa 2019) in federal buildings, we used a Federal Energy Management Program data set that provides information on facilities that account for the majority of each agency's annual energy use.[1] The data do not include all federal buildings, and several observations had to be dropped because of apparent data entry errors. We also excluded buildings that were smaller than 10,000 square feet, which is the typical lower-bound threshold for a building to be subject to a building performance standard.

The data set originally covered more than 6,300 buildings, of which about 1,800 buildings exceeded the minimum 10,000-square-foot threshold. After removing obvious outliers (based on very high or very low energy use intensities[2]), we were left with about 1,700 buildings. We have no reason to believe that the eliminated observations are correlated in any way, and therefore the data presented here are likely a representative sample of the federal building stock.

Building energy data used in city benchmarking programs is generally screened for certain attributes to meet compliance requirements. Data quality tests include testing for outliers, ensuring that the data have a unique building identifier that can be matched across other data sets and across time, ensuring that there are no data gaps in the utility billing information, and checking that the utility bills span a full calendar year.

Despite its limitations, this data set provides useful estimates of energy consumption in federal buildings across agencies, building types, and locations.

1 The Energy Independence and Security Act (EISA) of 2007 requires federal agencies to report annual energy and water usage at the facility level for buildings that account for 75 percent of the agency's total energy use ("covered facilities"). FEMP tracks these data. Information is not available for every covered facility, however, because some do not publicly disclose energy usage for national security reasons.

2 We excluded energy use intensities that were most likely wrong because of data errors. Energy use intensities typically vary from about 10 kBtu to a few hundred kBtu per square foot. For this reason, we removed any EUIs that were above 1,000 kBtu per square foot or any that were below 10 kBtu per square foot.

A federal uniform intensity standard would have to factor in such differences by segmenting buildings by both end use and climate zone, necessitating a two-dimensional compliance matrix. With eight climate zones and 16 building types, a full compliance matrix would have 128 different targets. One impediment to developing a two-dimensional matrix is insufficient high-quality data on federal buildings' energy consumption, in particular for the less common building types (Box 1). Moreover, energy data are missing from buildings that aren't covered under EISA 432. Those two issues would raise questions about the robustness of any benchmark derived from the data set.

Another impediment to setting uniform consumption intensity targets is the lack of analysis on how to define reasonable interim and end targets and over what time frame the targets are to be achieved. A net-zero *consumption* standard would force every building (or groups of buildings, if trading or averaging is permitted) to become self-sufficient through on-site (or purchased, if allowed) renewable generation and storage. If net-zero is not an achievable goal, what is the right science-driven progression of consumption targets over time? And does such a consumption-focused policy create concerns about reductions in energy services that go below minimum standards?[9] By contrast, a net-zero *emissions* target (discussed below) could leverage building electrification, falling electricity emissions rates, and renewable energy to create pathways to low or zero emissions.

3.2.2. Greenhouse Gas Standards

Whereas consumption-based standards focus on a building's energy usage, greenhouse gas standards set targets for reducing emissions resulting from that energy usage. Programs that target greenhouse gas emissions have the benefit of directly tracking federal climate goals, but they can be more complicated for building managers to track than energy consumption-based metrics. Calculating a building's greenhouse gas emissions involves multiplying the fuel-specific consumption by emissions factors. For some fuels, like propane, the emissions factor is not affected by policy and thus the same across the country. For other fuels, like heating oil or natural gas, the emissions rate could vary with policy. For example, under a potential future regional or federal renewable fuel standards (RFS),[10] the emissions factor for the fuel should track the RFS target. Electricity emissions rates are calculated based on the regional fuel mix of the electric grid but also should reflect statewide renewable energy standards. In a state with ambitious renewable energy standards, greenhouse gas targets could be met in all-electric buildings by riding down the curve of the local

9 Note that EPA's Energy Star certification for commercial buildings requires building owners to have a building audit to ensure that the energy savings are not achieved at the expense of essential energy services, such as a minimal level of lighting or space conditioning.

10 Although most existing fuel standards apply to transportation fuels only, there is growing interest in using renewable natural gas—that is, gas produced as a by-product from agriculture, wastewater treatment plants, or other processes—in buildings. States could possibly require fuel standards for buildings as part of decarbonization efforts.

grid's improved emissions intensity without additional efficiency gains in the building. Assuming that the grid decarbonization trajectory resulting from the renewables policy matches the building policy trajectory, this opportunity provides a strong incentive for building electrification under a greenhouse gas–based program.

One potential downside of a greenhouse gas standard is that unlike energy consumption, emissions per se are not under the building owner's control, and this is particularly true of emissions from the grid. Thus, which type of generation gets displaced as new renewables come online will affect the rate of decarbonization under an increasingly renewable (or zero-emitting, factoring in nuclear) grid. Understanding how grid emissions are calculated and updated will be important for illuminating effective compliance strategies for building owners.

The same caveats about segmentation by building type and climate zone apply to uniform greenhouse gas program designs. For example, Boston proposes segmenting its buildings into 13 categories, each with a distinct emissions intensity target, to reflect differences in buildings' energy intensity. This complexity disappears with building-specific targets, but building-specific standards create their own operational complexity.

3.2.3. Energy Star Score

Energy Star scores are a percentile-based rating of building energy consumption efficiency: a score of 60 implies that the building is more efficient than 60 percent of its peers, where peers are defined by building type.[11] The score is calculated by adjusting building operations to reflect normalized occupancy and weather conditions, creating a metric that is comparable across the country. Comparability and simplicity are the advantages of an Energy Star–based approach.

A drawback of the Energy Star score is that it is a moving target: the curve, which maps a building's normalized consumption to the score, is derived from building survey data that are updated every five or six years (EPA 2021a). If the pool of buildings in the survey becomes more efficient, a building that makes no improvements will see its score drop even if its consumption is unchanged. Because of this moving target, it is difficult to translate long-term Energy Star targets into consumption or emissions gains. The nature of the metric also makes it difficult for building managers to plan efficiency improvements, not knowing what gains in score they will achieve.

11 EPA's Energy Star Portfolio Manager program, which evaluates and benchmarks energy use in buildings, includes roughly 80 types of buildings, and for roughly 21 of these, the program can calculate an Energy Star score. For more information on the property types included in Portfolio Manager, see **https://www.energystar.gov/buildings/benchmark/understand_metrics/property_types**.

3.2.4. Prescriptive Measures or Code-Based Compliance

A prescriptive pathway allows buildings to comply by making specified building upgrades. The policy can prescribe measures by building category; take a checklist approach that assigns points to individual upgrades; or be customized, based on an individual building audit, modeled estimates of energy savings, or the payback period of an efficiency measure. The prescriptive pathway can also be designed variously:

- a standalone program, as in the city of Boulder's rental housing program;
- part of a larger BPS program for certain categories of buildings, as is the case for rent-controlled, low-income, and subsidized housing and houses of worship in New York City; or
- complementary to data-driven compliance pathways for the buildings that fail the quantitative program thresholds, as is the case in the District of Columbia and St. Louis programs.

Energy savings are estimated either ex ante (using building energy models) or ex post. However, given the complex interplay of individual efficiency measures and the lack of research on the accuracy of commercial buildings' savings estimates, prescriptive pathways don't necessarily provide a clear consumption or emissions trajectory.

Standard energy codes and "stretch" codes prescribe how buildings should be designed and constructed and are thus difficult to translate into consumption pathways. However, outcome-based codes establish target energy consumption levels and measure compliance through reported data. If applied to existing as well as new buildings, an outcome-based code is similar to a building performance standard but without some of the design flexibility afforded by BPS programs.

3.2.5. Cross-Metric Considerations

Which metrics are used will affect building owners' compliance strategies. Comparing and prioritizing individual retrofit options or groups of measures should be done in the same units as the BPS program targets: energy use–based programs should prioritize projects with the greatest MMBtu reduction per dollar invested, while programs with greenhouse gas targets should focus on the greatest CO_2-equivalent reduction per amount invested. If the program targets emissions, the most effective strategies for building owners in the near term depend on the regional electric grid emissions rate. Buildings in a region with very low electricity emissions rates would prioritize reducing fuel-based emissions to achieve compliance. Conversely, buildings in regions with high grid emissions rates might reduce electricity consumption first—for example, via updated lighting or by using occupancy sensors.

The expected evolution of grid emissions rates also affects building investment decisions. In an environment with strong growth in renewables and an expectation that the grid emissions factor will drop significantly, owners would focus on reducing fuel emissions via electrification pathways, but only if the target metric is in CO_2-equivalent units. In absence of a federal clean energy target, this means the building-specific compliance strategy will vary regionally, based on the expected combination of the state's renewable policies and renewable generation growth outlook. Although building electrification may be the desired strategy, it also has greater policy risk than other approaches because it depends on other policies' coming to fruition.

3.3. Flexibility Mechanisms

A BPS with no compliance flexibility is a strict standards-based approach. With full program trading, however, it becomes a market mechanism. Other flexibility mechanisms fall between these two bookends. To date, the jurisdictions that have implemented or proposed BPS programs have included innovative mechanisms to give the covered entities financing, incentives, and flexibility. Several options are discussed below.

3.3.1. Averaging within Agency and Other Forms of Trading

Setting portfolio-level targets instead of individual building targets and allowing overperforming buildings to be averaged with underperformers gives owners or managers (including federal agencies) the flexibility to schedule major improvements according to the expected lifetimes of the building energy systems. As discussed in Bugnion and Palmer (2020), this type of flexibility reduces costs. Portfolios can be ownership based (Boston), associated with educational or health care campuses (District of Columbia), or allowed across all buildings (Tokyo, and under study in New York City). Portfolio-level compliance requires a metric that can be summed across buildings, so this approach does not work for a ratings-based approach like Energy Star scores. Regional, agency-level, and portfolio-wide compliance approaches are all possibilities in a federal BPS program, though pushing the overall point of compliance too far from individual buildings risks diluting the sense of responsibility for meeting the program objectives.

3.3.2. Temporal Flexibility

Temporal flexibility, known as *banking* in emissions markets, incentivizes early action by allowing any excess compliance to be carried over to later compliance periods. Banking is used in the Tokyo BPS design (ICAP 2021) and is under consideration in New York City. The amounts kept for later compliance build what is called the allowance or credit bank. In a well-designed program, temporal flexibility creates incentives for early compliance by allowing building owners to plan building improvement decisions, knowing that the benefits of the reductions will accrue over time. Because deeper savings can be accrued across time, temporal flexibility creates incentives for system-based approaches to building retrofits: owners look beyond individual component changes and toward whole-building energy system optimization. System retrofits can facilitate deeper energy gains—from 49 to 82 percent greater savings, according to one analysis (Regnier et al. 2020)—and system requirements are often a prerequisite to enabling grid-interactivity in buildings. Two caveats are worth noting:

- A program deliberately designed with “easy” early phases risks creating a large pool of banked compliance units. Until this bank is reabsorbed, the program’s effectiveness is blunted.
- A program that relies on sample or inconsistent data to set baselines runs a risk of being poorly calibrated and thus either too stringent or not stringent enough. In the latter case, a large compliance bank could form.

Compliance banking is applicable to federal buildings and would incentivize investments that yield rapid efficiency improvements.

3.3.3. Equivalent Prescriptive Measures Pathway

A program can rely exclusively on reported data to track compliance or can allow a prescriptive pathway as an alternative to data-driven compliance. This approach guarantees compliance for a period or two if a list of measures is implemented, effectively relying on an *ex ante* estimate of the associated efficiency gains to gauge equivalency to consumption- or emissions-derived improvements. Hypothetically, however, a building could replace its lights with efficient fixtures and then leave them on 24/7 with no penalty other than the energy costs, risking a rebound effect. Equally important is the question of accuracy of the ex ante estimates of efficiency gains and what represents a truly equivalent pathway. Few studies have addressed this question, but we note that it is only of short-term relevance, since the buildings that select this approach are expected to reenter the standard data-driven compliance track after one or two periods.

Applicability of an alternative prescriptive pathway in a federal BPS requires additional research on methods to evaluate packages of building measures for equivalency. By effectively pulling buildings out of the regular compliance track, prescriptive pathways can also muddle the effectiveness of banking and trading, as these options are not included in a prescriptive approach.

3.3.4. Other Flexibility Considerations

Two jurisdictions (New York City, Boston) are allowing partial compliance through externally purchased renewable energy credits (RECs) or carbon offsets. This approach creates flexibility if a building finds itself with a small compliance shortfall, but it should not substitute for in situ building improvements. The provenance and type of allowed credits should be carefully restricted to ensure equivalence, which is easier to manage in a local environment than at the federal level. Boston, for example, can restrict credits to be Class I Massachusetts RECs of the same vintage as the compliance period. The lack of federal REC standards leaves a program at risk of drawing in low-value RECs that have few other sales outlets.

In several jurisdictions, incentive and financing programs are being implemented in conjunction with BPS requirements.

3.4. Accounting for Grid Operations in Program Design

Building performance standards are typically designed and enforced using annual metrics. Consequently, they do not take into account how the benefits of reducing electricity consumption or emissions vary with the time of day or season. Programs with consumption targets will value electric energy savings equally no matter when they occur. Similarly, emissions-based programs tend to use EGRID average emissions rates for a wide region to assign emissions values to electricity consumption (or savings) and thus fail to capture differences in emissions across more fine-grained locations or by time of day.

Aside from reducing energy use and emissions, buildings may help the grid decarbonize through demand-side management. As states start to substantially decarbonize their electricity sectors to realize their clean energy goals (as in California, New York, and Virginia), wind and solar energy will become increasingly important. These renewable technologies are variable and intermittent, and periods of resource abundance do not necessarily align with periods of high electricity demand, when electricity is most valuable to customers. The need to match demand to supply creates opportunities for buildings to better align their electricity consumption with periods of abundant renewable energy and associated low energy prices, at least at the wholesale level.

Examples of demand-shifting activity include precooling and preheating of building space when electricity is cheap—activities that could facilitate the integration of renewable sources of electricity onto the grid by better matching electricity demand with supply and avoiding renewables curtailment. Accounting for these forms of demand-side management in BPS programs that focus on consumption will require granular metering data and a new program design.[12]

Grid operations also can have important implications for the design of programs that target emissions reductions. Measures of indirect emissions from electricity consumption in buildings tend to focus on regional annual average emissions rates, which fail to account for changes in electricity system emissions rates by time and place. The emissions effects of reduced consumption (from energy efficiency investments) or of increased electricity use (from substituting electricity for fossil fuel use in a building) will depend on what generators are supplying the marginal kilowatt-hour of electricity when that electricity is being saved (or newly consumed).[13]

12 See Institute for Market Transformation (2021a) for a discussion of how grid-interactive efficient buildings might be incentivized under a BPS or associated policies.

13 Large corporate entities that are seeking to match their procurement of clean energy with their electricity consumption are moving toward contracting for a combination of (1) directly procured renewable generation, (2) storage that is capable of shifting clean generation in time and operated in a way that does so, and (3) grid-provided electricity to ensure that 24 hours of demand (or close to it) across all days is ultimately met by clean energy (so-called 24/7 clean). For more information about Google's approach to measuring its clean electricity matchup to load and plans for procuring 24/7 clean

Capturing such variation could be particularly important if electricity use for heating or cooling can be separated in time, through the use of thermal storage technology, from when the energy services are needed. Operated flexibly in this way, newly electrified loads can actually be a complement to grid decarbonization, raising the value of electricity from renewable generators during hours when it is abundant and lowering the need for (typically) fossil fuel–fired marginal generators. Similarly, energy efficiency investments that target reducing electricity use when fossil generators are on the margin will reduce CO_2 emissions more than across-the-board electricity savings.

Accounting for those aspects of grid operation in a building performance standards program dramatically increases the complexity of the policy and the associated data needs. With the growing adoption of dynamic meters and with regional transmission operators' move toward collecting high-frequency marginal emissions rates for grid operations, however, the data hurdle is shrinking. A federal program can play an important leadership role in addressing these complexities.

A federal BPS can be used to pilot a voluntary option to use time-of-day emissions rates for compliance. Buildings that can show greater emissions savings through flexible operations and creative use of renewables and storage would have an incentive to opt in. Such a pilot would allow the federal administration to work out the required technological solutions to track regional time-of-day emissions rates and match them with electricity production and usage, to the benefit of other jurisdictions and programs. The pilot would help quantify how grid-interactive buildings can promote grid penetration of renewables.

energy, see Google (2021).

4. Federal BPS Policy Considerations

4.1. Authority

In May 2021, the Biden administration announced plans to direct the Council on Environmental Quality to lead an interagency effort to design a building performance standard for federal buildings. How would the federal government go about requiring a BPS, and does it have the authority to do so?

As mentioned in Section 2.3, building performance standards for federal buildings are not unprecedented. Such standards can be brought into effect by executive order or self-directed through individual agencies. The most recent building performance standards that would have been in effect through FY 2025 (but were rescinded by the Trump administration) were introduced by President Obama through Executive Order 13693.

Federal buildings are either managed by the agencies themselves or by the General Services Administration, and both could reasonably impose a BPS on themselves in the absence of an executive order.[14] In the former case, a designated authority within the agency could possibly impose a BPS on its own buildings without any explicit statutory or regulatory authority. For the latter case, GSA, which owns and operates a portion of the federal building stock, has general authority to "operate, maintain, and protect" federal buildings under 40 USC 582, which could reasonably include setting standards for energy use or emissions. However, though a self-imposed program is possible, an executive order coming from the administration would presumably be better for enforcing compliance.

4.2. Program Implementation

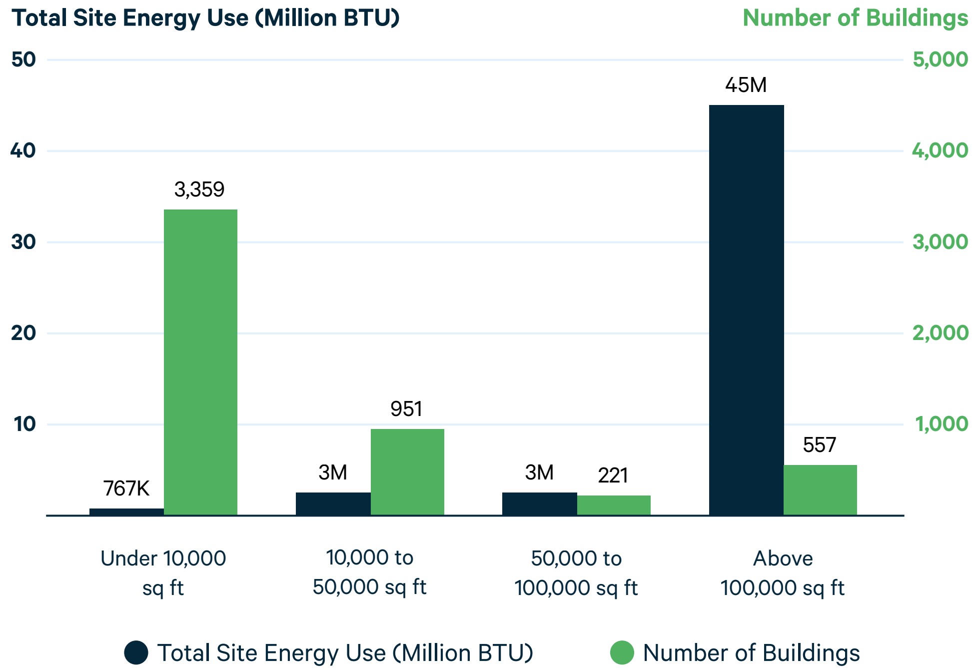
Data quality is an important factor affecting program design choices. A BPS with good-quality reference data sets can set benchmarks for individual building groups. Where there are concerns about substantial variability in consumption across buildings within a pool of building types, or about data privacy, a program with building-specific baselines can avoid data-related pitfalls and avoid exposing buildings to very different compliance burdens.

Existing municipal and state programs typically launch by imposing requirements on the largest buildings or largest emitters, and then gradually work their way down to smaller buildings or lower emissions brackets. All the US city and state programs have set scope thresholds by building size; Tokyo designed its program to capture only the largest emitters.

14 Personal communication, Todd Aagaard, Resources for the Future and Villanova University, May 12, 2021.

Starting with the largest buildings appears to be a good strategy to follow for federal buildings, since more than 90 percent of these facilities' energy usage is reported via the "covered buildings" program under EISA (FEMP 2021) and the vast majority of that usage comes from buildings that are at least 100,000 square feet.

Figure 9. Federal Civilian Buildings Covered by EISA



Source: FEMP EISA 432 Compliance Tracking System for FY 2019

Figure 9 shows that starting with buildings larger than 100,000 square feet captures 88 percent of the EISA buildings' consumption given here. (Because of apparent data entry errors, this data set was scrubbed and therefore this chart does not include all buildings covered by EISA.) This small number of buildings also allows for manual data cleaning and validation, plus streamlining and standardizing the data collection process along the following principles:

- Buildings must have unique identifiers to allow linking of data characteristics across time. The data should be managed in a platform that allows buildings to be matched across data sets and years.
- Benchmarking should be reported annually, leveraging federal data-reporting tools.
- Building emissions should be included in the EISA reported data.

Municipal and state programs are gradually beginning to set longer-term targets, with Boston planning on establishing targets for net-zero greenhouse gas emissions in 2050. The programs are setting goals that increase in stringency every five to seven years, depending on design, though compliance can be required either on an annual cycle or toward the end of a multiyear compliance period. In a federal design, the compliance periods should match the design of other federal climate programs. The Paris agreement sets a five-year period for nations to set increasingly aggressive goals. This approach creates a framework for interim program goals that would work well with a BPS design. Compliance should be evaluated annually to provide guidance to building operators, but penalties might be assessed either annually or at the end of the compliance period to average out weather fluctuations.

4.3. Moving from Local to National Policy

Addressing climate variability is the biggest issue to resolve in designing a national framework. Two approaches avoid having to break down consumption or emissions intensity targets by climate zone or other climate metric:

- By design, the Energy Star score adjusts consumption for standard weather to create a metric comparable across the country. However, Energy Star score–based targets lack predictability on the emissions reduction outcomes of the program.
- A building-specific intensity target, where every building receives a baseline calculated from its own historical data with common percentage reduction goals for each compliance period, forces all buildings to converge on a common target (Figure 5, above). This matches the design of overall federal climate goals, which are a 50 to 52 percent reduction in emissions by 2030 and net-zero by 2050 (White House 2021a). Proper baseline setting is crucial and should avoid outlier years (e.g., the 2020–2021 Covid period) and be sufficient to average out weather anomalies.

4.4. Compliance and Enforcement

In a federal BPS, the federal government is, at the same time, the policymaker, policy enforcer, and policy object. With respect to that last role, the covered entities are numerous. GSA is responsible for managing some 8,000 properties (ranging from a few hundred to more than 200,000 square feet), but most of the 100,000-plus federally owned or leased buildings are managed by the agencies themselves. This could create administrative hurdles for reducing energy usage and complying with a common standard across all federal properties.

A unique issue for a federal BPS is enforcement. A city can levy fines or civil penalties if buildings, mostly privately owned, fail to report data or comply with the BPS targets.

The federal administration can follow two principles to manage compliance. First, transparency on the buildings out of compliance will help external parties identify laggards, hold them to account, and evaluate the overall performance of the program.

Second, the federal administration can use a shadow price or “shadow penalty” to track and hold accountable poorly performing buildings. Analysis of the federal building stock's abatement costs can help inform the level of the shadow penalty. The building energy survey requirements of 42 USC 8253 include a compilation by agencies of a list of specific energy savings measures undertaken, organized by cost, estimated energy savings, and payback period. These data can form the basis for a curve of abatement potential as a function of cost that can be used to inform the selection of a shadow penalty.

Figure 10 illustrates the concept in a curve derived from EISA 432 program compliance data for the reported building retrofit projects awarded through the program from 2017 through March 2021 (about 300 projects). All initiated efficiency projects were sorted by cost, lowest to highest, per first-year unit energy savings to form a consumption abatement cost curve for federal buildings. Because this curve is based on existing projects, it may not be representative of the abatement costs for the next generation of projects, which should be derived from the proposed savings measures in audits of federal buildings, perhaps adjusted for lessons from recent experience with such measures.[15] Nonetheless, the concept involves looking up the abatement cost required to achieve a desired quantity of consumption savings and using that estimate to inform the level of a shadow penalty. For a program with a greenhouse gas metric, the shadow penalty would in effect be a shadow price of carbon specific to the building sector (Morris 2015).

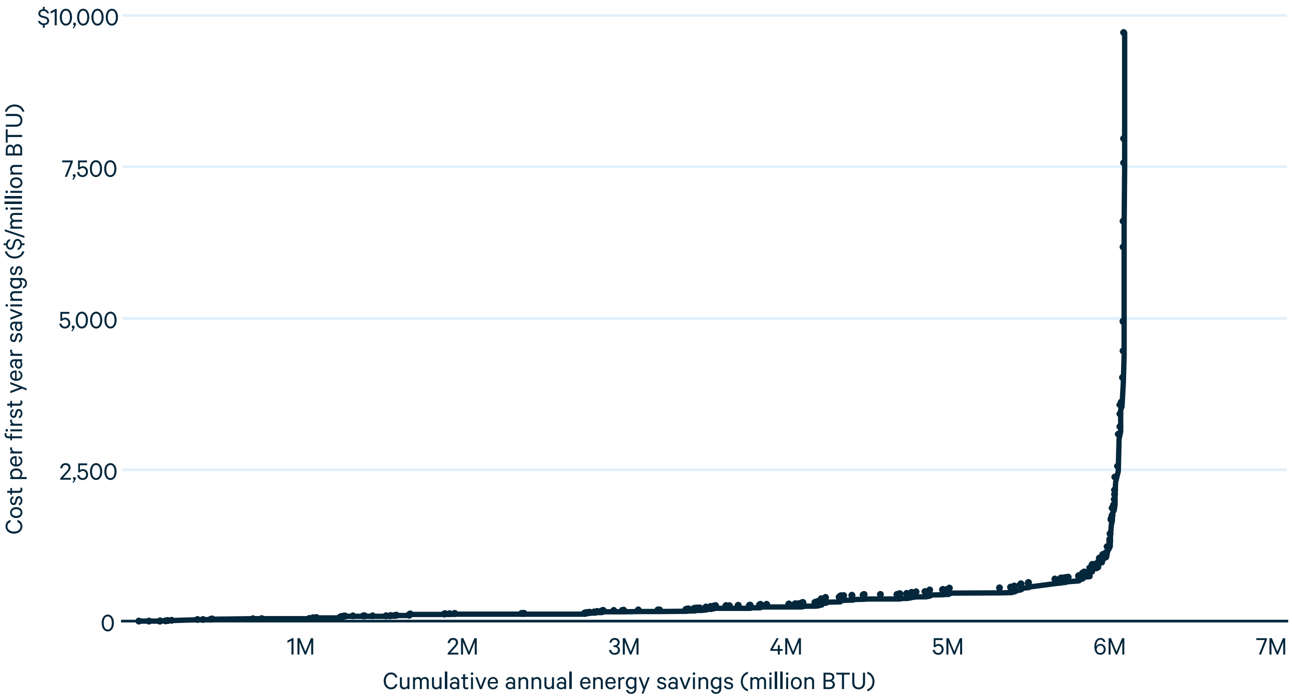
The abatement cost curve can also help provide a budgetary guide for the investment amounts needed to meet the program goals: the area under the curve to the left of the desired level of abatement represents the required investments.

Compliance with the building performance standards will require investments by the federal agencies or GSA, depending on who manages the property. A program component focused on optimizing investment to bring up laggards and meet program goals should be an intrinsic part of the design. The basic tenets should be as follows:

- Budgets should be allocated at the agency or subagency level to match the form of program compliance flexibility.
- The investment budget should be sufficient to enable building managers to track program goals. If the overall building portfolio's performance falls short, the budget should increase in the following year or compliance cycle.
- Specific investments should be prioritized strategically to meet program goals cost-effectively, with the most cost-effective approaches dependent on the program's metrics and flexibility measures.
- Building managers should have confidence that proposed efficiency investments will provide the energy savings advertised. Different approaches offer different degrees of certainty. Investment in onsite renewable generation will have yearly variability associated with weather but otherwise a fairly high degree of

15 The savings estimates presented here are also primarily based on engineering estimates of savings. The federal government could use experimental or quasi-experimental approaches to test whether the measures in fact deliver the modeled energy savings. For more information, see Palmer (2016), State and Local Energy Efficiency Action Network (2012), and Gillingham et al. (2018).

Figure 10. Incremental Cost of Energy Savings in Federal Buildings for Projects after 2017



Source: FEMP EISA 432 Compliance Tracking System, Initiated Projects

predictability. Upgrading or replacing individual appliances with known and stable usage patterns also offers reasonably predictable outcomes. Most other efficiency measures have fairly poor predictability because of the complexity of building energy systems and their interaction with building construction, and because of uncertainty about behavioral changes. Tracking the efficiency gains of individual or groups of measures relative to ex ante savings calculated with building energy models will help reduce this uncertainty.

Federal BPS Strawperson

Our analysis of the opportunities and challenges associated with developing a federal building performance standard suggests the following as reasonable features to consider in designing a policy.

Reference data. Data collected under EISA 432, mapped to individual buildings and with additional emissions calculations.

Metric. Greenhouse gas emissions (pounds of CO_2-equivalent) per square foot.

Type. Building-level greenhouse gas intensity target, starting from a multiyear baseline (excluding 2020–2021 because of the pandemic's effects on occupancy).

Target. Net-zero emissions by 2050, with intermediate five-year targets to match Biden administration objectives.

Compliance. Annual, with transparent reporting at the building level or agency (or region) level to enable independent tracking of progress toward goals.

Penalties. Tracking of penalties for noncompliant facilities, with a shadow price of carbon calculated for federal buildings based on marginal costs of compliance.

Ramp-in. Initially, buildings larger than 100,000 square feet, followed by 50,000–100,000-square-foot and then 10,000–50,000-square-foot buildings.

Flexibility mechanisms. Compliance banking to incentivize deep retrofits and portfolio-level compliance set at the agency (or regional) level to help operators optimize investments across properties.

Pilot programs. Voluntary opt-in to a program that uses time-of-day emissions rates for compliance.

Learning and collection of evidence. Incentives for agencies or portfolio managers to use experiments or quasi-experimental methods to augment our understanding of how new approaches (e.g., system-level investments, connected building controls) reduce energy use and emissions.

5. Conclusions

The use of building performance standards is on the rise domestically and abroad as governments seek more targeted policy solutions to reduce emissions from energy use in buildings. The policy designs proposed or implemented in US cities vary significantly in terms of metrics chosen and options for flexible compliance. Here, we have explored how to design a larger-scale program for federal buildings of various sizes and uses across the entire country.

Designing a federal BPS program is more complex than creating a local program, for several reasons. Differences in climate complicate how standards should be chosen, since energy use for the same building type and size can vary significantly by location. A well-designed program also hinges on the availability of quality benchmarking data. Although many local programs have long-standing, reliable benchmarking information, data sources available for energy use in federal buildings are not comprehensive (though they cover a significant portion of buildings, accounting for about 90 percent of total energy use), are not traceable across time because unique building identifiers are lacking, and contain data errors. A federal program must also create its own unique enforcement mechanism, since the federal government would be responsible for regulating itself. We have addressed these complications and presented options for how best to design a federal BPS, including a straw proposal for a federal building policy (Section 4).

An important goal of a federal building performance standard is leading by example and creating a blueprint for other jurisdictions to follow. We aim both to help inform federal policymakers in designing a program for federal buildings and to illustrate how a broad-reaching program could serve as a blueprint for city, state, and federal legislation for commercial buildings. The implementation of a BPS for federal buildings can also encourage large corporations with net-zero emissions commitments to adopt similar targets for their building portfolios. Finally, a federal BPS could be useful for informing national policy for buildings by collecting data on abatement costs. For this reason, the policy must be designed in a way to collect evidence, as is called for in the Biden administration's Memorandum on Restoring Trust in Government through Scientific Integrity and Evidence-Based Policymaking, dated January 2021.

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