A Tale of Four Cities: Data Analysis Lessons for Building Performance Standard Policy Design

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ABSTRACT

Building Performance Standards (BPS) can play a critical role in helping cities meet their climate goals by reducing emissions from existing buildings. To develop a BPS, a jurisdiction needs credible data on the local building stock to make decisions about four key elements: the scope of buildings covered, the metric used, the stringency of the targets, and the timeframe for compliance. However, there is currently little practical guidance about when and how a jurisdiction should use data analysis to support these decisions. The goal of this paper is to demonstrate how data analysis can be used to support the BPS policy development process, using recent work in four Ohio cities as a case study. First, we describe the project's overall approach to data analysis, which was tightly coupled with the stakeholder engagement process. Then, we detail the process of assembling and analyzing the building stock models, which combined metered utility data with building characteristics. Finally, we share lessons learned from leveraging this information for discussion with stakeholders. We highlight examples of what worked (and what did not) and discuss why. Overall, this paper presents data analysis as an ongoing, evolving companion to the policy development process. It adds to the body of work on BPS by offering a set of actionable insights to support data-driven BPS policy development.

Introduction

Building Performance Standards (BPS) can play a critical role in helping cities meet their climate goals by reducing emissions from existing buildings. A BPS is a policy that requires existing buildings to meet an energy or greenhouse gas (GHG) emissions target by a specified date. Unlike mandatory energy benchmarking and disclosure requirements, which are focused on data collection, BPS are focused on action: buildings that do not meet their BPS target must take action to improve their performance. This focus on action means that BPS have the potential to produce substantial savings: prior work has estimated that BPS can reduce cumulative building emissions by 12-34% over a 30-year period (Walter and Mathew 2021), and meeting BPS targets can reduce energy use from covered buildings by 25-45% (Webb and McConnell 2023).

To develop a BPS, a jurisdiction must make decisions about four key elements: the scope of buildings covered, the metric used, the stringency of the target, and the timeframe for compliance (ASHRAE 2023). These elements look different in every adopting jurisdiction; to date, 16 cities, counties, and states have enacted a BPS, and each jurisdiction has their own special combination of scope, metric, targets, and timeframe (IMT 2026). Decisions about these elements shape the potential impacts of the policy, as well as its feasibility. They determine the total energy and GHG emissions savings, the level of investment required of building owners to comply, and the corresponding level of staffing and support that the jurisdiction will need to provide, among other outcomes. In order to develop a BPS that matches a jurisdiction's unique circumstances, "policy makers and stakeholders need credible, quantitative information on these impacts to evaluate trade-offs and make informed decisions on policy design." (ASHRAE 2023, 75). Reliable data on the energy performance and characteristics of the local building stock, and effective approaches to analyzing BPS scenarios are both essential to meeting this need.

However, there is currently limited practical guidance about how data analysis should be used to support the policy development process. BPS enacted to date have each been bespoke design exercises, and while papers and technical reports describing the supporting data analysis are useful, they are specific to a single jurisdiction (e.g., Bergfeld et al. 2020; Walter and Mathew 2021; Brinker et al. 2022; Eash-Gates and Takahashi 2022). BPS standards and guides describe data analysis methods but are missing a discussion of how to apply these methods in practice, and in collaboration with local stakeholders. For example, ASHRAE Standard 100 provides a model BPS, but the discussion of local data analysis in Appendix J is limited to target-setting approaches (ASHRAE 2024). Similarly, ASHRAE's *Building Performance Standards: A Technical Resource Guide* contains an extensive section on data analysis methods, highlighting the key questions, considerations, and pros and cons of different approaches (ASHRAE 2023). Yet, it stops short of providing guidance to jurisdictions and their technical consultants on what types of analysis and visualizations are most useful in different contexts. The need for extensive analysis to support BPS is currently a barrier to their potential growth in more locations (especially in under-resourced jurisdictions), and increased transparency about what type of analysis works, when it works, and why it works can help overcome this.

The goal of this paper is to demonstrate how data analysis can be used to support the BPS policy development process. We focus here on our experience working with four Ohio cities—Columbus, Cleveland, Cincinnati, and Dayton—which have been concurrently developing their own BPS policies through a project funded by the U.S. Department of Energy. First, we describe the project's overall approach to data analysis, which was tightly coupled with the stakeholder engagement process. Building stock models were developed for each city that combined metered utility data with building characteristics, and these were leveraged for discussion and decision-making with stakeholders during the policy development process. Then, we provide technical details on the process of assembling and analyzing the building stock models. Finally, the bulk of the paper is dedicated to sharing lessons learned from our data analysis work. We highlight examples of what worked (and what did not) and discuss why. This paper adds to the body of work on BPS by offering a set of actionable insights to support data-driven BPS policy development in other jurisdictions.

Background

BPS development in Ohio's large cities

Like many cities across the U.S., Columbus, Cleveland, Cincinnati, and Dayton each have a climate action plan with ambitious goals. Columbus, Cincinnati, and Cleveland each set a city-wide goal of carbon neutrality by 2050, and Dayton wants to have 100% clean, renewable electricity by 2050 (City of Cincinnati 2023; City of Cleveland 2025; City of Columbus 2025; City of Dayton 2021). To support their overall goals, these cities also have specific goals for the buildings sector. Columbus has a goal of a 50% residential, commercial, and municipal energy use reduction by 2050, with interim goals for each sub-sector by 2030. Cleveland set a goal of net zero emissions for commercial and residential buildings by 2050. Cincinnati is dedicated to a 30% reduction in emissions from buildings by 2030. Dayton does not have specific buildings sector goals, but highlights energy efficiency and renewable energy projects as focus areas.

Although these cities have bold goals and operate within the same statewide context, they currently have different local policy environments. Columbus is the only city in Ohio to date with a mandatory energy benchmarking policy, which was enacted in 2020. Columbus is also the only city in Ohio committed to BPS by joining the National BPS Coalition. The other three cities have a history of voluntary benchmarking through 2030 Districts in Cleveland and Cincinnati, and a similar local initiative in Dayton called Dayton Regional Green. The consequence is that each city has similar overall goals, but different starting points and support needs for advancing energy policies for existing buildings.

To support these four cities in meeting their buildings sector goals, the University of Cincinnati led a collaborative project starting in early 2024 that was funded by the U.S. Department of Energy. The goal of the project was to support the development and implementation of BPS in each city. The project had three major tasks: (1) quantitative data collection and analysis of the building stock in each city to inform BPS policy development; (2) qualitative analysis of the legal pathways, financing options, and workforce development opportunities to support BPS in Ohio; and (3) stakeholder engagement to shape and advance BPS legislation. The project was highly collaborative, with more than a dozen partner organizations across Ohio working in a coordinated effort to advance a BPS in each of the four cities. For an overview of the overall project, see Webb et al. (2024).

An integrated data analysis approach

The project tasks were highly integrated; in particular, the data analysis was tightly coupled with the stakeholder engagement. Figure 1 illustrates the major stages in both the data analysis and stakeholder engagement processes along a timeline, as well as their relationship.

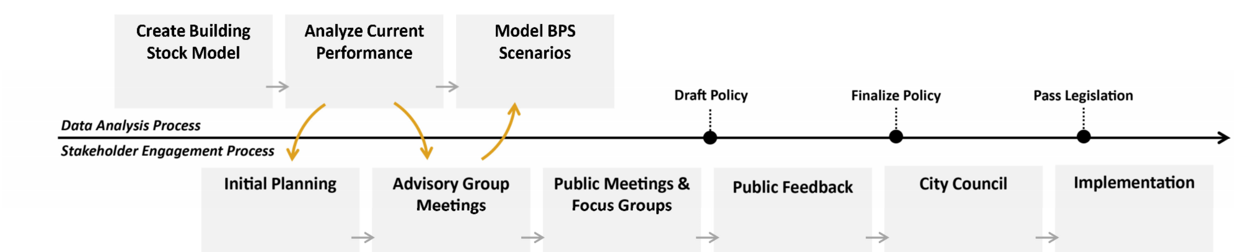

Figure 1. Integration of data analysis and stakeholder engagement processes

The data analysis process consisted of three major stages. First, building stock models were developed for each city that combined metered utility data with building characteristics. Then, the models were analyzed across multiple variables to understand the current composition and performance of the building stock in each city. Third, a range of potential BPS scenarios were developed and modeled. Each scenario represented a particular combination of scope, metric, targets, and timeframe, and the performance of each scenario was evaluated using several outcomes of interest to the cities.

The stakeholder engagement process consisted of six major stages, which were formalized by each city in a stakeholder engagement plan. The initial planning stage included internal meetings within city government, and stakeholder mapping to identify individuals and entities that should be engaged in the policy development process. Then, a series of meetings were held with an Advisory Group, an invited leadership group of key stakeholders providing input on policy design. The specific number and makeup of this group differed slightly across the cities but generally ranged from 20-40 participants across many stakeholder types, including large building owners, developers, architects and engineers, utilities, and tenant groups. Public meetings and focus groups on special topics of interest were then held to collect feedback from the broader community, and a policy was drafted. This was followed by an additional public feedback period, and then finalizing and passing the policy.

At the time of writing, each of the cities were at different places in the stakeholder engagement process. Columbus had completed public meetings and focus groups and recently released a draft BPS policy for public comment. Cleveland and Cincinnati had both finished the Advisory Group meeting series. Dayton decided to delay its stakeholder meeting series until the completion of a BPS pilot program currently in development.

The data analysis and early-stage stakeholder engagement work were integrated into a tight feedback loop. The analysis of the current stock was used to inform stakeholders, and, in turn, their ideas and concerns informed the development of the BPS scenarios. Because BPS policy development was in the early stages when this project began, a unique aspect of our work was exploring how to use the data to educate stakeholders on the value and benefits of a BPS, in addition to providing a technical analysis of policy options. The remainder of this paper describes the process of assembling and analyzing the building stock models, and then shares our insights from using these models for discussion and decision-making with stakeholders.

Assembling and Analyzing the Building Stock Models

Data Collection

Developing a building stock model is the first step in the data analysis process, as it will be the primary source of information supporting any further investigation. The construction of each city's building stock model, outlined in Figure 2, combined two main sources of information: tax assessor data and metered energy usage.

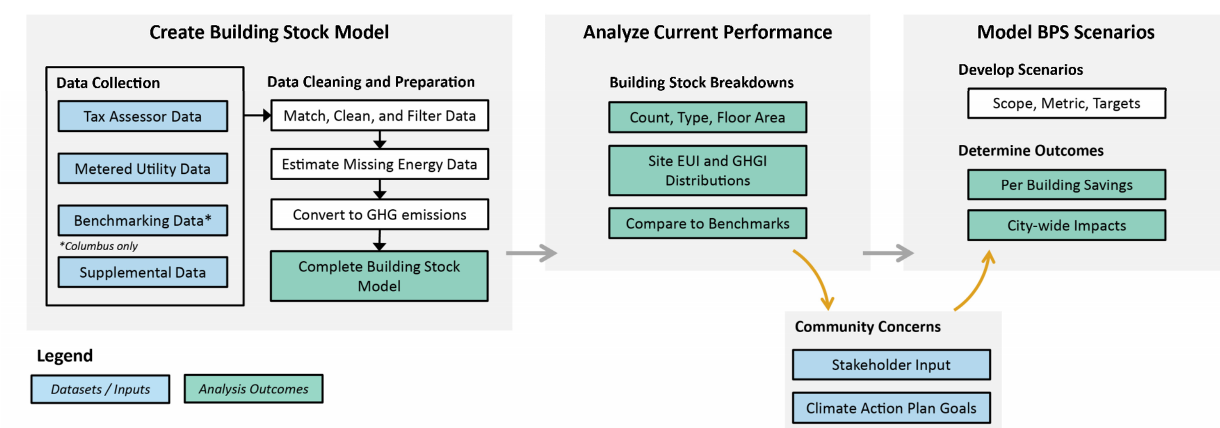

Figure 2. Building stock model development and analysis process

Each city also provided supplemental datasets that contained information on large buildings. In Columbus, this was data from the city's mandatory benchmarking ordinance, which contained building characteristic data and energy use reported by building owners. In Cincinnati, the 2030 District provided building characteristics for its member buildings (e.g., floor area and property type), though energy use was not provided. Although the Cleveland 2030 District and Dayton Regional Green collect building characteristics and energy data, it is confidential and could not be used for this project.

Data Cleaning and Preparation

In each of the four cities, datasets were merged and filtered to remove missing data. Each energy meter was geocoded and matched to a parcel of land in the tax assessor data. The supplemental data in Cincinnati and Columbus were also geocoded by address and linked to a parcel, allowing this information to be pulled into the dataset. An important assumption in this matching process is that parcels represent buildings. In reality, there is not always a one-to-one match between parcels and buildings, but, for this analysis, the floor area and energy use of all buildings and energy meters contained on a parcel was aggregated, and each parcel was treated as representative of one building. Once merged, properties with missing data and outliers were removed using the following criteria, (1) floor area missing or zero; (2) property type or land use missing; (3) site energy use intensity (EUI) values above 1,000 kBtu/ft^2. After filtering, land use codes from the tax assessor data were aggregated to fewer, less granular property types. Property type is an important variable in BPS development, since targets are typically set separately for each property type. However, tax assessor data assigns each parcel a land use code, sometimes containing more than 100 codes, which differ by jurisdiction. ENERGY STAR Portfolio Manager (ESPM), which is typically used in benchmarking ordinances, contains over 80 property types (U.S. EPA 2024). For this analysis, the tax assessor land use codes were each mapped onto an ESPM property type. ESPM was used because it was the basis for our approach to imputing missing energy data, and because it was used in Columbus' benchmarking data.

Multi-use properties are very common in dense urban areas, and one limitation of tax assessor data and the supplementary datasets was the lack of secondary property types. In reality, buildings commonly have multiple use types within the same building. Some of the tax assessor data land use codes indicated mixed-use property types (e.g., apartments or offices over retail), which were mapped to the ESPM "mixed-use" property type for this analysis. This was the only indicator of mixed-use properties and, even then, the dominant property type was unknown. All other buildings were assumed to have 100% of their floor area used as its assigned property type.

When energy data was missing for a parcel, we imputed it. We used a very simple method of assuming the ENERGY STAR national median EUI for each property type (U.S. EPA 2024) and then scaling by floor area to get energy use. To determine the split of electricity and natural gas when estimating energy use, representative splits from Cincinnati property types and floor area categories were used. This is because Cincinnati had the most complete metered energy dataset of all the four cities. Greenhouse gas (GHG) emissions factors were then applied to calculate the electricity, natural gas, and total GHG emissions of each building. Natural gas emissions were calculated using a direct emissions factor of 53.11 kg CO_2e/MBtu and electricity use was converted using an indirect emissions factor for the Ohio Valley (RFCW) eGRID subregion of 121.78 kg CO_2e/MBtu (U.S. EPA 2025).

Current Performance and BPS Scenario Analyses

The stock models were then used to help city staff and other stakeholders understand the current composition and performance of their building stock. Prior work suggests the need to slice and dice the building stock by count, type, age, floor area and other factors (ASHRAE 2023; Walter and Mathew 2021). These are important variables to investigate and reveal where energy use is concentrated and where large portions of emissions come from. Using the models, we developed different graphical breakdowns of each city's building stock according to these variables, some of which are highlighted in Figure 2, and these were used in meetings and workshops with city staff and stakeholders. We also visualized distributions of current building energy and emissions performance and compared them to national benchmarks, such as ASHARE Standard 100 targets (2024). These comparisons helped stakeholders understand which building types performed well, and which performed poorly. We also broke out buildings by floor area category and neighborhood, to provide a sense for where buildings impacted by a BPS might be located. Overall, this analysis helped provide rationale for BPS, and gave stakeholders and city staff an initial sense for what scope might make sense for their BPS.

The discussions with stakeholders about the current performance of the building stock yielded ideas that informed the exploration of possible BPS scenarios. Scenarios were generated for a range of scope, target, and metric considerations. For each BPS scenario, a scope of covered buildings was set based on building sector(s) and a floor area threshold. For these covered buildings, targets were determined by grouping buildings by property type, selecting a performance metric—either site EUI or GHG intensity (GHGI, measured in kg CO_2e/ft^2)—and setting targets at a percentile of each property type's current distribution of that metric. Buildings already at or below their target required no action, while those above it were assumed to reduce their EUI to meet the target, with the per building fuel mix assumed to be the same before and after meeting the target. The total emissions savings from each scenario were aggregated from all buildings not meeting the original target, and divided by the city's baseline building sector emissions to understand total percent savings in each scenario.

Lessons Learned

Based on our experience conducting data analysis to support BPS development in four Ohio cities, we have developed a set of nine lessons learned across each of the three stages of the data analysis process. Lessons 1 and 2 discuss some of the limitations we encountered creating the building stock models, and how we overcame them. Lessons 3, 4, and 5 highlight insights from discussing the current building stock performance with stakeholders. The remaining lessons provide tips for modeling BPS scenarios.

Lesson 1: Get creative if you don't have benchmarking data

Ideally, data from a mandatory benchmarking ordinance would serve as a key source for a building stock model, providing energy data and property characteristics for covered buildings. However, only Columbus had enacted a mandatory benchmarking ordinance; our other three partner cities had not. So, what's a jurisdiction to do if benchmarking data is unavailable? There are two broad options outlined by ASHRAE (2023): use other sources of publicly available empirical data or use energy simulation models. Both options have drawbacks, as neither precisely represents the actual, metered energy performance of a building.

For this project, we used benchmarking data where available (for large buildings in Columbus only) plus a unique source of empirical energy data: meter-level utility data from certified retail electric and natural gas suppliers. Additional information about this data source is discussed in Webb et al. (2024). Twelve months of recent, anonymized, utility data were obtained from retail electric and natural gas suppliers. The files contained monthly usage data for all electricity or natural gas meters, which was aggregated to a yearly summary per meter.

The retail electric and natural gas supplier files were a valuable but imperfect solution for several reasons. First, the files did not include information on fuel sources other than electricity and natural gas. We know that a small number of buildings in each city are on campus central plants or downtown thermal loops and use district energy, but this usage was not included in our analysis unless it was listed in the Columbus benchmarking data. Second, in some cases the files were difficult to obtain. The files for each utility had to be obtained separately, which meant getting eleven different files across the four cities (Cleveland, for example, has two electric utilities and two natural gas utilities). In some cases, we were unable to obtain the files within the project timeframe. Third, even when energy data was available, the files themselves were missing some data. This was likely the result of account holders opting out of sharing their usage, or a meter or data error. Table 1 shows metered records by fuel type in each city as a percentage of total buildings. Natural gas data from retail supplier files were available only in Cincinnati, where the same utility provides both electricity and gas. The natural gas data available for Columbus was provided in its benchmarking data.

Table 1. Metered utility records in each city

Utility Type	Cincinnati	Cleveland	Columbus	Dayton
Electricity Records (% Total)	90.8	38.1	83.4	83.6
Natural Gas Records (% Total)	85.7	0.0	0.2	0.0

Lesson 2: A benchmarking ordinance makes a difference

A benchmarking ordinance should precede a BPS, due to the increased level of confidence in, and ease of access to, building characteristic and energy data. Benchmarking data (or lack thereof) impacted our analysis in two ways. First, the supplementary datasets in Columbus and Cincinnati served as data validation checks. For example, since tax assessor data is mainly used for tax purposes, some land use codes only denote ownership or tax exemption status. So, where available, property type data from the supplemental datasets was used in place of tax assessor data to correctly identify these properties. Second, the retail electric and natural gas supplier data was at the meter level, not the building level, so each meter had to be matched to a parcel from the tax assessor records. Parcels may contain multiple buildings or buildings may overlap multiple parcels, and in both cases energy data would not be correctly attributed to its source. This is an important issue for the large buildings typically covered by a BPS, as they can have numerous utility meters associated with the building. Mandatory benchmarking data circumvents this issue by collecting aggregated data at the whole building level, which would have made our analysis much more straightforward.

Yet, a benchmarking ordinance does not ensure a complete or accurate dataset. Even jurisdictions with a mandatory benchmarking ordinance do not have data for buildings outside of the policy scope, such as smaller buildings, and benchmarking compliance rates for large buildings are less than perfect: Frick et al. (2017) showed that compliance rates range from 73-99% across ten large cities reporting compliance, and this is likely to be lower in cities that do not formally report a compliance rate. Our use of ENERGY STAR national median EUIs to estimate missing energy data is a very simple approach, one which could be replicated in any jurisdiction with or without benchmarking data, and should yield reasonable aggregate estimates of total emissions. The downside is that the distribution of energy use for each property type will be skewed towards the median, and more heavily when more data is missing. This was the case in Cleveland, where utility data was harder to obtain. ASHRAE (2023) recommends imputing energy data by sampling from a distribution of representative buildings and Walter and Mathew (2021) provide an example of this, filling in energy use for smaller buildings using distributions from benchmarking data on larger buildings. In general, more work is needed to determine accurate methods for imputing missing benchmarking data in jurisdictions with missing, limited, or no benchmarking data..

Lesson 3: Look at all buildings, not just large ones

The backbone of the building stock model in each of the four cities was tax assessor data. The advantage to starting with tax assessor data in each city, rather than benchmarking data, was that it allowed us to develop a model of the entire building stock for each city. This included both the large buildings typically covered by benchmarking and BPS policies, as well as smaller buildings. While this required greater analysis effort, it provided our partner cities with a more comprehensive understanding of their energy and emissions breakdowns, and allowed us to model a wider range of potential BPS scenarios for exploration with stakeholders. Since the climate action plan goals in Cincinnati, Cleveland, and Columbus are set relative to the whole buildings sector, not just large buildings, by including all buildings in the stock models, we could evaluate the BPS scenarios relative to these goals and show the percent of emissions saved relative to city's baseline building emissions. Ultimately, the true portion of large building emissions becomes clearer as smaller buildings are added, showing stakeholders that BPS are a powerful tool, but only touch a portion of city-wide emissions.

The caveat is that the ease of access and format of this data differed across the jurisdictions. In Ohio, the tax assessor data was collected from publicly available property records at the county level. In some counties, the data were readily available in spreadsheet format, while in others the data was in GIS format or had to be web scraped. The specific property characteristics available in each dataset also differed across the four cities; while all datasets contained the minimal variables noted above, some included more detailed information such as property condition, and wall construction material.

Lesson 4: Use data analysis to set BPS expectations

When talking to stakeholders about the current building stock in each city, a frequently used image was a side-by-side plot showing the count of buildings compared to their emissions. Figure 3 shows an example of this kind of image for Cincinnati. The left plot shows the percent of total buildings by count, and the right plot shows percent of emissions for five main sectors broken out by floor area category. Municipal buildings are broken out separately because many jurisdictions have set a smaller floor area threshold for municipally-owned buildings in benchmarking and BPS. Breaking out city-owned buildings in the analysis can help support cities in "leading by example" in their BPS. Another useful way to break this out was to show count of buildings and energy use, but since emissions reductions are often the goal of cities considering a BPS, current emissions are highlighted.

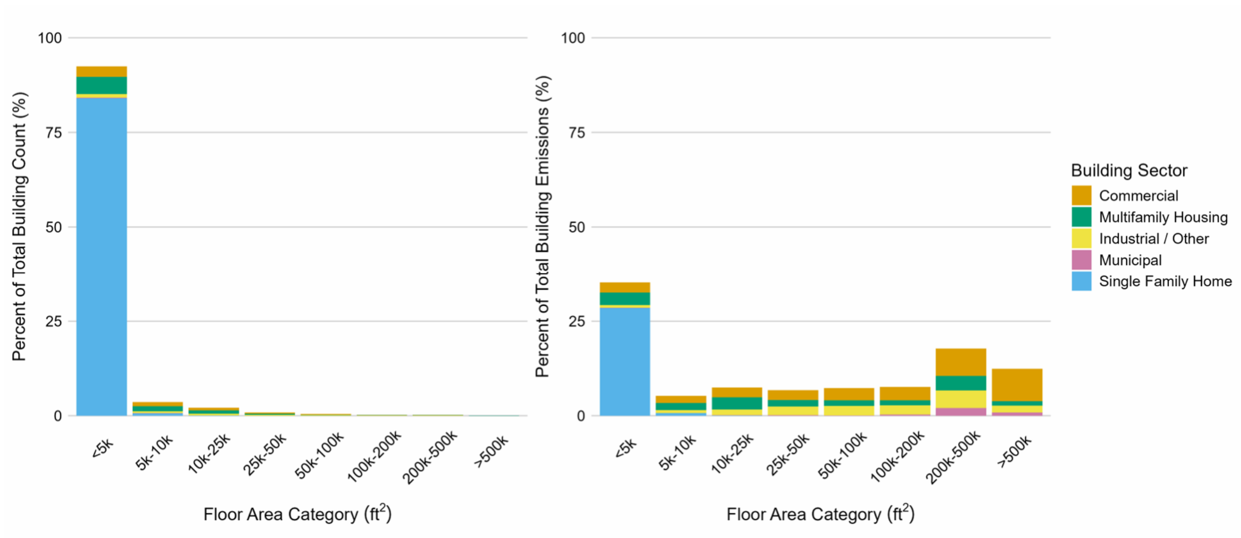

Figure 3. Building count and emissions by floor area category and building sector in Cincinnati

This count vs. emissions plot revealed two simple but important lessons about BPS for our stakeholders. First, large buildings are few in number, but account for a large portion of emissions. Despite making up only 1% of all buildings by count, buildings larger than 50,000 ft^2 are responsible for 45% of Cincinnati's building emissions. These percentages were generally similar in the other three cities, and this trend forms a "1% rule" where targeting a small number of large buildings can have a substantial impact on building emissions. This image helped us explain to stakeholders that a BPS policy covering large buildings is a good value proposition, addressing a lot of emissions with only a few buildings. It also helped us explain why BPS in other jurisdictions focus on large buildings, as 50,000 ft^2 mimics the size threshold for multiple benchmarking and BPS policies elsewhere. Second, the corollary to this rule is that a large portion of emissions will remain unaffected by a BPS that only targets large buildings. Single-family homes alone make up over 25% of building emissions in Cincinnati, and these would not be addressed by a BPS. While not excluded by a size threshold, industrial buildings also account for a large amount of emissions and have been exempt in most BPS. Figure 3 highlighted for our stakeholders the need for complementary policies to address emissions from existing smaller buildings and industrial buildings, which a typical large-buildings BPS may miss.

Lesson 5: Make the data real

One of the first questions that often came up when discussing a potential BPS with stakeholders was "How many buildings?" followed by "Which ones?" This was true in discussions with city staff and elected officials, as well as in the stakeholder advisory group meetings. Since covered buildings in most benchmarking and BPS policies are defined by a floor area threshold, over the course of the project we provided various breakdowns of the building stock by floor area category as both tables and figures (such as in Figure 3). In some cases, sector was broken into more detailed property types to provide a better understanding of exactly which types of buildings might be covered.

Yet, when reviewing these summary tables and plots, we noticed that stakeholders had trouble connecting the data to real buildings in their city. We were often asked which kinds of buildings fall into a given square footage category. To address this, we developed a graphical matrix showing images of real local buildings for each square footage category of interest. Figure 4 shows an example of one of these from our work in Cincinnati. We purposely tried to select prominent buildings for each category that were in or around downtown or on major roads, so that the audience was very likely to be familiar with them.

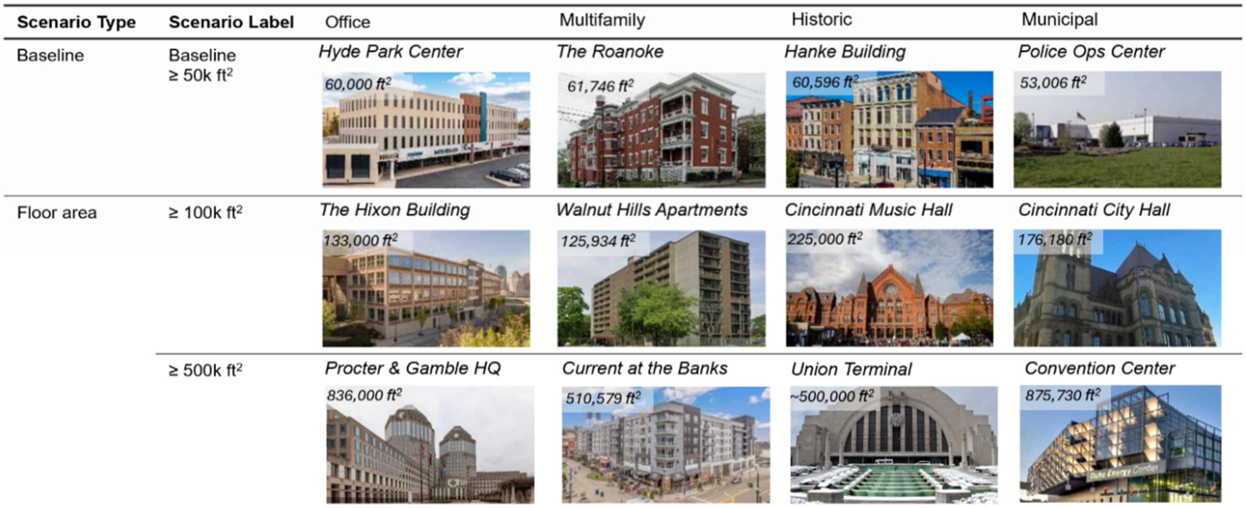

Figure 4. Graphical matrix of potential covered building scenarios in Cincinnati

The need for this image taught us the importance of making the data real for stakeholders through tangible, meaningful connections to local buildings. Concern about which buildings would be covered by a BPS is not theoretical for our stakeholders, it is grounded in their lived experience. Ultimately, a BPS will impact buildings that our stakeholders own, live or work in, or walk by. The data analysis process and visualizations need to reflect this. An alternative method of making the data real could also be to map covered buildings by neighborhood, as we noticed many stakeholders had a strong understanding of buildings in particular locations within the city. One advantage to the type of data presentation shown in Figure 4 is that it could be made very early on using a sample of tax assessor or other publicly accessible data, even before a complete building stock model is developed. We did not develop this image until fairly late in our stakeholder engagement process, and it would have been useful much earlier.

Lesson 6: Don’t pull policy levers in isolation

During discussions about potential BPS policy designs, stakeholders often wanted to know, “What BPS scenarios would help the city meet its goals?” Climate action plan goals were a meaningful point of reference throughout the stakeholder engagement, and BPS were framed as important policy to make progress toward these goals. To visualize how effective BPS could be, a matrix of savings from different policy options was created and used to answer this question. Table 2 is an example of this approach applied to Cincinnati, showing emissions savings from different BPS policy options, varying the scope and target stringency for each option. Emissions savings in the table are shown as a percent relative to total building sector emissions, and the green highlights indicate policy options that could achieve Cincinnati’s interim goal of 30% emissions reduction by 2030. This matrix approach was based on work done by Group 14 Engineering (2021) during their work on Denver’s BPS. No building types or sectors were excluded from this analysis, and targets are recalculated for each floor area threshold.

Table 2. Emissions reduction from Cincinnati baseline by policy scope and target (%)

Floor Area Threshold	Buildings Covered	10th Percentile EUI	25th Percentile EUI	50th Percentile EUI	75th Percentile EUI	90th Percentile EUI
All buildings	78,829	50	37	22	10	6
≥ 5,000 ft^2	5,941	38	28	17	8	5
≥ 10,000 ft^2	3,091	36	26	16	8	5
≥ 25,000 ft^2	1,413	32	24	14	7	4
≥ 50,000 ft^2	766	27	20	12	6	3
≥ 100,000 ft^2	412	23	17	9	4	3
≥ 500,000 ft^2	51	6	4	2	1	0

The advantage to this analysis is that it shows many different policy options at once, and how changing one element (moving directly vertically or horizontally) affects savings. Often, the elements in a BPS are evaluated separately. ASHRAE Standard 100-2024 Appendix J (2024), for example, provides guidance on setting targets but has no mention of scope. By looking at scope and targets together, our stakeholders could better understand how many buildings each policy scenario would cover, and how changing the target would affect savings across those same buildings. The realization for many of the cities, and in Cincinnati specifically, was that their goal could only be accomplished by a few scenarios from the matrix, ones with the most stringent targets and large numbers of covered buildings. This analysis, similar to Figure 3, highlighted for cities that large amounts of emissions savings may be generally unfeasible, and set expectations for what a BPS focused on large buildings could achieve.

Lesson 7: Incorporate the community's ideas and concerns

Given that each BPS is crafted to be specific to a jurisdiction, it seems logical that the local community's concerns should be incorporated into the data analysis process in some way. Guidance from ASHRAE (2023) suggests that the data analysis should be framed around questions driven by local stakeholder concerns. But it stops short of providing ideas for how and when the data analyst can gather these concerns and reflect them in the analysis. In our work in Ohio, we integrated community concerns by developing a tight feedback loop between the data analysis and the stakeholder engagement work.

The stakeholder engagement work in each city included a series of workshops with an Advisory Group, an invited group of key stakeholders. One of these workshops in each city focused on policy design, first presenting background on BPS basics and breakdowns of the current building stock, and then engaging participants in a policy design exercise. The exercise divided participants into small groups and asked them to "design a policy to improve energy performance in existing buildings in your city" and then listed four questions aligning with the key elements of a BPS: (1) What buildings should be included? (2) What metric should be used and why? (3) How should the targets be set? (4) What timeline should be used?

This open-ended design exercise allowed the stakeholders' ideas and concerns to emerge organically, and within the framework of BPS design. Some of the ideas were similar across cities; for example, in all three cities, stakeholders generally agreed that site EUI was the preferred metric, largely due to simplicity. But most of the ideas and concerns were unique in each city. In Columbus, stakeholders were more concerned about new construction, multifamily and affordable housing, and manufacturing and data centers.[1] In Cincinnati, stakeholders were concerned about historic buildings, and were interested in exploring percent reduction targets rather than site EUI targets, as well as percent renewable electricity targets.

Based on the results of this exercise, in Columbus and Cincinnati we collaborated with city staff to develop a set of BPS scenarios that we then analyzed and presented back to stakeholders in a future meeting. We framed these scenarios as differences from a baseline similar to the approach used by Walter and Mathew (2021). As an example, an abridged version of the scenarios modeled for Cincinnati are provided in Table 3. The baseline scenario represented a size threshold of 100,000 ft^2 and the 50th percentile EUI target for all buildings except industrial buildings. From there, each scenario represented a change from the baseline, reflecting and exploring the impact of stakeholder concerns and ideas.

Table 3. BPS scenarios analyzed in Cincinnati

Scenario Type	Scenario Label	Description
Baseline	Nominal	All commercial, municipal, and multifamily buildings ≥ 100k ft^2 are included, with a metric of site EUI targets set at the 50th percentile of local buildings by type
Floor area	≥ 50k ft^2	Same as nominal, except all buildings ≥ 50k ft^2 are included
Metric	GHGI target	Same as nominal, except metric changed to GHG intensity, set at the 50th percentile for all building types
Targets	25th percentile	Same as nominal, except site EUI targets set at the 25th percentile of local buildings by type
Metric and Targets: Energy Use	15% EUI reduction	Same as nominal, except metric changed to % reduction per property and target set at 15% reduction from current performance
Metric and Targets: Energy Supply	25% carbon-free electricity	Same as nominal, except metric changed to % green power and target set at 25% of electricity from carbon-free sources
Building type	Municipal ≥ 10k ft^2	Same as nominal, except municipal buildings ≥ 10k ft^2 are included
	Multifamily	Same as nominal, except multifamily buildings are exempt
	Historic	Same as nominal, except designated historic properties are exempt

Interestingly, ASHRAE (2023) notes that developing these policy questions should be a first step in BPS analysis. Yet, our experience suggests that these questions emerge over time, and through an evolving and open dialogue with stakeholders. It would have been impossible for us to capture the breadth of stakeholder interests in our BPS scenarios without first having discussed initial data analysis results with them. Data analysts should not underestimate the importance of this earlier stage work, assembling the stock model and socializing it with stakeholders prior to framing out specific scenarios of interest.

[1] The notes from Columbus' Healthy Buildings Advisory Group meetings are publicly accessible on their BPS webpage: https://www.columbus.gov/Services/Columbus-Water-Power/About-Columbus-Water-Power/Sustainability-at-Columbus-Water-Power/Energy-and-Water-Benchmarking-and-Transparency-Policy/Building-Performance-Standards

Lesson 8: Some concerns may be difficult to model

Some of the ideas and concerns that came up in discussion with stakeholders went beyond energy or emissions outcomes. Most were related to economics in some way, although they often went beyond traditional engineering economics. Many of these ideas and concerns we considered to be hard-to-model, either because they required major, unfounded assumptions, needed additional information that we did not have access to, or involved expertise that we, as engineers, did not have. Some of these hard-to-model concerns included:

- What would the long-term energy reduction be for a fixed vs. recalculated target cycle?
- How many vacant, unoccupied, or distressed properties would be included in a BPS?
- How much would it cost for buildings to meet their BPS target?
- How does target stringency affect rent prices in multifamily buildings?
- How many jobs would be created by enacting a BPS?

Each of these concerns is hard-to-model in its own way. For example, a recalculated approach, where targets are determined each cycle based on the results of the previous cycle, is difficult to model without major additional assumptions, since we modeled buildings to meet targets, not fall short of or exceed them. This means a recalculation would not produce new targets, because after the first cycle all non-compliant buildings were assumed to have the same EUI. The last two concerns, about rent prices and job creation, are generally beyond the scope of our expertise as engineers. Some recent work has begun to address these issues, for example, Jain et. al (2026) recently developed a tool for estimating the impact of building retrofits on rental prices. However, understanding the economic impacts (both positive and negative) of BPS remains a critical knowledge gap and deserves more attention in future work.

Lesson 9: Feasibility is key, take it one-at-a-time

Developing a BPS is a balance between environmental impact and feasibility. While the policy needs to be ambitious enough to make meaningful progress towards a jurisdiction's energy and/or emissions goals, it also needs to be manageable for city staff and achievable for building owners. In collaboration with city staff, we framed our BPS scenario analysis to address this balancing act in two major ways.

First, we looked at multiple outcomes beyond just energy or emissions. An example of the four outcomes we used in Cincinnati is shown in Table 4. Only one of the outcomes, total building emissions savings, measures environmental impact. Here, it is expressed as a percentage relative to all building sector emissions in Cincinnati, to allow for a direct comparison to Cincinnati's climate action plan goal. The other three outcomes are all measures of feasibility: number of properties in scope indicates the level of effort required from the jurisdiction, as they would have to manage interactions with these building owners under the BPS, while the number of properties not meeting the target and median energy reduction needed indicate the level of effort that would be required from building owners to meet the target.

Second, each scenario was developed as a one-at-a-time change from a baseline scenario. BPS discussions with city staff and stakeholders were intensely driven by "What if?" questions. Varying each element one-at-a-time while holding the other elements constant was a simple approach to a sensitivity analysis. The advantage of evaluating each BPS scenario one-at-a-time across multiple outcomes is that it gives decisionmakers the ability to weigh the consequences of gaining greater emissions savings. The results in Table 4 illustrate this point. The baseline scenario would provide 4% total emissions savings and is achieved with a 21% median energy reduction across 127 buildings. Lowering the floor area threshold to ≥ 50,000 ft^2 doubles the number of buildings covered and increases overall BPS savings by 1%. This second scenario does not impact the median EUI reduction required on a building-by-building basis, but does require more effort from city staff to manage for comparatively little improvement in emissions savings. Overall, this approach allowed decisionmakers to quickly see which potential design decisions affected the outcomes, and which did not.

Table 4. BPS scenario outcomes in Cincinnati

Scenario Label	Buildings in Scope	Buildings Not Meeting Targets	Total Emissions Savings (%)	Median Reduction Needed Across all Types
Nominal	310	127	4	21
≥ 50k ft^2	556	264	5	21
GHGI Target	310	143	4	20
25th Percentile	310	206	10	37
Flat 15% Reduction	310	310	4	15
25% Green Electricity	310	310	10	*No EUI reduction required
Municipal ≥ 10k ft^2	363	147	4	22
Multifamily Excluded	205	75	3	27
Historic Excluded	268	108	3	18

Conclusions

Effective data analysis is critical for helping jurisdictions develop a BPS that meets their unique needs. We share our process and lessons learned here as a reference point for other jurisdictions and their technical consultants engaging in this work. Integrating the data analysis with stakeholder engagement allowed us to tailor the analysis to each city's needs, as questions and concerns from stakeholders prompted us to evolve our approach at each stage of the process. Our overarching takeaway from this work is that data analysis to support BPS does not need to be complicated, nor perfect. But it does need to be useful, and to be useful it needs to be part of an ongoing dialogue with city staff and stakeholders in the jurisdiction. Ultimately, the data analysis process is only partly about the data itself, and equally about holding a meaningful conversation using the data.

BPS development in Ohio is still a work in progress. The data analysis efforts discussed here have fostered honest dialogue about the capabilities and limitations of BPS and helped build a foundation of support in each of the four cities. But this work is still in the early stages, and most of our observations derive from conversations with city staff, elected officials, and an invited group of key stakeholders in this nascent period. More analysis and dialogue will be required as cities move forward with their policy development work, and we anticipate different data analysis techniques and visualizations may be more effective in those later stages. As they have so far, the building stock datasets and supporting analyses will continue to evolve as more data becomes available and more questions are asked.

Acknowledgements

This material is based upon work supported by the U.S. Department of Energy's Office of Critical Minerals and Energy Innovation (CMEI) under the Building Technologies Office, award number DE-EE0010953. The views expressed herein do not necessarily represent the views of the U.S. Department of Energy or the United States Government. The authors gratefully acknowledge the time and perspectives of the city staff and stakeholders in each city, and especially the following individuals who helped support and shape the BPS scenario discussions in Columbus and Cincinnati: Eric Porr (Columbus Department of Building and Zoning Services); Cassie Johnson and Erin Beck (Sustainable Columbus); Rob McCracken, Chris Heckman, Hallie Grant, and Oliver Kroner (Cincinnati Office of Environment and Sustainability).

This research used Anthropic's Claude to assist with code development throughout the analysis. No project datasets were shared with or processed by the AI tool; all guidance was limited to code logic. The authors reviewed and verified all code generated.

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