Building Performance Standards to Drive Market Transformation

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ABSTRACT

Because buildings contribute to the majority of urban emissions, cities, counties, and states with climate ambitions are increasingly turning to Building Performance Standards (BPS) as a new policy option to reduce building energy consumption and emissions. The White House (White House, 2022) has also recently announced a BPS design effort for federal buildings. BPS policies can target consumption or emissions and put buildings on an abatement pathway consistent with the jurisdiction's climate goals. To date, no two policy designs are alike. This paper leverages the experience with the Building Energy Analysis Manager (BEAM), a platform developed from DOE's Standard Energy Efficiency Data (SEED) Platform. BEAM is used to manage the implementation of several BPS programs including those of the District of Columbia, Cambridge and Boston in Massachusetts, Reno in Nevada and Ann Arbor in Michigan, and has the support and input of a dozen jurisdictions at various stages of BPS program implementation. The paper discusses:

- The background of the SEED Platform as a benchmarking and property data management tool.
- How BEAM extends SEED to manage Building Performance Standards, including experience implementing programs with different target metrics, from ENERGY STAR scores to energy consumption and greenhouse gas emissions, and the policy and operational complexities of each approach.
- Different approaches to measuring compliance, from tracking progress relative to a building-specific baseline to tracking compliance with program-wide goals.
- Integration with other tools and platforms (e.g., Department of Energy BETTER and Audit Template) to conduct quick potential retrofit screenings across a portfolio of buildings and offer alternative prescriptive pathways for BPS programs.
- How policy design influences building retrofit choices and affect market transformation.

Building Emissions in the Urban Environments

Buildings contribute to the majority of emissions in urban areas. For example, in New York City (New York City Office of Sustainability, 2020) and Boston (Boston, 2019), approximately 70% of greenhouse gas emissions are from buildings. Cities are also leading the climate effort at a local level, with over 170 cities taking on commitments to reduce their greenhouse gas footprint (McCoy, 2019). To meet the goals, it becomes evident that cities must tackle building emissions. Building Performance Standards (BPS) are emerging as the policy of choice to meet these objectives. However, because of the regional diversity of emissions profiles, local stakeholder concerns, and limitations on cities' regulatory reach, BPS designs to date have

been unique. This paper discusses how software designed and developed by the Lawrence Berkeley National Laboratory (LBNL) and the National Renewable Energy Laboratories (NREL) was adapted and extended to meet the policy and operational challenges posed by the multi-faceted design of BPS programs. The paper also discusses tools developed within this platform to help building managers understand and manage the carbon footprint of their portfolio. Building Performance Standards build on a long history of building data collection for the purpose of making buildings more energy efficient through building labeling, asset scoring, energy quotients, audit data, benchmarking, and others. The interconnection of these efforts is important to consider since collecting the data for one use case can reduce data collection and transmission requirements for another use case.

Building emissions come from burning of fossil fuels on-site, generally referred to as Scope 1 emissions, and emissions associated with electricity consumption, known as Scope 2 emissions. Scope 1 building emissions are the product of on-site fuel consumption of heating oil, propane or natural gas with emissions factors that have, to date, been largely static. This may change as jurisdictions introduce targets on fossil fuel renewable content such as California's Low Carbon Fuel Standard (California, 2020) or Vermont's proposed Clean Heat Standard (Vermont, 2022). For example, ENERGY STAR Portfolio Manager already uses province level emissions rates for natural gas in Canada (EPA, 2021). Scope 2 emissions are, however, dynamic since most cities implementing BPS programs are in States with policy ambitions that increase the renewable content of electricity. These broader policies are expected to, over time, reduce the effective emissions rate applied to electricity consumption.

Building Performance Standard Primer

The first Building Performance Standard implemented covered the largest consumers of energy in the city of Tokyo, primarily buildings, and is often referred to as the Tokyo carbon market. The program started in 2010 and by 2018, buildings subject to the program had reduced emissions by 27% relative to the 2010 baseline (Tokyo, 2020).

BPS programs build off energy benchmarking requirements in which large buildings must submit annual energy consumption information to the local jurisdiction.

The key design elements of a BPS program are:

- *Who* is covered: typically the largest commercial, multi-family residential and municipal buildings measured by square feet of occupied building space or aggregated area for buildings in a tax lot.
- A *timetable* which sets out compliance periods and overall compliance timeline. Many programs increase the stringency of the target every five years. Some require compliance every year while others mandate compliance at the end of the period.
- *Metric* or unit of compliance. Options include energy consumption or greenhouse gas emissions. Either approach can be measured on a per building or per square foot basis, and can be adjusted for weather variability. Other metrics include a building's ENERGY STAR score. Some programs, such as Reno's (Reno, 2020), require compliance with both energy and water metrics.

- The *baseline* or reference level from which buildings measure their reductions. Baselines can be building specific, be attached to the use of the building or be common to all buildings in the program.
- *Alternative* or *prescriptive* compliance pathways which allow buildings to meet the requirements by implementing a set of energy efficiency measures in lieu of adopting quantitative targets.
- *Flexibility* mechanisms to facilitate compliance. One approach allows external emissions reductions, renewable energy credits or carbon offsets, to be used for partial compliance. Another approach relies on market mechanisms by allowing compliance at the building owner or campus level, program-wide trading or banking of excess compliance across time.

Since the District of Columbia and New York City passed their BPS policies in 2019 , three States, Maryland, Colorado and Washington, three counties (Denver- CO, Montogmery - MD and Prince Georges -MD) and several cities have passed BPS policies. Over thirty cities have joined the White House BPS Coalition (White House, 2022).

SEED as a Platform to Manage Benchmarking Programs

The Standard Energy Efficient Data Platform (SEED) is an open-source, web-based application for managing disparate datasets of building characteristics and performance. The original, and still most supported, use case of SEED is for managing city and jurisdictional ordinances on commercial building benchmarks. NREL launched the initial application in 2013 (Alschuler et al. 2014) and a major rewrite was completed in 2016 to support the shifting needs from cities and jurisdictions on how data needs to be structured (Long et al. 2020). The current version of SEED allows users to manage building portfolios coming from various file formats including CSV, Microsoft Excel, BuildingSync (Long et al. 2021), ENERGY STAR Portfolio Manager, GeoJSON and Green Button meter level data. Figure 1 shows the overall SEED architecture. SEED's meter reading data are stored in a time series database extension which eases data aggregation, fills missing data, and increases performance on large datasets.

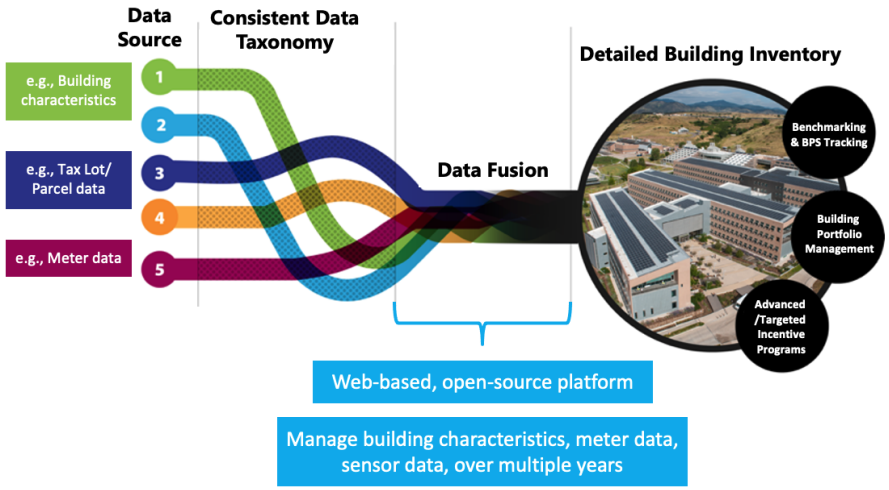

Figure 1. SEED architecture.

One of the most important features that was added during the reworking of SEED was the ability for properties and tax lots to be managed independently and then linked as needed. Figure 1 shows potential property and tax lot relationships; for example, the most complex case is where multiple buildings are span across multiple tax lots. This worst case scenario often exists in campuses and demonstrates the complexity of mapping building and tax lot owner.

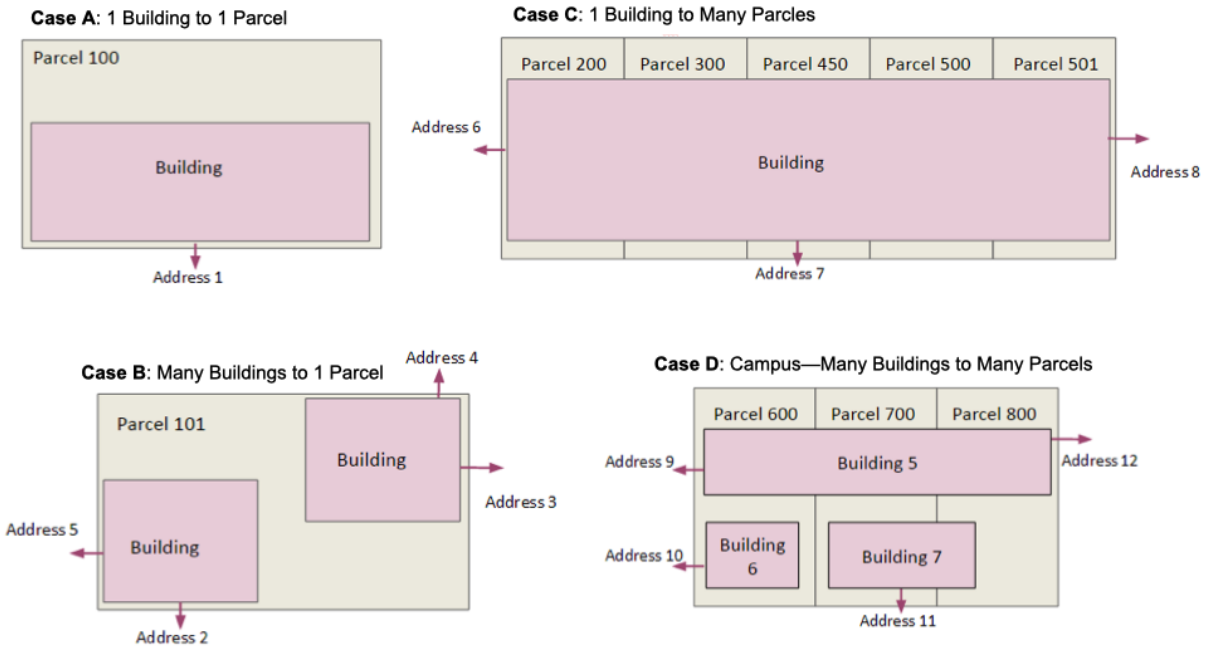

Figure 2. SEED's properties and tax lot relationships.

The property and tax lot challenge manifests itself due to the disconnect between how building owners tracking buildings and city managers tracking tax lots. New tools to match buildings to tax lots have been developed which are aiding in this challenge, notably the Unique Building Identifier (UBID) (Wang 2019), which enable fast matching of geometric bounding boxes. UBIDs are now a part of the SEED database design. SEED's ability to jointly manage data pertaining to buildings and tax lots is critical to Building Performance Standards , which often have compliance requirements which span both. For example, New York's Local Law 97 imposes emissions limits on "*exceed 100,000 gross square feet (9290 m²), or (iii) two or more buildings held in the condominium form of ownership that are governed by the same board of managers and that together exceed 100,000 gross square feet (9290 m²), or (iv) a city building" (New York City, 2019).*

Other key design features of SEED are:

- *Cycles* allow users to group buildings/tax lots by arbitrary beginning and ending dates. *Cycles* are linked together upon import through *Matching Fields*. An accurately configured dataset can show data across cycles, which allows for tracking buildings/tax lots over multiple years as is required by many BPS policies.

- *Labels* allow users to add a named (and colored) tags to any property or tax lot. Multiple labels can be applied to a record. *Labels* are the easiest method to find buildings of interest as a user can filter by multiple labels using Boolean logic
- *Data Quality (DQ) Checks* build on top of the *labels* feature. DQ checks are configured at the organization level and allow for checking the bounds or text of all the fields across an organization. The results of a DQ run can be seen in a table view (and exported) or any individual DQ check can apply a *Label* if a value is not in compliance. This feature works for a single cycle at a time and automatically runs on all imports.
- *Derived Columns* are columns of building data that have been created by SEED. They are calculated interactively from the dataset

A more recent addition to SEED is *Analysis Functionality* which provides an extensible framework for sending SEED data to third-party API-based applications and returning the results back into SEED's property records. The initial prototype of SEED's Analysis was connecting SEED to the BETTER tool (Szum, et al 2018). BETTER generates a change point model based on provided meter data and returns potential energy savings and recommended energy conservation measures for each property or the entire portfolio. The communication with BETTER leverages BuildingSync for data transfer. A major advantage of BuildingSync is that BuildingSync defines a set of energy conservation measures (ECMs) and is (currently) the only method to import ECMs into a SEED property. Tracking ECMs by property is a key requirement to a number of Building Performance Standard.

SEED's user interface provides users a workflow to manage the import of datasets, inspection of the data, and view the history of building changes. Any functionality that is available in the user interface is also available through an Application Programming Interface (API). In 2021, the API was updated to Version 3 which includes more consistent naming conventions, authorization, and new documentation. In addition, Open Efficiency Platform (PSD, 2019) created a Mule-based application to connect building records in SEED to Salesforce.

SEED is an application, an API, and a platform where third parties are extending the source code itself to develop new tools. Figure 3 shows how SEED as a platform is being built. SEED is the base layer and includes the basic ability for benchmarking, self-hosting, portfolio tracking and analysis, and the developer platform. A few organizations, including ClearlyEnergy, have leveraged the developer platform to build the Building Energy Analysis Manager - BEAM and further extend the usefulness of SEED.

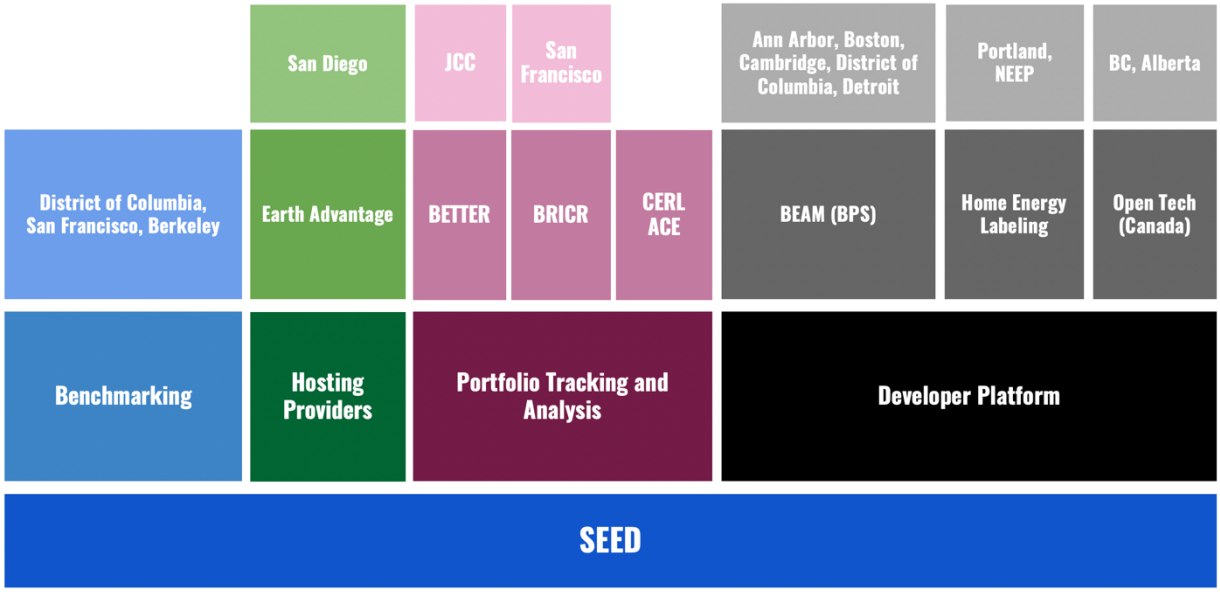

Figure 3. SEED as a platform structure.

BEAM Extends SEED to Manage Building Performance Standards

BEAM is a set of extensions to SEED designed to help manage the additional policy complexities of Building Performance Standards

Managing Compliance Periods

While compliance with the benchmarking elements of an ordinance happens at the annual cycle level, compliance with building performance standards is often more complicated. This includes establishing BPS baselines, which often use data averaged over multiple years and checking for compliance at the end of a multi-year period. SEED was designed with a flexible cycle model that BEAM expanded to allow multiple data cycles to be grouped into compliance periods while keeping the benefits of cycle-level data management and display. Figure 4 shows how different categories of buildings, each with a different four-year compliance period, can be tracked separately in BEAM.

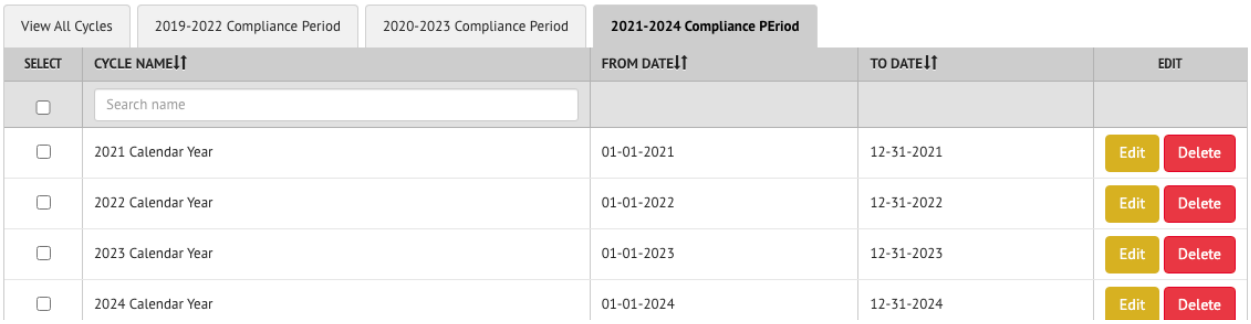

Figure 4. Example compliance period made up of four individual data cycles

Managing Compliance Metrics and Baselines

Programs with a single common ENERGY STAR, greenhouse gas, or energy use intensity target can be managed using the data quality framework inherited from SEED. However, most BPS programs have much more complex compliance criteria. For example, the District of Columbia's program relies on ENERGY STAR score and Energy Use Intensity thresholds for two dozen building categories while the Boston limits on the greenhouse gas intensity per square foot of building space must take into account the mix of use types in the building. BEAM extends SEED to allow different data quality tests with increasingly stringent criteria to be applied to subsequent compliance periods, as well as to allow complex Boolean logic to be applied within the data quality tests, as shown in Figure 6.

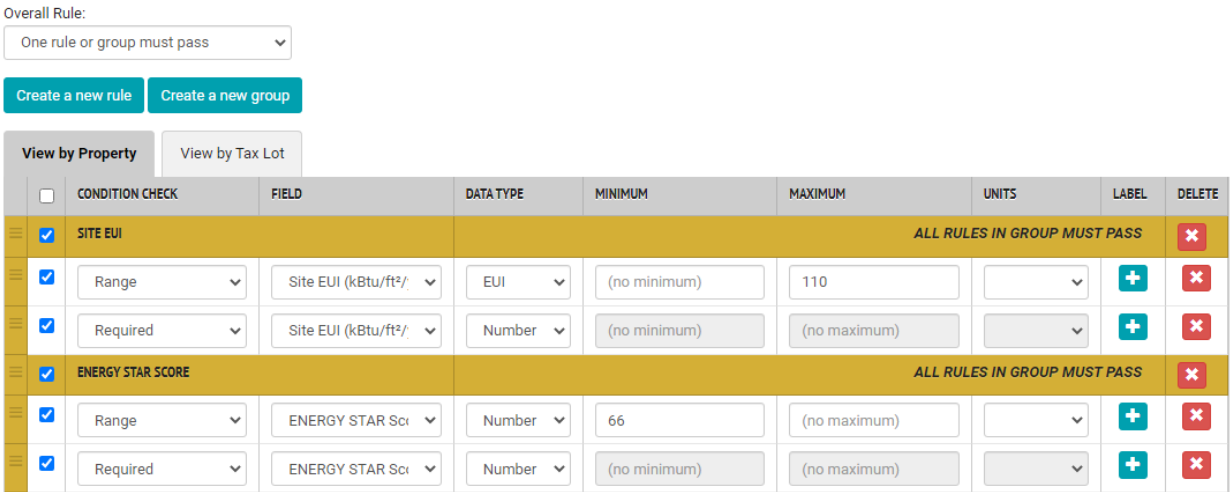

Figure 6. Data quality tests with Boolean logic.

Programs in Boston, New York and the District of Columbia's (DC, 2018) have targets at the building category level. These programs require different compliance tests for different groups of buildings and compliance periods. Multi-use buildings are either assigned to the category of their primary building use or require the calculation of a customized baseline by weighing individual metrics with the building's usage factors.

Another approach assigns individual baselines to each building, tax lot, laboratory or campus. This is the approach used by the City of Cambridge and Montgomery County in Maryland (Montgomery County, 2022). BEAM calculates and saves both the individual building level baseline and the applicable target emissions or consumption limit for each compliance period.

Managing Prescriptive and Alternative Compliance Pathways

A number of programs offer a "prescriptive" pathway either for a subset of the buildings enrolled in the BPS program or as an alternative to the quantitative targets of the "performance" pathway. The prescriptive pathway involves completing a list of energy conservation measures (ECMs) to achieve compliance; this list can be the same for all participants or the product of an agreement between the jurisdiction and the building owners. New York City for example uses a

prescriptive pathway for rent controlled buildings, buildings participating in project based assistance programs, and religious institutions (New York City, 2019). St. Louis (S. Louis, 2020) and the District of Columbia (DC, 2018) offer the prescriptive pathway to all buildings that are out of compliance but require the list of ECMs to be deemed equivalent in energy savings to the performance pathway.

BEAM allows each compliance period to have one or many compliance tracks. In the example below, these tracks are a Performance Pathway and a Prescriptive Pathway. Each track can then be divided into a set of milestones whose status is updated by the jurisdiction as the building moves through the process; the milestones are flexible by design and can be customized at the building level. Milestones can, optionally, require the completion of a list of ECMs imported from an audit program via a BuildingSync file. Finishing the set of milestones brings the building back into compliance with the BPS program.

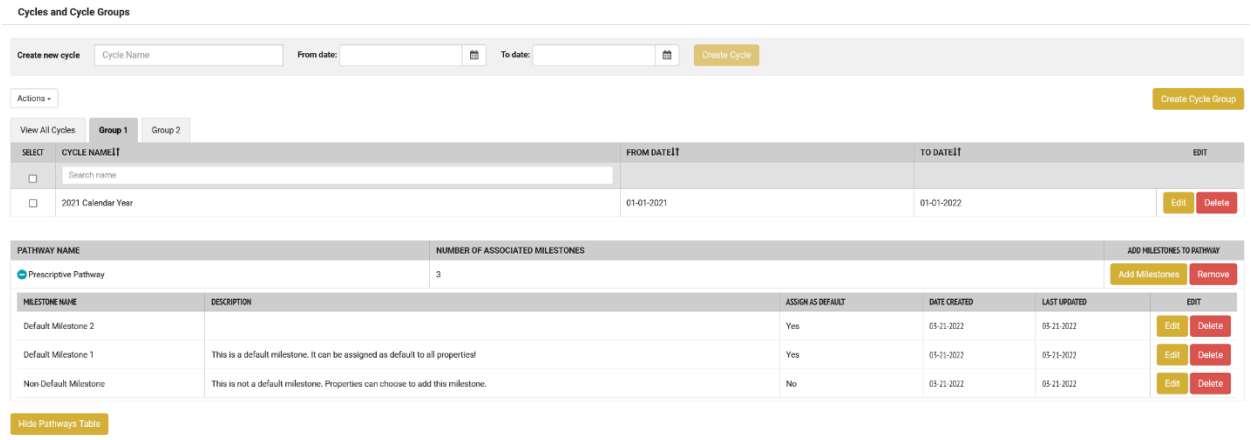

Figure 7. Example pathway and milestone for a compliance period.

Managing Portfolio Level Compliance and Flexibility Measures

BEAM incorporates other BPS flexibility measures such as allowing partial compliance with carbon offsets or renewable energy credits. A number of jurisdictions also require a re-calculation of emissions with local emissions rates instead of the default regional rates applied in ENERGY STAR Portfolio Manager. Future work might involve connecting BEAM to renewable or carbon credit registries to facilitate the authentication, transfer and retirement of credits as part of a BPS program.

How Do BEAM and SEED Facilitate Market Transformation?

The design of a BPS program will drive the timing, extent and focus of retrofit decisions for covered buildings. For example, a BPS with a greenhouse gas metric creates a very strong incentive for electrification of buildings if the State also has policies that are expected to increase the renewable content of electricity. For BPS designs with energy use intensity targets, the incentive for weatherization and efficiency improvements is greater.

The SEED/BEAM framework facilitates the collection of all building data in a single platform, minimizing redundant efforts. There are several building data collection platforms for commercial building performance data, and SEED and BEAM integrate with a few of those,

including ENERGY STAR Portfolio Manager, the Audit Template Tool and the Building Efficiency Targeting Tool for Energy Retrofits (BETTER) to reduce data "recollection". This integration is critical since building owners will need a suite of tools to understand their abatement and compliance options with BPS programs.

The Audit Template Tool is a web-based application for collecting detailed building characteristics (similar to the level of data needed for an ASHRAE Level 2 audit). The data are expected to be entered by a building owner or auditor who is able to accurately represent the building characteristics. SEED has been extended to support the integration of the BuildingSync files from Audit Template and high-level characteristics are extracted and stored into SEED's main record (e.g., floor areas, addresses, etc.), while the remaining BuildingSync file is stored alongside the SEED record for safekeeping and later access as needed. SEED records ECMs proposed in a BuildingSync file. BEAM in turn allows program managers to track progress with these measures as a building completes on-site improvements in BPS Prescriptive or Alternative Pathways.

Another third-party tool integrated into SEED through its *Analysis* functionality is BETTER. BETTER has a cleanly defined API that receives a BuildingSync file exported from SEED with building characteristics (e.g., location, use type, floor areas) as well as monthly metered data. BETTER returns potential energy and carbon savings results which are saved back into the SEED record. Having all the data in one location (Audit Template + BETTER + other) allows a portfolio manager or city manager to quickly assess the potential consumption and cost savings of new program requirements, see Figure 8. Ongoing BEAM development includes taking a list of potential efficiency measures and programmatically selecting the subset which will facilitate compliance with BPS programs.

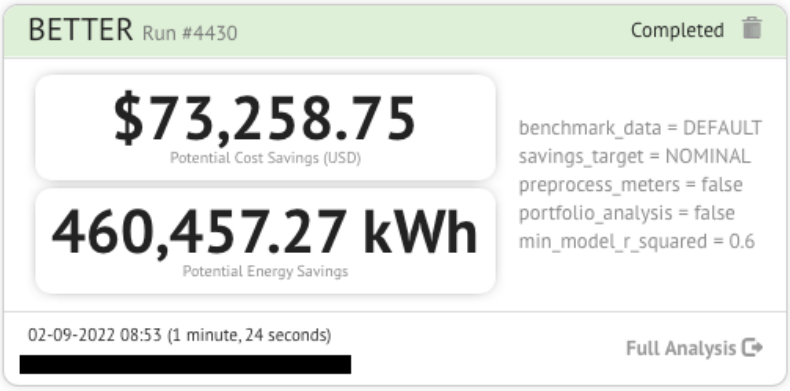

Figure 8. BETTER results showing energy savings after passed back to SEED.

Conclusion

BPS policies are a ground-up effort by cities, counties, states and federal buildings (White House, 2021) to mitigate the consumption and emissions from the commercial building stock. Building Performance Standards and transformational policies posing significant new challenges both for the jurisdictions and the building owners.

The variety of emerging policy designs reflects local stakeholder concerns, regulatory restrictions and design preferences. SEED was designed to facilitate energy benchmarking. BEAM extends SEED to help jurisdictions large and small implement BPS programs regardless of their policy design; a challenging endeavor because no consensus model of BPS design has yet to emerge. BPS programs represent a significant change in strategy for building energy efficiency programs, adding compliance requirements and possible penalties to what have traditionally been incentive-based approaches. For example, BPS designs often include monetary penalties for non-compliance, which pose significant new oversight challenges for the jurisdictions.

The policy complexities of BPS programs also add significant challenges for building owners. Buildings are often forced to comply with a moving target. For example, a program which requires buildings to have a lower ENERGY STAR score or emissions intensity than the average in their group creates a moving target. For programs with targets in greenhouse gas units, building emissions are expected to decrease with grid decarbonization efforts. In New York City, this could contribute 50% of compliance with the BPS program with no effort on the buildings' part (Spiegel-Feld, 2021). BPS programs require a compliance strategy for individual buildings that combines the regulatory targets with limits on investment budgets and the remaining life expectancy of existing systems. Programs which allow portfolio-level compliance add even more complexity by allowing building owners to comply across a group of buildings. BEAM is building tools to help building owners understand their current and prospective compliance situation, and to optimize possible retrofit strategies.

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