

Boston's Net-Zero Building Performance Standard: Making a Policy that's Inclusive and Flexible

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ABSTRACT

In 2021, the City of Boston established a building performance standard with requirements for existing medium and large commercial buildings to reduce greenhouse gas emissions. Boston's performance standard was the first in United States to establish a timeline for buildings to achieve carbon neutrality. The successful adoption of this policy is due in part to the City's inclusive policy development process that focused on equity, stakeholder engagement, and compliance flexibility. The policy incorporates a range of strategies that create benefits for occupants, help building owners drive down emissions, and enable strategic oversight by the City: multiple emissions compliance pathways, periodic reporting on environmental justice and equity metrics, a mayor-appointed emissions Review Board, an equitable investment fund, and more. The authors of this paper facilitated the technical advisory process to develop recommendations for establishing the policy. Based on this experience, our paper provides an overview of the policy, summarizes how different stakeholders reacted to initial policy proposals, and review how the City addressed stakeholder concerns. Finally, the paper identifies and assesses the future challenges for implementing this ground-breaking policy. Such challenges include providing technical assistance for policy implementation, developing detailed regulations, expanding the policy to smaller buildings, improving reported building data quality, and administering the policy Review Board. This case study provides a model for local governments seeking to establish strong building performance standards while meeting the needs of their stakeholders.

Background

The City of Boston has long been recognized as a national leader in climate action and energy policy. It has scored first among 100 major U.S. cities in four out of six ACEEE city energy scorecards (Mackres et al. 2013; Ribeiro et al. 2015; Ribeiro et al. 2017; Ribeiro et al. 2019; Ribeiro et al. 2020; Samarripas et al. 2021). In 2007, the City began releasing and updating its *Climate Action Plan* that sets goals to reduce emissions and prepare for the impacts of climate change. Boston's greenhouse gas inventories identify buildings as the largest source of emissions, responsible for more than 70 percent of greenhouse gas emissions (Hatchadorian et al. 2019). In 2017, the City committed to achieving carbon neutrality by 2050 and determined that addressing emissions from energy use in existing large- and medium-sized buildings would be a crucial aspect of attaining this goal. Specifically, the City's *Climate Action Plan* called for a greenhouse gas emissions performance standard:

[The performance standard] will require that all buildings larger than a certain threshold meet fixed carbon targets that decrease over time. Performance standards specific to

different building typologies will ensure that buildings make steady progress on emissions reductions, while allowing building owners to develop solutions that are cost-effective and appropriate for the building's use (City of Boston 2019).

In 2021, the City met an important milestone in its plan to decarbonize existing buildings by formally enacting the *Building Emissions Reduction and Disclosure Ordinance* (BERDO 2.0).¹ Boston Mayor Kim Janey signed the new ordinance into law on October 5, 2021 (Ordinance 2021; City of Boston 2021). Figure 1 summarizes the policy development timeline (City of Boston 2021). The recently enacted policy is designed to expand upon early policy successes in reducing building energy use and emissions. Specifically, it updates a 2013 ordinance, the *Building Energy Reporting and Disclosure Ordinance* (BERDO 1.0), which requires owners of large buildings to report their annual energy and water use to the City for public disclosure (City of Boston 2021).² The 2013 ordinance also required these buildings to complete an energy audit or actions to reduce energy use every five years. Nonetheless, building energy use and emissions did not decline significantly under BERDO 1.0 (City of Boston 2020b). Further, the enactment of more aggressive policies to reduce building energy use and emissions in other jurisdictions such as New York City³ catalyzed local environmental groups and the City of Boston to seek a better and more comprehensive policy than BERDO 1.0 (B. Silverman, program manager, City of Boston, pers. comm., October 20, 2021). With the adoption of its building performance standard, BERDO 2.0, Boston has joined the ranks of jurisdictions that directly regulate the energy or emissions of buildings, including New York City, St. Louis, Washington, D.C., the state of Washington, and the state of Colorado.

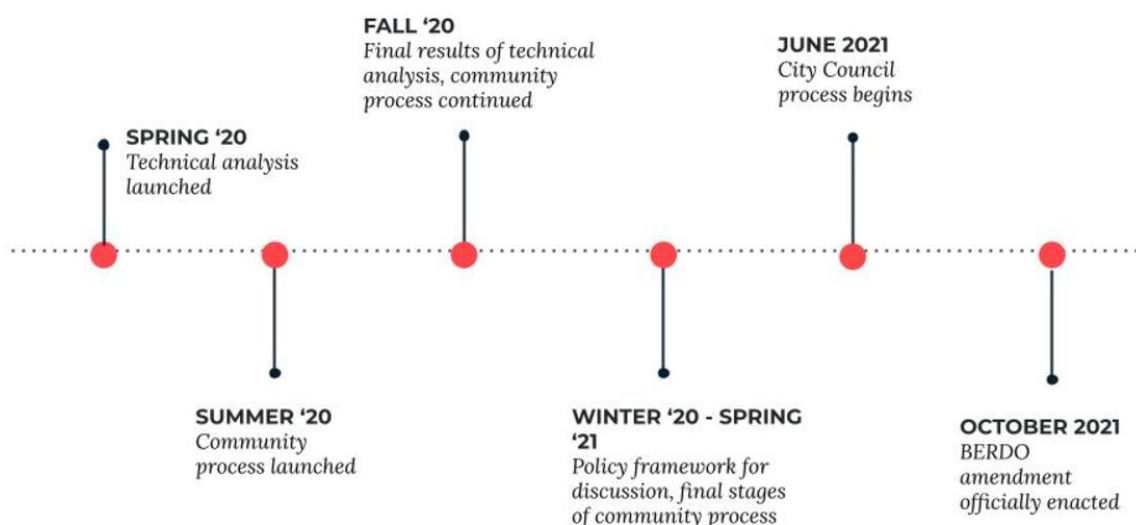


Figure 1. BERDO 2.0 building performance standard policy development timeline. *Source:* City of Boston 2021.

1 The Building Emissions Reduction and Disclosure Ordinance is locally called “BERDO 2.0” to signify the substantial advancement of the policy over the City’s former benchmarking and disclosure ordinance, which is sometimes called “BERDO 1.0.” This paper adopts that nomenclature.

2 The reported data is made publicly available at the City’s website (City of Boston 2020).

3 Such as New York City’s Local Law 97, which sets emissions limits for large buildings (New York City 2022).

Key Policy Contents

The Boston building performance standard sets annual emissions thresholds for large and mid-sized commercial and multifamily buildings through 2050. The policy incorporates a range of innovative and flexible strategies to help building owners drive down emissions, create benefits for occupants, and ensure thorough oversight. The ordinance creates multiple compliance pathways, requires periodic reporting on environmental justice and equity metrics, creates a mayor-appointed emissions Review Board, and establishes an equitable investment fund.

The annual emission thresholds vary by building use type to accommodate differences in energy use patterns across the large and diverse stock of buildings in the city. Annual carbon limits are set per square foot, as shown in Table 1. The threshold limits go into effect in 2025 and become more stringent every five years, moving toward net-zero emissions by 2050. For each building type, the thresholds are designed to achieve a 50 percent reduction in emissions by 2030, relative to 2005 emission levels. The ordinance applies to existing properties with over 20,000 square feet of gross floor area or with 15 or more housing units; approximately 3,500 buildings fall into this category. Buildings over 20,000 square feet or 15 units but less than 35,000 square feet or 35 units are not subject to the standards until 2030. City-owned buildings are included in the policy, while state- and federally-owned buildings are exempt. The policy applies to all energy use in the regulated buildings; however, owners may choose to deduct use from backup generators and electric vehicle charging equipment.⁴

Table 1. Building performance standard annual emission thresholds (kilogram carbon dioxide equivalent per square foot).

Building use type	2025– 2029	2030– 2034	2035– 2039	2040– 2044	2045– 2049	2050–
Assembly	7.8	4.6	3.3	2.1	1.1	0.0
College/University	10.2	5.3	3.8	2.5	1.2	0.0
Education	3.9	2.4	1.8	1.2	0.6	0.0
Food Sales & Service	17.4	10.9	8.0	5.4	2.7	0.0

⁴ To ensure this provision does not create a loophole, the City defines Emergency Backup Generation/Backup Power as a device that “serves solely as a secondary source of mechanical or electrical power whenever the primary energy supply is disrupted or discontinued during power outages or natural disasters that are beyond the control of the owner, occupant or operator of a Building” (Ordinance 2021). ENERGY STAR Portfolio Manager allows the exclusion of electric vehicle charging equipment from benchmarking reports.

Healthcare	15.4	10.0	7.4	4.9	2.4	0.0
Lodging	5.8	3.7	2.7	1.8	0.9	0.0
Manufacturing/Industrial	23.9	15.3	10.9	6.7	3.2	0.0
Multifamily housing	4.1	2.4	1.8	1.1	0.6	0.0
Office	5.3	3.2	2.4	1.6	0.8	0.0
Retail	7.1	3.4	2.4	1.5	0.7	0.0
Services	7.5	4.5	3.3	2.2	1.1	0.0
Storage	5.4	2.8	1.8	1.0	0.4	0.0
Technology/Science	19.2	11.1	7.8	5.1	2.5	0.0

Column headings (e.g., 2025–2029) refer to the range of calendar years in which the threshold is in effect. *Source:* Ordinance 2021.

The policy was designed to provide flexibility to building owners by allowing various approaches to achieving compliance. Mixed-use buildings and portfolios of buildings may comply by meeting a “blended” emission target that is a floor area-weighted average of the targets for the various use types of the building or buildings. Owners may also apply to use a custom compliance schedule that demonstrates emissions reductions every five years, provided the schedule reaches a 50 percent reduction by 2030 and a 100 percent reduction by 2050.⁵ Alternatively, building owners facing unusual or challenging circumstances may request to follow a hardship compliance plan. Finally, the ordinance allows building owners to balance on-site actions—such as energy efficiency, fuel switching, and distributed renewables—with off-site strategies. Specifically, owners can use the following off-site compliance mechanisms to demonstrate reductions in emissions:

- **Municipal aggregation:** Building owners may purchase electricity through the City’s Community Choice Electricity program, which has higher percentage of renewable attributes than the electric grid supply.
- **Renewable Energy Certificates:** Building owners may mitigate emissions from electricity use by purchasing qualified renewable energy certificates (RECs). The RECs must meet a range of compliance criteria intended to ensure a net reduction in greenhouse gas emissions: RECs must be generated by non-emitting renewable sources, meet the

⁵ These targets are aligned to the City’s climate action plan, which includes a 50 percent reduction in emissions by 2030 relative to 2005, and a 100 percent reduction by 2050. Building owners may select a baseline from any year starting in 2005 up to the first required reporting year.

State's renewable portfolio standard criteria (Eligibility Criteria for RPS 2021), be tracked in the regional power generation information system, be generated in a concurrent time period as the building's electricity use, and be retired by the building owner in a timely manner.

- **Power purchase agreements:** Building owners may purchase electricity directly from qualified non-emitting renewable generators. The purchase must meet a range of compliance criteria intended to ensure a net reduction in greenhouse gas emissions: RECs must be generated by non-emitting renewable sources, be generated in a concurrent time period as the building's electricity use, and be retired by the building owner in a timely manner.
- **Alternative compliance payments:** Building owners may make alternative compliance payments at a cost of \$234 per metric ton of carbon dioxide for any emissions above the threshold limit each year. The cost of the payment is based upon the estimated cost for locally appropriate strategies to decarbonize the regulated buildings (Eash-Gates et al. 2021). The City and the mayor-appointed emissions Review Board will review these estimated costs every five years and may adjust the alternative compliance payments accordingly.

A mayor-appointed Review Board oversees enforcement of the policy. Members will have expertise in environmental justice, affordable housing, labor, workers' rights, workforce development, building engineering and energy, real estate development and management, public health and hospitals, and historic preservation. Two-thirds of the members will be nominated by community-based organizations. The Review Board will oversee a range of compliance decisions. It will have the authority to levy penalties and fines for failure to comply with the emissions standard or inaccurate reporting. Fines vary by the type of violation and based on the size of the building.

The City of Boston's Environment Department led the development of the building performance standard and is responsible for administering it. The Boston Air Pollution Control Commission will direct the Environment Department to review the ordinance every five years. The review process will include soliciting input from the public, analyzing qualitative and quantitative performance metrics, verifying equitable implementation of the policy, and updating the cost of alternative compliance payments. The Commission is responsible for reporting metrics relevant to implementation of BERDO 2.0, such as air quality, energy cost burdens, fair housing, housing displacement, jobs, and other environmental justice and equity data.

Stakeholder Participation

The City of Boston involved a wide array of stakeholders in the policy development and review process. The City actively sought involvement from a broad range of stakeholders, including building residents, building owners and operators, architects, engineers, building scientists, construction professionals, equipment manufacturers, energy policy professionals, renewable energy experts, utility representatives, government officials, as well as members of the general community. Figure 2 summarizes the policy development process, which included a series of 12 technical advisory group meetings, three resident advisory group meetings, numerous focus group and direct stakeholder meetings, and four community open house events.

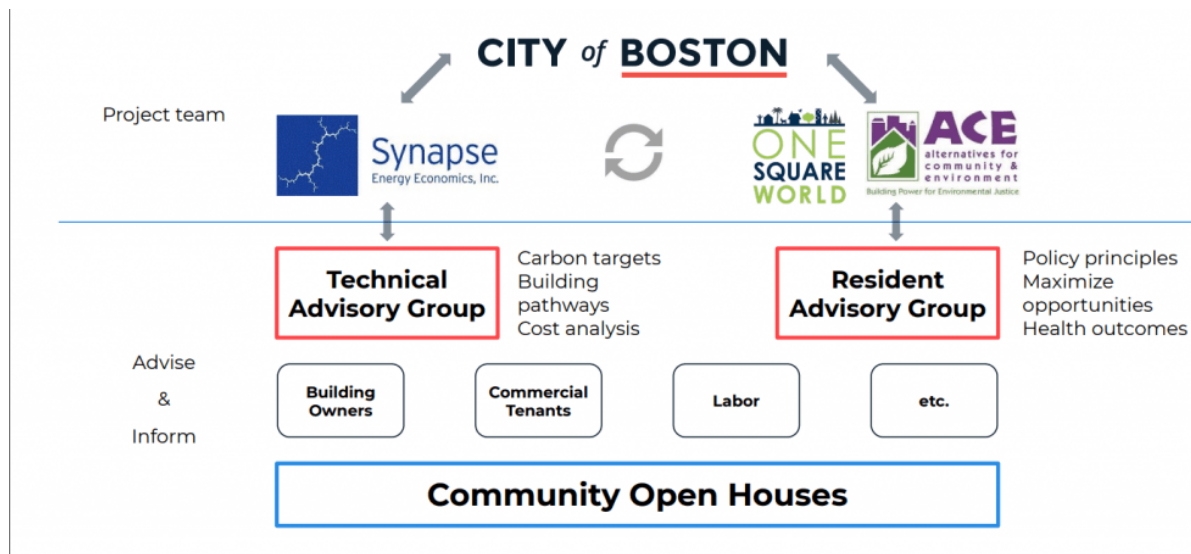


Figure 2. Policy development process. Arrows indicate flow of information among entities formally engaged in the process. Boxes represent stakeholder groups and events for policy engagement. *Source:* City of Boston 2021b.

Various stakeholders engaged actively in the policy development process and were effective in shaping the ordinance. This group included owners of large portfolios of buildings, building science consultants with a strong local presence, and environmental advocates (B. Silverman, program manager, City of Boston, pers. comm., October 20, 2021). Stakeholders that participated in advisory groups, community open houses, and feedback sessions directly influenced the technical analysis and policy design process, summarized in Figure 3. While some stakeholders critiqued the proposed building performance standard, the City's active engagement and feedback process helped to circumvent direct opposition by encouraging participation and feedback. The successful enactment of the ordinance may be credited to a few factors: the long time horizon through 2050 to achieve full decarbonization, which allows sufficient time for planning; the City's pre-established commitment to carbon neutrality including a focus on emissions from energy use in large buildings and goal of establishing a building performance standard; and extensive efforts to involve stakeholders in the policy development process. Instead of simply opposing the policy, stakeholders sought to influence the performance standard by participating in various series of engagement meetings; these included community open houses (City of Boston 2020b, 2020c, 2020d, 2020e), technical advisory meetings (Eash-Gates 2020a, 2020b, 2020c, 2020d, 2020e, 2020f), technical advisory discussions on special topics, resident advisory group meetings (One Square World and ACE 2020a, 2020b, 2020c), and individual conversations with stakeholders. Below is a summary of the dominant stakeholder perspectives:

- **Building owners** were most concerned about the cost and technical feasibility of achieving compliance. In particular, owners of hospitals⁶ laboratories, and buildings that use district steam urged the City to incorporate flexibility in the standard, alternative

⁶ Hospitals cited concerns over the impact of a building performance standard in a post-Covid era where higher ventilation rates may already create economic burdens due to increased ventilation rates. The City's consultant worked with local architects and engineers to identify local case studies and energy conservation strategies appropriate to hospitals and laboratories that do not diminish necessary ventilation.

compliance mechanisms, and allow for the use of offsets. The City responded by allowing off-site renewable electricity to be used to offset electricity emissions, presenting relevant case studies, and preparing a building retrofit resource hub.⁷

- **Sustainability-minded consultants and community members** favored a policy that would reduce emissions as comprehensively as possible and guard against compliance loopholes. Within the technical advisory group, these participants advocated for a lower size threshold for covered buildings, which may have influenced the City’s decision for BERDO 2.0 to include buildings at least 20,000 square feet in gross floor area or that include at least 15 dwelling units.⁸ These stakeholders also favored on-site actions (*e.g.*, electrification and energy efficiency retrofits); the City responded by not allowing the use of carbon offsets, despite precedence for inclusion in other jurisdictions (New York City 2022).
- **Renewable energy consultants** encouraged the use of on-site solar and superior quality RECs from new renewable generators. This input helped shape the City’s renewable energy procurement eligibility criteria, described above.
- **Residents, community-based organizations, and labor groups** supported a policy design that would create local jobs, improve air quality in buildings, reduce energy bills, not contribute to housing displacement, and improve heating and cooling in homes. The input of these stakeholders contributed to the City’s decision to develop an “equitable emissions investment fund” to support decarbonization efforts, prioritizing projects for environmental justice populations. The requirements to report equity and environmental justice metrics associated with BERDO 2.0 was another outcome of these stakeholders’ participation.
- **The electric and gas utilities** (Eversource Energy and National Grid Service Company) were initially concerned about the policy and communicated their concerns directly with City executive leadership. The utilities favored a longer implementation time, especially to give adequate time to address the additional strain of building electrification on grid infrastructure. The final decision to achieve net-zero carbon by 2050 provides a long time horizon for capital planning while aligning to the City’s *Climate Action Plan*.

7 The building energy retrofit resource hub is a clearinghouse to connect large- and medium-sized Boston buildings with energy efficiency services and technical support. It is a partnership between the City and local electric utility, Eversource (Eversource also provides gas service in Massachusetts, including portions of the greater Boston area). Source: City of Boston 2021c.

8 BERDO 1.0 applied to buildings that were at least 35,000 square feet in gross floor area or included at least 35 dwelling units.

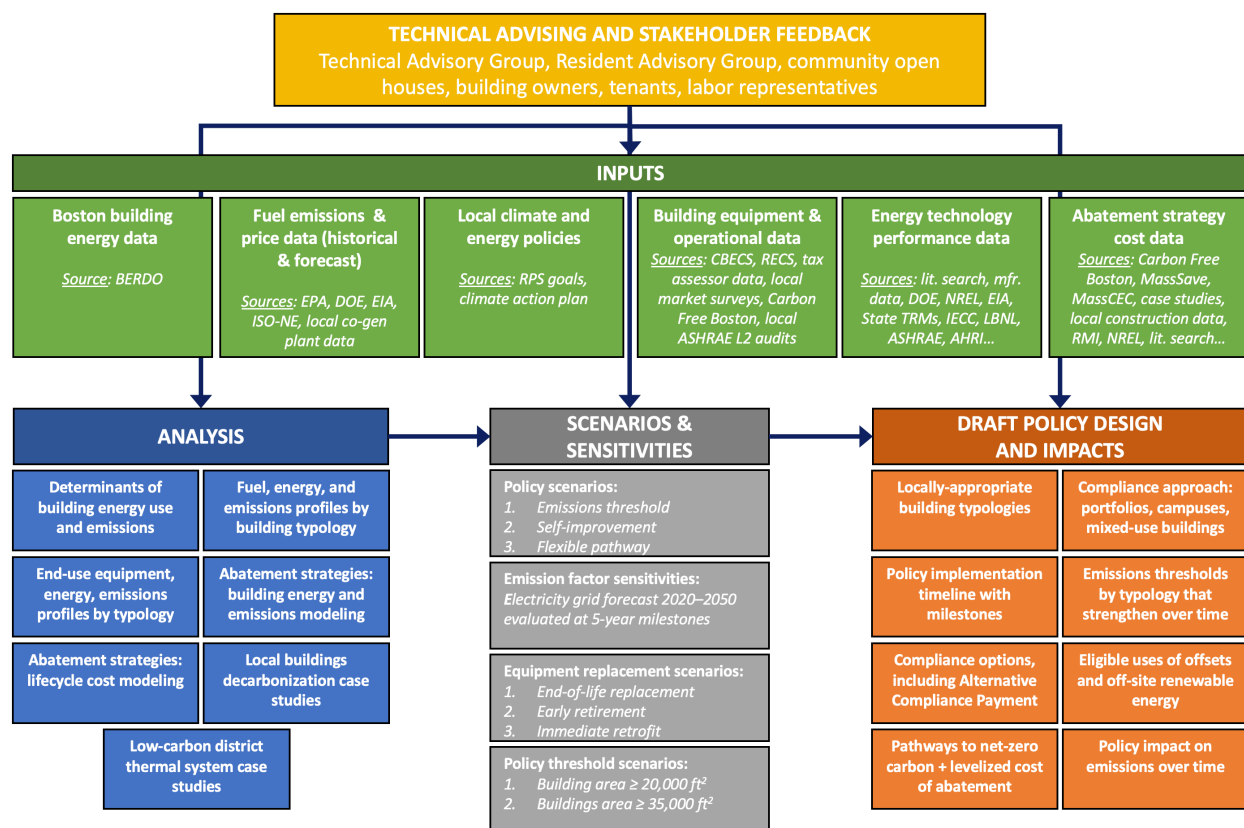


Figure 3. Technical modeling and policy design process. Arrows indicate flow of information from participants and among the components of the technical model, indicated by colored boxes. *Source: Eash-Gates et al. 2021.*

A variety of participants in the stakeholder process encouraged the City to offer technical support and financial incentives to help buildings comply. The policy requires that all alternative compliance payments be directed into the “equitable emissions investment fund” to which will provide financial support to local decarbonization projects. Additionally, in partnership with other state and local actors, the City has engaged a consultant to explore developing a climate bank to help finance decarbonization efforts.

Stakeholders also had varying opinions about the best approaches to decarbonizing buildings and the associated costs (City of Boston 2020b, 2020c, 2020d, 2020e; Eash-Gates 2020a, 2020b, 2020c, 2020d, 2020e, 2020f; One Square World and ACE 2020a, 2020b, 2020c). Synapse Energy Economics, with input from the technical advisory group, quantified the potential energy and emissions savings associated with implementation of various strategies across the stock of regulated buildings, and then estimated the lifecycle costs and savings (Eash-Gates et al. 2020). Table 2 summarizes the strategies included in this analysis. Fuel switching from on-site combustion of fossil fuels to electricity—“electrification”—was determined to be a critical strategy for achieving net-zero carbon. A few decarbonization strategies were particularly controversial, including:

- Whether space heating throughout Boston buildings can be electrified without overwhelming the electric grid;

- if it is necessary to retrofit building envelopes prior to electrifying space heating;⁹
- if large-scale, high-temperature commercial heat pumps are market-ready and appropriate to a range of applications;
- how to effectively decarbonize district energy systems that currently rely on fossil fuels;
- to what extent commercial building envelopes can be retrofitted with additional insulation; and
- what types of off-site renewable energy purchases should be allowed.

Table 2. Decarbonization strategies evaluated for Boston’s building performance standard.

System	Strategy
Envelope	• Air seal exterior penetrations • Add insulation to walls and roof • Window replacement and storm windows
Electrification of energy end-uses and supply	• Heating electrification: boiler to heat pump • Heating electrification: furnace to heat pump • Cooling electrification: absorption chiller to electric chiller • Water heating electrification: natural gas to heat pump • Cooking electrification: ovens, griddles, fryers • District energy system electrification: absorption chiller to heat recovery electric chiller • District energy system electrification: boilers and co-gen heat recovery to heat pumps
Heating, ventilation, air-conditioning, and refrigeration	• Cooling system replacement: heat pump • Mini split heat pump conversion: individual room A/C • Heat pump conversion: electric resistive heater • Comprehensive HVAC controls and retuning measures • Enhanced energy recovery ventilation • Convert constant air volume to variable air volume • Demand controlled ventilation • Refrigeration retrofits and controls
Lighting	• LED lighting conversion • Lighting controls: occupancy sensors, daylight dimming, timers
Water heating	• Heat pump water heater conversion: resistive water heater • Water conservation retrofits
Plug loads, process loads, and miscellaneous loads	• IT and process load energy management • Smart strip for plug load control
Renewable energy	• On-site solar photovoltaic • Off-site renewable energy purchase

Source: Eash-Gates et al. 2021.

⁹ Some stakeholders strongly recommended pairing electrification with thermal envelope upgrades while others argued that envelope retrofits may not be needed in thermally heavy buildings.

Challenges and Future Directions

Boston's building performance standard sets aggressive goals and incorporates a range of innovative and flexible strategies. The policy's ambition may create a large and lasting impact, yet it also increases the complexity of implementation. The City of Boston faces a range of challenges as it transitions from policy development and enactment to execution and administration. Possible challenges include:

Technical assistance. The City of Boston will need to provide building owners the support they need to understand the policy, navigate the reporting and compliance requirements, and begin to decarbonize their operations. Providing this assistance will require coordinated and consistent resources over the next three decades. This effort will increase in the years leading up to 2030 when the policy expands to include buildings between 20,000 and 35,000 square feet.

Rulemaking. While the ordinance is now law, the City and Review Board still need to establish regulations that provide the details of a complete policy framework. The rulemaking process must navigate support and opposition from various stakeholders, avoid creating regulatory loopholes, and ensure fair and equitable implementation of the law.

Adequate staff. The City will need to maintain a team of qualified personnel to assist with technical support, program monitoring, and administration. Ensuring adequate staffing is likely to require additional funding. This may be challenging in the post-COVID era if local governments continue to experience revenue shortfalls. However, additional funding from the federal or state government may become available for local governments, such as through the federal Bipartisan Infrastructure Law (The White House 2021).

Harder-to-decarbonize sectors. Some building types, end-uses, and existing technologies will prove more challenging to decarbonize. Compared to other jurisdictions, Boston has a high prevalence of medical facilities, laboratories, district energy systems (especially central steam plants), and historic buildings—which present a range of infrastructure and energy constraints.

Smaller buildings. Expanding the policy to buildings between 20,000 and 35,000 square feet will include properties that may have fewer in-house resources and technical capabilities. The City of Boston may need to dedicate additional time and resources to assisting properties without dedicated facilities staff, such as energy managers or equipment technicians.

New construction. Achieving net-zero emissions in Boston requires strategies for new construction as well. The City set a goal of achieving net zero carbon new construction by 2030 in the 2019 update to its *Climate Action Plan*. This target was developed based on the City-commissioned study “Carbon Free Boston” (Cutler et al. 2019). The 2019 update also established a plan to develop and implement net zero carbon emissions guidelines for city-funded affordable housing construction in Boston (City of Boston 2019). The City currently has adopted the state's “stretch” code for all new construction.¹⁰

¹⁰ Massachusetts law requires statewide adoption of each new International Energy Conservation Code (IECC) within one year after publication. The State adopted the 2018 IECC for residential and commercial

User-reported data. Under BERDO 1.0, the City faced issues with the quality of data reported by building owners who may not have had a deep understanding of building equipment systems, utility bills, and energy terminology. BERDO 2.0 will increase the types and quantity of user-reported data Boston receives, which may exacerbate this challenge. To address this, the City will require periodic verification by a third-party qualified energy professional.

Integrity of renewable energy attributes and custom emission factors. The policy allows building owners to demonstrate compliance by purchasing qualified RECs, purchasing qualified off-site renewable energy, and reporting custom emission factors. Validating the data and ensuring that the actions taken by building owners reduce emissions (i.e., are additional) will take time and effort. Clarity in the City's compliance and reporting criteria will help avoid any potential disputes. The BERDO 2.0 rulemaking process will further define qualifications for renewable energy purchases and methods for calculating emission factors.

Emission factors and accounting for renewable energy purchase. The technical analysis supporting the development of BERDO 2.0 assumed future grid emissions will decline under state policy (Clean Energy Standard 2020) and used generic, time-independent emission factors for district energy systems. However, state policy in Massachusetts and other New England states has evolved since the BERDO 2.0 analysis, and local district energy system operators have adopted plans to incorporate low- or zero-emissions technologies (Vicinity 2022). The City recently hired Synapse Energy Economics to help refine forecasted emission factors, develop emission factors for local district energy systems, and recommend methods for attributing emissions from co-generation plants to the various outputs, such as steam, chilled water, and electricity. Periodically updating emission factors will help improve local planning and inform the rulemaking process. The consultant is also recommending eligibility criteria for offsite renewable energy purchases and associated emission accounting practices.

Balanced and informed decision-making by the emissions Review Board. In its oversight role, the Review Board will make technically challenging decisions such as ensuring the full decarbonization of hospitals, labs, and district energy systems. The City is planning to provide neutral, third-party technical assistance to the Review Board and help manage power dynamics between the board and powerful stakeholders. Technical support and education will help inform and empower members of the board to be fully engaged and respected in their role.

The City of Boston's building performance standard is a case study in how an inclusive policy development process can create an ambitious yet flexible climate policy. Boston's commitment to ongoing rulemaking, public feedback, and periodic review of the ordinance will help the policy adapt to its dynamic and diverse landscape of buildings and stakeholder needs. The City's process to develop and implement the performance standard offers valuable lessons for other cities and states across the country seeking to implement their own performance standards.

buildings. Massachusetts provides local communities two options for building energy codes: the base IECC code or a state-determined optional "stretch" code. Boston adopted the stretch code, thereby requiring new buildings to exceed the base energy code by 20 percent.

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