Two Approaches to Scaling Commercial Building Decarbonization Retrofits: Breadth and Depth

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ABSTRACT

The Building Electrification and Transformation Accelerator (BETA): Roadmaps and Planning programs seek to prove out assessment and planning strategies at two different scales. BETA: Roadmaps takes a streamlined approach, utilizing high-level building modeling as part of a desktop analysis and roadmap reports useful for capital planning, internal stakeholder education, and action item guidance across multiple buildings in a portfolio. Using a templatized model that leverages the LBNL BETTER tool and Helioscope, minimal information from owners is required to chart a least-cost trajectory of emissions reduction interventions to reach full decarbonization by 2050. BETA: Planning provides individual commercial and multifamily buildings with on-site audits, in-depth engineering, and capital planning analysis to determine all-at-once and zero-over-time approaches to building decarbonization by 2050. Projects are enrolled across a representative subset of commercial and multifamily building typologies, prioritizing representation in environmental justice communities, and individual decarbonization plans will provide insights for the creation of best practices, case studies, resources, and guides. Program materials will be of use to building owners and operators, technical professionals, and policy makers. This paper will compare the two approaches and discuss their potential contributions toward equitable building decarbonization.

Introduction

In December 2022, the Commonwealth of Massachusetts' Executive Office of Energy and Environmental Affairs released its Clean Energy and Climate Plan for 2050 (CECP) as required by the Commonwealth's Global Warming Solutions Act of 2008 and the 2021 Climate Law (An Act Creating a Next Generation Roadmap for Massachusetts Climate Policy) (EEA 2022). The CECP identifies comprehensive strategies and sector specific greenhouse gas emissions sublimits for the state to achieve net zero emissions by 2050. Currently, approximately 27% of the state's emissions are from on-site combustion of fuels in the buildings sector (EEA 2020). To accomplish the CECP's goals, the vast majority of buildings will need to utilize electric appliances for all end uses and many will require extensive weatherization. Eighty seven percent of commercial space will need to be heated by either electricity or carbon-neutral fuels. Once the building stock in Massachusetts is fully electrified, due to reductions in electric grid emissions through the Commonwealth's ongoing and planned expansion of renewable energy supply through 2050, building emissions will be at or near zero. Furthermore, to reach net zero emissions by 2050, the Commonwealth will need to develop and implement programs that

support multiple pathways for commercial and large multi-family building decarbonization assessments and plans.

The process of making a building "2050-Ready", or net zero carbon by 2050, with either an "all-at-once" or "zero-over-time" decarbonization planning approach requires many steps; the first hurdle is getting started. Compared to business-as-usual planning for building maintenance and construction whereby existing fossil fuel equipment is replaced with new fossil fuel equipment, decarbonization planning requires additional time, an understanding of energy efficiency and decarbonization options, and support from decarbonization professionals. To begin planning the construction of a fully electrified building retrofit project, building owners and decision makers must assess their buildings' energy usage and develop a comprehensive plan. This can be a daunting task, especially the first time, and therefore requires more "activation energy" than a like-for-like replacement retrofit project. In particular, this additional effort can be difficult for affordable housing building owners and owners with properties in environmental justice (EJ) communities that often have more start up challenges due to organizational capacity and financial constraints. As a result, it is critical to have technical support available from the beginning of a decarbonization project through to completion.

Currently, the Commonwealth does not have statewide programs or regulations that support existing building owners through the non-standard process of building electrification and decarbonization. The state's main programmatic support for commercial building owners is through Mass Save, the utility rebate program managed by the investor-owned utility program administrators, and that program's Commercial and Industrial Deep Energy Retrofit (C&I DER) offering (Mass Save 2024). Participants receive planning assistance through a no-cost site energy assessment and scoping study providing a roadmap detailing energy and greenhouse gas emissions reduction opportunities, in addition to financial incentives. The program was established recently, and is relatively untested in the marketplace, although the mechanism of interaction by building owners and operators is substantially the same as for other Mass Save C&I programs with lower incentives and less ambitious savings goals.

In terms of regulations, only two municipalities in the state currently have greenhouse gas emissions reporting and reduction requirements for large existing buildings, the City of Boston's Building Emissions Reduction and Disclosure Ordinance (BERDO) and the City of Cambridge's Building Energy Use Disclosure Ordinance (BEUDO). These reporting and reduction requirements are important as they require both energy efficiency investments and the scaling of building decarbonization retrofits. To ensure that the Commonwealth meets its CECP goals, a similar model of decarbonization regulation complemented with support for building owners at any entry point in the electrification and decarbonization planning process is needed, and the work described here allows decarbonization planning process support mechanisms to be tested.

The Massachusetts Clean Energy Center (MassCEC) is a quasi-governmental economic development agency dedicated to accelerating the growth of the clean energy sector across the state. Its High Performance Buildings team supports the CECP goals by demonstrating building decarbonization solutions through development and testing of a comprehensive set of technical, planning, and implementation approaches. MassCEC aims to unlock pathways for economy wide

highly efficient electrification while also supporting the growth of critical emerging technologies.

Through two of its recent pilot initiatives, BETA: Roadmaps and BETA: Project Planning, MassCEC has focused on developing and testing different approaches to initial building assessments and project plans for commercial and large multi-family buildings. The scale of assessment, level of detail, and support provided to building owners in each pilot varies. BETA: Roadmaps takes a streamlined approach, utilizing high-level building modeling as part of a desktop analysis and roadmap reports useful for capital planning, internal stakeholder education, and action item guidance for individual buildings or across multiple buildings in a portfolio. Using a templatized model that leverages the LBNL BETTER tool, a software tool enabling virtual energy efficiency audits, and Helioscope, a solar design software tool, minimal information from owners is required to chart a least-cost trajectory of emissions reduction interventions to reach full decarbonization by 2050. The resulting 25-year decarbonization plan fundamentally shifts the norm for building owner planning to a much longer time horizon than is usual. BETA: Project Planning provides individual commercial and multi-family buildings with on-site audits, in-depth engineering studies, and capital planning analysis to determine all-at-once and zero-over-time approaches to building decarbonization by 2050. The two approaches together test the hypothesis that each approach has been targeted to the typical needs of each building category and its decision makers, tenants, and uses, the state's building stock will have the necessary guidance in the transition to being 2050-Ready.

The ideal statewide program would help building owners at any stage of their decarbonization "journey" and include comprehensive assistance with an assessment and plan, project design, contracting, implementation, commissioning, and post-retrofit operation. The ideal journey towards full building electrification and decarbonization would incorporate both roadmaps and project planning as needed. Both high-level and in-depth scales are required for most projects, sequentially. In both MassCEC pilots, an energy usage assessment is the first step in the participant process, because identifying major sources of greenhouse gas emissions and electrification priorities for the site will have a significant impact on the overall plan. It is also important for decision makers to understand what the electricity sources are for their buildings, including current and projected future grid emissions. All decarbonization projects should consider both on-site and off-site renewable energy opportunities as applicable.

A zero-over-time approach means implementing measures over time to decarbonize a building fully by a target date. After the initial assessment, especially when using a zero-over-time approach, decision makers should be supported in setting reasonable targets and end points to their electrification and decarbonization projects. This planning will be the most successful if it incorporates capital planning unrelated to decarbonization at either a high or detailed level depending on the appropriate strategy for a building. This is a key part of a roadmap or project plan, as immediate and long term decarbonization targets will be least costly if they are combined with other major renovations and required maintenance for the building or systems being renovated. In addition, plans should consider disposition and redevelopment decisions early on, to avoid stranded electrification and decarbonization assets in buildings slated for demolition or gut renovation. The initial planning conversations should also include projections

and expectation setting discussions about cost savings, capital cost assumptions, and operating cost and utility rate assumptions including projected future rate estimates where possible. In addition to considering the installation and implementation of measures directly related to decarbonization, successful program support would include discussions about how to coordinate with other guidelines and needs such as electrical upgrades, ADA compliance, and fire safety requirements. All of this additional assessment lays the foundation for the design and next steps of a project.

Furthermore, it is important that a large-scale program guide participants through applying for and securing available state and federal incentives. The planning timeline in the program should align with existing and future funding and financing opportunities wherever possible, such as eligible installation year requirements in some tax credit offerings. Similarly, a review of the constantly evolving list of incentive programs available should be discussed at the time of plan creation to ensure that participants are receiving as much funding support as possible. For eligible participants in Massachusetts, programs such as the Mass Save C&I DER offering and the Department of Energy Resources Low- and Moderate-Income Housing Decarbonization Grant Program (DOER 2023) should be discussed.

Moreover, a stepwise, iterative statewide planning program will not be successful if it is not equitable. Part of a roadmap or project plan must be careful consideration of how the project may negatively impact low-income building owners or tenants or other EJ communities. For example, plans should focus on reducing operating costs for low-income tenants such that their energy cost burden isn't increased wherever possible. The level of technical support available should also accommodate decision makers that may have additional constraints such as capacity and capital for a project or even to develop a plan. These types of decision makers are more often small or medium businesses. Both of MassCEC's planning pilots aim to address these challenges through the selection of participants, assistance provided, and resources to be created for distribution at the conclusions of the pilots.

These programs work to surface and disseminate best practices in the broader marketplace, with the aim of being taken up by more mainstream programs or by owners directly. BETA: Roadmaps specifically supports non-profit entities, which often have limited capacity and financing and funding constraints. For example, many non-profits such as affordable multifamily housing developers are subject to extensive regulation and only selectively eligible for tax credits. In BETA: Project Planning, project sites that are located in EJ communities or have uses that serve EJ communities are prioritized during the participant building selection process. This prioritization is supported by EJ community outreach to ensure program information is widely shared, and participants are recruited in line with programmatic EJ goals. In the longer term, larger scale versions of these pilot programs will need to determine how to direct their resources such that they are maximizing their assistance to entities with limited capacity and to underserved communities in order to facilitate a just transition to zero emissions buildings.

In the two main sections below, we outline the tools, process, and outcomes of the roadmapping and planning approaches we are piloting with the BETA: Roadmaps and BETA: Planning programs.

Breadth—BETA: Roadmaps

Non-profits and public entities face unique procurement, financing, and management processes for their building portfolios, which result in additional barriers to implementing already-challenging building decarbonization interventions for existing buildings. Given that non-profits and public entities own a sizable portion of the Commonwealth's building stock, and that many of these buildings have the potential to "lead by example," this sector offers a great opportunity to establish practices for the decarbonization of building portfolios. To facilitate these transitions, these building owners often need roadmaps to:

- Initiate planning discussions;
- Support capital and budget planning;
- Enable procurement pathways; and,
- Identify options for reducing cost, risk, and process challenges in decarbonizing.

BETA: Roadmaps is a MassCEC initiative in partnership with PowerOptions, a non-profit corporation with a proven track record supporting non-profits and public entities in energy procurement and facilitating energy transition actions. This makes PowerOptions a uniquely qualified partner for this building decarbonization initiative which has the objective of accelerating the electrification and decarbonization of the building segment owned by non-profits and public entities. This pilot provides non-profit and public-entity building owners with a high-level overview of decarbonization opportunities aligned with building capital needs across their portfolios, with the target of zero-emissions building portfolios by 2050. The pilot provides actionable roadmaps and is intended to enable efficient, effective procurement strategies that address the unique needs of non-profits and public entities.

The BETA: Roadmaps pilot aligns with the MassCEC High-Performance Buildings strategy, which has as top priorities (1) the surfacing and demonstration of building decarbonization approaches and (2) the support of "zero-over-time" planning. This pilot also supports the Commonwealth's building decarbonization goals expressed in the Clean Energy & Climate Plan for 2030 (EEA 2022), which calls for a broad and aggressive transition of statewide buildings by 2030, including improving building envelopes and electrifying 300 to 400 million square feet of commercial buildings. The pilot approach consists of the following components performed by PowerOptions:

- Capturing and analyzing the carbon footprint of building portfolios using:
    - Building-level energy usage data collected from an energy bill data management platform that PowerOptions offers to its customers;
    - Building characteristic data collected using a building information intake form completed by building owners or operators; and
    - Brief interviews with building owners as needed.
- Developing a multi-year roadmap and implementation plan for energy efficiency measures, electrification of fossil-fuel end uses, on-site solar, and REC purchases as offsets) at each building in the portfolio. Recommendations are made using "trigger events" such as the end of life of equipment, building additions, renovations, etc.

- Energy Efficiency Measures: These are approximated using Lawrence Berkeley National Laboratory's BETTER tool which uses a benchmarking algorithm to analyze monthly energy consumption data to recommend likely energy efficiency measures for commercial buildings.
- On-site Solar: Rooftop, ground-mount, or canopy solar projects are designed using Helioscope software
- Electrification: The potential to electrify all fossil-fuel end uses (space heating and cooling, water heating, cooking) is analyzed using a custom-made Excel model that estimates the sizing, cost, and incentives associated with electrifying the building. Note that electrical service upgrade costs are excluded from these estimates.
- REC purchases: The need to purchase RECs is calculated based on projected grid emissions factors. RECs are only used to offset electricity-based emissions and are only recommended in the latter portion of the roadmap timeline as a final action item.

PowerOptions established and is utilizing several key resources to provide these services, including:

- Offering the services of a carbon reduction advisor and data analyst;
- Implementing an energy bill data management platform for automation of energy data collection;
- Integrating supplier and utility energy data, building typology, HVAC, and other source data available through data licenses, as well as data from the building owners.

To-date, 28 roadmaps have been completed, representing 99 buildings. The complete statistics from the program thus far (January 2023 through May 2024) are presented in Table 1. The emissions reductions projected from the implementation of roadmap recommendations are summarized in an emissions reduction trajectory by scenario and measure categories, respectively, in Figures 1 and 2. In Figure 2, efficiency appears to result in diminishing CO_2e reductions over time compared to heat pump implementation. This is because, though the same number of MWh are avoided each year from 2023-2050, each MWh gets "cleaner" (has lower CO_2e emissions per MWh) over time as the grid decarbonizes. Meanwhile, heat pumps avoid therms of gas which have an emissions factor that doesn't change over time. Stepwise and gradual changes in CO_2e reductions over time for heat pumps are due to some years having a greater conversion rate to heat pumps than others, reflecting the timing of heat pump conversions in different buildings.

At the completion of each roadmap, building owners are guided through the process of getting an on-site energy audit through Mass Save, representing a near 100 percent conversion rate from a roadmap to implementing energy efficiency measures. Building owners are guided through the process of procuring solar and heat pumps at the time when the roadmap recommends. Building owners have reported that the roadmaps are helpful and a cost-effective way to get them headed towards decarbonization.

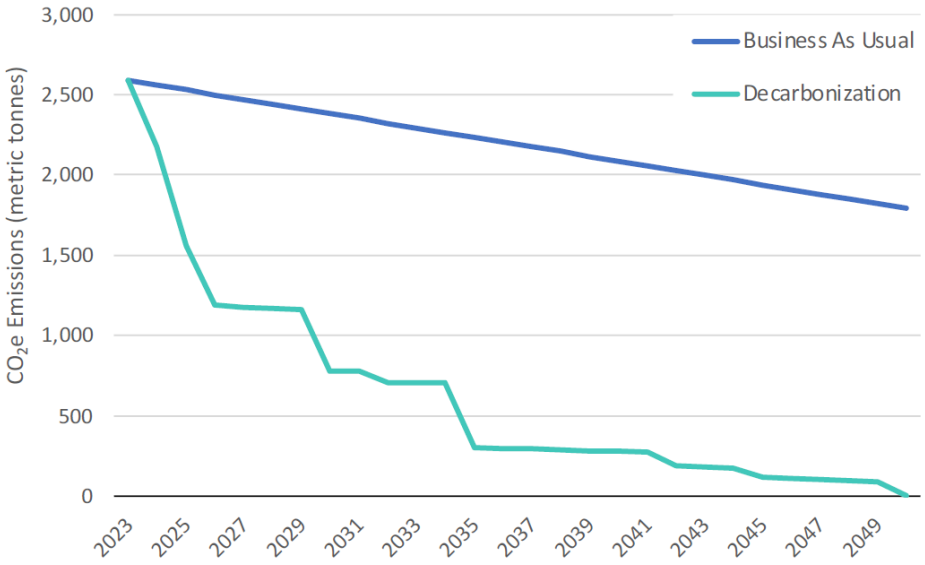

Figure 1. Example CO_2e emissions by scenario for sample BETA: Roadmaps portfolio roadmap

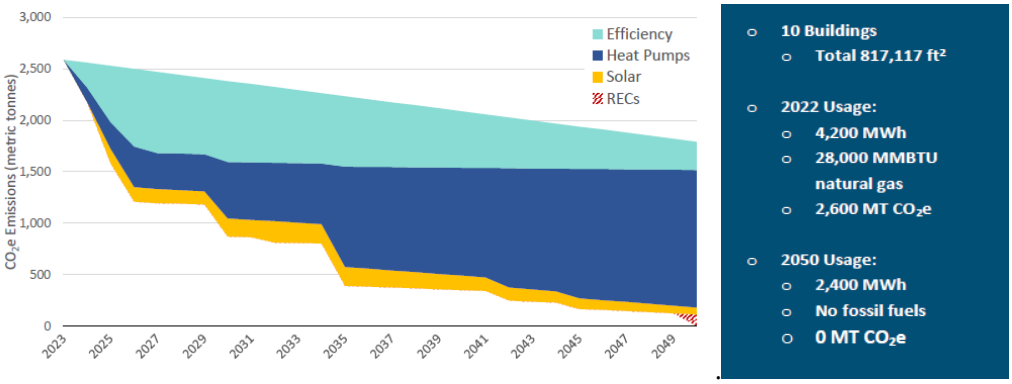

Figure 2. Example CO_2e reduction by measure for sample BETA: Roadmaps portfolio roadmap

The approach to initial building decarbonization roadmapping developed for BETA: Roadmaps works in any geography and can be scaled to buildings outside Massachusetts. Completed roadmaps then serve as an organizing framework for building owners, decision makers, facilities staff, and consultants to building owners when developing in-depth plans on the pathway to design and implementation.

While BETA: Roadmaps is geared towards portfolio owners, the roadmaps provided indicate least-cost emissions reduction measures aligned with ongoing capital investments at the building level as well, allowing individual building owner and portfolio owner participants to prioritize investments at a particular building and across a group of buildings, over time.

Table 1. Statistics from BETA: Roadmaps program from January 2023 through May 2024.

Statistic	Value

Quantity of Organizations	28
Quantity of Boston Organizations	15
Quantity of Buildings	99
Total Square Footage	4,400,000
Average Building Square Footage	44,000
Total Annual Energy Savings (mmBTU)	270,000
Average Annual Energy Savings Percentage	65%
Average Annual Building Energy Savings (mmBTU)	2,700
Total CO_2 Savings (metric tons)	24,000
Total CO_2 Savings Percentage by 2050	100%
Average Building CO_2 Savings (metric tons)	250
Total MW Solar PV Recommended	6.0
Average Building Solar PV Recommendation (kW)	60
Total Gross Installation Cost (across all buildings) (millions)	$100
Average Portfolio Gross Installation Cost (millions)	$3.7
Average Building Gross Installation Cost (millions)	$1.1
Total Net Installation Cost (post-incentives) (millions)	$58
Average Portfolio Net Installation Cost (millions)	$2.1
Average Building Installation Cost Net of Utility Incentives (millions)	$0.58

Depth—BETA: Project Planning

The decarbonization of larger commercial buildings with complex HVAC, water heating, and process heating systems is often not as simple as swapping out existing equipment for heat pumps, like it might be for residential or small commercial buildings. Many barriers can prevent this simple substitution, including available space, infrastructure constraints, costs, and technology limitations. Despite these challenges, there are pathways to decarbonization for these facilities—they just take significant planning and strategy and may need to occur over time rather than all at once.

The BETA: Project Planning program seeks to develop flexible yet in-depth guidance and discrete steps to decarbonize complex buildings in cold climates. The pilot brings together local and national thought leaders to support a cohort of 15 commercial building sites across Massachusetts in the development of full building decarbonization plans. These plans are customized to the specific needs of the building and owner while considering a range of technoeconomic drivers. Each plan results in an all-at-once solution set or a zero-over-time approach, either of which include the level of analysis and direction needed to provide the basis of design work for implementation.

Using findings from the individual plans and review of industry best practices, the BETA team will create a series of case studies, toolkits and market-facing support documents toward the end of the pilot. These tools will provide decarbonization planning resources across a wide

range of building typologies, systems, and capital planning scenarios. As this pilot is still in progress— recruiting buildings, conducting assessments, and generating case studies—this section will focus on the pilot's framework, processes, and insights to serve as an outline for other in-depth commercial building decarbonization planning programs.

In researching reference materials for complex building decarbonization, our team found a limited number of guidelines and similarly focused programs. Top references include NYSERDA's Empire Building Challenge and Playbook (NYSERDA 2022), RMI's Realize Case studies (RMI 2023), U.S. Department of Energy's Better Buildings Solution Center (DOE 2021), and New Building Institute's Building Electrification Roadmap (NBI 2021). ASHRAE plans to release a Building Decarbonization Retrofits Guide for Commercial and Multifamily Buildings, in July 2024 (ASHRAE 2024). Most guides and programs that have been developed tend to focus on multifamily sites, so existing resources—or lack thereof—might not address the complex considerations of the full universe of commercial buildings. The BETA: Project Planning program aims to fill this knowledge gap in Massachusetts, empowering project teams and owners across a wide range of complex building types to make informed, cost-effective decisions to eliminate onsite fossil fuels.

As the efficiency industry transitions to electrification and decarbonization assessment methods, planning pathways and programs must evolve to ensure successful outcomes. This inclusive framework can be replicated in other cold climate states through programs or education materials that support complex building decarbonization.

The approach to the pilot can be separated into five main parts:

1. A **market summary** used to support outreach and selection of the pilot cohort sites.
2. **Outreach and site selection** including pilot marketing and collateral development.
3. **Protocol and process development** for conducting decarbonization assessments.
4. **Assessments and custom plans** for each of the cohort sites.
5. Development of **case studies and market guidance.**

First, we conducted a market summary characterizing the common commercial and multifamily buildings within Massachusetts (MassCEC 2023). This study was used to inform and select specific building typologies that would be most beneficial to enroll within the pilot. As a preparatory step to collecting data, the team worked with local stakeholders to identify value propositions to prioritize within the following areas:

- **High-Impact Scaling**: The types of buildings selected for participation should have characteristics that will make it easier and more impactful to scale the decarbonization approaches to the statewide population of commercial buildings.
- **Environmental Justice**: Commercial and multifamily buildings in designated EJ communities may have unique challenges and opportunities associated with decarbonizing that must be understood so that EJ communities can be best served.

- **Widespread Applicability**: Participating buildings should feature a variety of HVAC system types, ages, sizes, ownership structures, and retrofit pathways so that lessons learned from the pilot can apply broadly.

Through analysis of public data sources and relevant market research reports, the team identified key building characteristics, such as primary building use, HVAC system, environmental justice indicators, size, vintage, square footage, energy use, and emissions. We used these characteristics to distinguish between key building typologies that would follow common decarbonization pathways, which could be further developed through this pilot. For each of these aggregate categories, Figure 2illustrates a comparison between total area, number of buildings, and percent of total emissions. Medium residential buildings make up the most total buildings, yet they do not result in the largest emissions. Instead, we see a greater percentage of total emissions from large complex HVAC typologies and large residential sites—which, unfortunately, are also much harder to decarbonize.

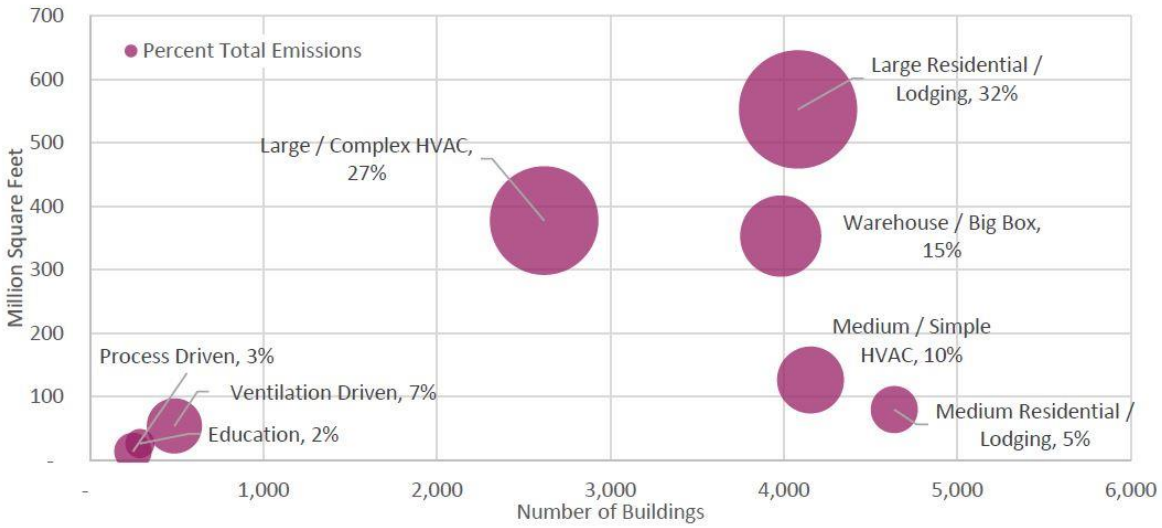

Figure 2. Square footage and percentage of commercial building sector emissions by commercial building count and type in Massachusetts, from BETA: Project Planning Market Characterization report.

A scoring matrix was developed to support targeted enrollment prioritizing the desired building typologies, complex or simplified HVAC systems, and applicable sizes, ownership cases, vintages, and locations. For outreach, the team hosted an introductory webinar and launched a project website that provides pilot program materials and guidelines as well as regular updates through blog posts. The team also developed a web application to support site scoring by requesting detailed information on key building and system characteristics. As of March 2024, over 50 individual building sites have applied to the BETA: Planning program.

In development of the protocol, our aim is to create and test an assessment framework that is comprehensive yet also flexible enough to address the wide variety in the commercial

building stock. The structure of the assessment protocol resulting in a Strategic Decarbonization Plan is twofold, combining (1) a technical review and optimization of system selection and (2) capital planning considerations, as illustrated in Figure 3.

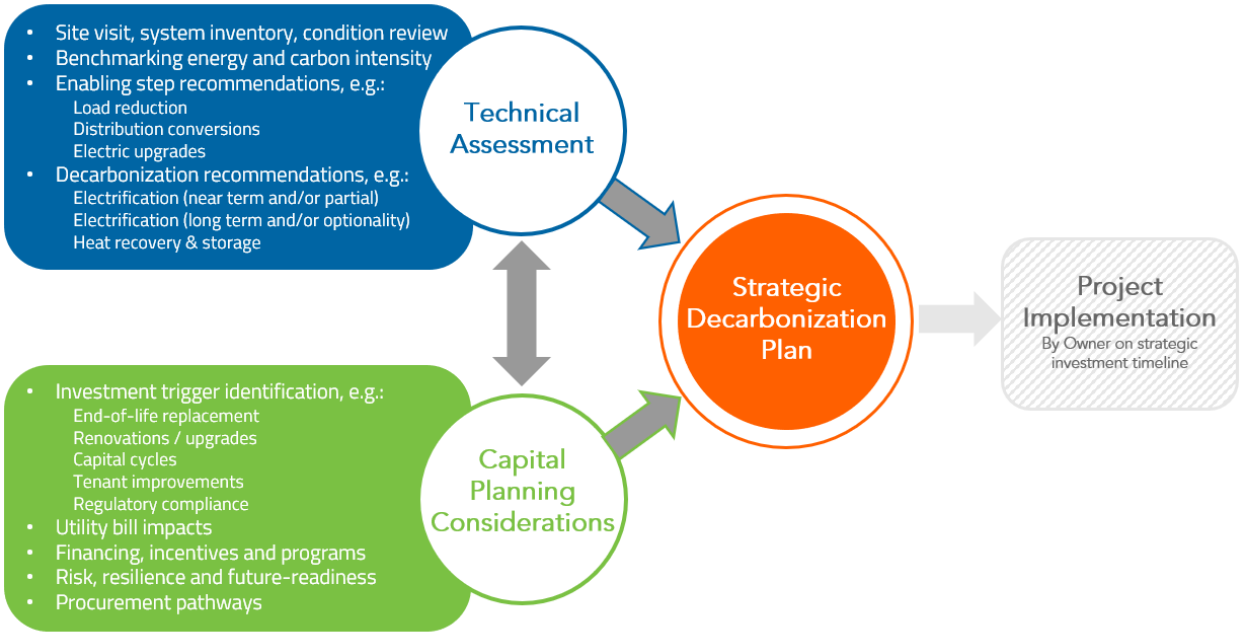

Figure 3. BETA: Project Planning assessment and plan process diagram.

While following a similar procedure, each Strategic Decarbonization plan is custom to the individual building or site. The conventional processes for energy efficiency assessments provided a foundation for the technical approaches for decarbonization planning. The planning starts with a pre-walkthrough stage collecting facility description information, owner goals, existing energy use, and building operational data. The pilot assessment team will provide energy and carbon benchmarking prior to the facility walkthrough as well as an introductory overview of potential energy efficiency and electrification and decarbonization (i.e., greenhouse gas emissions reduction) opportunities that align with the building owner's goals.

During the onsite assessment, a detailed review of building systems and their condition takes place. The protocol places a particular focus on space conditioning and ventilation strategies, envelope performance, resilience considerations, and electrical infrastructure. (For a familiar comparison, the level of scope and effort falls between an ASHRAE Level 1 and Level 2 audit.) Once the assessment is completed, the protocol places the building's decarbonization options into three categories:

- **Efficiency and load reductions**: A base improvement package would bring the building up to an efficient level of operations utilizing typical cost-effective energy conservation measures. Similarly, a base-level improvement package includes recommendations for load reductions focused on low cost, high impact measures such as air sealing or roof insulation depending on site needs. Outside of these base improvements, we identify potential options that may coincide with partial replacement of HVAC systems or

warrant a parametric approach to assessing and optimizing load reduction benefits such as window replacement or overcladding.

- **Electrification**: Depending on existing equipment and site conditions, we present a range of HVAC, domestic hot water, and process/cooking equipment electrification options. Where applicable, the protocol can compare the effects of a full system replacement versus maintaining partial components. Market-ready technologies for heating, hot water, and cooking electrification fill out a shortlist of options depending on site conditions and constraints. For consistency with best market practices, the electrification package may use industry specifications such as Very High Efficiency (VHE) HVAC or ASHRAE Guideline 36 for controls.

Many of these electrification technologies cannot simply be swapped in for an existing piece of combustion-based equipment. Important steps such as electrical infrastructure upgrades, control reconfigurations, retro-commissioning, targeted load reductions or changes in heating distribution and delivery must take place prior to implementation. These *enabling* measures reconfigure or upgrade equipment to prepare for electrification with little or no decarbonization impact themselves. However, planning and coordination of these elements with specific site constraints, equipment replacement cycles, and timing of tenant improvements is an important consideration. The commercial electrification equipment market is rapidly advancing. Some sites, depending on individual needs, may be better served by taking a more phased approach so that they can implement the best available solutions at an optimized time or are ready if a critical need arises. To support future planning recommendations once enabling measures are put in place, the program tracks emerging technology advancements such as high-lift air-to-water heat pumps, unitized thermal storage packages, or large-capacity heat pump make-up air systems. Whether or not they'd be immediately effective, these types of measures likely necessitate staged upgrades which require thoughtful planning prior to installation.

- **Renewable energy:** Distributed energy resources play an important role in cost-effectively decarbonizing. Assessments will include a review of the potential for on-site solar and its use to offset increased electricity demands. A high-level review of load shedding and shifting technologies through grid-interactive efficient building controls and battery energy storage systems further support peak load reductions.

Each of these base packages and options undergo analysis using a calibrated energy model to assess their implications on energy, carbon, heating load, and electricity demand. This information is fed into a lifecycle cost analysis to suggest the optimal set of measures to choose, including a calculation of where load reduction measures and heating system electrification intersect. Fully electrified solution sets are optimized on first costs and operational costs which are driven by heating loads, heat pump and distribution system sizing, and resulting peak electricity loads.

Conventional simple paybacks will likely underestimate the overall benefit of the electrification technologies. Instead, various metrics are used to support the financial case, i.e., net present value tied to value propositions such as completing deferred maintenance,

compliance with current or future building performance standards, and meeting carbon goals through measurable scope 1 and scope 2 emission reductions.

A critical step in this process is to tie site-specific investment triggers and long-term planning considerations into a timeline for implementation. To accomplish this, we developed a range of questions and opportunities to guide conversations with stakeholders. A funding matrix supports conversation around potential programs, grants, incentives, and financing depending on circumstance. Gathering of financial planning information starts during the pre-walkthrough questionnaire and continues through each interaction with project stakeholders to refine an overall strategy that fits within their needs, cash flows, and reinvestment cycles. Gathered in parallel with the technology and enabling measure assessment, this information is used to identify a workable pathway towards full building decarbonization. This process is illustrated in the diagram in Figure 4.

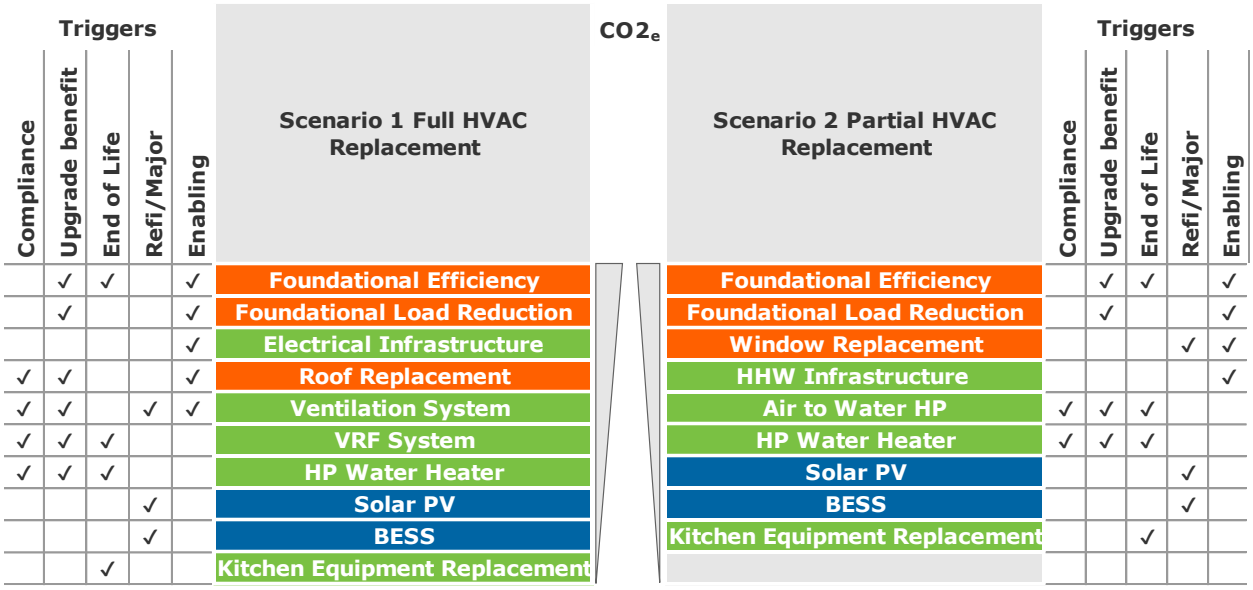

Figure 4. Interim reporting table outlining steps and potential triggers for decarbonization planning. For the items above, the orange category is efficiency, green is mechanical, electrical, and plumbing equipment, and blue is renewable energy.

Participants work with assessment teams to review interim decarbonization steps and potential triggers for implementation. Then the team optimizes components and sequencing for the final plan based on existing building conditions and context. Building owners emerge from the program with an outline of recommended measures and performance drivers for efficiency and load reductions, electrification of systems, and potential impacts from renewable energy and storage. This outline lays out a path to eliminate carbon emissions through tangible steps, system improvements or replacements, capital planning triggers, and other considerations.

Coupled with these steps is an emissions forecast which plots anticipated CO_2 impacts year over year as components of the plan succeed and the grid continues to deliver cleaner, more renewable energy. Similarly, a life cycle cost comparison looks at both operational and capital expenditures comparing a business-as-usual case with limited decarbonization to the fully

decarbonized scenario. The cash flow includes utility expenditures, equipment replacements, potential building performance ordinance implications, incentive payments, and capital improvements over the next 10-20 years depending on the owner's planning timeframe. The plan also includes additional supporting materials and best practices for procurement.

Figure 5 shows an example overview report for decarbonization as part of the larger strategic decarbonization plan. The goal for this document is to provide both an easy-to-follow summary of considerations for a building owner and implementation team and act as a market-facing case study as part of a greater package of resources.

Figure 5. Example BETA: Project Planning decarbonization plan overview report.

As more projects complete their strategic decarbonization plans, these processes and deliverables will be refined into market facing protocols and guides. We will use interviews with participants as well as industry roundtables to inform the ways these toolkits can address barriers and support the Commonwealth in meeting its 2050 goals.

Conclusion

We have outlined the tools, processes, and outcomes for two different approaches to assessing and planning for electrification and decarbonization in existing commercial buildings in Massachusetts. The tools and processes piloted through the BETA: Roadmaps and BETA: Planning programs generally take two different approaches, one of breadth and one of depth.

Many existing buildings will have owners who have begun electrification and decarbonization planning and now require in-depth planning at the building level. Many building owners will not have started planning to make their buildings 2050-Ready at all. And still other buildings will be fairly simple and can proceed directly to design and contracting for electrification and decarbonization retrofits. Through the two program approaches outlined above, we are testing and mapping these various decarbonization planning scenarios while building the tools and processes to do existing commercial building electrification and decarbonization planning at scale.

The BETA: Roadmaps program has the additional goal of project pipeline development and high-level building decarbonization education for building owners. BETA: Planning additionally seeks to find common approaches to most commercial building typologies for in-depth assessment and planning, while documenting and disseminating those approaches. Through both, we hope to demonstrate how replicating this work at scale, as with BETA: Roadmaps, and in-depth, as with BETA: Project Planning, will help to meet the Commonwealth's building sector net zero emissions goal of decarbonizing existing buildings by 2050.

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