

Tools & Lessons for Large Building Practitioners

Building Energy Boston 2024

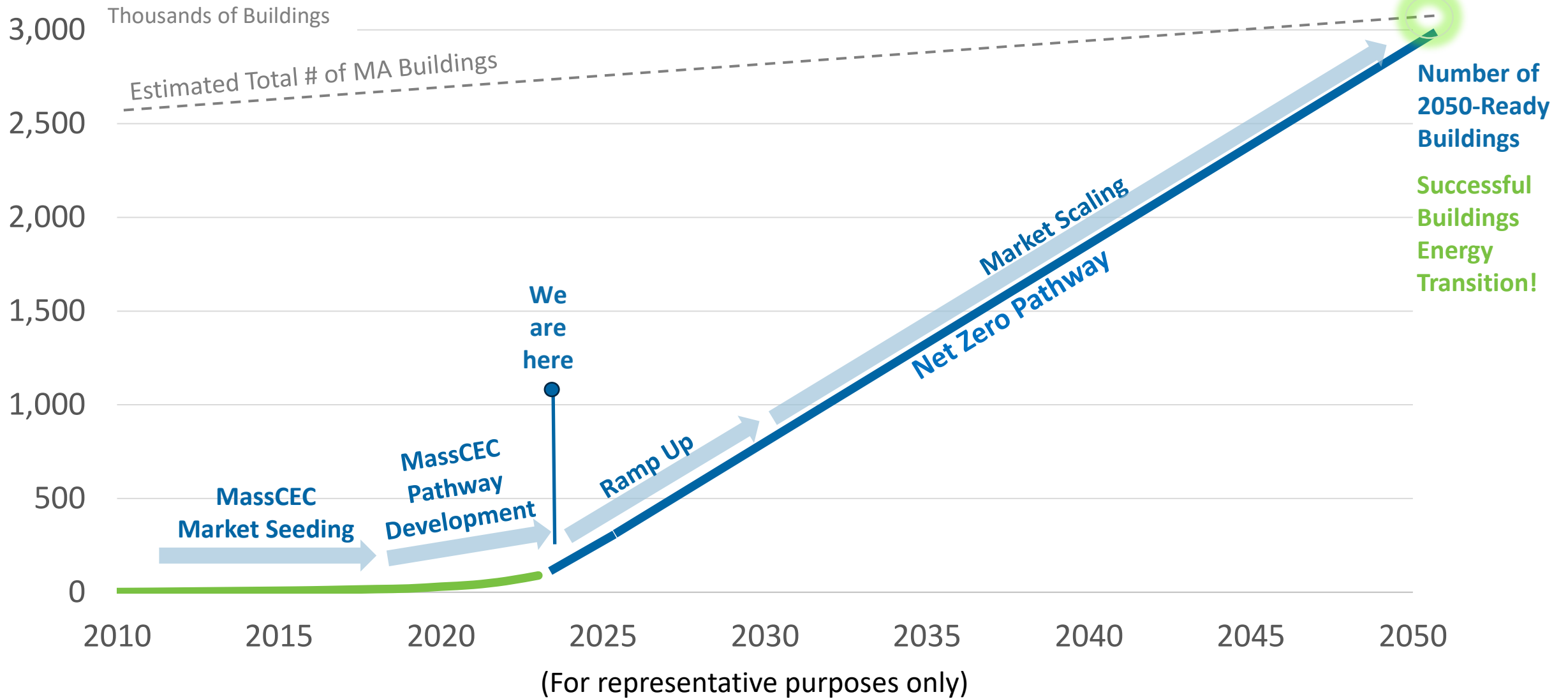


TOOLS & LESSONS FROM:

- Passive House Design Challenge
 - Embodied Carbon Challenge
 - Concrete Environmental Product Declarations
 - Portfolio-Level Decarbonization Planning
 - Project-Level Decarbonization Planning
 - “Find a Pro” - BE+ Connects
- Exciting News! State investment in centralizing retrofit content

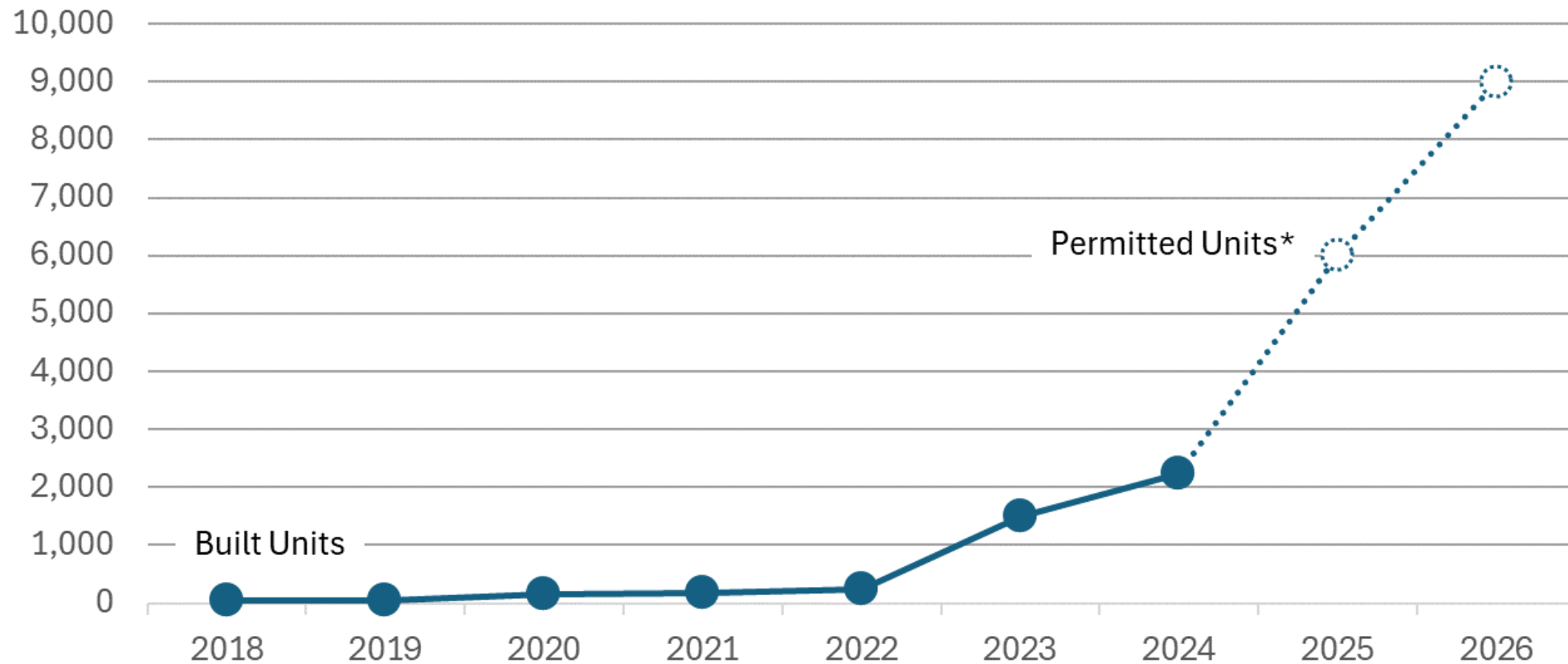


Building Sector Decarbonization Scale & Trajectory

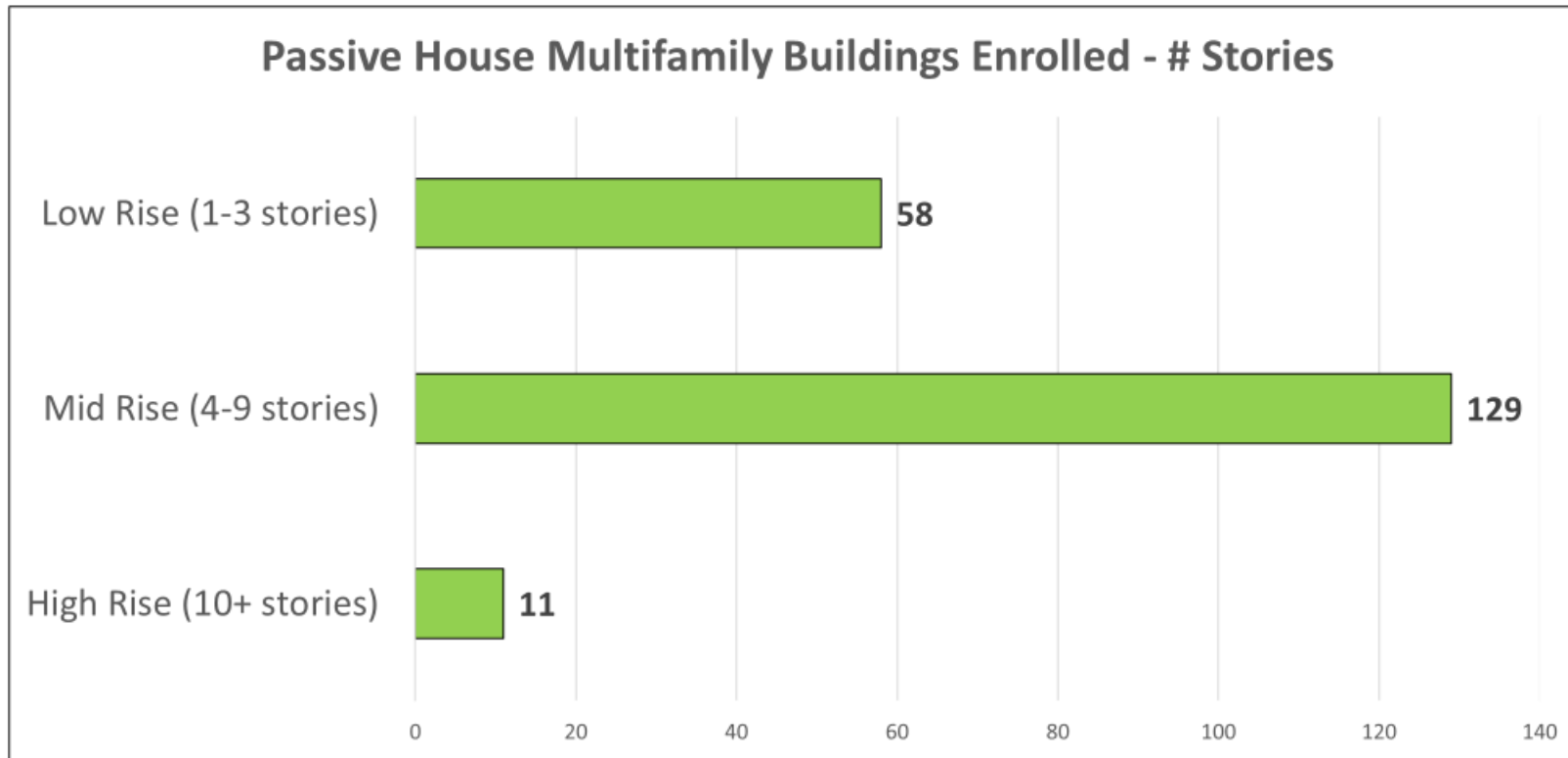


Passive House Trends in Massachusetts

Even before the Opt-In Stretch Code Takes Effect, The Cumulative Number of Passive House Units Is Dramatically Increasing



Most Passive House Multifamily Buildings are 4-9 Stories



WE ARE MASS SAVE®:



Passive House Is Possible In All Looks and Sizes



Tips after 8 MassCEC Passive House Multifamily Projects

Most Challenging Issues for Achieving Passive House Certification

- Whole building air tightness
- Ventilation (duct tightness, meeting flow rates, or achieving balancing)
- Laundry rooms

Tips:

- Projects with more team members with education and experience had the lowest incremental costs and best outcomes.
- If podium, talk to others who have succeeded.
- Important to require Verifier do a design review, prior to CDs
- Don't use double or single hung windows. Casement, awning or picture windows will provide passing air tightness.
- Aerosol seal ventilation ductwork.
- Require that testing and balancing contractor balance ventilation system, using flow hood/balometer.



Air Sealing Tips after 8 MassCEC Passive House Multifamily Projects

Tips:

- Mid point whole building blower door **critically important**; build in plenty of room
 - ✓ be extremely on top of sealing before midpoint whole building testing
 - ✓ manual sealing, with more than 1 midpoint whole building test
 - ✓ potential for reducing leaks with aid of ultrasonic wand or aerosolized air barrier before drywall
- Midpoint blower door, Verifier should be ready to do after hours/weekend, when site is shut down, especially if podium
- Pay particular attention to intentional penetrations, both to the exterior and to separately certified commercial spaces



Photo courtesy of AeroBarrier



Incremental costs trends in completed Passive House

Less Expensive Upgrade Than Most Teams Expect

- <3% before incentives
- \$3K per unit MassSave incentive offsets some of increase

Incremental Cost Increase Trends

- Ventilation
- Efforts to reduce thermal bridging
- Shading features
- Higher level of construction verification

Heating and Cooling Equipment Cost Decrease Trends

- 6 out of 8 projects have significantly lower size and cost for heating and cooling equipment
- In most cases, NO incremental cost for additional insulation
- Window premium coming way down

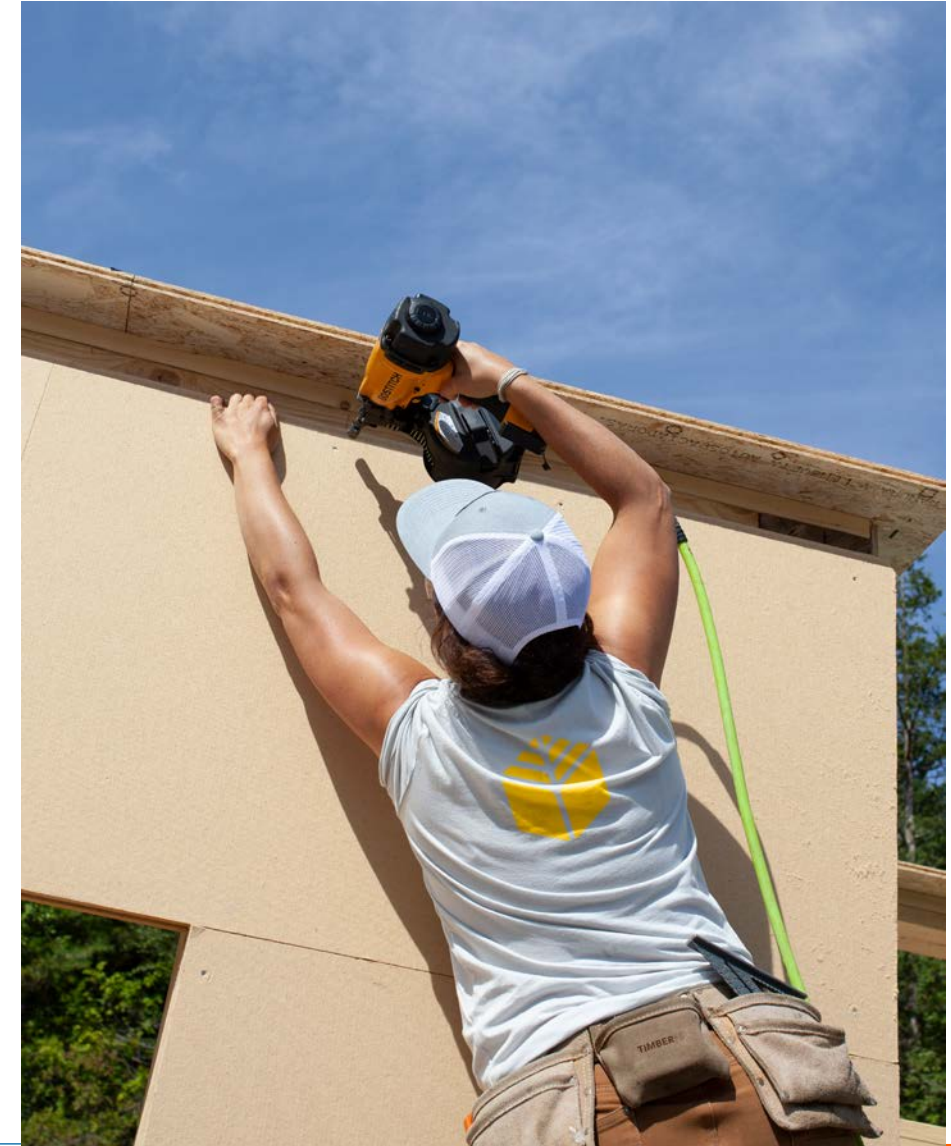


Photo courtesy of HP Timber





EMBODIED CARBON REDUCTION CHALLENGE

THE CHALLENGE: REDUCE UPFRONT CARBON OF BUILDINGS

ENTRIES DUE APRIL 3, 2024 | 5:00 PM





EMBODIED CARBON REDUCTION CHALLENGE

11

PRIZES

\$30,000 - \$50,000

20,000+

SQUARE FEET

New construction or renovation
in CDs by April 3rd, 2024

TRAINING

recorded/on-demand
free

1 YEAR

COMPETITION

VIEW & VOTE

People's Choice April - May

ATTEND

Boston Embodied Carbon Summit
June 20th and 21st





EMBODIED CARBON REDUCTION CHALLENGE

FREE ON DEMAND TRAININGS

- “Easy” Wins for Embodied Carbon Reduction
- Embodied Carbon Tools Overview
- Embodied Carbon Case Studies

More resources: <https://builtenvironmentplus.org/embodied-carbon-challenge/>

Concrete Environmental Product Declarations

READY-MIX CONCRETE PLANTS WITH EPD CAPABILITY FOR ALL MIXES

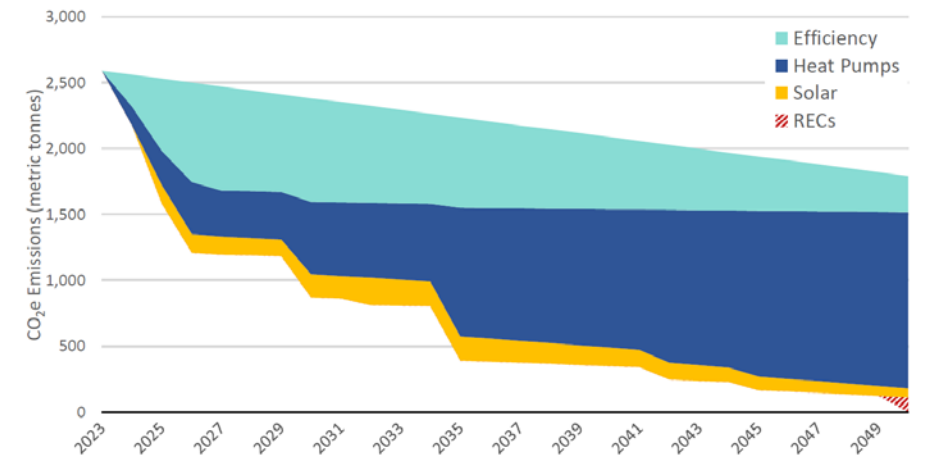
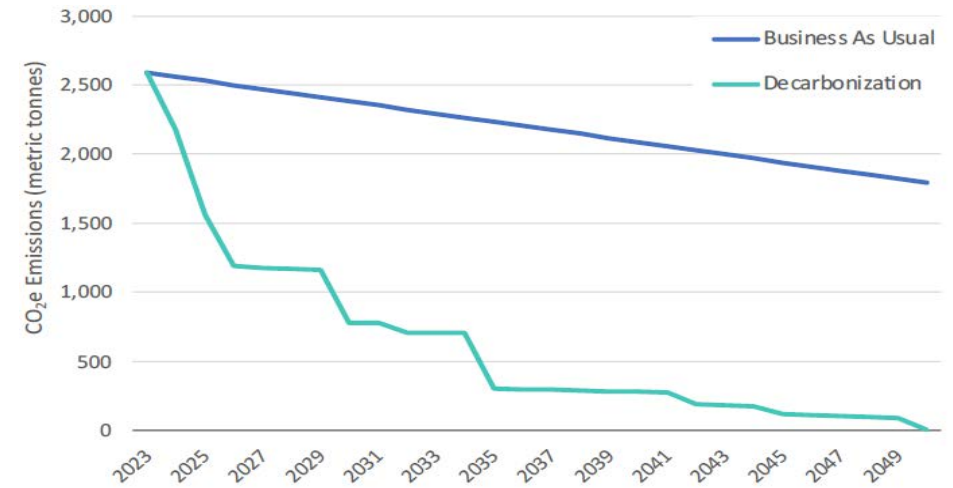
Company	# of plants	Location
Sterling Concrete	2	Oxford, Sterling
Holcim NE/Aggregate	3	Waltham
J. G. Maclellan Concrete Co	3	Lowell, Worcester, Lunenburg
Construction Service	2	Springfield, Northampton
Boston Sand and Gravel Co.	3	Boston, Rosenfield
Cape Code Ready Mix	4	Brewster, South Dennis, Sandwich
Dauphinais Concrete	3	Worcester, Norfolk (in process)
Tresca	1	(in process)
	21	
Jandris Block		



BETA: Non-Profits and Public Entities (Portfolio Roadmaps)


ROADMAPS FOR 2050-READY BUILDING PORTFOLIOS

- ▶ Decarbonization over time requires:
 - Understanding current and future emissions
 - Creating plan for emissions reductions aligned with capital needs
- ▶ With partner PowerOptions, BETA: NP provides **individual building and building portfolio roadmaps**, including:
 - Efficiency
 - Electrification, and
 - On- and offsite renewables
- ▶ To-date, PowerOptions has completed **22** portfolio roadmaps covering over **80** buildings, including a large public school district and the Boston YMCA



BETA: Non-Profit Roadmaps

COMMUNICATING THE PLAN



Building Decarbonization Roadmap

Prepared for The City of Melrose Public

PowerOptions

JULY 2023

Roadmap Timeline

The overarching roadmap timeline is shown below for the City of Melrose's ten buildings:

Building 1: Beebe Elementary School	Building 6: Melrose High School
Building 2: Franklin Early Childhood Center	Building 7: Melrose Memorial Middle School
Building 3: Hoover Elementary School	Building 8: Ripley Elementary School
Building 4: Horace Mann Elementary School	Building 9: Roosevelt Elementary School
Building 5: Lincoln Elementary School	Building 10: Winthrop Elementary School

- 2023**
 - Energy efficiency audit (all buildings)
 - Reassess heating setpoints and equipment schedules (all buildings)
 - Continue to reduce lighting and plug loads (all buildings)
- 2024**
 - Update or replace outdated building management systems (Buildings 2-7 & 9-10)
 - Implement building management system (Buildings 1 & 8)
 - Consider additional air sealing and insulation upgrades (Buildings 2-6 & 8-10)
- 2025**
 - Replace natural gas water heaters with heat pump water heaters (Buildings 5 & 9)
 - Installation of heat pumps (Buildings 2, 3 & 5)
 - Installation of on-site solar (Buildings 1, 2, & 5)
- 2026**
 - Upgrade windows (Buildings 1 & 2)
- 2027**
 - Installation of heat pumps (Building 9)
 - Replace natural gas water heater with heat pump water heater (Building 7)
- 2028**
 - Upgrade windows (Buildings 4-6)

...Continued on next page...

Energy Efficiency

Energy efficiency (EE) refers to any upgrade to a building that reduces energy usage and costs. Because energy efficiency projects are cost-effective today, our roadmap prioritizing it early in the roadmap to capitalize on energy savings for the remainder of the project.

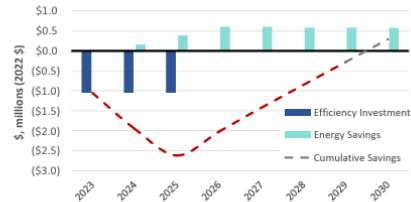
Based on one year of utility bills, the BETTER tool recommends at least the following **efficiency projects**:

- Reassess heating setpoints and equipment schedules within existing Building Management System (BMS) (Buildings 2-7 & 9-10)
- Implement BMS (Buildings 1 & 8)
- Retro-commission existing BMS and confirm it is working as installed and programmed in 2014
- Improve building envelopes and pursue additional air sealing (Buildings 2-6, & 8-10)
- Continue to reduce lighting and plug loads (all buildings)
- Upgrade windows (Buildings 1-2, 4-6, & 7-10)

Massachusetts offers strong incentives for commercial customers to implement certain efficiency projects. As a result, the up-front cost of efficiency projects is reduced by 58%. The **payback period is about 7 years**. Relative to operating "business as usual," the City will **save about \$550,000 annually on energy costs** by implementing efficiency projects.

Energy Efficiency Investment Summary:
 Investment: \$7.5m | Incentives: \$3.1m
 Net cost: \$3.1m
 Year 1 Savings: \$1.1m
 Annual Savings after Commissioning: \$1.1m
 Payback: 7 years

Figure 2. Net savings from implementing energy efficiency projects, 2023-2030.




Electrification

After the buildings have been made as efficient as possible, the next step is to electrify fuel equipment by converting space and water heating equipment to high-efficiency cooking ranges to induction ranges.

Heat pumps (HP) are an efficient all-electric solution for a building's space heating and hot water. Heat pumps work similarly to an air conditioner, but they are more efficient and provide cooling in the summer by operating in reverse. In contrast to fossil fuel heating equipment that has an efficiency of 80-95%, heat pumps have an efficiency ranging from 250% to 400%, meaning they produce more heat than is put into them. The two primary types are air-source heat pumps and ground-source heat pumps, often referred to as geothermal heat pumps, transfer heat to or from the ground to cool a building. Ground-source heat pumps are extremely efficient—even more so than air-source heat pumps—because the temperatures deep in the earth are constant year-round.

The ten buildings currently utilize natural gas boilers for space heating. Our recommendation is to replace these systems with ground-source heat pumps (GSHP) at Melrose Veterans Memorial Middle School and Melrose High School, and Variable Refrigerant Flow (VRF) heat pumps at the other buildings. VRFs are advanced heat pumps that can provide both heating and cooling to different parts of the building, and ductwork is not required in the buildings. We recommend starting these electrification projects around 2025 to maximize the remaining life of the City of Melrose's heating systems.

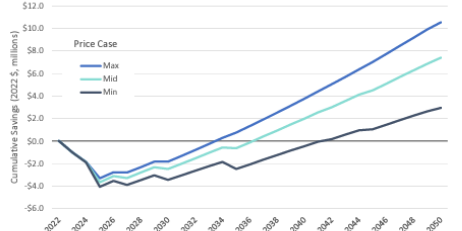
Figure 3. Recommended location of GSHP wellfield at Melrose Veterans Memorial Middle School and Melrose High School.



Financial Impact

After incentives, the total investment required to execute this roadmap is estimated at \$9 million. Of the possible ways to decarbonize the City of Melrose's buildings, we believe this is the most cost-effective way. Depending on future energy prices, the City of Melrose is expected to save between \$3 million and \$10 million by 2050 (Figure 6).

Figure 6. Cumulative savings from Decarbonization Scenario, by price case.



Implementation and Next Steps

This roadmap illustrates that the City of Melrose can cost-effectively reach net zero GHG emissions by 2050. To achieve that goal, we recommend setting interim targets of 50% by 2030 and 75% by 2040.

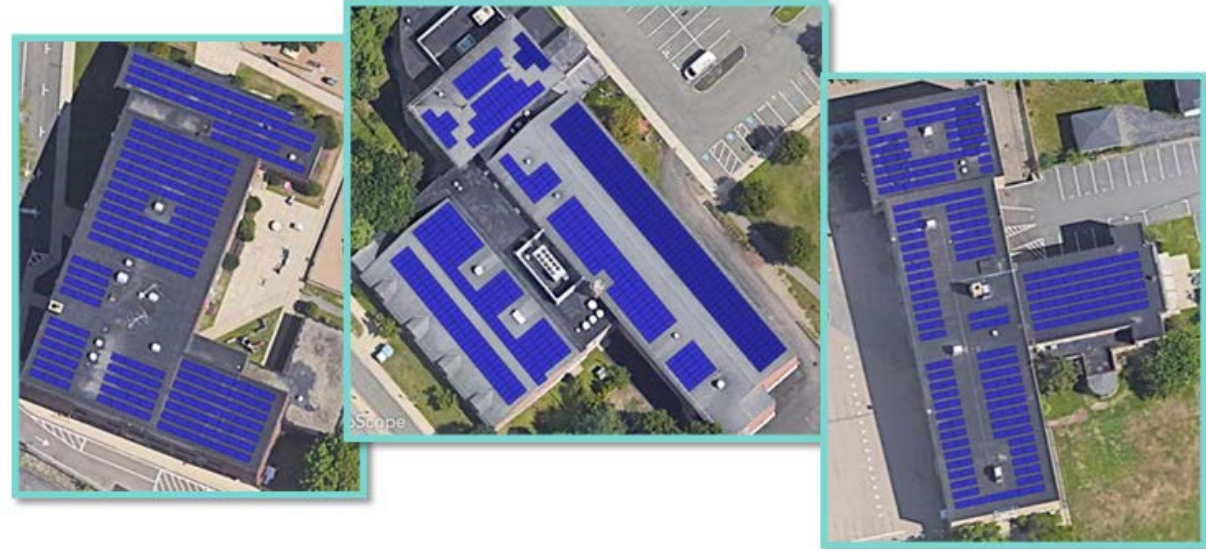
PowerOptions' assistance is available to put this roadmap into action. The first step to embarking on your building electrification roadmap is to receive a no-cost energy efficiency audit for your buildings. PowerOptions has an energy efficiency program to help you get started on this path. We have two utility-approved vendors on hand to conduct **free energy audits** and **implement turnkey efficiency solutions**. PowerOptions has been working with members to help streamline the process and ensure they are receiving maximum possible incentives, lowest costs on equipment through our competitive procurements, financing opportunities, and guidance and assistance through every step of the process. To get started, please contact Erin Camp, PowerOptions' Energy Sustainability and Analytics Program Manager at ecamp@poweroptions.org.



BETA: Roadmaps - Lessons Learned Informing Future Programming

BETA: NON-PROFITS AND PUBLIC ENTITIES (ROADMAPS)

- Roadmaps are the **first step in planning for full decarbonization**.
- High level direction on **which buildings and which projects to focus on first** is very valuable for internal communications early in decarbonization planning.
- Roadmaps **inform in-depth individual building project planning**.
- Due to grid emissions trajectory, **solar PV has an outsized role early** in a building decarbonization timeline.
- Opportunity to **build and characterize the pipeline for electrification and decarbonization** projects.



BETA: Commercial Buildings Pilot

OVERVIEW

- ▶ **Slipstream Group, Inc.** leading team of consultants to provide in-depth planning and technical decarbonization strategy studies, including all-at-once and zero-over-time approaches for a range of commercial building typologies.
- ▶ **"Deep dive" on decarbonization planning** the next step after initial planning efforts.
- ▶ Initial cohort to include at least 15 buildings, **application window is rolling** with regular review periods.
- ▶ **Market characterization report** published Fall 2023
- ▶ **Buildings Solicitation released November 1, 2023**
 - ▶ Over 50 applications to date

<https://www.masscec.com/program/beta-commercial-buildings-pilot>

TARGET OUTCOMES

- ▶ Example decarbonization plans for “2050-Ready” buildings.
- ▶ Gap analysis of technical and financial challenges to achieving 2050-Ready buildings.
- ▶ Decarbonization assessment framework based on ASHRAE II Audit protocol with additional capital planning and financing considerations.
- ▶ Case studies and white paper.
- ▶ Coordination with **Mass Save’s Deep Energy Retrofit** incentive program and identification of other implementation funding sources.



BETA: Commercial Buildings Pilot - Status Update

► Timeline Overview

- Market summary (complete)
 - Completed and used to inform project selection
- Protocol development (complete)
 - Draft internal assessment procedures and steps
- Reporting templates (Apr)
 - Roadmap completed and full report outline drafted
- Project enrollment (Jan-May)
 - On-going, 4–6-month timeline for custom plan completion
- Market resources (June-Dec)
 - Guideline develop to begin after first custom plans completed



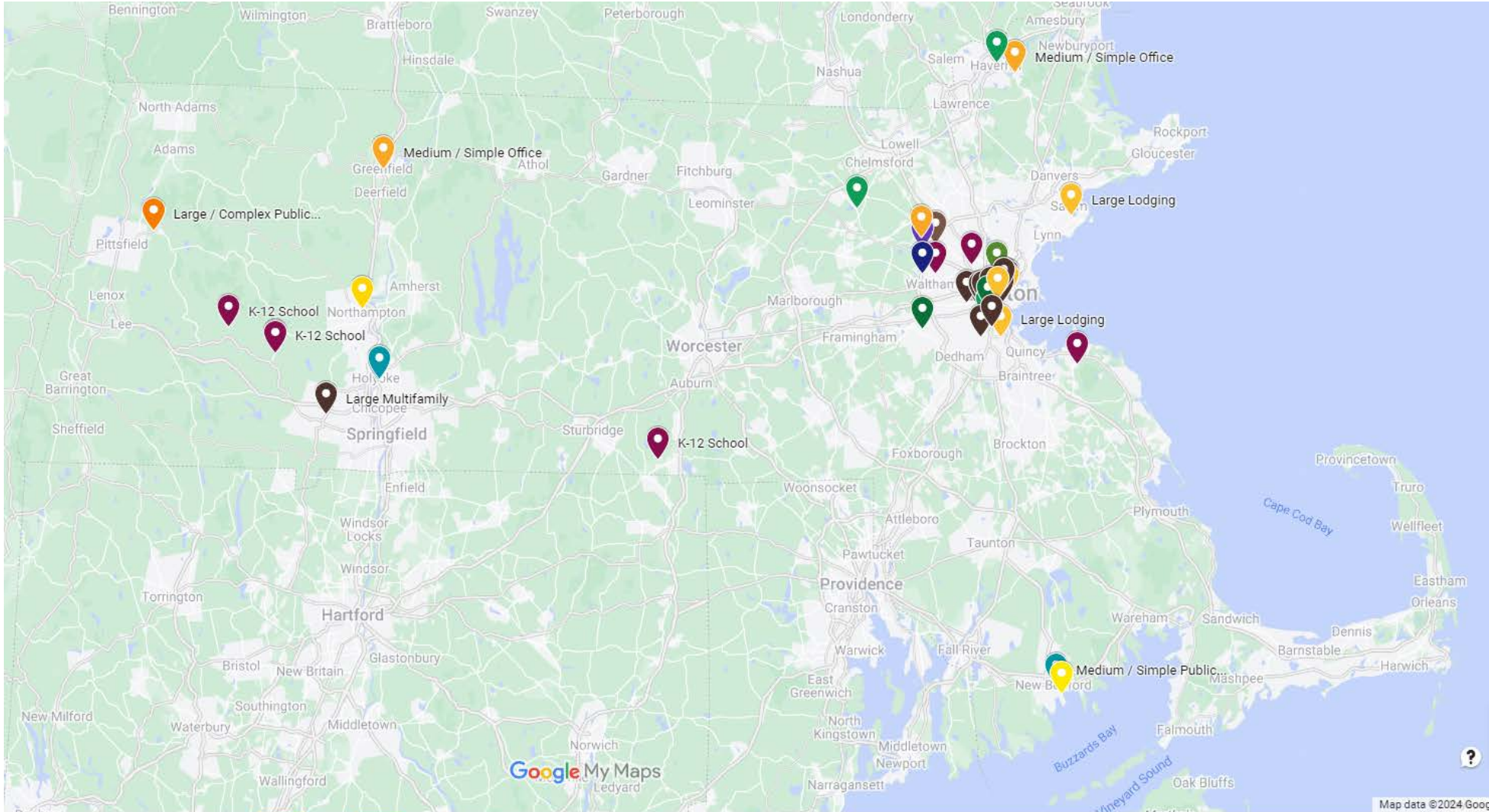
BETA: Commercial Buildings Pilot - Status Update

▶ Top Typology Targets

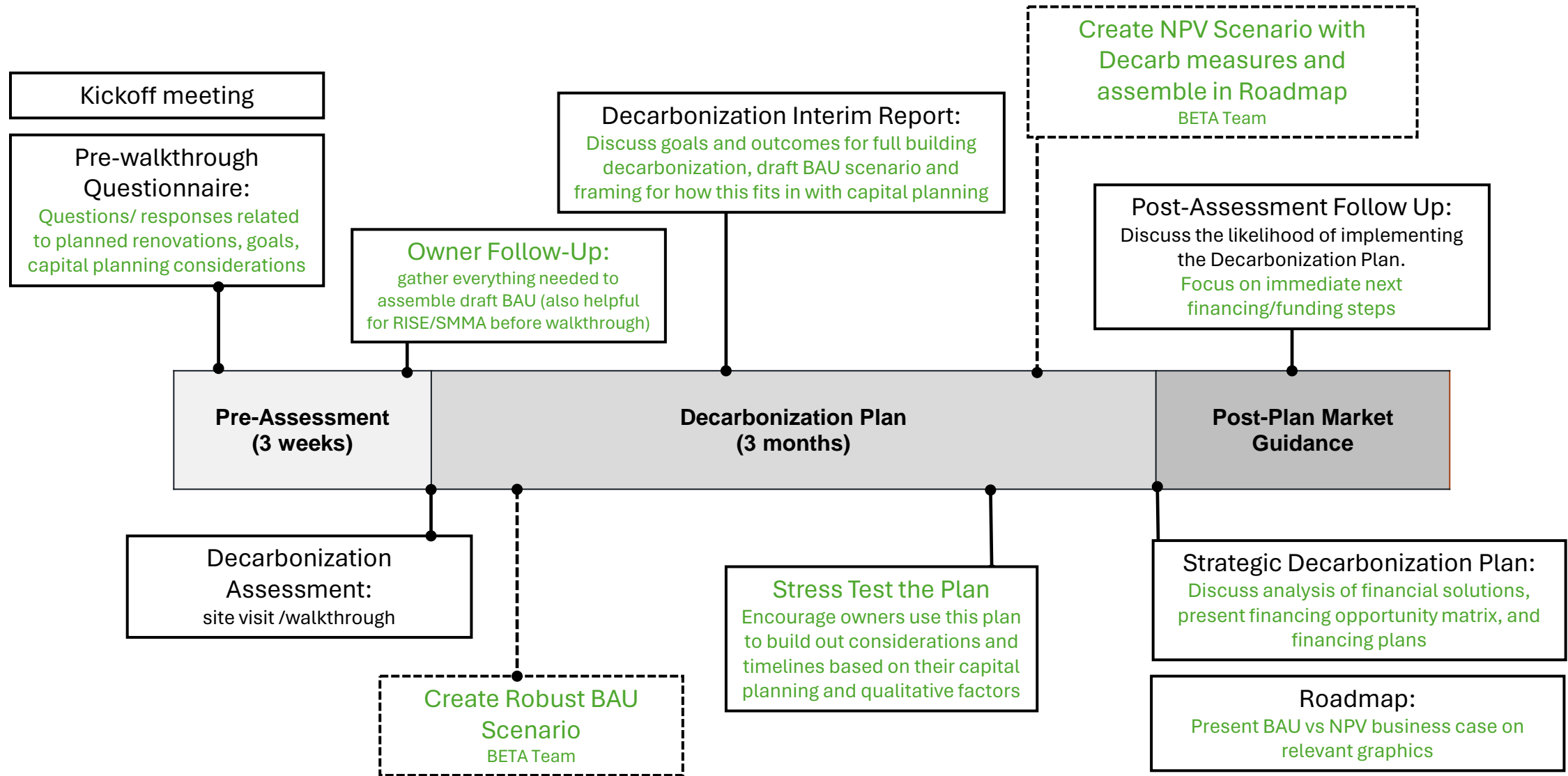
- Warehouse
- Mercantile
- Out-patient healthcare
- Religious worship
- Food service
- Grocery



BETA: Commercial Buildings Pilot - Applicant Map



Capital Planning - Owner Interaction Points



Capital Planning - Opportunity Matrix

➤ Combined list of funding and financing opportunities

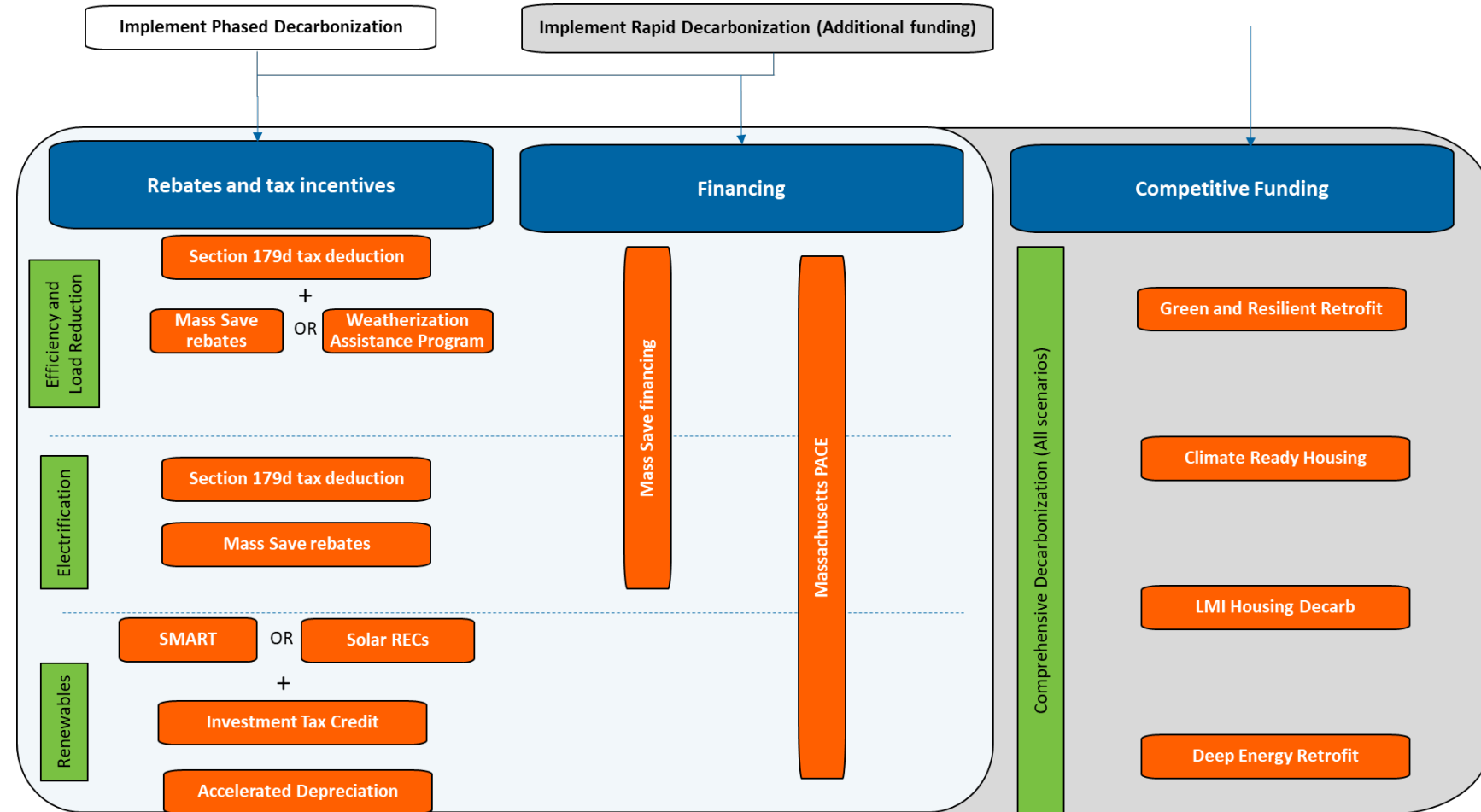
- Mass Save
- MA DOER
- MassCEC
- Federal tax incentives
- HUD resources

➤ Segmentation by decarbonization strategy

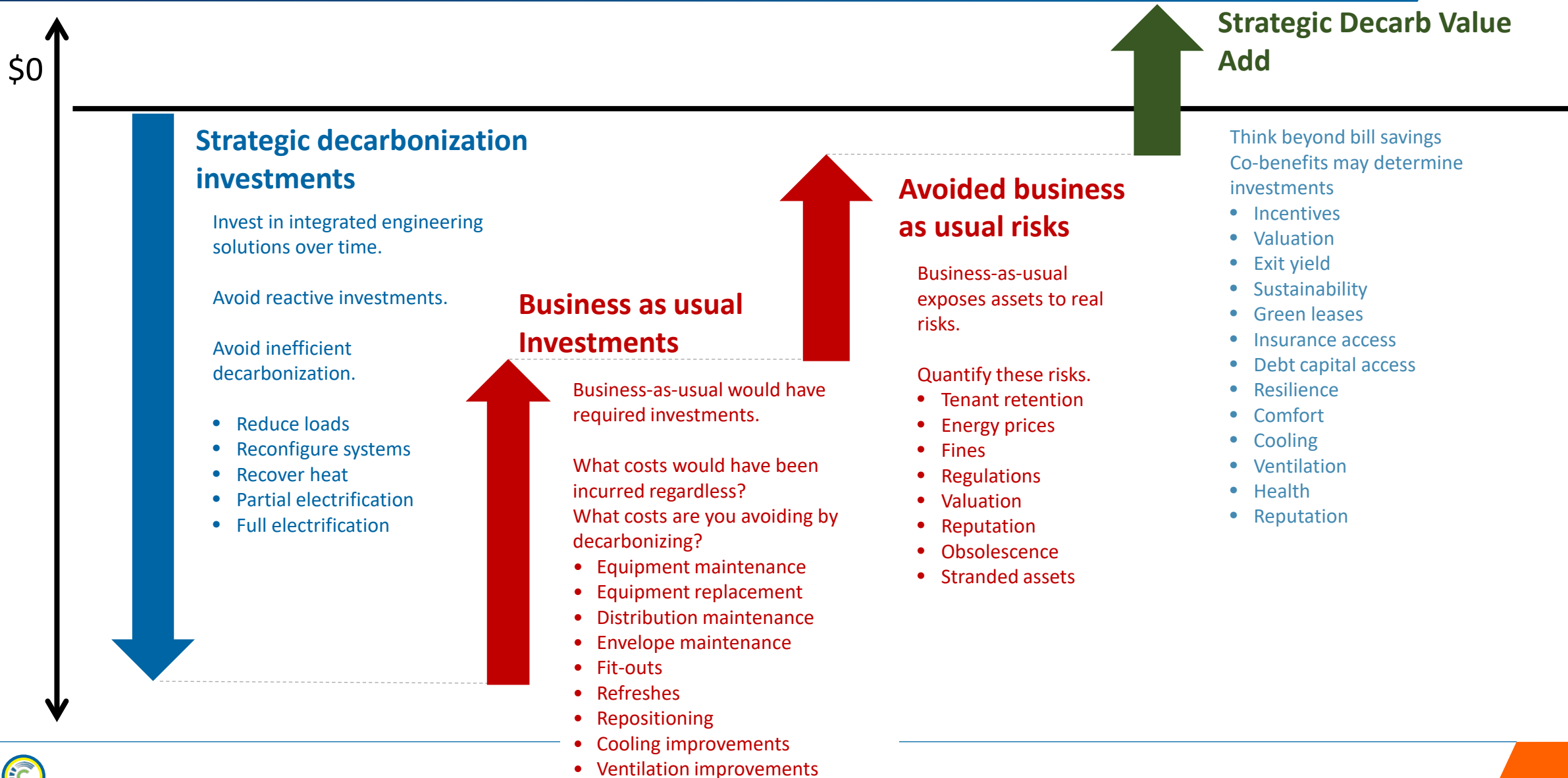
- HVAC and DHW electrification
- Building envelope improvements
- Renewable energy systems
- Energy Storage
- EV infrastructure
- Pre-weatherization upgrades

➤ Segmentation by building type

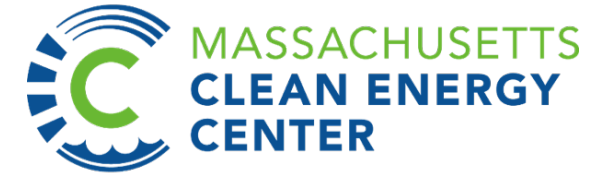
- Commercial
- Multifamily
- Other



Elements of a Strategic Decarbonization Net Value Add



Communicating the Decarbonization Plan



MassCEC BETA: Commercial Buildings Pilot

Carol Avenue Apartments

This building is a Commercial Building selection of commercial buildings.

Building type: Residential multifamily
 Location: Brighton, MA
 Year built: 1910
 Stories: 3
 Square footage: 34,883
 Existing energy use intensity (EUI): 80

Project Triggers & Goals:

- BERDO Compliance
- Capital Cycles
- End of Life Replacement

Decarbonization Performance Target

Based on our analysis of the property and the project goals set by the BETA team in coordination with the owners, Carol Avenue Apartments can reach a 55% EUI reduction and 41% greenhouse gas (GHG) reduction from the measures outlined in this case study. Carol Avenue plans to integrate heat pump water heaters in the future to align with impending GHG emissions compliance. Rooftop solar will be optimized to cover 19% of building electric loads.

Existing Conditions

Like many existing buildings in the Northeast, Carol Avenue has a historic brick façade and is subject to zoning restrictions that precluded the possibility of substantially retrofitting the envelopes from the exterior. The single pane windows and poorly insulated roof and walls contribute to poor overall air tightness and inefficiencies. Built in 1910, these apartments currently rely on gas-fired systems for heating and hot water, with no cooling or ventilation. Recent renovations have included a boiler replacement in 2013 and a kitchen and bath renovation in 2009.

MassCEC BETA: Commercial Buildings Pilot

Decarbonization Recommendations

- Energy Efficiency & Load Reduction**
 - Envelope improvements: EIFS over uninsulated masonry, new windows, new roof
 - 1 1/2" mineral wool board applied from inside
 - Efficiency improvements: All new LED lighting
 - New ENERGY STAR appliances
- Building Electrification**
 - Heating and cooling: Centralized, all-electric Variable Refrigerant Flow (VRF) system
 - Ventilation: Central fresh air distribution through common areas paired with in-unit bathroom exhausts
 - Hot water heating: Electric resistance water heaters (plans to convert to heat pump water heater)
- Renewables**
 - Two rooftop solar systems at 6 kW system each

Annual Energy Savings Projections

Annual Utility Project

Measure Description	Electricity Savings (kWh)	F	S	I
Interior Lighting	3,450	-	-	-
Appliances	(2,250)	-	-	-
Exterior Lighting	1,000	-	-	-
Heating & Cooling	(10,000)	-	-	-
Water Heating	(8,000)	-	-	-
Solar	29,000	-	-	-
Total (Recommended Measures)	(15,800)	-	-	-

19% of total load served by solar
64% EUI reduction

MassCEC BETA: Commercial Buildings Pilot

Pathway to Decarbonization

The order of implementation provides a list of the measures and actions within the scope of this decarbonization recommendation of the order for implementing them. The measures are grouped into bundles, based on when they are implemented at the same intervention point. This order of implementation outlines a maximum number of interventions however an all at once approach is advantageous for accessing incentives, minimizing upfront costs, and reducing risk.

Considerations

- 2025: BERDO regulations are enforced
- 2027: end of service life for existing boiler
- Tenant relocation will likely be necessary during this stage of intervention
- 2030: Renewable energy tax credits from the IRA expires
- Electric resistance water heater will have approximately 10-year life span. Upgrading to WSHP will improve efficiency by 50%

Order of Implementation

- Envelope Improvements: EIFS over uninsulated masonry, new windows, new roof
- Lighting & Appliances: Install new LED lights and appliances
- Electrical Service Upgrade: Upgrade electrical for mechanical system electrification
- Existing Boiler: Remove existing gas-fired boiler
- Central ASHP: Install 2 ASHPs for space heating and cooling
- Electric Resistance Water Heater: Install x water heater temporarily for building electrification
- System Controls: Install new system controls for mechanicals
- Renewables / Energy Storage: Install rooftop solar to offset the energy load by 19%
- WSHP for DHW: Install modular WSHPs supplied by hydronic loop
- Central DOAS+ERV: Heat pump DOAS with ERV to supply tempered air to units via common areas
- Exterior Lighting: Install LED exterior lights
- High Efficiency Appliances: Install all new ENERGY STAR appliances

Total GHG reduction potential from assessment

*Full decarbonization will be achieved as the electrical grid decarbonizes
 GHG calculations are based on eGRID

MassCEC BETA: Commercial Buildings Pilot

Cost Analysis

Available Incentives

The estimated value of available incentives is based on project scope. Some of these incentives are performance based and may vary based on measures taken to improve building performance. Many of these incentives are only available within a fixed time frame, without promise of their renewal, emphasizing the value in making upgrades as soon as possible when incentives can help cover the cost of decarbonization.

- DOER
- Climate Ready Housing
- Mass Save
- IRA Rebates
- Solar Tax Credits
- Boston Mayor's Office of Housing
- Green and Resilient Retrofit Program
- Greenhouse Gas Reduction Fund

Operating Cost Comparison*

*Forecasted operating expenses and costs, and full measures are assumed

MassCEC BETA: Commercial Buildings Pilot

Decarbonization Benefits

Emissions Forecasting

BERDO greenhouse gas emissions requirements are a guideline for tracking building emissions to align with Massachusetts's goal of reaching net zero by 2050. The graph is based on building emissions over time as the grid cleans if all recommendations were to be implemented now. The two decarbonization pathways outline an all-at-once approach and a phased approach that follows the dates provided in the key considerations.

Building Resilience

Building envelope renovations can also improve a building's resilience during power outages, where buildings with higher performance envelopes can retain indoor temperatures for longer in extreme weather. Other climate change impacts include poor air quality and higher temperatures, especially in urban areas, which can be mitigated through decarbonization measures. High performance building envelopes when paired with an integrated and all-electric heating, cooling, and ventilation systems provide tenants with fresh, temperate air consistently.

Climate Risk Rating Summary	Sea Level Rise/Storm Surge	Extreme Precipitation: Urban Flooding	Extreme Precipitation: Riverine Flooding	Extreme Heat
Asset Risk				

Next Steps and Best Practices

- Energy Audit
- Decarbonization Assessment
- Hire Design Team
- Apply for Incentive Funding
- Assemble Capital Stack
- Start Construction

Within the scope of this decarbonization assessment, this building has completed an energy audit and feasibility study for the outlined decarbonization measures. The data and scoping from this assessment can be used by design teams, including architects and engineers, to begin drafting project plans and timelines which will help bolster applications for incentive funding. As you start to assemble these resources with your project team for applications, it is important to consider various funding and financing opportunities to assemble the project capital stack, as these projects tend to have a mix of sources.

(in progress)



Find High Performance Pros with proven experience

Find a Pro Search

Profession Type

All



Project Type

All



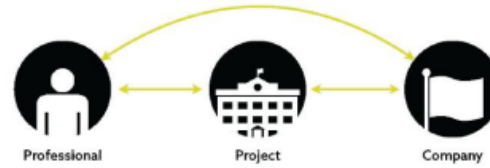
Show Me*

Professionals by # of Projects



SEARCH

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1. Everything is interconnected.

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Sort by

Number of Projects

Top Result



2. Filtering and sorting is super-powered by project data.

The results reward companies and individual professionals with proven high-performance project experience.

CONTACT



PROFESSIONAL
Name
Credentials

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EMAIL

3. Search users are guided to contact a professional directly.

Results are ranked by relevant industry and project experience, and once they discover a potential collaborator, they are always guided to a selected contact.

All U.S. States and Territories



Filter by

Profession Type

- Architecture
- Construction
- Development
- Engineering
- Sustainability Consulting

4. Companies, pros, and projects can be anywhere in the U.S.

Architects, contractors, developers, engineers, sub-contractors, and sustainability consultants who work on commercial and large residential buildings are welcome.

Building Energy Exchange - RFP \$4 million over 4 years

The Challenge: Building professionals don't have central organization where they can find content and training related to retrofit strategies on buildings <20K sf

- When decarbonization roadmaps, resources, and examples do exist, that information is not reaching audiences that need the information.

Invest in a Building Energy Exchange for Buildings >20K sf:

- Model on hubs in NYC (Building Energy Exchange), Washington DC (Building Innovation Hub), St. Louis, Kansas City & those developing in Denver and Chicago.
- Provide multiyear funding to build out staffing, informational events, and resources for 4 years.
- Host events highlighting existing, newly customized, and developing retrofit resources
- Hold online and in person events with recordings for on-demand viewing.



Salem Heights Deep Retrofit - POAH



Thank you!!

- ▶ Beverly Craig bcraig@masscec.com
- ▶ Tom Chase tchase@masscec.com

