BUILDINGENERGY BOSTON

Onward to 2050! Two Existing Commercial Building Decarbonization Case Studies

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Northeast Sustainable Energy Association (NESEA) | March 23, 2026

MassCEC BETA: Existing Buildings' Pathway to Net Zero/ Introduction

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MassCEC BETA: Existing Buildings' Pathway to Net Zero/ SMMA

10+

NZE/NZER schools

65+

LEED certified projects

15+

GHG Emissions Carbon Analysis

1st project in New England awarded WELL Platinum

55

Professionals certified in LEED, Fitwel, WELL, Living Future, and Passive House

Recent Fitwel Platinum Certification

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MassCEC BETA: Existing Buildings' Pathway to Net Zero/ Program Overview

BETA:
Building Electrification and Transformation Accelerator

- **Decarbonization analysis** [Case studies]
- **Decarbonization protocol development**

45+

Existing Facilities

Geographical diversity

Environmental justice communities

Diversified building types:

- Commercial
- Institutional
- Healthcare
- Residential/multi-family

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BETA Partnerships:

slipstream

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RISE
AN EMPLOYEE-OWNED COMPANY

RMI
ENERGY, TRANSFORMED.

TSK Energy Solutions LLC
Energy Innovations

MassCEC BETA: Existing Buildings' Pathway to Net Zero/ Program Overview

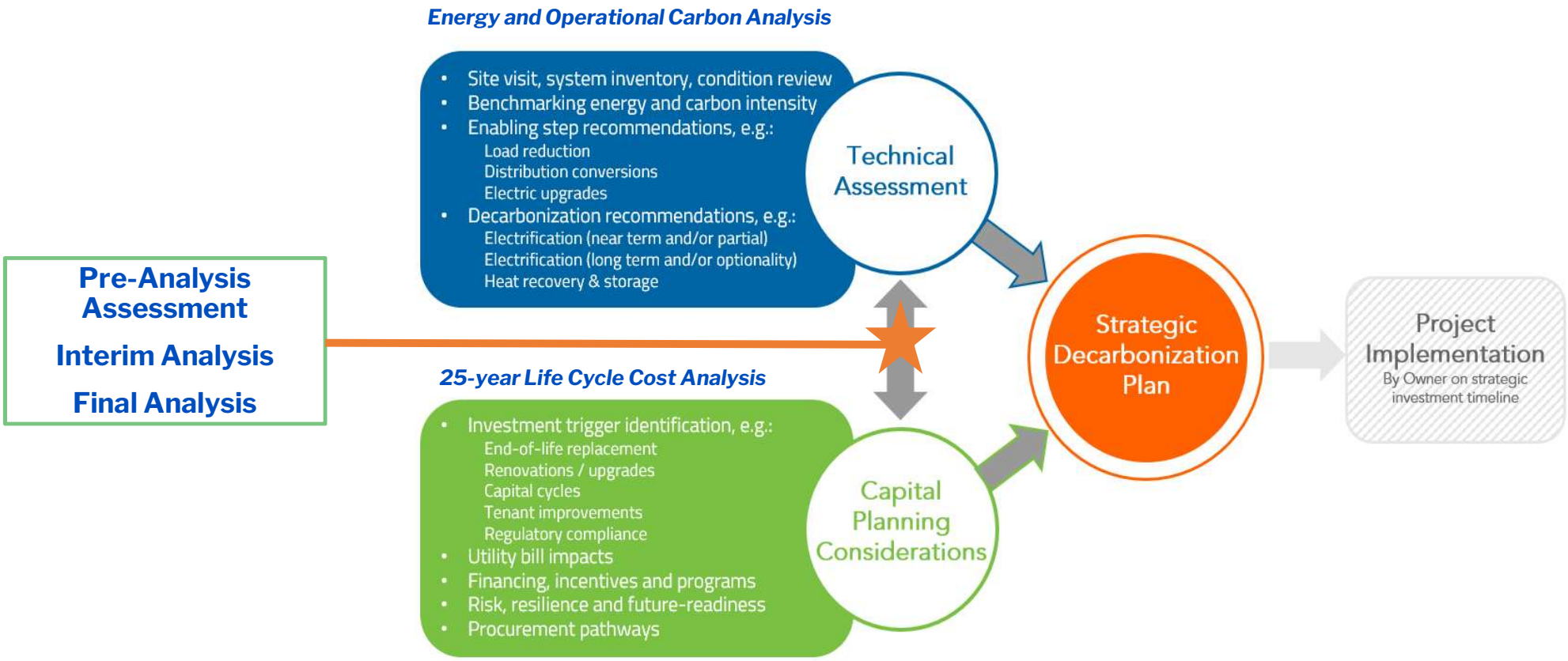
BETA Vision:

- Establish a foundation for long-term decarbonization planning, giving owners a starting point and strategic roadmap to eliminate fossil fuels and reduce building emissions.

BETA Assessment Goals:

- Align the commercial building stock with state GHG emissions reduction goals.
- Provide building owners an industry-wide road map to optimized decarbonization by 2050.
- Prioritize the most effective all-electric HVAC solutions.
- Site-specific based reports with replicable and comprehensive decarbonization strategies and best practices for electrification of heating and cooling systems.

MassCEC BETA: Existing Buildings' Pathway to Net Zero/ Program Approach



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MassCEC BETA: Existing Buildings' Pathway to Net Zero/ Preliminary Key Challenges and Solutions

Case Study 1
Commercial / Boston Lab-Office Facility

Challenge	Solution
High ventilation building type	Install energy recovery coils in exhaust air stream (i.e. Konvekta heat recovery type) to capture significant heating and cooling savings.
Limited mechanical space	Prioritizing foundational energy efficiency and load reduction measures to reduce the energy demand for new mechanical equipment upgrades needed for electrification.
Staggering equipment replacement timeline	Equip AHUs with water coils designed for future electrification at time of replacement.

Case Study 2
K-12 Education / Massachusetts High School

Challenge	Solution
Thermal discomfort in classrooms	AtWHP adding cooling to unit ventilators (refurbished). Air sealing to reduce drafts
Nonfunctional existing solar PV and aging roof	Remove existing solar PV and consider increasing insulation at time of roof replacement. Install new (expanded) solar PV system.
Multiple HVAC systems service different areas	Multi-system AtWHP and HP RTUs/HRVs systems to minimize intrusive and costly interior renovations.

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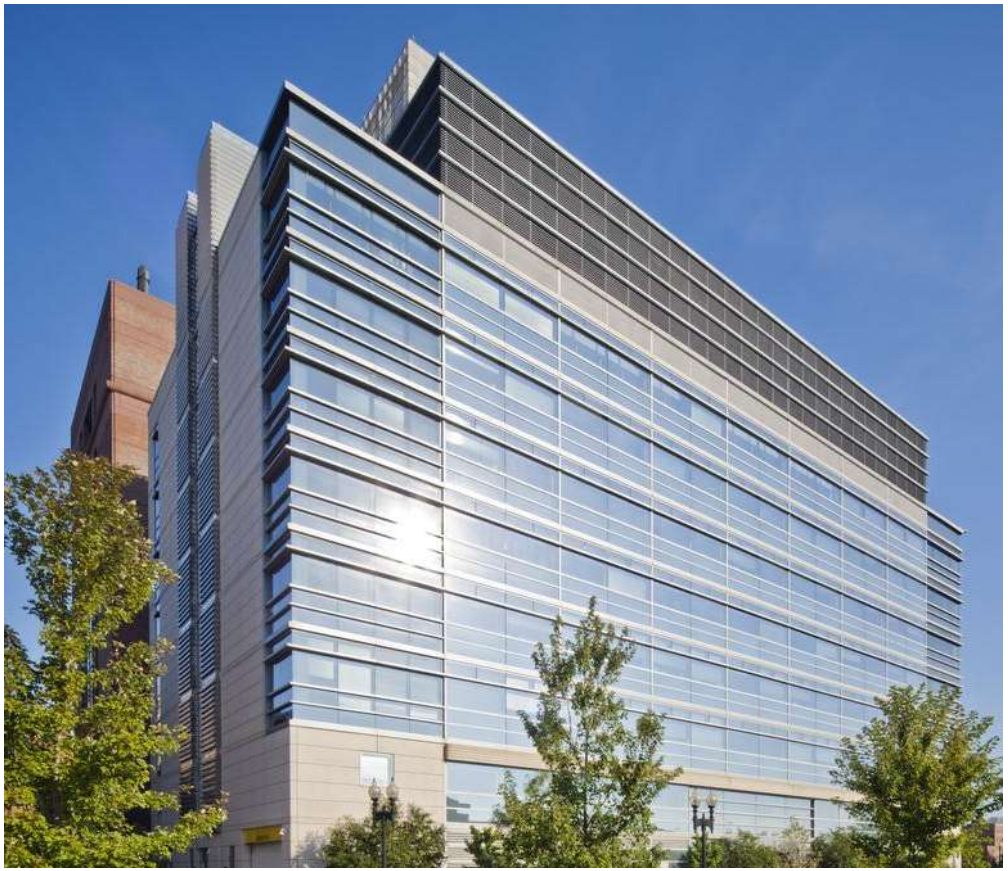
MassCEC BETA: Existing Buildings' Pathway to Net Zero/ Case Study 1

Bio-Medical Lab-Office Facility

Boston, MA

Bio-Medical Lab-Office Facility / Pre-Analysis

- **2005 Construction**
- **HVAC systems:**
  - District Steam heating and DHW
  - Chilled Water cooling
  - 100% OA to VAVs, Hot Water reheat
  - Ventilation: lab exhaust system, no heat recovery
  - BAU Replacement of mechanical systems between 2025-2035
- **Frequent tenant turnover/fit outs**
- **2005 Enclosure in good condition**
- **Roof replacement due in 2035**



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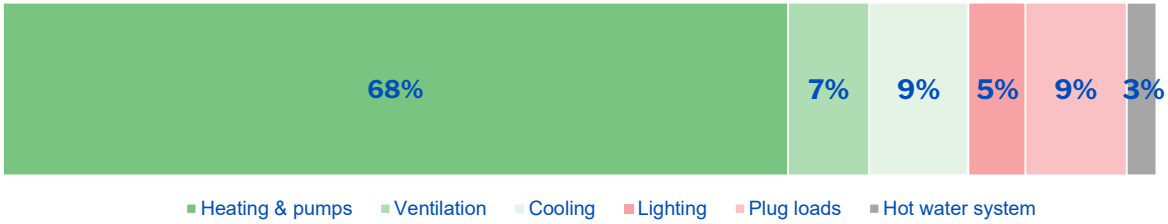
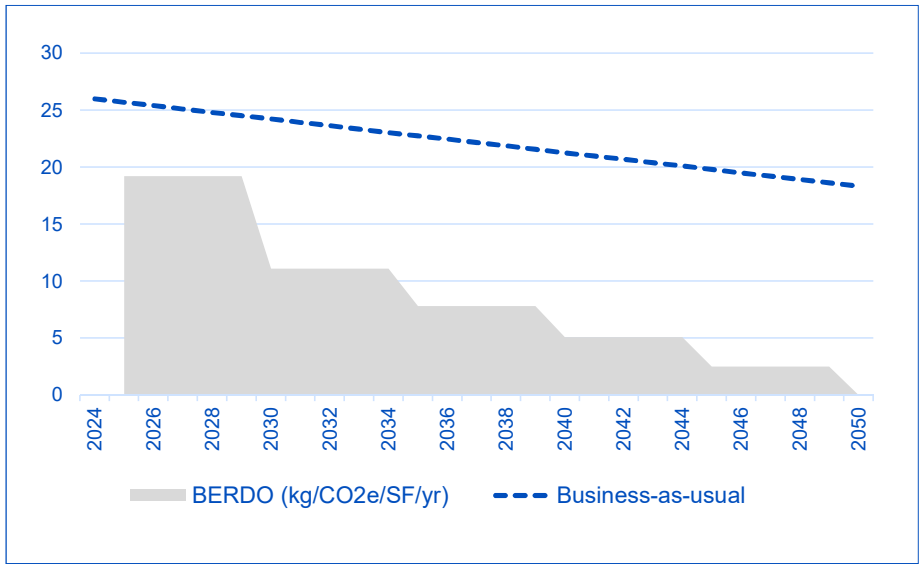
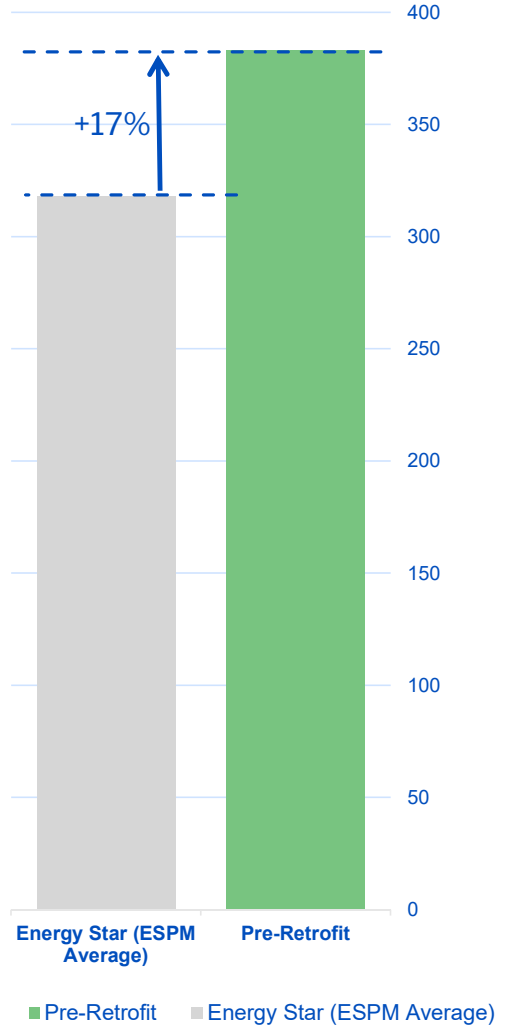
Bio-Medical Lab-Office Facility / Interim Decarbonization Analysis

GHG emission break down by end use





Note: *Currently BERDO does not recognize any green ("clean") steam initiatives, and thus the BERDO emission factor for district steam remains static through 2050.*



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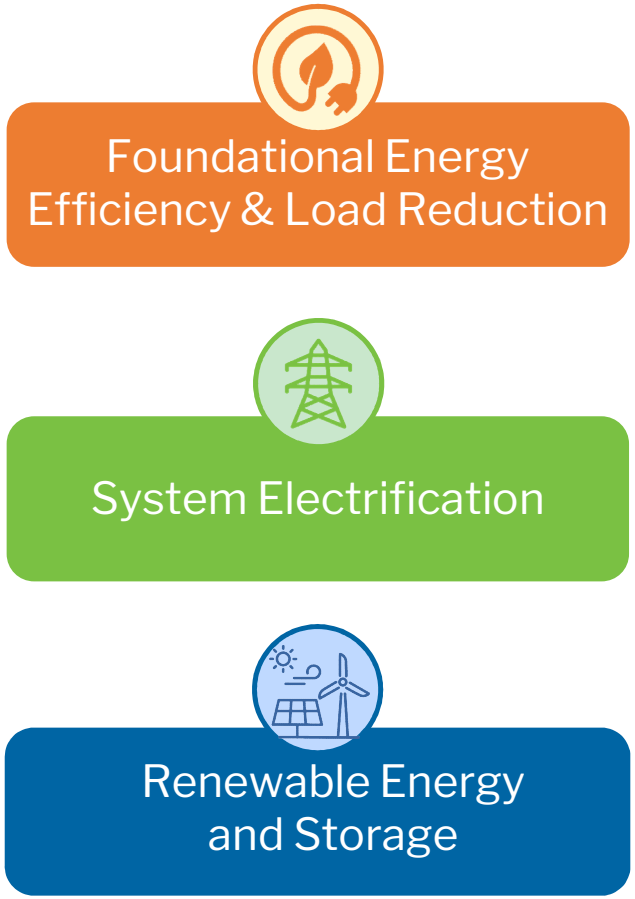
Bio-Medical Lab-Office Facility / Comprehensive Decarbonization Approach



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Bio-Medical Lab-Office Facility / Comprehensive Decarbonization Approach

Foundational Energy Efficiency & Load Reduction

Foundational Energy Efficiency

- LED lighting and Controls
- Demand Control Ventilation (DCV)
- Temperature Setbacks

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Foundational Load Reduction

- Air sealing and Weatherstripping

Advanced Load Reduction

- Roof replacement

Included in the base electrification analysis

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Bio-Medical Lab-Office Facility / Comprehensive Decarbonization Approach

System Electrification

Simplified Electrification

- New energy recovery air cooled heat pump chillers.
- New HP DHW system.
- Maintains existing HW reheat in VAVs.

- *Minor impact on interior upgrades*
- *Lower upfront costs*

Optimized Decarbonization 1

- Simplified Electrification
- Heat Recovery (Konvecta type)
- Foundational Energy Efficiency and air sealing and weatherstripping measures.

Intrusive interior upgrades:

- *New heat recovery coils (Konvekta type) to AHUs/exhaust*
- *Requires replacement of AHUs with potential limited penthouse space*

Optimized Decarbonization 2

- Optimized Decarbonization 1
- Roof replacement with added insulation (Code).

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Bio-Medical Lab-Office Facility / Comprehensive Decarbonization Approach

Renewable Energy and Storage

Solar PV

- Roof Solar PV not feasible
- Consideration for a 200kW Battery Storage

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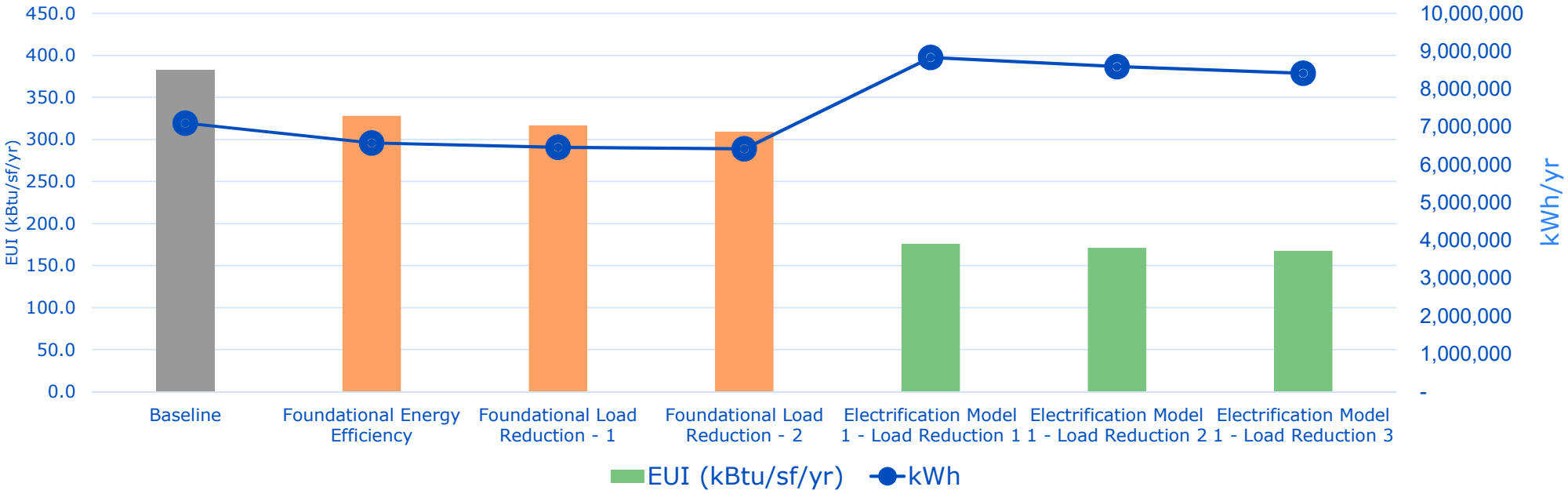
Bio-Medical Lab-Office Facility / Decarbonization Measures Summary



Scenario	EUI (kBtu/sf/yr)	kWh	Therms	% Progress to ZNC
Baseline	444.5	8,922,391	473,460	0%
Foundational Energy Efficiency	321.1	6,576,557	337,890	28%
Foundational Load Reduction - 1	310.1	6,462,924	322,140	30%
Foundational Load Reduction - 2	302.1	6,423,500	310,570	32%
Simplified Electrification	172.3	8,836,664	-	57%
Optimized Decarbonization 1	167.5	8,593,198	-	59%
Optimized Decarbonization 2	164.5	8,419,998	-	59%

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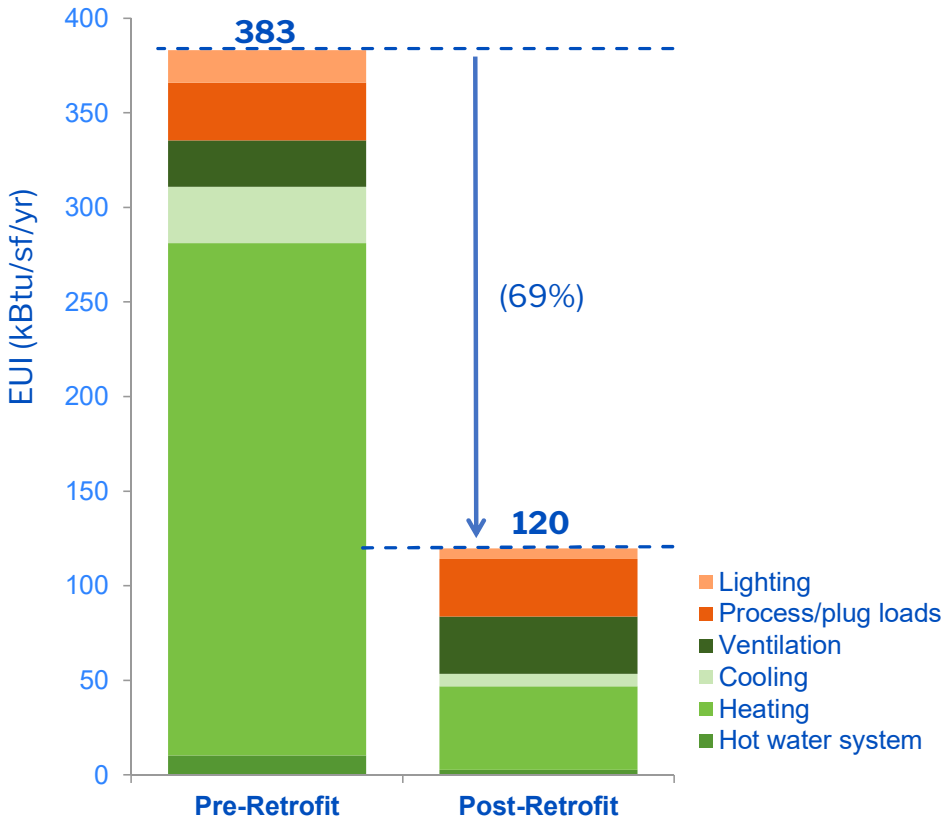
Bio-Medical Lab-Office Facility / Annual Energy and Cost Impact Final Analysis



Measure description	Changes in annual utility costs		
	Electricity	*Fossil Fuel (Steam)*	*Net total changes*
Lighting	($150,990)	-	($150,990)
Process/plug loads	($13,488)	-	($13,488)
Ventilation	$59,823	-	$59,823
Cooling	($297,221)	-	($297,221)
Heating	$37,462	($593,894)	($556,432)
Hot water system	$35,023	($26,900)	($8,123)
Total from recommended measures	**($329,391)**	**($620,794)**	**($950,185)**
Renewable energy	($98,055)	-	($98,055)

Note: A 200kW battery storage system may reduce peak load energy use by up to 13%.

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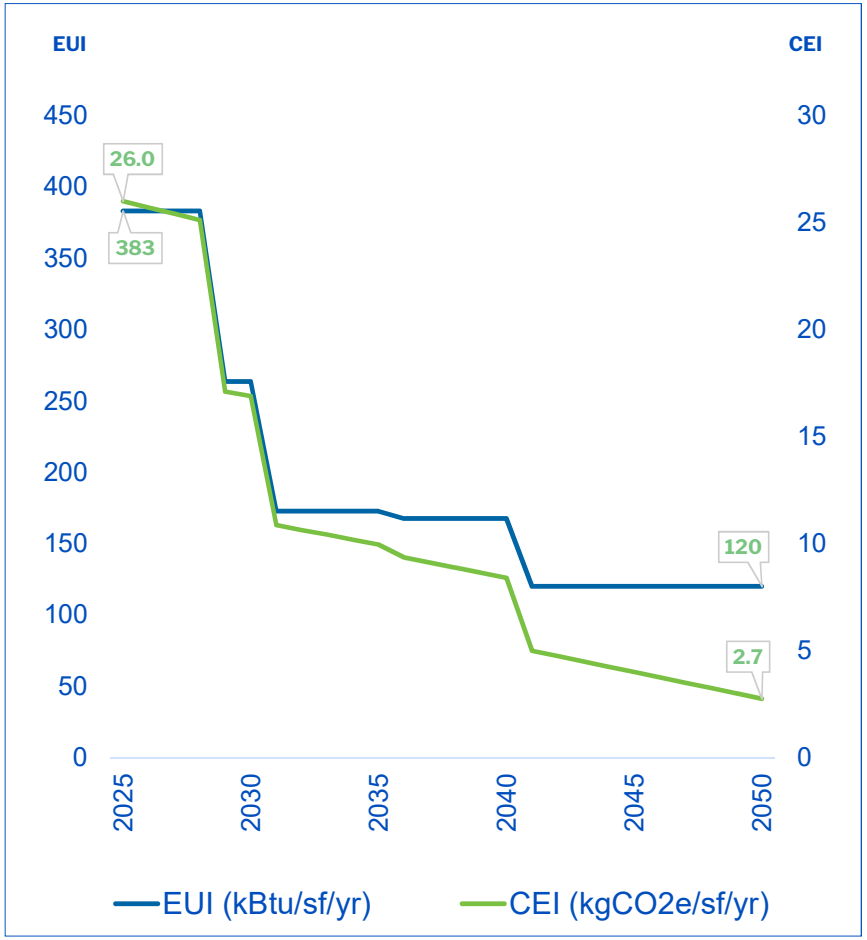
Bio-Medical Lab-Office Facility / Energy and GHG Emissions Benchmarking



2050: Pending on Massachusetts Grid Emissions and Solar PV production, Owner may have to procure GHG Offsets.

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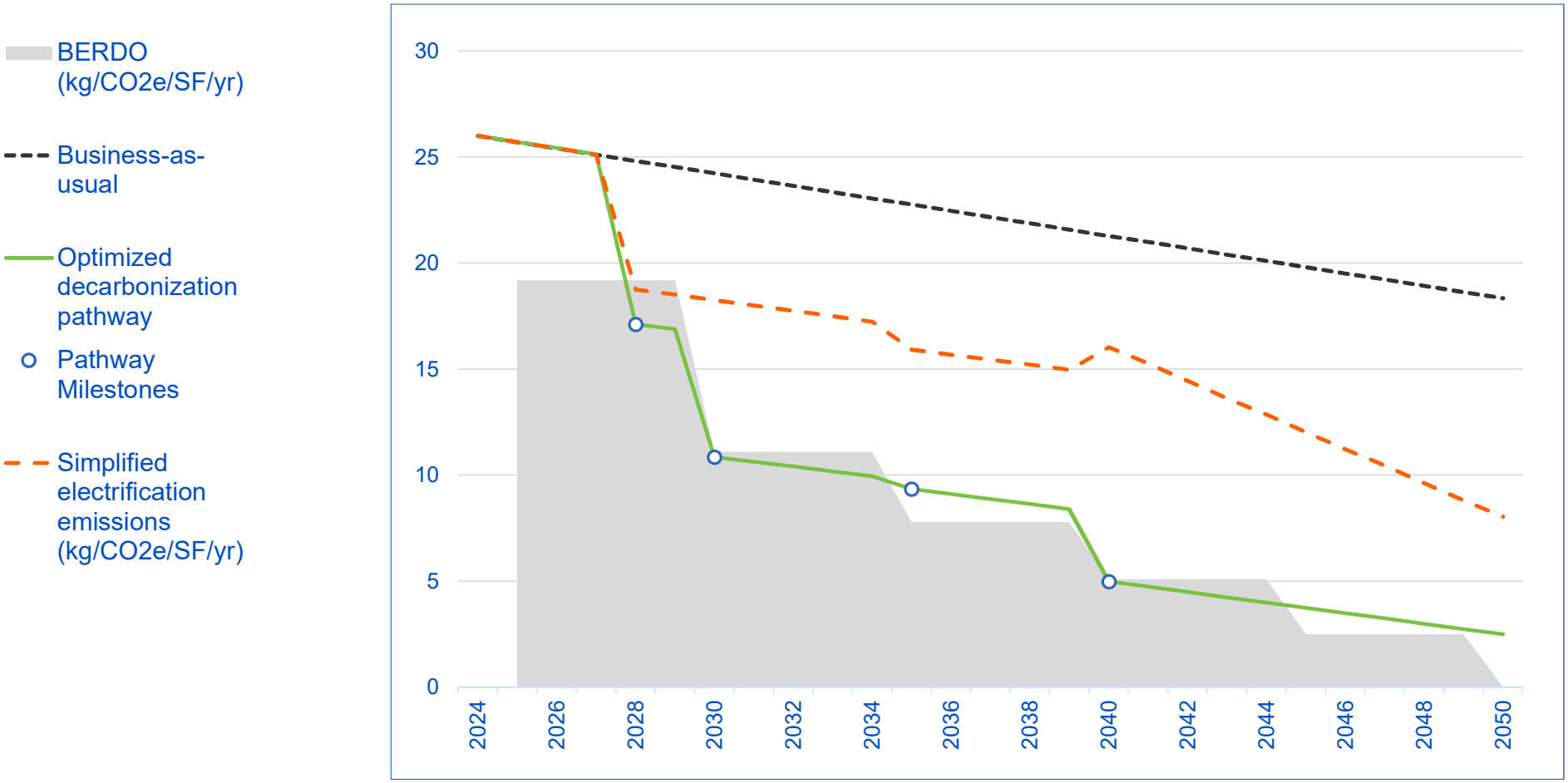
Bio-Medical Lab-Office Facility / GHG Emissions CEI Benchmarking vs. BERDO



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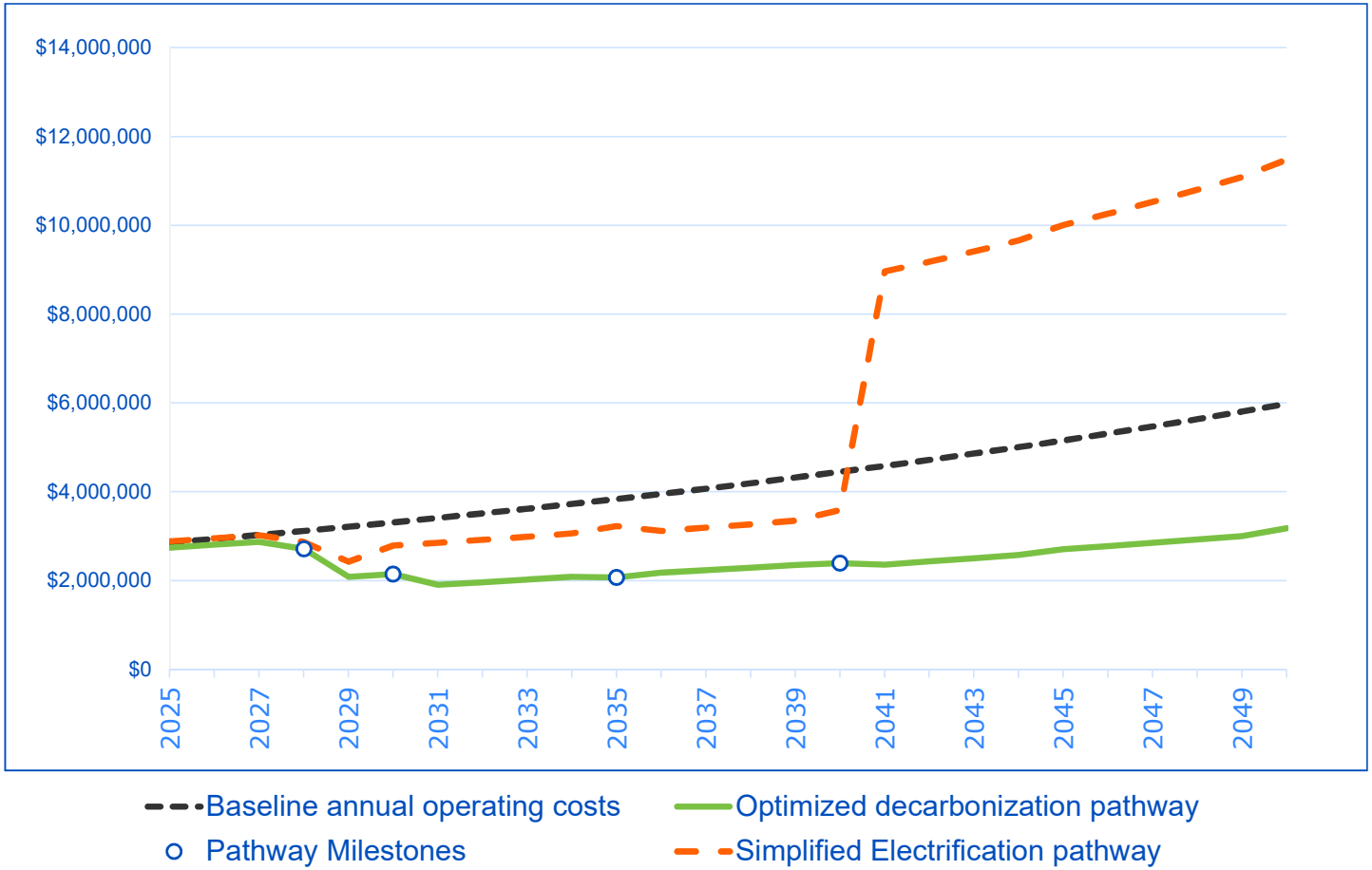
Bio-Medical Lab-Office Facility / 25-Year Operating Cash Flow



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Bio-Medical Lab-Office Facility / 25-Year Life Cycle Cost Analysis

Costs	BAU retrofit	Optimized decarbonization pathway
Base building and envelope costs	$1,123,000	$2,966,000
		$1,210,000
Mechanical costs	$23,246,000	$2,739,000
		$23,639,000
Renewable energy costs	$0	$838,000
Soft costs	$8,529,000	$10,028,000
Total upfront costs	**$32,898,000**	**$41,420,000**
Utility incentive opportunities	$0	$1,530,000
25-year total accrued utility costs	$108,226,000	$61,030,000
25-year accrued total operating costs	$110,211,000	$64,227,000
25-year LCCA	**$143,109,000**	**$104,117,000**

Foundational efficiency and load reduction

Advanced load reduction

BAU= Code level Roof

Electrification enablers

System electrification

BAU= larger HVAC sizing (no heat recovery)

Renewable energy

BAU= higher future fees (Carbon)

Payback period for incremental costs: 4 years

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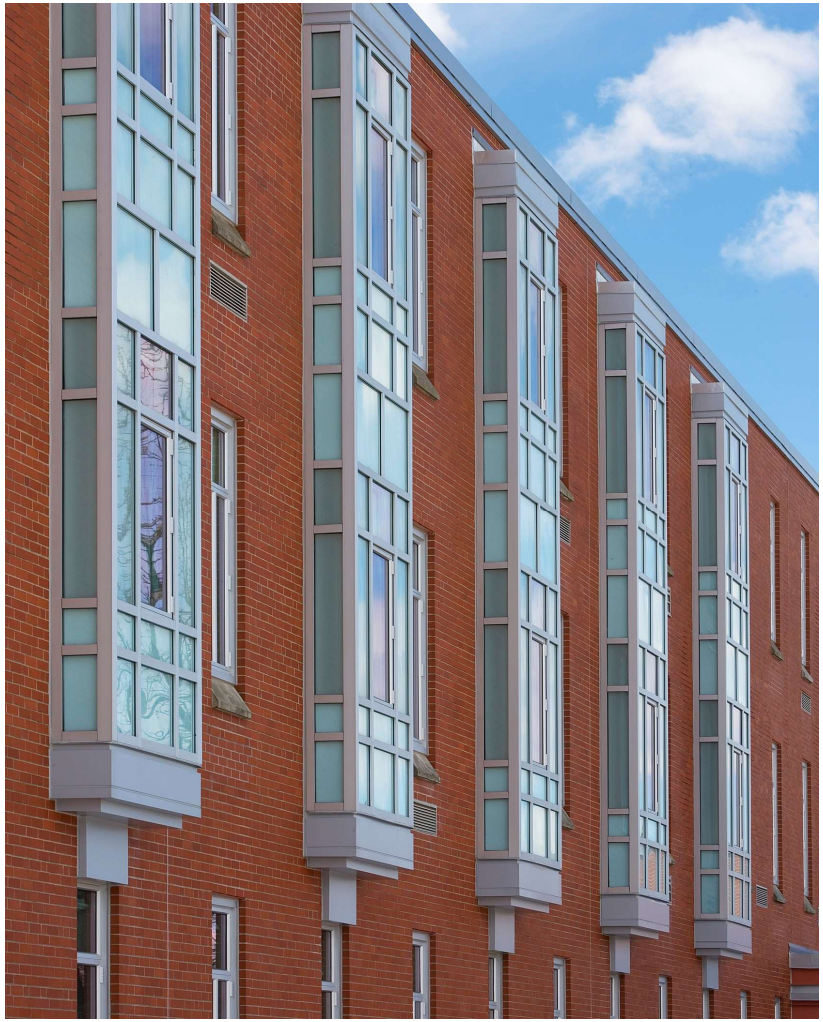
Massachusetts High School

Western MA

MA High School / Pre-Analysis

- **2004 Renovation/Addition**
- **HVAC systems:**
  - Natural gas heating, DX cooling
  - Classrooms: unit ventilators, no cooling
  - Auxiliary spaces: RTUs and a few HRVs
  - Central DHW
  - Replacement between 2025-2035
  - Low floor to structure
- **Roof replacement due**
- **Enclosure in good condition**
- **Pool building excluded from analysis**
- **Existing Solar PV (2004), not functioning**



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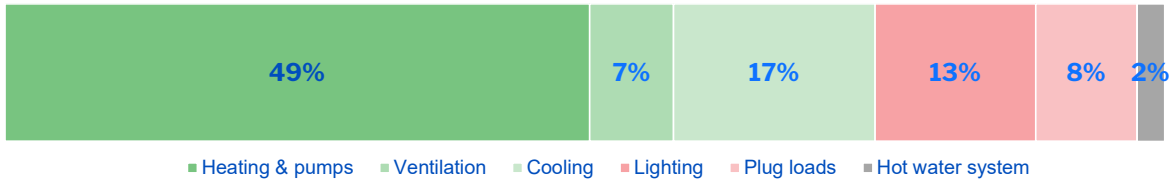
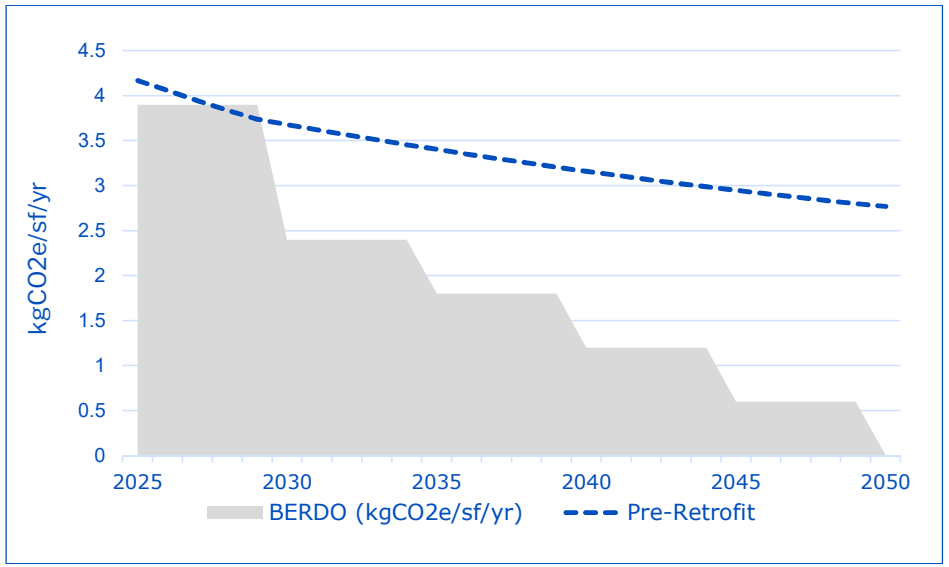
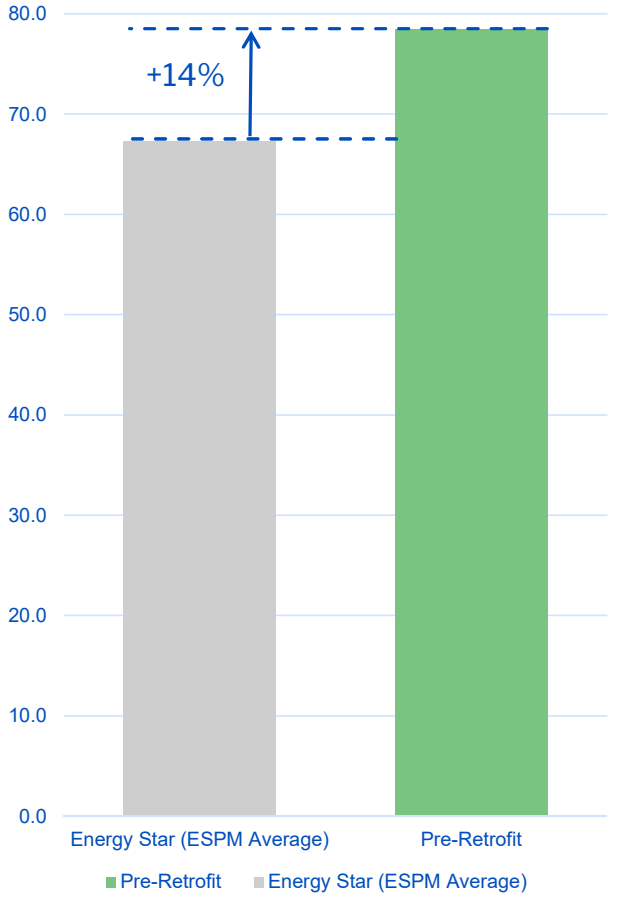
MA High School / Interim Decarbonization Analysis

GHG emission break down by end use







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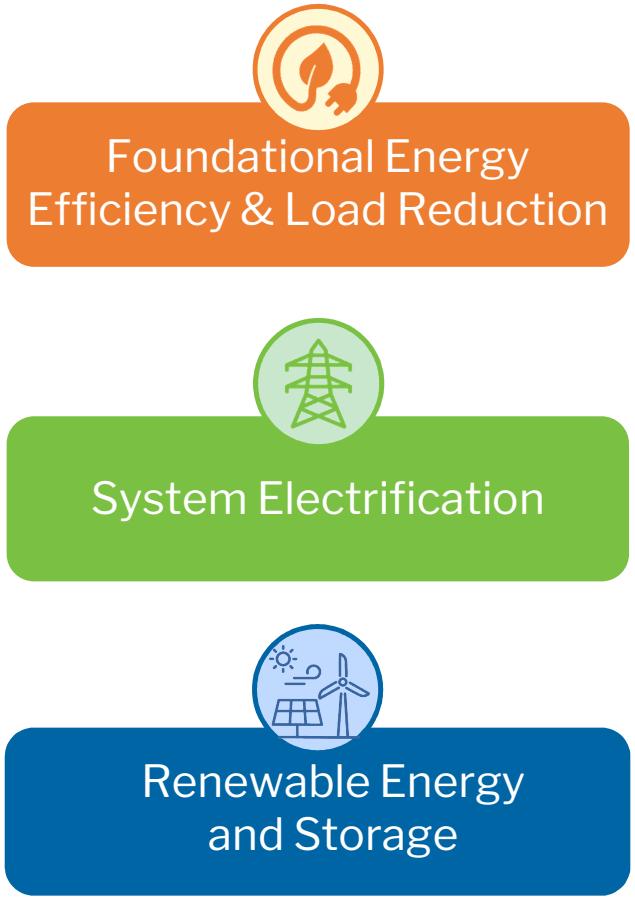
MA High School / Comprehensive Decarbonization Approach



MA High School / Comprehensive Decarbonization Approach

Foundational Energy Efficiency & Load Reduction

Foundational Energy Efficiency

- Lighting efficiency
- Demand Control Ventilation (DCV)

+

Load Reduction Option 1

- Air sealing

Load Reduction Option 2

- Roof replacement

Load Reduction Option 3

- Window replacement
- Roof replacement

Included in the base electrification analysis

MA High School / Comprehensive Decarbonization Approach

System Electrification

Electrification Option 1
No additional cooling

- New Air to Water Heat Pump (AtWHP)
- New Heat Pump RTUs (add heat recovery)
- New Heat pump DHW system

- *Minor impact on interior and unit ventilators*

Electrification Option 2
Additional Cooling

- New Air to Water Heat Pump (AtWHP)
- Upgrade/new Unit ventilators for cooling.
- New Heat Pump RTUs (add heat recovery)
- New Heat pump DHW system

- *Unit ventilators and piping upgrades*

Electrification Option 3
Additional Cooling

- New VRF/ASHP with DOAS
- New Heat Pump RTUs (add heat recovery)
- New Heat pump DHW system

- *Intrusive interior upgrades: removal of unit ventilators, RTUs, and refrigerant piping (code restrictions)*

MA High School / Comprehensive Decarbonization Approach

Renewable Energy and Storage

Solar PV

- Install new solar PV array
- Install battery storage
- Remove existing solar PV (34kW not functional)

- *Utility savings are based on a new owned 300kW solar PV roof system and a 200kW battery storage system*

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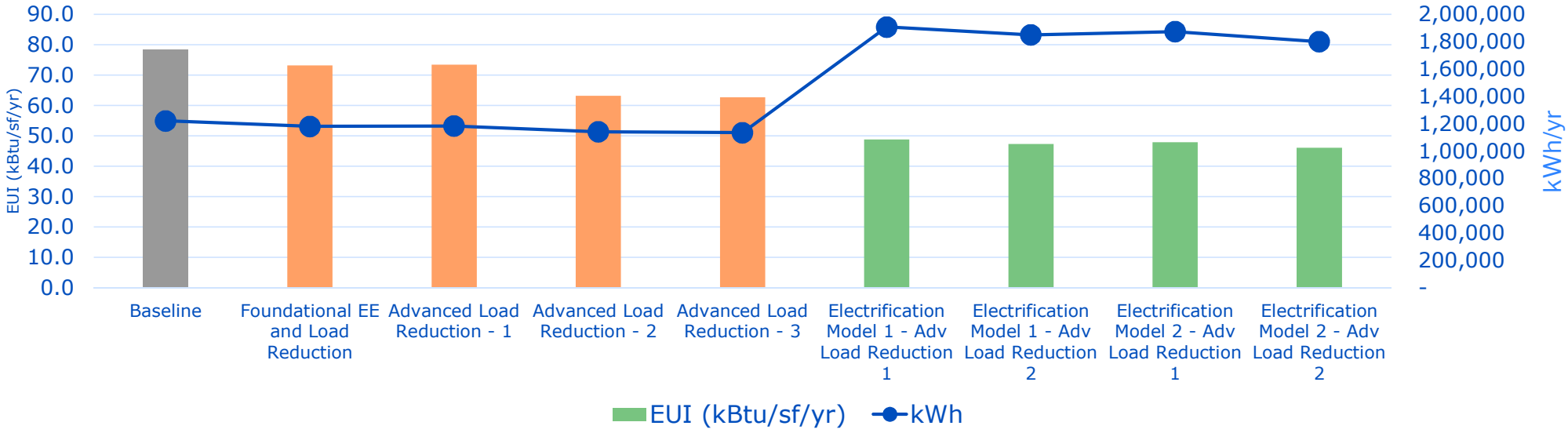
MA High School / Decarbonization Measures Summary



Scenario	EUI (kBtu/sf/yr)	kWh	Therms	% Progress to ZNC
Baseline	87.3	1,346,077	70,498	-
Foundational Energy Efficiency	73.2	1,179,808	57,346	16%
Advanced Load Reduction - 1	73.4	1,182,424	57,568	15%
Advanced Load Reduction - 2	63.2	1,140,549	45,400	26%
Advanced Load Reduction - 3	62.7	1,134,108	44,897	26%
Electrification Model 1 – Adv. Load Reduction 1	48.8	1,907,070	-	32%
Electrification Model 1 – Adv. Load Reduction 2	47.3	1,848,746	-	34%
Electrification Model 2 – Adv. Load Reduction 1	47.9	1,873,065	-	33%
Electrification Model 2 – Adv. Load Reduction 2	46.0	1,799,603	-	36%

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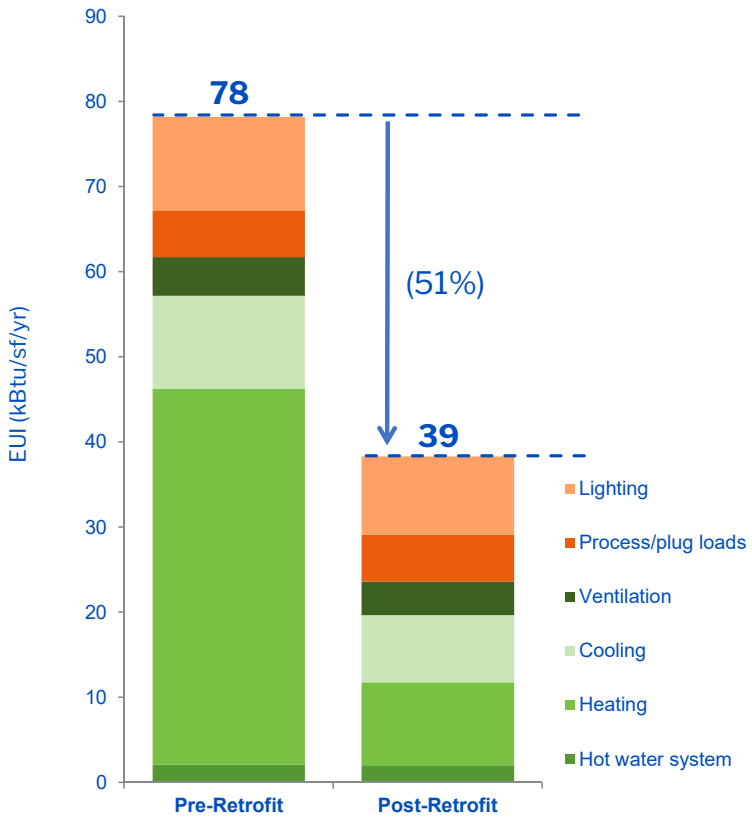
MA High School / Annual Energy and Cost Impact Final Analysis



Measure description	Changes in annual utility costs		
	Electricity	Fossil fuel	Net total changes
Lighting	($26,900)	-	($26,900)
Process/plug loads	$39,800	($6,200)	$33,600
Ventilation	($8,100)	-	($8,100)
Cooling	($42,400)	-	($42,400)
Heating	$117,700	($104,000)	$13,700
Hot water system	$29,200	($5,100)	$24,100
Total from recommended measures	**$109,300**	**($115,300)**	**($6,000)**
Renewable energy* (New solar PV roof and battery storage)	($68,000)	-	($68,000+)

Note: the estimated additional utility savings are based on a new owned 300kW solar PV roof system and a 200kW battery storage system. Existing Solar PV is not functional. Additional solar PV parking canopy may be considered for additional savings, although were not included in this study.

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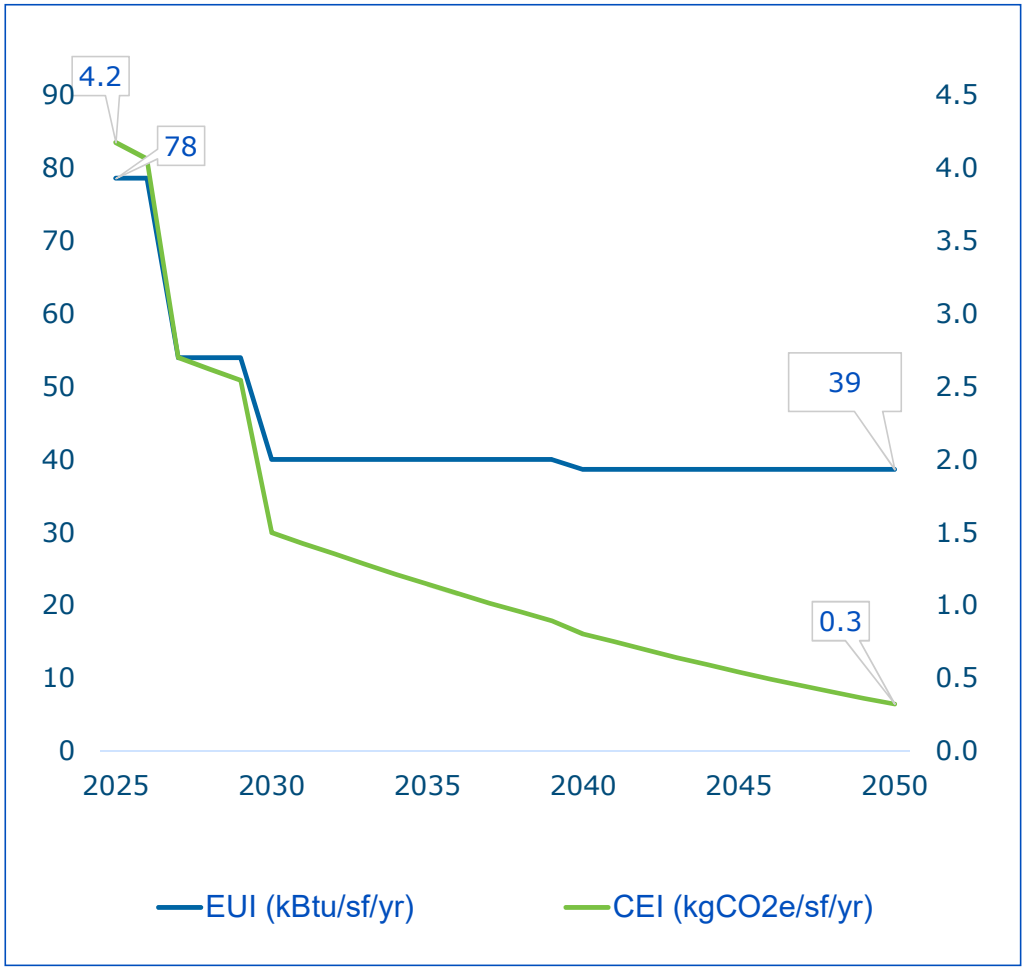
MA High School / Energy and GHG Emissions Benchmarking



2050: Pending on Massachusetts Grid Emissions and Solar PV production, Owner may have to procure GHG Offsets.

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MA High School / GHG Emissions CEI Benchmarking vs. BERDO

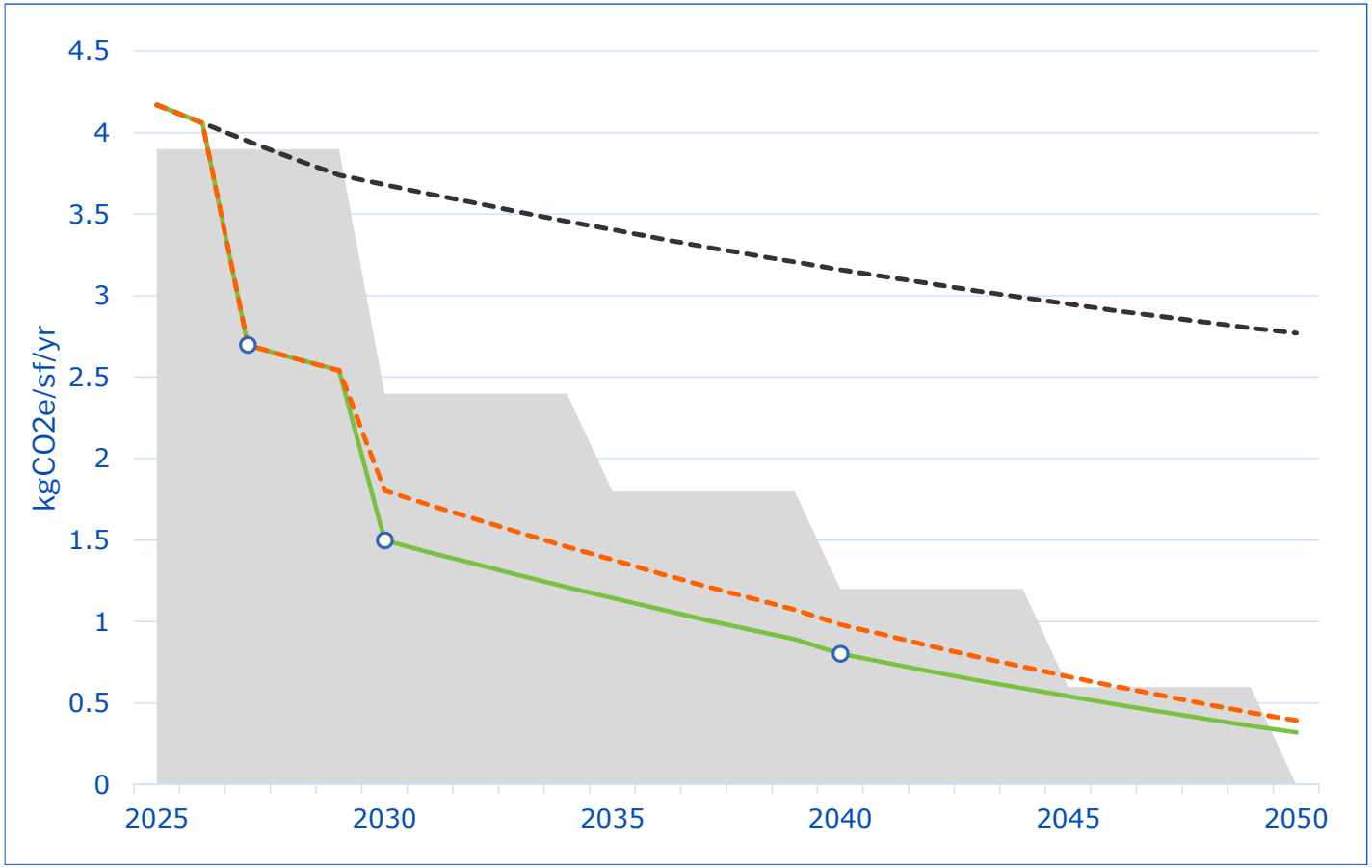
BERDO (kgCO2e/sf/yr)

Business-as-Usual

Optimized decarbonization

Simplified electrification

Implementation milestones



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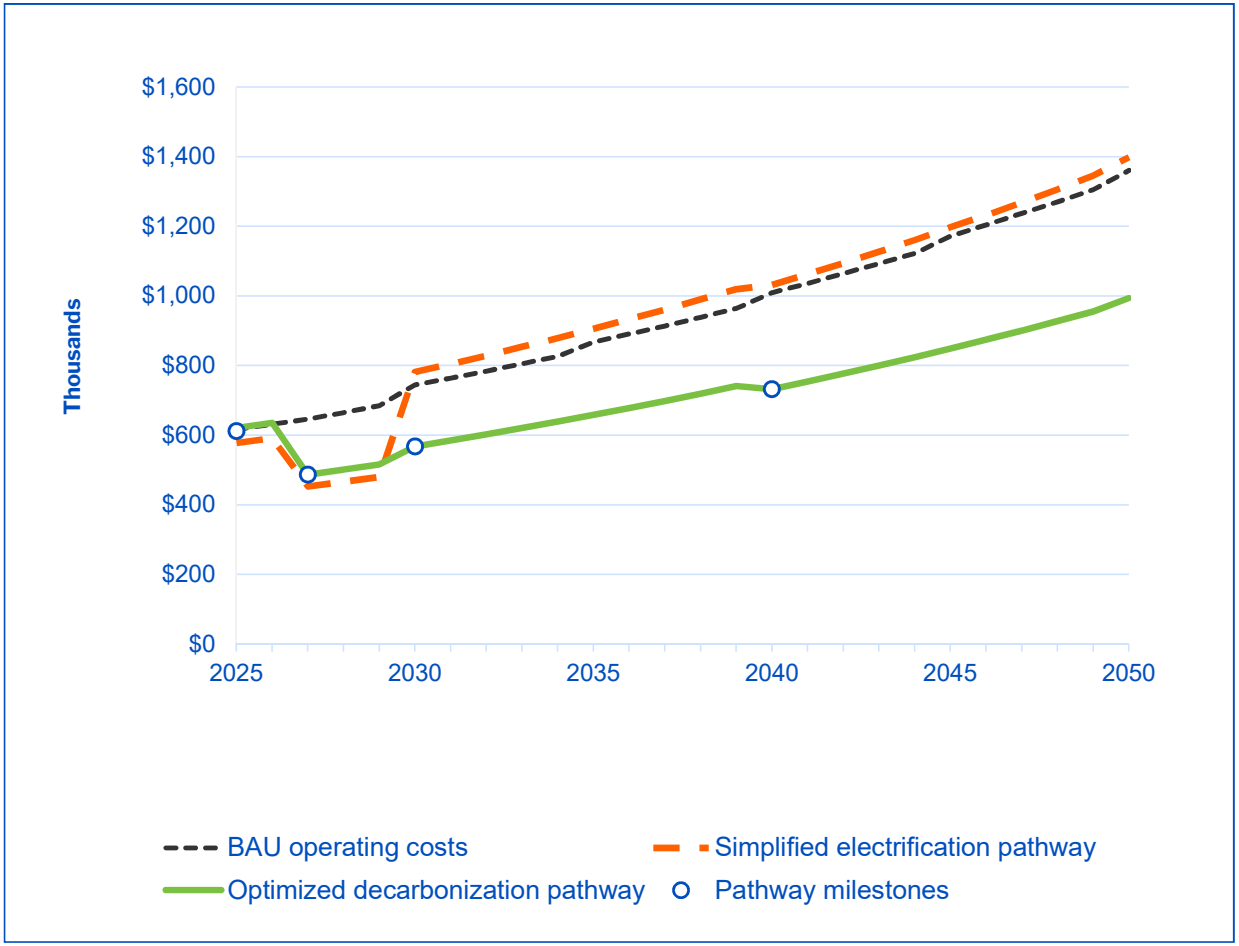
MA High School / 25-Year Operating Cash Flow



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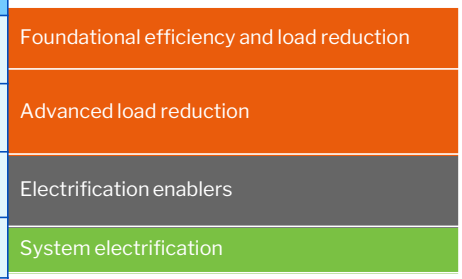
MA High School / 25-Year Life Cycle Cost Analysis

	BAU retrofit	Simplified electrification	Optimized Decarbonization
Base building and envelope costs	$4,494,108	$1,411,498	$1,411,498
		$5,438,857	$6,386,490
Mechanical costs	$9,844,157	$2,133,712	$2,133,712
		$8,683,027	$7,276,301
Renewable energy costs	$0	$0	$1,173,080
Soft costs	$5,018,393	$5,689,458	$5,939,354
Total upfront costs	**$19,356,657**	**$23,356,552**	**$24,320,435**
25-year accrued utility costs	$21,548,000	$22,814,000	$16,716,000
25-year accrued total operating costs	$24,642,000	$24,770,000	$18,667,000
Competitive incentives	$0	($425,957)	($614,530)
Non-competitive incentives	$0	($505,863)	(505,863)
25-year LCCA Costs	**$43,998,657**	**$47,194,733**	**$41,867,042**
25-year LCCA incremental (savings) costs		**$3,196,075**	**($2,131,615)**



Simplified= Code level Roof/Windows

Simplified= larger HVAC sizing

Simplified= added cooling, less efficient enclosure

BAU= higher future fees (carbon)

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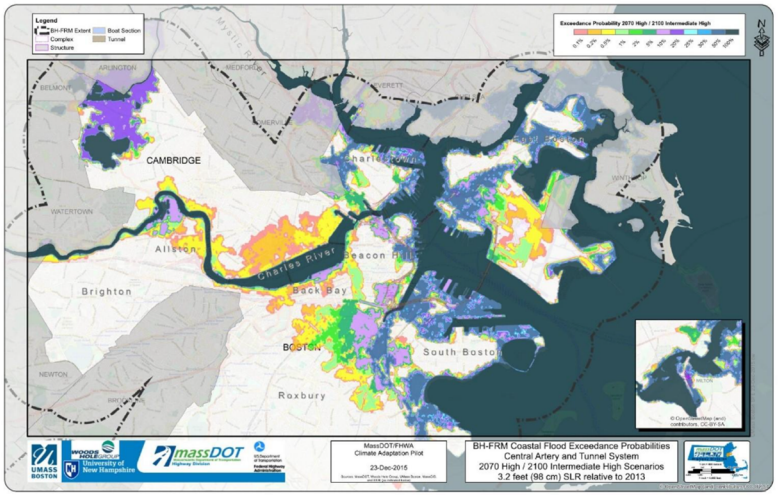
MassCEC's BETA: Existing Buildings' Pathway to Net Zero/ Resiliency: Flood Maps and Future Weather

Commercial / Boston Lab-Office Facility



Impact Area	Electricity Consumption	Heating Load	Cooling Load
Energy Impact (Percent difference between optimized current climate and 2050 climate scenario)	-7%	-19%	31%

K-12 Education / Massachusetts High School

Impact Area	Electricity Consumption	Heating Load	Cooling Load
Energy Impact (Percent difference between optimized current climate and 2050 climate scenario)	-15%	-18%	4%

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MassCEC BETA: Existing Buildings' Pathway to Net Zero

Early Takeaways:

- Existing Data availability often limited.
- Considerable variety of applicable electrification system solutions.
- Requires a comprehensive solution vs. "one-fit-all" applications.
- Protocols intent for a thorough assessment approach vs. a pre-set systems solutions.

There is still time to apply for the BETA Program Today!

Public application:
https://www.masscec.com/program/beta-project-planning

www.masscec.com

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Thank You!

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