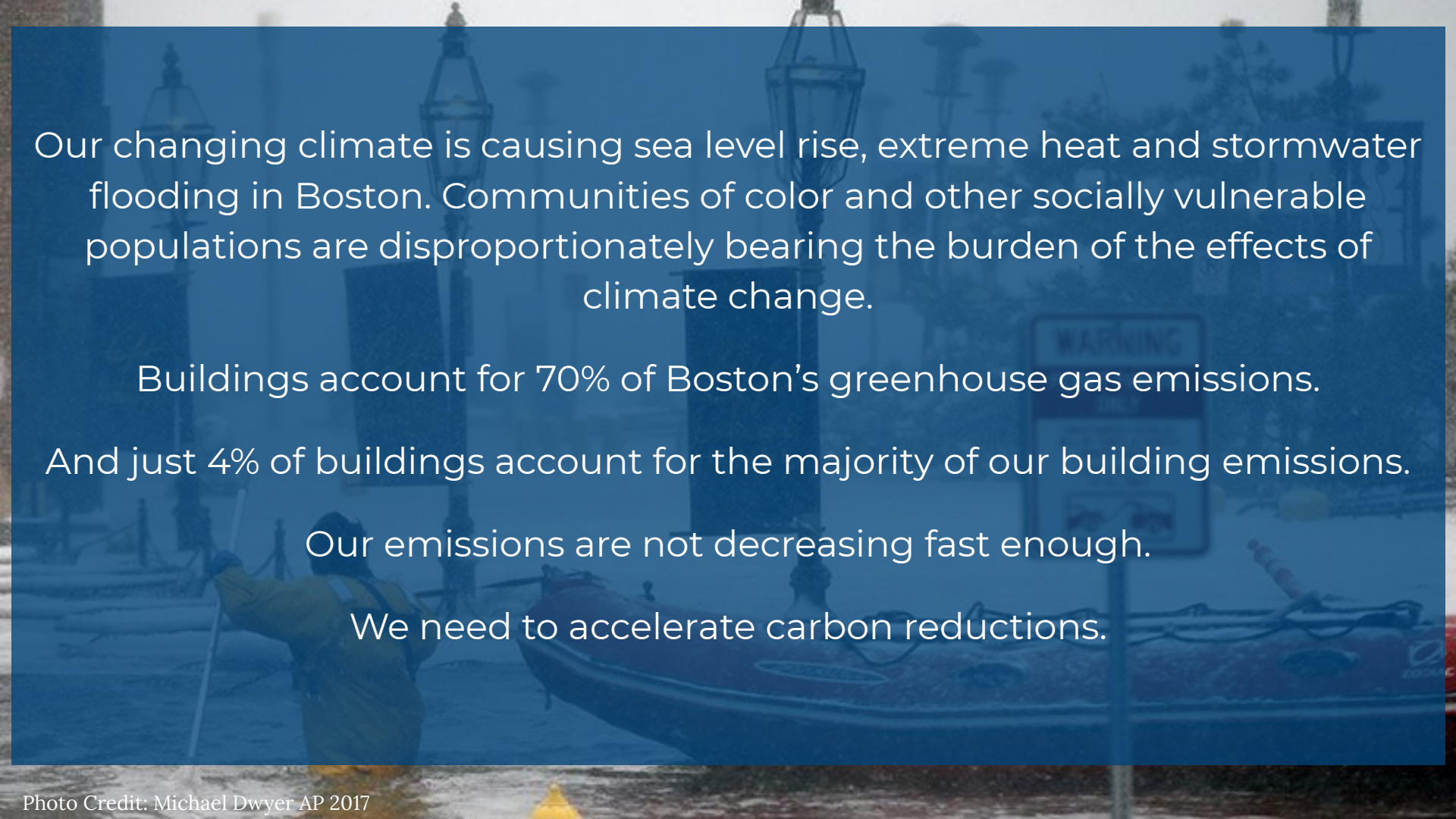
Building Emissions Performance Standards



Our changing climate is causing sea level rise, extreme heat and stormwater flooding in Boston. Communities of color and other socially vulnerable populations are disproportionately bearing the burden of the effects of climate change.

Buildings account for 70% of Boston's greenhouse gas emissions.

And just 4% of buildings account for the majority of our building emissions.

Our emissions are not decreasing fast enough.

We need to accelerate carbon reductions.

Photo Credit: Michael Dwyer AP 2017

BERDO 1.0

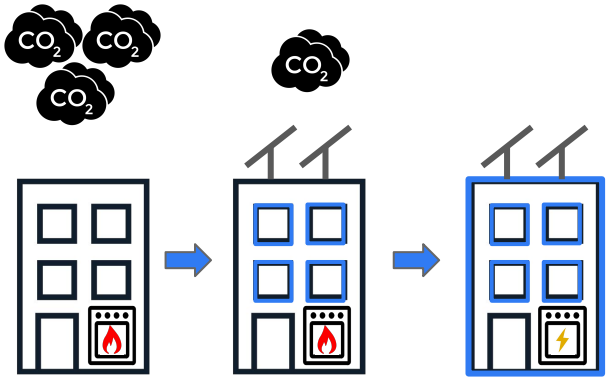
Building Energy Reporting & Disclosure Ordinance

- *Established 2013*
- *Covers 35,000 sf +*
- *Citywide benchmarking ordinance*
- *Annual reporting*
- *Energy action or audit requirement every 5 years*

WHAT AND WHY

A building performance standard sets carbon targets for existing large buildings that decrease over time. A performance standard:

- Directly targets our largest source of emissions;
- Sets long planning horizons;
- Provides flexibility in how buildings meet targets and when they make investments.



NEW POLICY ELEMENTS

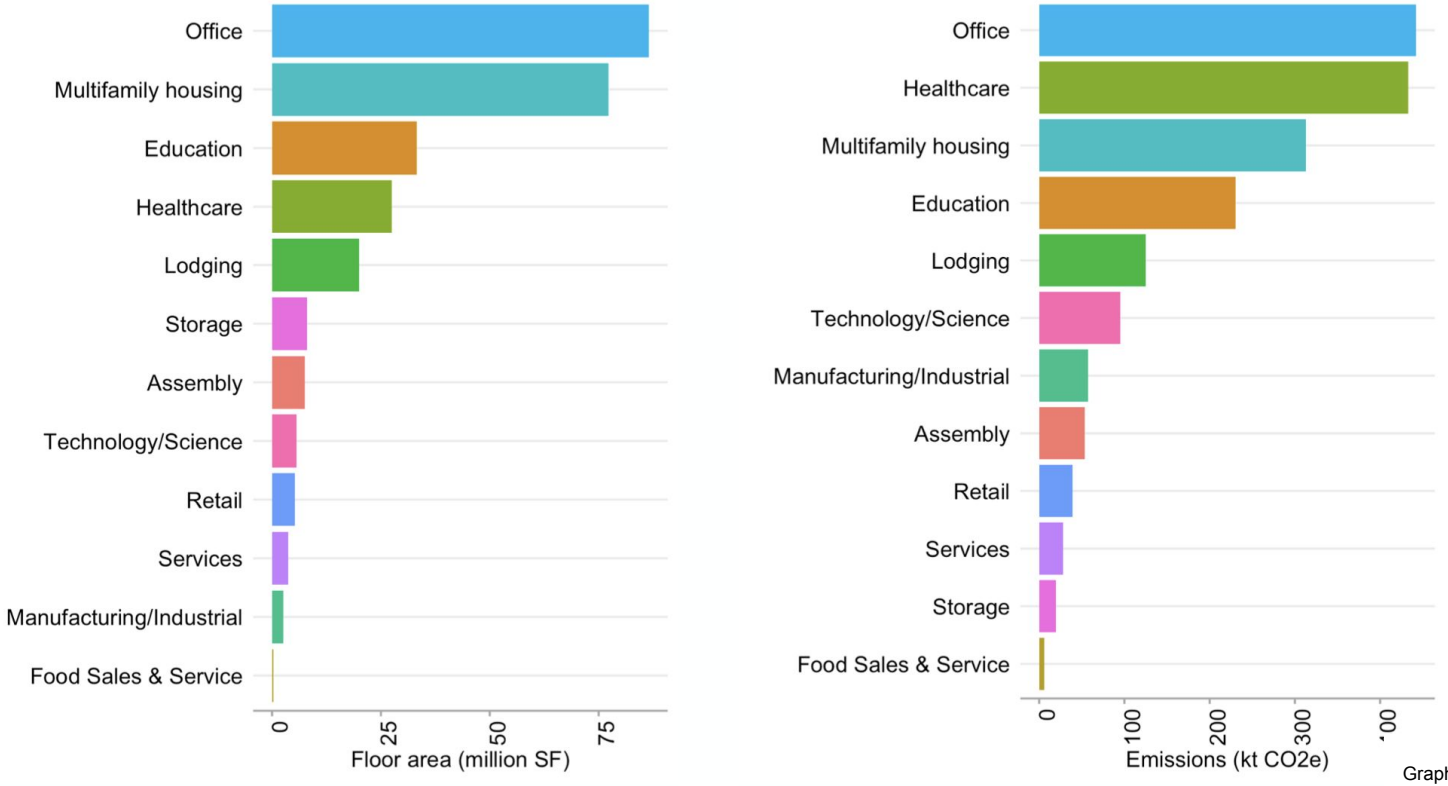
- Many pathways to achieve targets:
  - *Energy efficiency*
  - *Electrification and fuel switching*
  - *Renewable energy*
  - *Alternative compliance payments*
- 20,000+ sq ft or 15+ units

- Additional flexibility:
  - *Portfolio*
  - *Individual compliance schedule*
  - *Hardship compliance plan*
- Review Board
- Equitable Emissions Investment Fund

boston.gov/berdo

BUILDING AREA AND EMISSIONS (35k+)

Floor area and total emissions of BERDO buildings by type, 2018

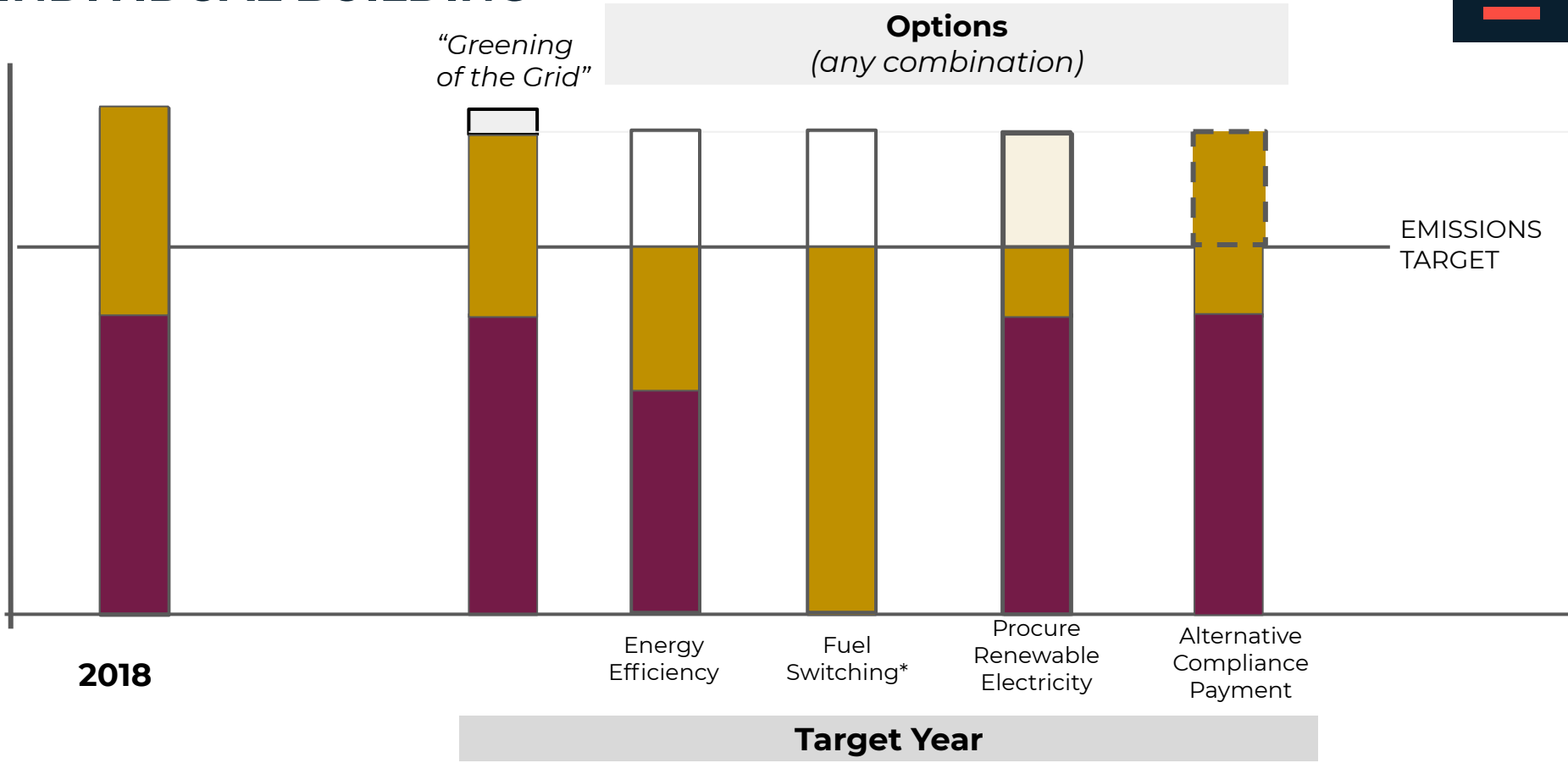


EMISSIONS STANDARDS

Emissions Standards for Highest-Emitting Building Types (kgCO2e/SF/yr)						
	2025	**2030**	**2035**	**2040**	**2045**	**2050**
Office	5.3	3.2	2.4	1.6	0.8	0
Multifamily Housing	4.1	2.4	1.8	1.1	0.6	0
Healthcare	15.4	10	7.4	4.9	2.4	0
Education	3.9	2.4	1.8	1.2	0.6	0

*See full list at Boston.gov/BERDO

INDIVIDUAL BUILDING



** Fuel switching often best when combined with efficiency **For illustrative purposes only*

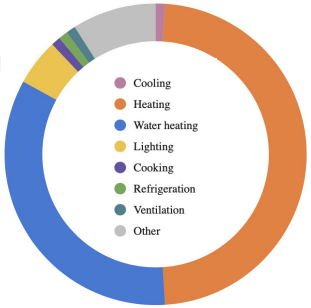
Alternative Compliance Payment

- Provide additional flexibility for covered buildings. If buildings miss their emissions targets, they can pay into the ACP in order achieve them.
- Ensure onsite efficiency work isn't being disincentivized. Set value such that buildings may choose to invest in efficiency rather than paying into the ACP.
- The average cost of abatement could serve as a basis for setting the price of an alternative compliance payment
  - This approach has been used in other jurisdictions
- Estimated incremental abatement cost in Boston: $234/mtCO2e
  - To be re-evaluated periodically to assess changes in cost of abatement technologies, energy, and grid impacts

CASE STUDY: MULTIFAMILY (HIGH EMISSIONS)

Multifamily housing

- Low-rise, multi-building property
- 280-300 housing units



Envelope insulation

- Walls: R-12
- Roof: R-2.5 (uninsulated).
- Roof expected end of life 2025-2030.

Heating, cooling, HVAC:

- 14,000 MBH hot water boilers. Boilers expected end of life: 2035.
- Split system condensers on rooftop.
- 40 HP hot water circulation pumps without VFD.
- Heating radiators in residences and common areas. Split system indoor units for cooling in residences and common areas.

Other: Electricity and natural gas are master metered.

Gross Floor Area: 140,000-160,000 SF

Year Built: 1970-1990

Emission Percentile: 97%

Windows: Double pane, vinyl-framed

Lighting: LEDs

Domestic hot water:

- 3,000 MBH condensing firetube water heaters.
- Water heater expected end of life: 2035-2040
- Fixtures: 2.5 GPM showerheads, 1.5 GPM sinks

Process equipment: On-site laundry

Cooking: Electric ranges

Refrigeration: 18 cu., mostly in poor to fair condition, in need of replacement

Condensing gas water heater

A/C indoor unit

Central hot water boilers

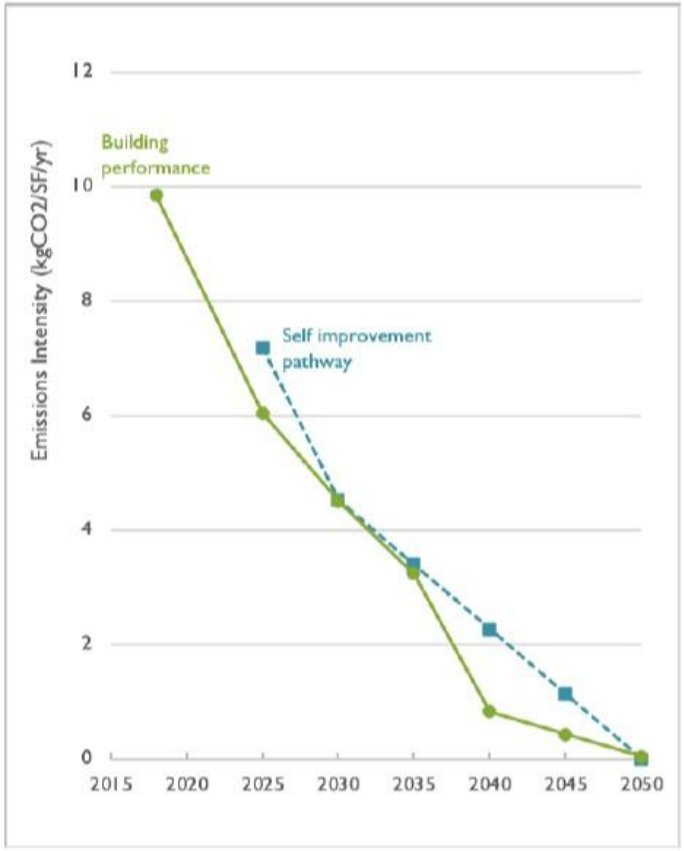
Photo credits: Conquest, PVHVAC, Patterson-Kelley

CASE STUDY: MULTIFAMILY (HIGH EMISSIONS) POSSIBLE PATHWAY

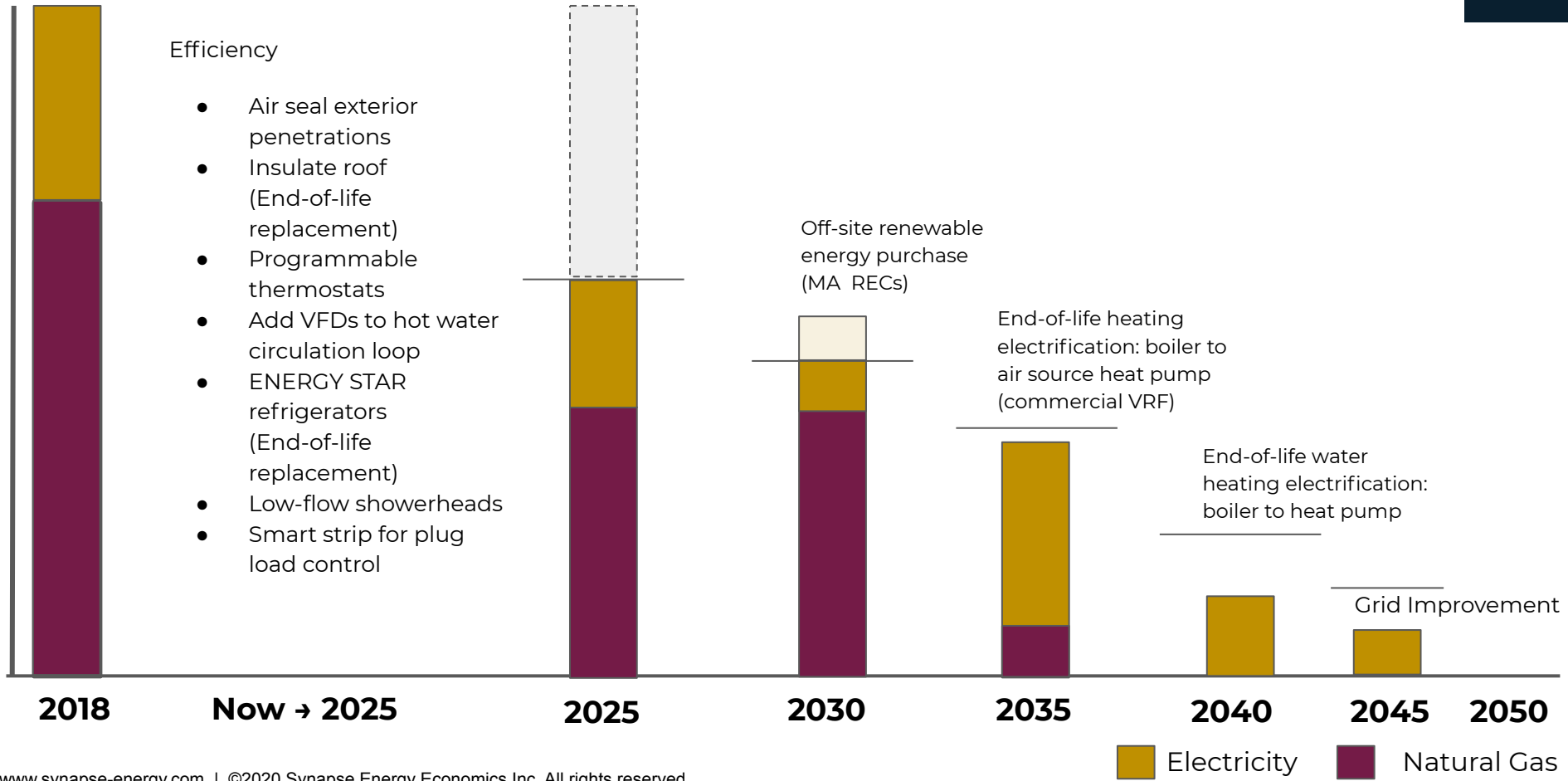
- Building would comply under **individual compliance schedule**

- Major improvements
  - 2025 add insulation at roof end of life, $1.0M
  - 2035 air-source heat pumps (VRF), $0.1M
  - 2040 heat pump water heaters, $0.5M

- Incremental abatement cost:
  - $1.9M over 30 years ($0.5M over 30 years with energy savings)
  - $89/ton ($22/ton with energy savings)
  - 42¢/SF/yr (10¢/SF/yr with energy savings)



CASE STUDY: MULTIFAMILY (HIGH EMISSIONS) POSSIBLE PATHWAY

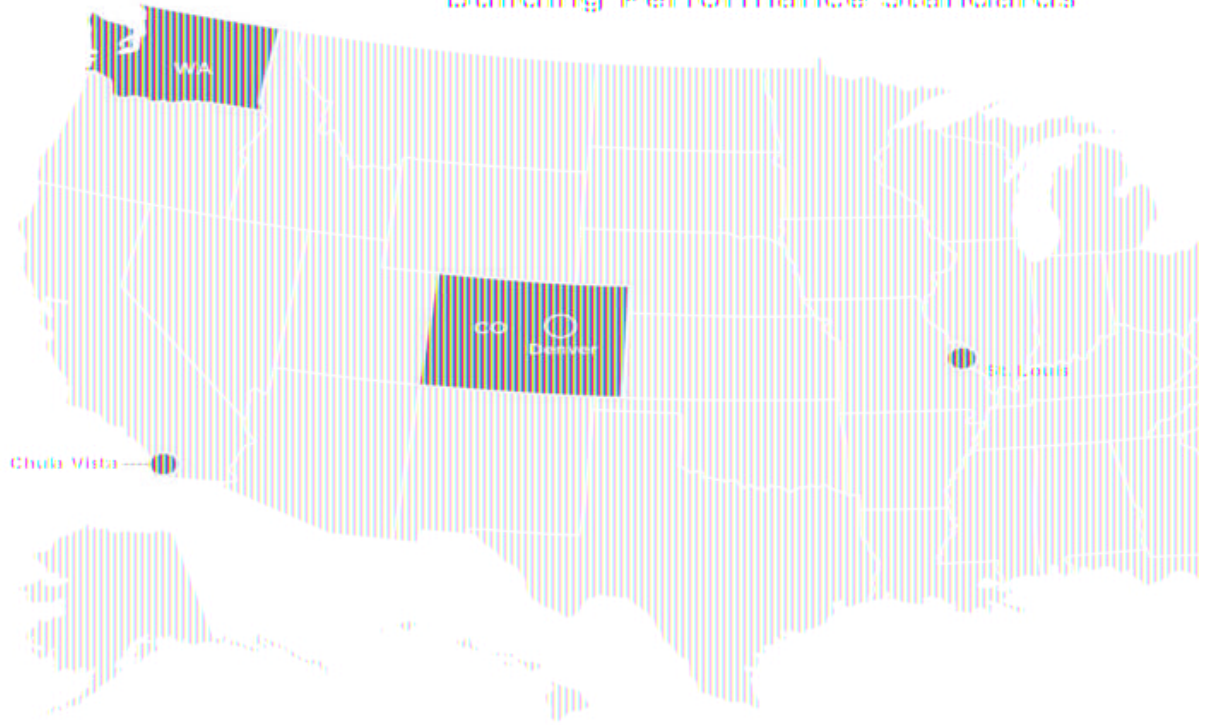


CASE STUDY: MULTIFAMILY (HIGH EMISSIONS)

Strategy	Approach	Timeline	Total Cost	Incremental Cost	Energy Savings				Avoided Emissions		Net Incremental Abatement Cost
					kBtu/yr	*%*	*$/yr*	*Lifetime $ total*	*ton/yr*	*%*	*$/ton*
Air seal exterior penetrations	Retrofit	2025	$82,317	$82,317	1,226,146	5%	$13,245	$157,272	65	4%	-$77
Insulate roof: add rigid foam panel over sheathing	End-of-life replacement	2025	$2,489,474	$1,032,221	6,645,976	27%	$71,791	$1,340,005	353	24%	-$29
Programmable thermostats	Retrofit	2025	$53,029	$53,029	183,504	1%	$8,991	$71,175	10	1%	-$190
Add VFDs to hot water circulation loop	Retrofit	2025	$53,425	$53,425	106,120	1%	$5,200	$53,360	6	1%	$1
ENERGY STAR refrigerators	End-of-life replacement	2025	$265,741	$83,044	225,400	1%	$11,044	$100,859	12	1%	-$130
Low-flow showerheads	Retrofit	2025	$8,327	$8,327	844,896	3%	$41,398	$272,196	44	3%	-$841
Smart strip for plug load control	Retrofit	2025	$4,828	$4,828	55,177	0%	$2,704	$11,540	3	0%	-$467
Off-site renewable energy purchase (Massachusetts RECs)	Procurement	2030	$44,991	$44,991	0	0%	$0	$0	142	10%	$16
Heating electrification: boiler to air source heat pump (commercial VRF)	End-of-life replacement	2035	$642,888	$71,241	3,042,455	12%	-$18,581	-$148,826	163	11%	$90
Water heating electrification: boiler to heat pump	End-of-life replacement	2040	$1,109,988	$470,594	5,697,490	23%	-$52,574	-$423,092	305	21%	$225
Grid improvement	Policy	2050	$0	$0	0	0%	$0	$0	380	25%	$0
Total			$4,755,008	$1,904,018	18,027,165	73%	$83,218	$1,434,490	1,481	100%	$22

All cost savings shown in 2020$ present value lifecycle costs. Utility incentives are not included. Negative energy savings indicate increased costs.

U.S. City and State Policies for Existing Building Building Performance Standards



IMT
INSTITUTE FOR MARKET TRANSFORMATION

U.S. CITY & STATE PERFORMANCE STANDARDS

Jurisdiction	Metric	Compliance Starts	Exemptions
New York City	Emissions intensity	2024	Affordable housing, city-owned, houses of worship
Denver	Energy use intensity	2024	
Boston	Emissions intensity	2025	
St Louis	Energy use intensity	2025	Industrial, communications
Washington, DC	Energy Star score or energy use intensity	2026	
Washington State	Energy use intensity	2026	Industrial, agricultural, historic
Colorado	TBD	2026	Manufacturing, industrial, or agricultural

https://www.imt.org/resources/comparison-of-u-s-building-performance-standards

QUESTIONS?

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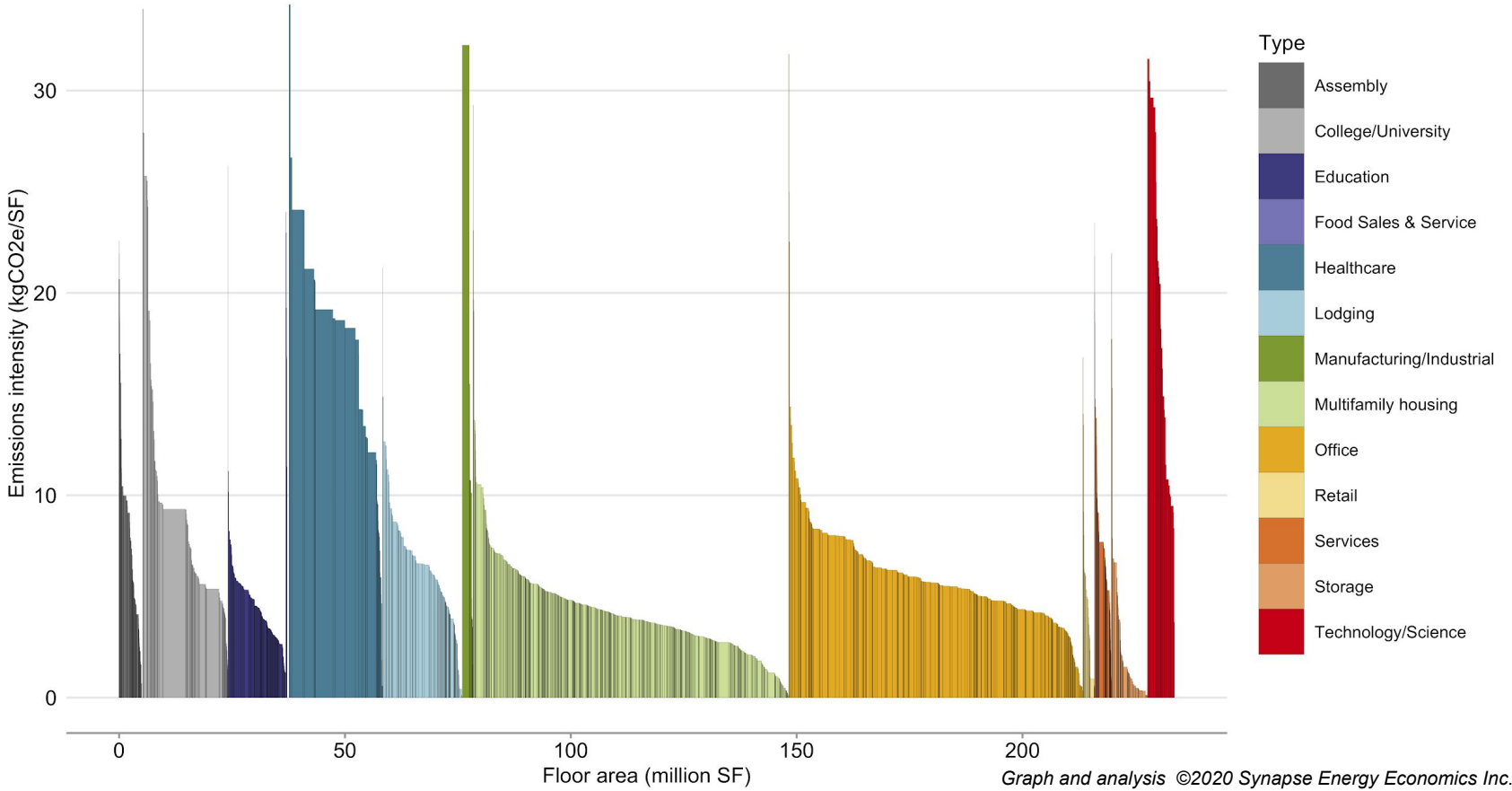
APPENDIX

LARGE BUILDING EMISSIONS (35k+ SF)



TREATMENT OF RECs and OFFSETS

Renewable Electricity Procurement

- Off-site renewable energy purchases, including RECs, used only to offset electricity consumption
- RECs retired in the year they were generated
  - Some flexibility for an accounting true-up period (e.g., 6 months)
- Accounts participating in the City's Community Choice Electricity program will have the appropriate emissions factor applied.
- **Options**
  - **Option 1:** Unbundled RECs that meet Massachusetts Class I eligibility
  - **Option 2:** Virtual Power Purchasing Agreements and directly owned off-site renewable
    - Must be traceable to a specific project and the RECs must be retired

Initially, GHG offsets for building-level fossil fuel combustion not considered. We will revisit by 2030, or sooner if a local offset option becomes available. Or a building my apply to the Review Board for consideration of a custom approach.

BUILDING EMISSIONS EQUITABLE INVESTMENT FUND

- New fund dedicated to emissions reduction projects that prioritize environmental justice populations and benefits including:
  - Affordable housing preservation and rent stabilization
  - Air quality improvements
  - Training and access to green jobs for residents, women and people of color
  - Clean energy deployment

- Funds to be allocated by the newly created Review Board.

REVIEW BOARD

- Two-thirds of board members to be nominated by the community and community-based organizations, with missions prioritizing environmental justice populations

- Expertise areas:
  - Environmental justice
  - Affordable housing
  - Labor and workforce development
  - Public health
  - Building engineering and energy
  - Environmental protection and climate change
  - Real estate development and management
  - Historic preservation

- Stipends would be available (amount and rules to be further detailed in regulations)

- Responsibilities:
  - Oversight and enforcement
  - Program review & regulation update recommendations
  - Review of alternative pathways*
  - Allocation of grants from the investment fund*

RESOURCE HUB

Acts as a single entry point for renters, workers and owners for access to resources for building retrofits. Resources will include connections to incentives and financing, expert guidance, training opportunities, fair housing resources, and educational materials.

Phase 1 - Informational website for building owners and tenants

- How to comply with the performance standard
- How to decarbonize a building
- Available funding options
- Tenant protections
- Green leasing
- Workforce training

Phase 2 - Technical Support

- Webinars
- Office hours
- One-on-one consultations

Phase 0.5 - Eversource Partnership

- Mass Save concierge service for large buildings

FUNDING OPTIONS

- **Existing**
  - *Incentives - Mass Save, SMART, MassCEC*
  - *Tax Credits - Solar ITC, Low-Income Housing Tax Credit, Historic Tax Credit*
  - *Financing - BIDFA Tax-Exempt Lease, Property Assessed Clean Energy*

- **Future**
  - *Alternative Compliance Payments*
  - *Climate Bank*

BUILDING RETROFITS CAN CREATE...

BETTER BUILDINGS FOR RESIDENTS

Building rehabs can improve comfort levels and indoor air quality, help lower energy use and bills, and support resilience.

QUALITY JOBS FOR WORKERS

Retrofitting Boston's buildings will create high-quality construction, energy efficiency and clean energy job opportunities for workers.

HEALTHIER CLIMATE FOR EVERYONE

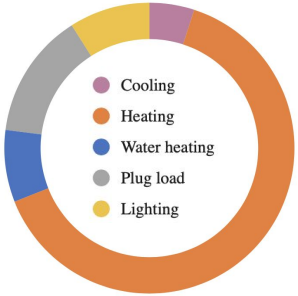
By making Boston's buildings carbon neutral, we will reduce our largest contribution to global climate change and make our city more resilient.

(Figures: Black Illustrations)

CASE STUDY: MULTIFAMILY (LOW EMISSIONS)

Multifamily housing
- Mid-rise, single building
- 120-140 housing units

Envelope insulation
- Walls: R-6
- Roof: R-19



Heating, cooling, HVAC:
- 8,400 MBH central steam boiler with steam to hot water heat exchanger
- 185 kW central chiller, cooling tower, two 30 HP pumps with VFDs for cooling tower and condenser loop
- 20-60 MBH fan coil units in residences; baseboard fin tube water loop in commercial
- (2) 7.5 HP circulation pumps with VFD for residences; (1) 3 HP circulation pump with VFD for commercial
- Terminal units have thermostats; boiler steam valve uncontrolled

Other: Resident gas and electricity master metered; commercial gas master metered, electricity separate

Gross Floor Area: 220,000-240,000 SF

Year Built: Pre-1900 (renovated 1970-80)

Emission Percentile: 32%

Windows: Double pane, seals in poor condition

Lighting:
- Residences: CFL, incandescent, T12 fluorescent
- Common areas: LED and T12 fluorescent

Domestic hot water:
- 620 MBH central indirect water heater with 2 tanks; 1/6 HP and 3/4 HP circulation pump
- Fixtures: 1.5 GPM showerheads and sinks

Process equipment: On-site laundry

Cooking: Electric ranges

Refrigeration: Mixture of 14 to 15 cu.

Central water heater

Fan coil unit

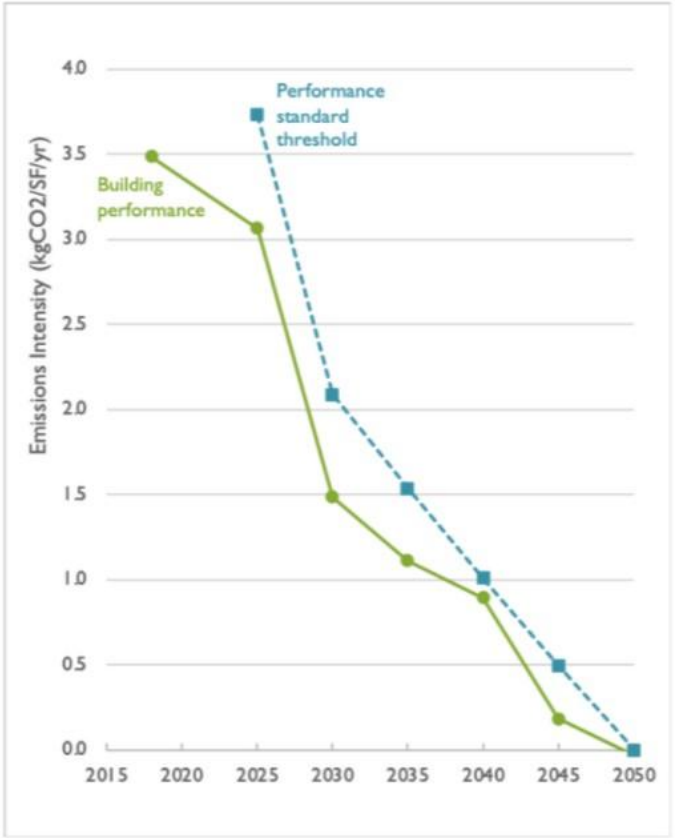
Central steam boiler

Photo credits: CEC

CASE STUDY: MULTIFAMILY (LOW EMISSIONS) POSSIBLE PATHWAY

- Major improvements
  - 2030 - air-to-water heat pump system, $0.9M
  - 2035 - heat pump water heater, $0.1M

- Incremental abatement cost:
  - $1.1M over 30 years ($1.2M over 30 years with energy costs)
  - $188/ton ($191/ton with energy costs)
  - 16¢/SF/yr (17¢/SF/yr with energy costs)



CASE STUDY: MULTIFAMILY (LOW EMISSIONS)

Strategy	Approach	Timeline	Total Cost	Incremental Cost	Energy Savings				Avoided Emissions		Net Incremental Abatement Cost
					kBtu/yr	%	$/yr	Lifetime $ total	ton/yr	%	$/ton
Air seal exterior doors, replace window seals	Retrofit	2025	$8,780	$8,780	175,837	1%	$2,127	$24,934	9	1%	-$114
Atrium destratification fans	Retrofit	2025	$6,438	$6,438	99,965	1%	$4,898	$44,731	6	1%	-$527
LED lighting conversion: in-unit fixtures	Retrofit	2025	$41,750	$41,750	177,196	1%	$8,682	$84,277	11	1%	-$298
Heating electrification: boiler to air-to-water heat pump	End-of-life replacement	2030	$1,199,978	$856,990	5,770,199	45%	-$35,239	-$282,257	286	36%	$266
Temperature limiting thermostats	Retrofit	2030	$65,132	$65,132	284,580	2%	$13,944	$110,379	18	2%	-$254
ENERGY STAR refrigerators	End-of-life replacement	2030	$78,538	$23,561	70,287	1%	$3,444	$31,451	4	1%	-$154
Smart strip for plug load control	Retrofit	2030	$4,828	$4,828	24,181	0%	$1,185	$5,057	2	0%	-$30
Water heating electrification: boiler to heat pump	End-of-life replacement	2035	$229,397	$97,256	729,124	6%	-$4,831	-$36,234	36	5%	$285
Off-site renewable energy purchase (Massachusetts RECs)	Procurement	2045	$8,939	$8,939	0	0%	$0	$0	113	14%	$16
Grid improvement post-electrification	Policy	2050	$0	$0	0	0%	$0	$0	315	39%	$0
Total			$1,643,781	$1,113,675	7,331,369	58%	-$5,791	-$17,661	799	100%	$191

All cost savings shown in 2020$ present value lifecycle costs. Utility incentives are not included. Negative energy savings indicate increased costs.

CASE STUDY: TECH/SCIENCE (HIGH EMISSIONS)

Technology/Science - Laboratory

Envelope insulation
- Primarily visible glass: R-1.15 (0.87 U-value)
- Roof: R-6

Heating, cooling, HVAC:
- District steam: direct steam supply for AHUs and indirect hot water supply (steam-to-water heat exchanger) for VAV boxes
- Two 775 ton central chillers with VFDs on three 75 HP pumps for chiller loops and three 663 ton cooling towers with VFDs on 40 HP fans. Equipment runs year-round
- Six AHU with 100 HP fan motor, 44,000 CFM each, steam and chilled water coils and four VAV boxes with 50 HP fan motors, hot water and chilled water coils. Lab spaces are humidity controlled. Labs and restrooms served by eight 7.5 exhaust fans

Other: Roof is original. Steel-framed construction.

Gross Floor Area: 160,000-180,000 SF

Year Built: Post-2000

Emission Percentile: 83%

Windows: Double pane, metal-framed, non-operable, good condition

Lighting:
- T8 fluorescent and CFL throughout
- Egress lighting exceeds required minimum light levels

Domestic hot water:
- Steam-to-water heat exchanger to provide hot water to bathrooms and lab spaces

Controls equipment: Central building management system with daily HVAC setback

Backup generator: 1,300kW engine onsite (diesel and natural gas)

Cooling tower

Ventilation system

Lighting (typical)

Photo credits: CEC

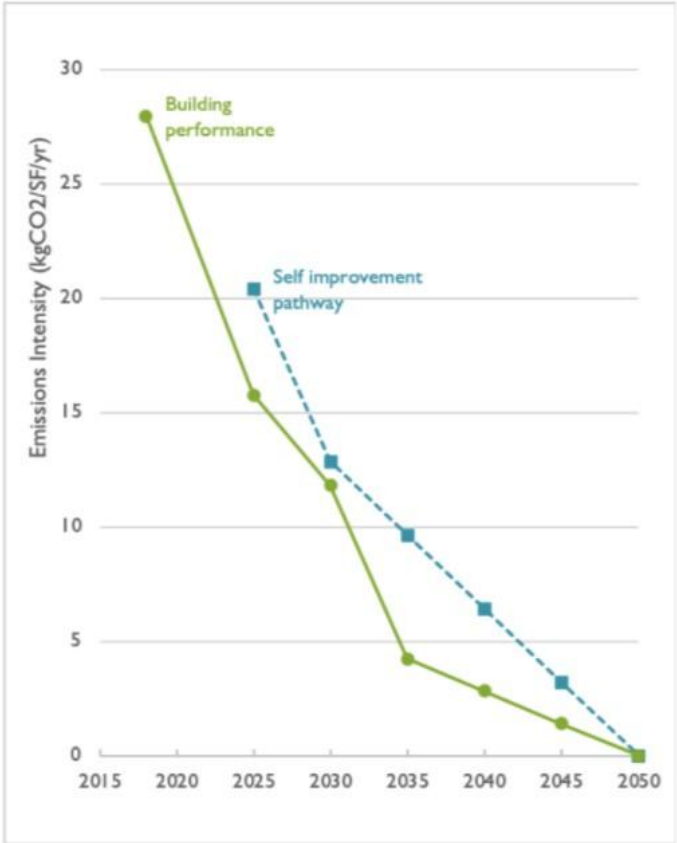
 |

CASE STUDY: TECH/SCIENCE (HIGH EMISSIONS) POSSIBLE PATHWAY

- Building would comply under **individual compliance schedule**

- Major improvements
  - 2025 - energy recovery ventilation (run-around), $1.5M
  - 2025 - LED lighting conversion, $0.4M
  - 2035 - district steam decarbonization + building retrofit: steam to hot water conversion, $4.2M

- Incremental abatement cost:
  - $6.4M over 30 years (-$0.8M over 30 years with energy savings)
  - $98/ton (-$12/ton with energy savings)
  - $1.24/SF/yr (-15¢/SF/yr with energy savings)



CASE STUDY: TECH/SCIENCE (HIGH EMISSIONS)

Strategy	Approach	Timeline	Total Cost	Incremental Cost	Energy Savings				Avoided Emissions		Net Incremental Abatement Cost
					kBtu/yr	%	$/yr	Lifetime $ total	ton/yr	%	$/ton
Chilled water loop re-commissioning (adjust setpoints and valve DP sensors)	Retrofit	2025	$2,262	$2,262	201,291	0%	$9,863	$42,098	10	0%	-$760
Energy recovery ventilation: run-around-coil loops	Retrofit	2025	$1,455,560	$1,455,560	21,111,478	33%	$336,440	$3,844,018	1,364	28%	-$117
VAV and exhaust fan static pressure reset	Retrofit	2025	$58,170	$58,170	758,966	1%	$16,378	$71,638	47	1%	-$57
LED lighting conversion: fluorescent and CFL	Retrofit	2025	$389,321	$389,321	5,660,398	9%	$277,349	$2,692,173	295	6%	-$607
IT and office equipment energy management	Retrofit	2025	$120,373	$120,373	621,576	1%	$30,456	$278,135	32	1%	-$406
Off-site renewable energy purchase (Massachusetts RECs)	Procurement	2030	$138,221	$138,221	0	0%	$0	$0	436	9%	$16
District steam decarbonization + building retrofit: steam to hot water conversion	End-of-life replacement	2035	$4,227,666	$4,227,666	14,860,298	23%	$20,197	$251,921	1,059	22%	$125
Grid improvement over time	Policy	2050	$0	$0	0	0%	$0	$0	1,546	32%	$0
Total			$6,391,572	$6,391,572	43,214,006	67%	$690,682	$7,179,984	4,789	100%	-$12

All cost savings shown in 2020$ present value lifecycle costs. Utility incentives are not included. Negative energy savings indicate increased costs.