

# BERDO 2.0

*Reducing carbon emissions from existing large buildings*





**MAYOR JANEY SIGNED THE  
BUILDING EMISSIONS  
REDUCTION AND DISCLOSURE  
ORDINANCE ON OCT. 5, 2021  
AFTER UNANIMOUS  
APPROVAL BY THE CITY  
COUNCIL.**



Boston's climate is changing.

Global climate change is causing sea level rise, extreme heat and stormwater flooding.

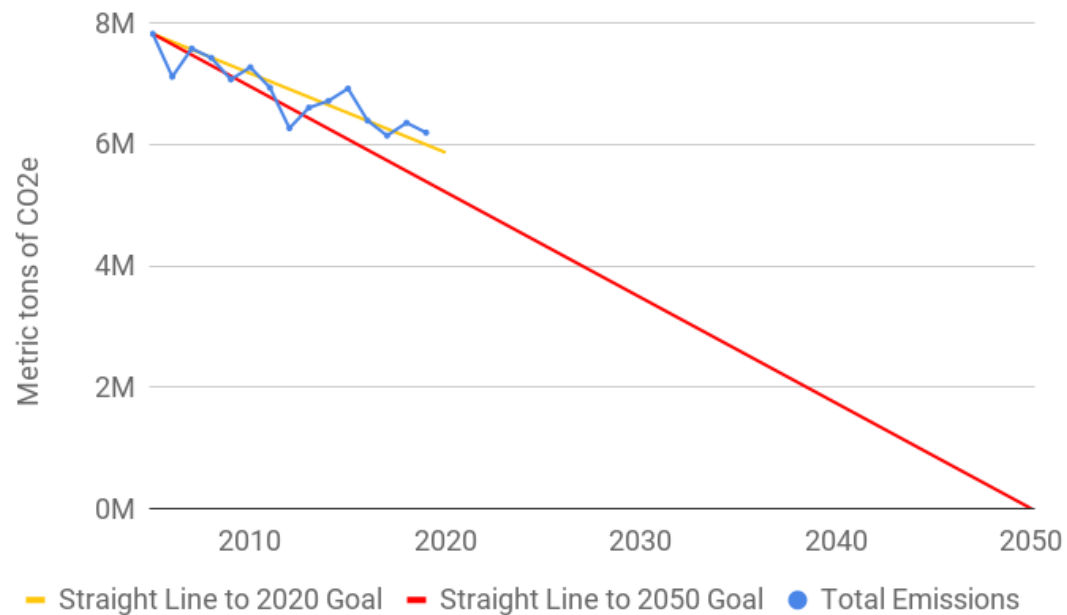


Communities of color and other socially vulnerable populations are disproportionately impacted.

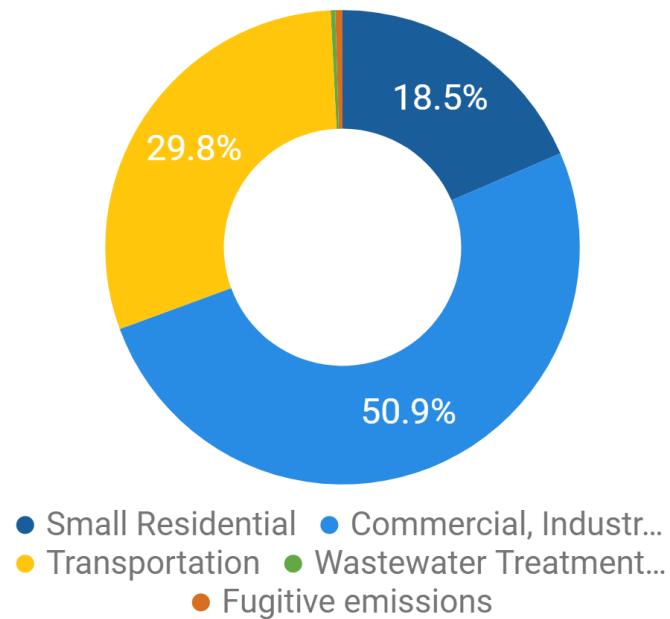
# BOSTON'S CARBON FOOTPRINT



## BOSTON COMMUNITY GREENHOUSE GAS EMISSIONS



## 2019 EMISSIONS BY SECTOR

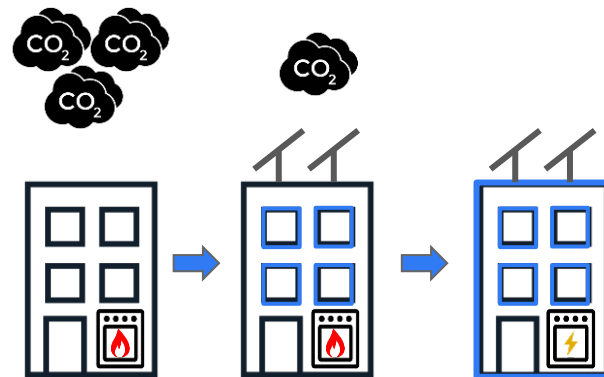




# WHAT AND WHY

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.



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



# BERDO 1.0

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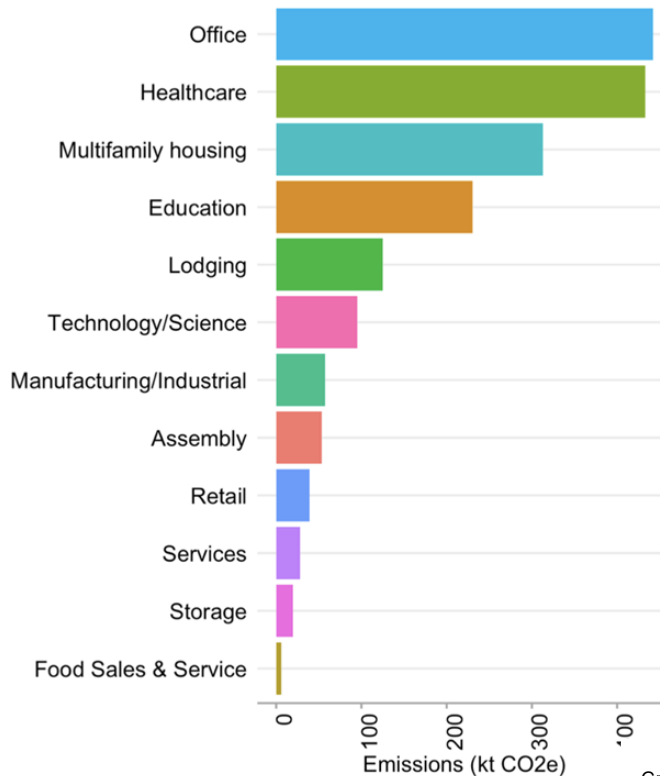
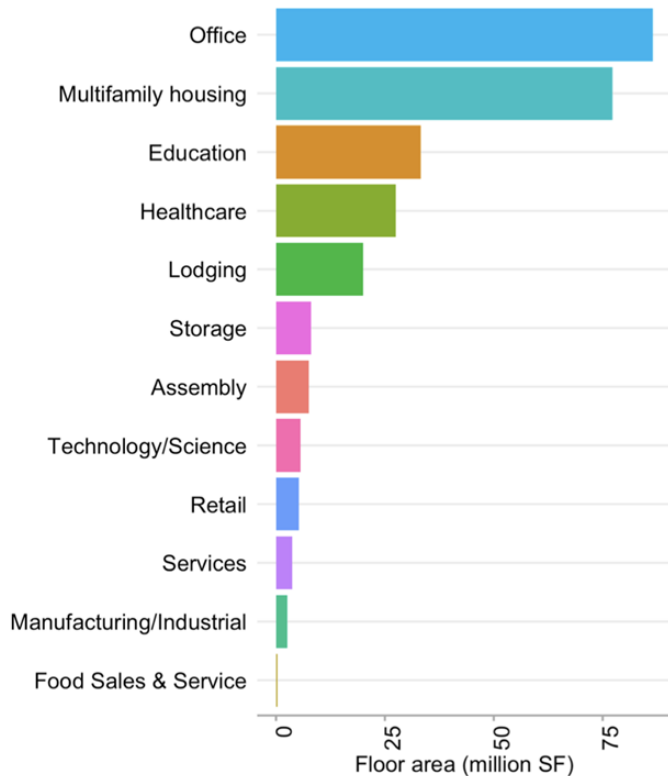
- Established 2013
- Covers 35,000 sf +
- Citywide benchmarking ordinance
- Annual reporting
- Energy action or audit requirement every 5 years



# BUILDING AREA AND EMISSIONS (35k+)



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





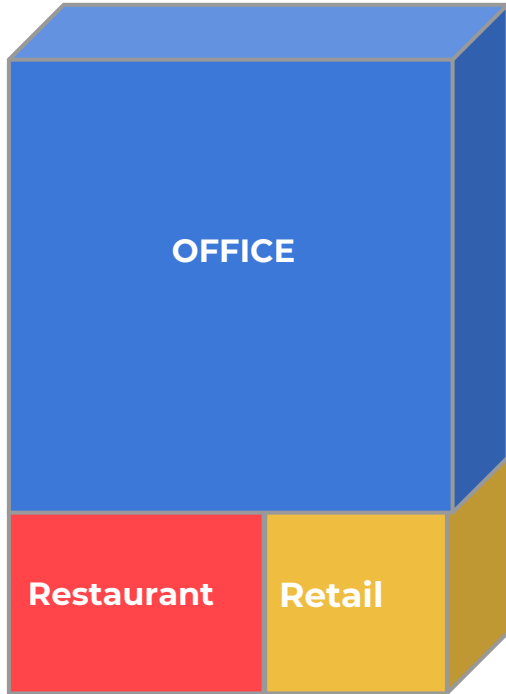
# EMISSIONS TARGETS



| Emissions Targets for Highest-Emitting Building Types (kgCO <sub>2</sub> e/SF/yr) |      |      |      |      |      |      |
|---|------|------|------|------|------|------|
|   | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
| <b>Office</b>   | 5.3  | 3.2  | 2.4  | 1.6  | 0.8  | 0    |
| <b>Multifamily Housing</b>  | 4.1  | 2.4  | 1.8  | 1.1  | 0.6  | 0    |
| <b>Healthcare</b>   | 15.4 | 10   | 7.4  | 4.9  | 2.4  | 0    |
| <b>Education</b>  | 3.9  | 2.4  | 1.8  | 1.2  | 0.6  | 0    |

\*See full list at [Boston.gov/BERDO](https://www.boston.gov/BERDO)

# BLENDING TARGETS FOR MIXED USE BUILDINGS



$$\begin{array}{c} \text{Office} \\ \text{Square Feet} \\ \times \\ \text{Office} \\ \text{Emissions Target} \end{array}$$

+

$$\begin{array}{c} \text{Food Sales \& Services} \\ \text{Square Feet} \\ \times \\ \text{Food Sales \& Services} \\ \text{Emissions Target} \end{array}$$

+

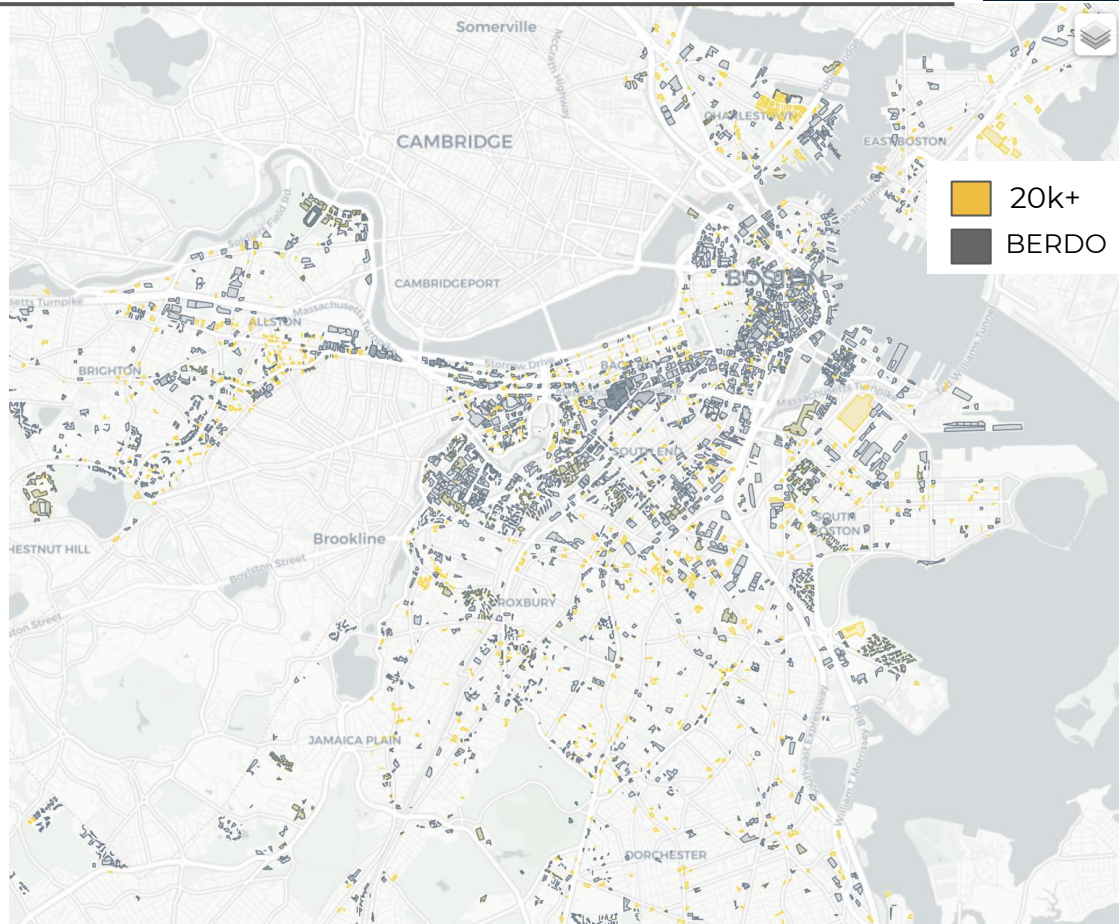
$$\begin{array}{c} \text{Retail} \\ \text{Square Feet} \\ \times \\ \text{Retail} \\ \text{Emissions Target} \end{array}$$

=

$$\text{Total Building Emissions Target}$$

# SIZE THRESHOLD

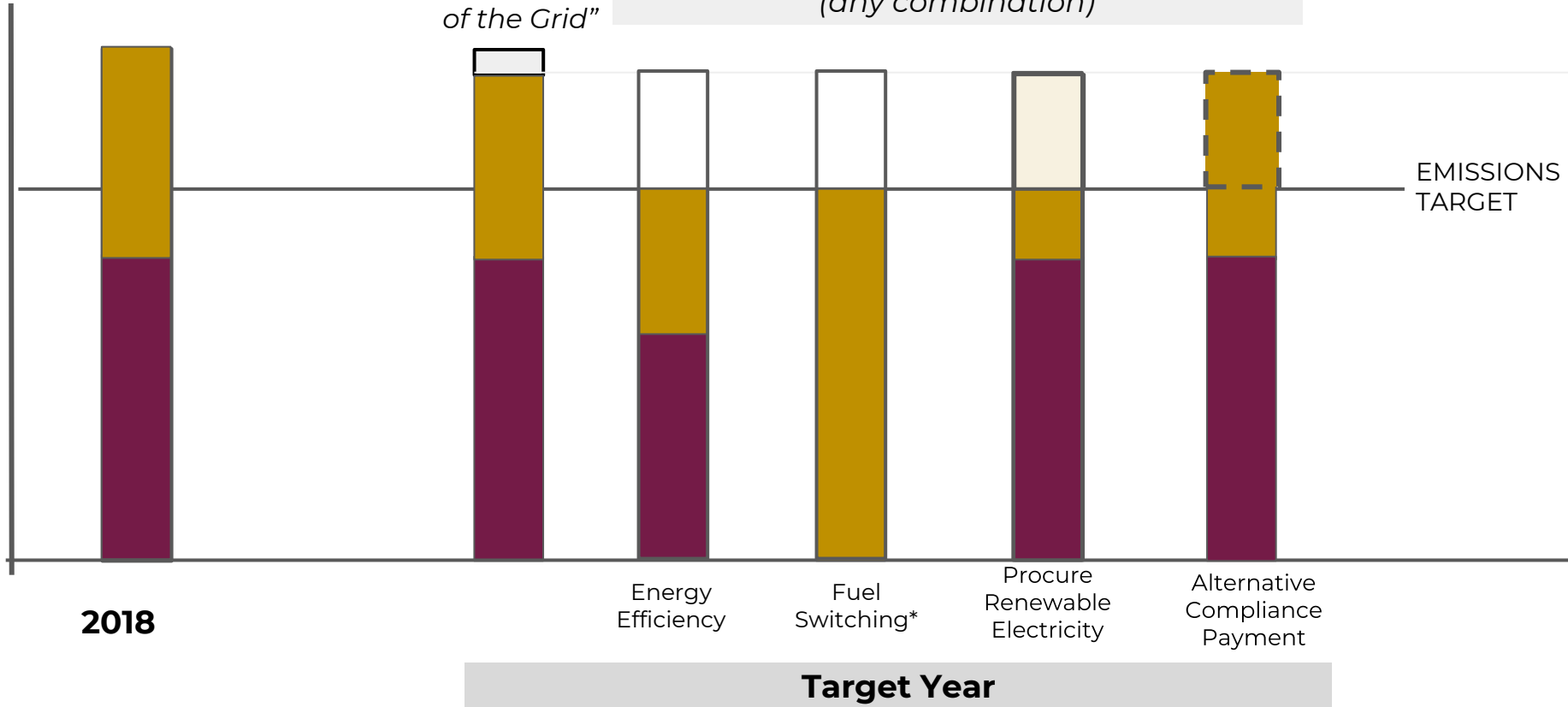
- **Previously:** 35,000+ square feet or 35+ units
- **Now:** 20,000+ square feet or 15+ units
  - First annual report due in 2022
  - Subject to emissions targets starting in 2030, and reported in 2031



# INDIVIDUAL BUILDING

*"Greening of the Grid"*

**Options**  
*(any combination)*



EMISSIONS TARGET

2018

Energy Efficiency

Fuel Switching\*

Procure Renewable Electricity

Alternative Compliance Payment

**Target Year**

Electricity Natural Gas

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

# FLEXIBILITY MEASURES

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- **Portfolios** - owners with more than one covered building may apply to comply across their portfolio.
- **Individual compliance schedules** - buildings or portfolios may apply for their own individual compliance plan, which must be aligned with citywide emissions goals for 2030 and 2050.
- **Hardship compliance plans** - buildings or portfolios with unique characteristics or circumstances that present a hardship (e.g., affordable housing refinancing timelines, historic designation, financial hardship) may apply for a hardship compliance plan.



# REVIEW BOARD

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## Responsibilities:

- Oversight and enforcement
- Program review & regulation update recommendations
- Review of alternative pathways
- Allocation of grants from the investment fund
  - Prioritizes emissions reduction projects that benefit environmental justice populations

*Note: The Air Pollution Control Commission will continue to oversee the ordinance and approve regulations changes, with the addition of the Commissioner of the Environment (ex officio) and a member with expertise in building design and energy systems.*

# REVIEW BOARD

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- Two-thirds of board members will be nominated by community-based organizations.
- Members will be appointed by the Mayor and approved by the City Council, with expertise in:
  - Environmental justice
  - Affordable housing
  - Labor and workforce development
  - Building engineering and energy
  - Public health
- Stipends will be available.

# ALTERNATIVE COMPLIANCE PAYMENT

- Additional option to meet carbon targets
- Tied to average retrofit cost per metric ton of CO<sub>2</sub>e, estimated at \$234/mtCO<sub>2</sub>e
  - *To be reviewed at least every 5 years and updated as needed*
- Paid into a new fund



# COMPLIANCE

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## **Data quality:**

- Self-certification with annual data submission
- Third-party verification every 5 years, including in first year of reporting to set the baseline

## **Non-compliance:**

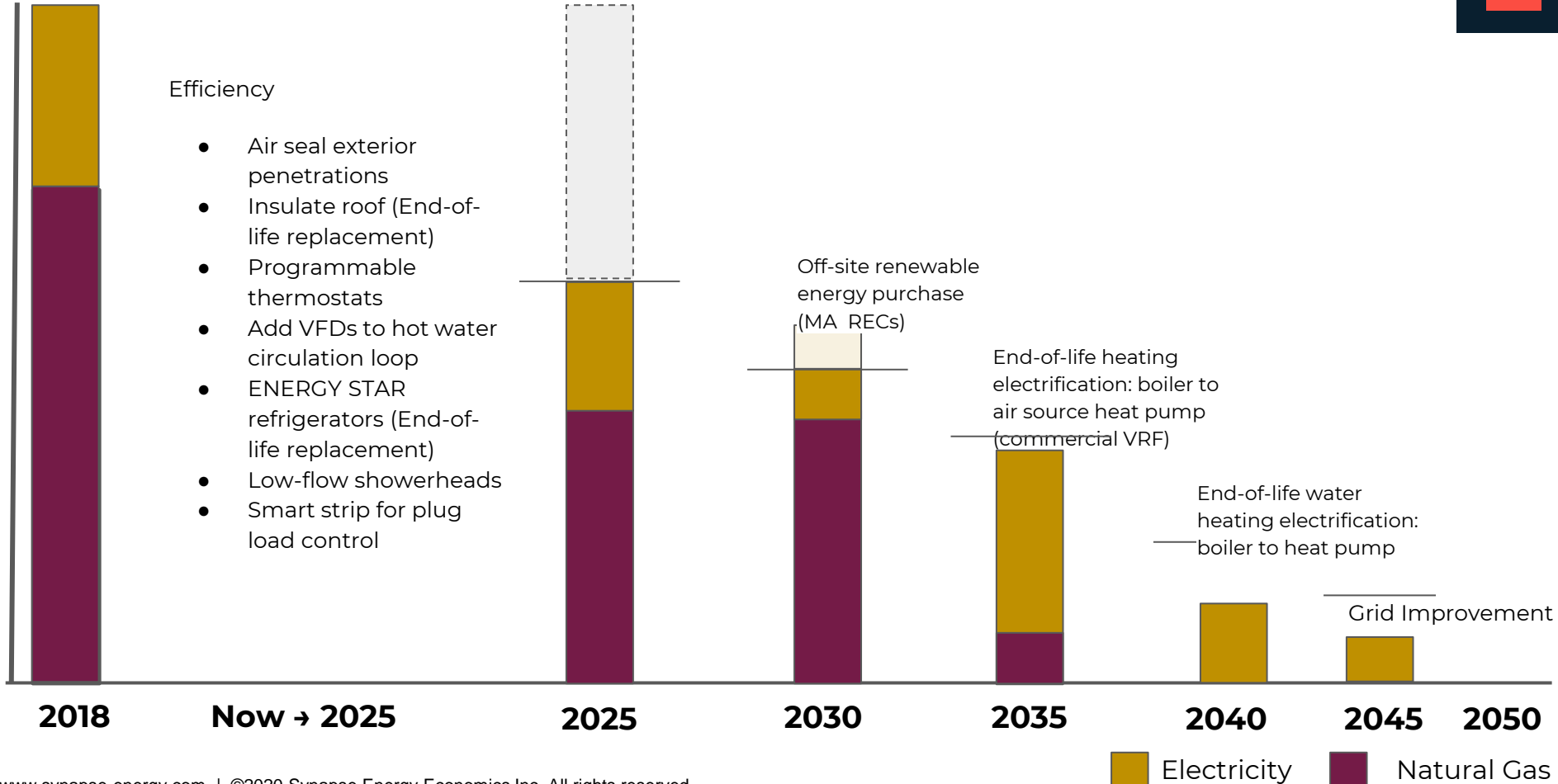
- Penalty for failure to comply with reporting requirements (\$150-\$300 per day depending on building size)
- Penalty for failure to comply with emissions standards (\$300-\$1,000 per day depending on building size)

# CASE STUDY: MULTIFAMILY (HIGH EMISSIONS) POSSIBLE PATHWAY



## Efficiency

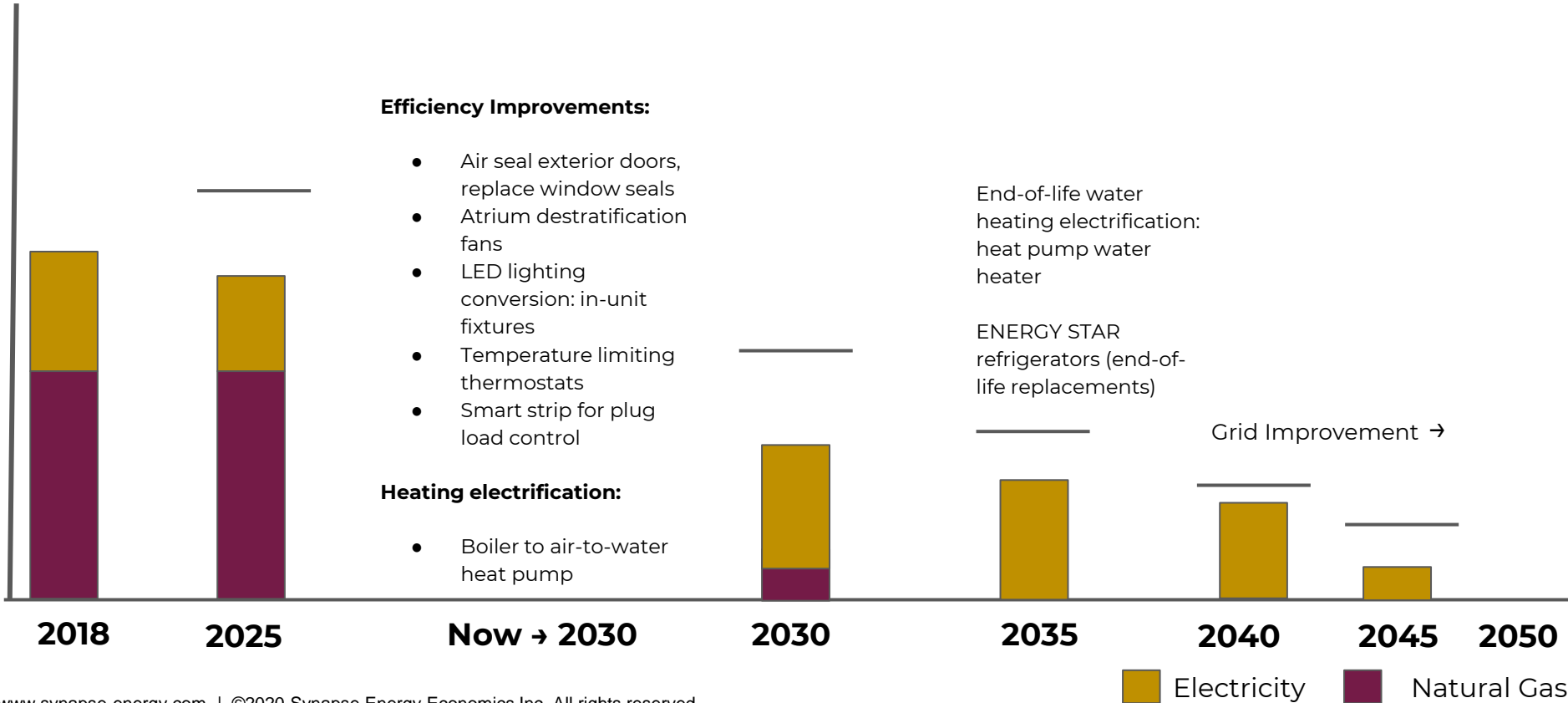
- Air seal exterior penetrations
- Insulate roof (End-of-life replacement)
- Programmable thermostats
- Add VFDs to hot water circulation loop
- ENERGY STAR refrigerators (End-of-life replacement)
- Low-flow showerheads
- Smart strip for plug load control



Electricity Natural Gas



# CASE STUDY: MULTIFAMILY (LOW EMISSIONS) POSSIBLE PATHWAY



# RESOURCE HUB

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Acts as a single entry point for renters, workers and owners for access to resources for building retrofits.



**Phase 1** - Informational website for building owners and tenants  
[boston.gov/departments/environment/retrofit-resource-hub](https://boston.gov/departments/environment/retrofit-resource-hub)

- 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

# REGULATIONS DEVELOPMENT

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- Phase 1: Winter 2022
  - Reporting requirements
  - Data verification
- Phase 2: Spring 2022-Winter 2023
  - Review Board
  - Compliance with emissions standards
  - Hardship compliance plans
  - Individual compliance schedules
  - Equitable emissions investment fund

Feedback form:

<https://forms.gle/wRko9z9CdxHseWc3>

6

# QUESTIONS?

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[boston.gov/berdo](https://boston.gov/berdo)



# APPENDIX





# Building Typologies (1 of 2)



## Assembly

- Aquarium
- Bar/Nightclub
- Bowling Alley
- Casino
- Fitness Center/Health Club/Gym
- Ice/Curling Rink
- Indoor Arena
- Movie Theater
- Museum
- Other - Entertainment/Public Assembly
- Other - Recreation
- Other - Stadium
- Performing Arts
- Racetrack
- Roller Rink
- Social/Meeting Hall
- Stadium (Closed)
- Stadium (Open)
- Swimming Pool
- Worship Facility
- Zoo



## College/University



## Education

- Adult Education
- Convention Center
- K-12 School
- Other - Education
- Pre-school/Daycare
- Vocational School



## Food Sales & Service

- Convenience Store with Gas Station
- Convenience Store without Gas Station
- Fast Food Restaurant
- Food Service
- Other - Restaurant/Bar
- Restaurant
- Supermarket/Grocery Store
- Wholesale Club/Supercenter



## Healthcare

- Ambulatory Surgical Center
- Hospital (General Medical & Surgical)
- Medical Office
- Other - Specialty Hospital
- Outpatient Rehabilitation/Physical Therapy
- Urgent Care/Clinic/Other Outpatient
- Veterinary Office

# Building Typologies (2 of 2)



## Lodging

- Barracks
- Hotel
- Other - Lodging/Residential
- Prison/Incarceration
- Residence Hall/Dormitory
- Residential Care Facility
- Senior Care Community



## Manufacturing/Industrial



## Services

- Courthouse
- Drinking Water Treatment & Distribution
- Energy/Power Station
- Fire Station
- Library
- Mailing Center/Post Office
- Other - Public Services
- Other - Services
- Other - Utility
- Personal Services (Health/Beauty, Dry Cleaning...)
- Police Station
- Repair Services (Vehicle, Shoe, Locksmith...)
- Transportation Terminal/Station
- Wastewater Treatment Plant



## Multifamily housing



## Office

- Bank Branch
- Financial Office
- Office



## Retail

- Automobile Dealership
- Enclosed Mall
- Lifestyle Center
- Other - Mall
- Retail Store
- Strip Mall



## Storage

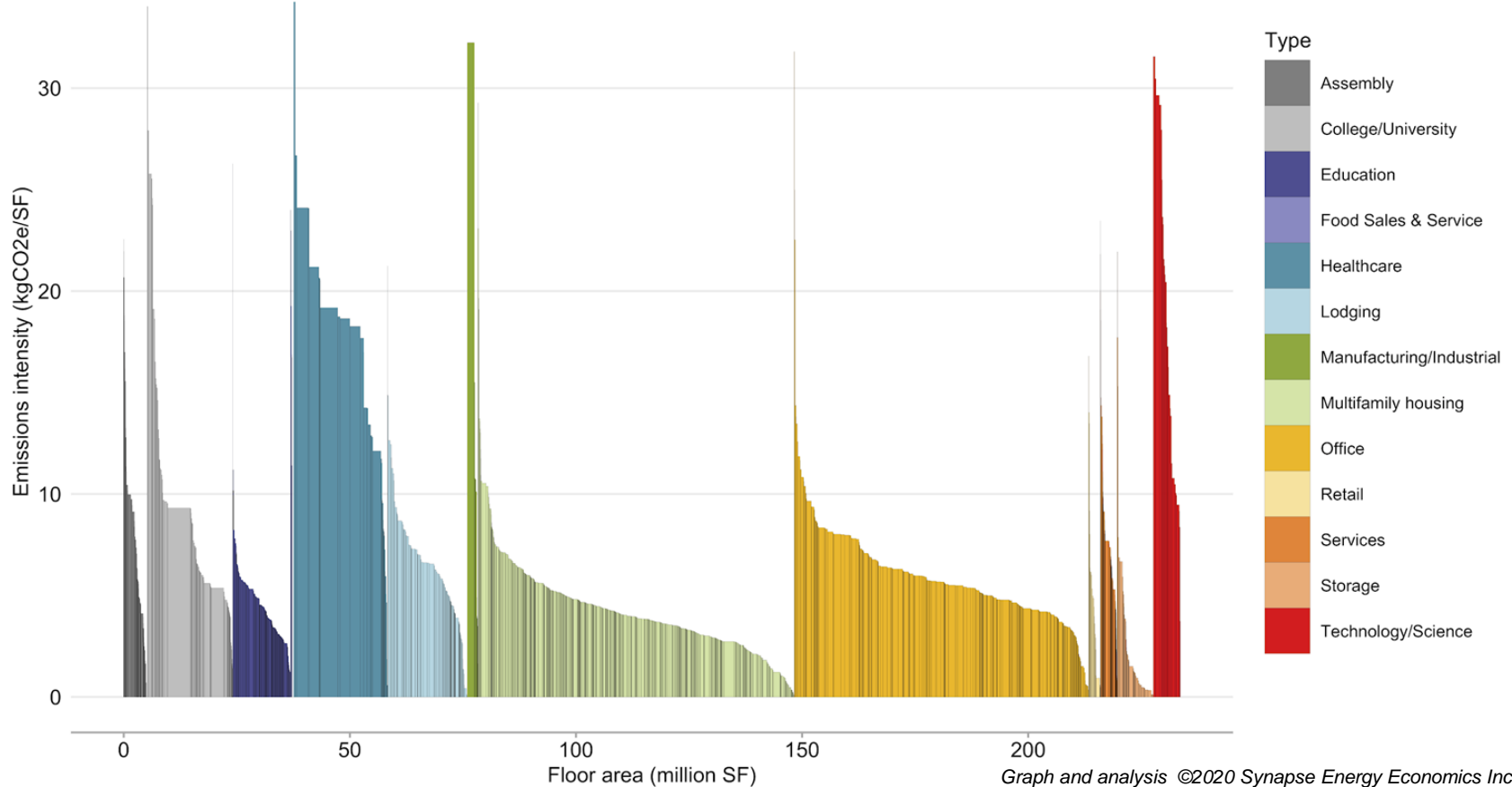
- Distribution Center
- Non-Refrigerated Warehouse
- Parking
- Refrigerated Warehouse
- Self-Storage Facility



## Technology/Science

- Data Center
- Laboratory
- Other - Technology/Science

# LARGE BUILDING EMISSIONS (35k+ SF)



# TREATMENT OF RECs and OFFSETS

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## 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 may apply to the Review Board for consideration of a custom approach.

# FUNDING OPTIONS

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- **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*



# CASE STUDY: MULTIFAMILY (HIGH EMISSIONS)

## Multifamily housing

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

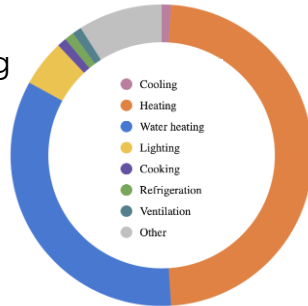
## Envelope insulation

- 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

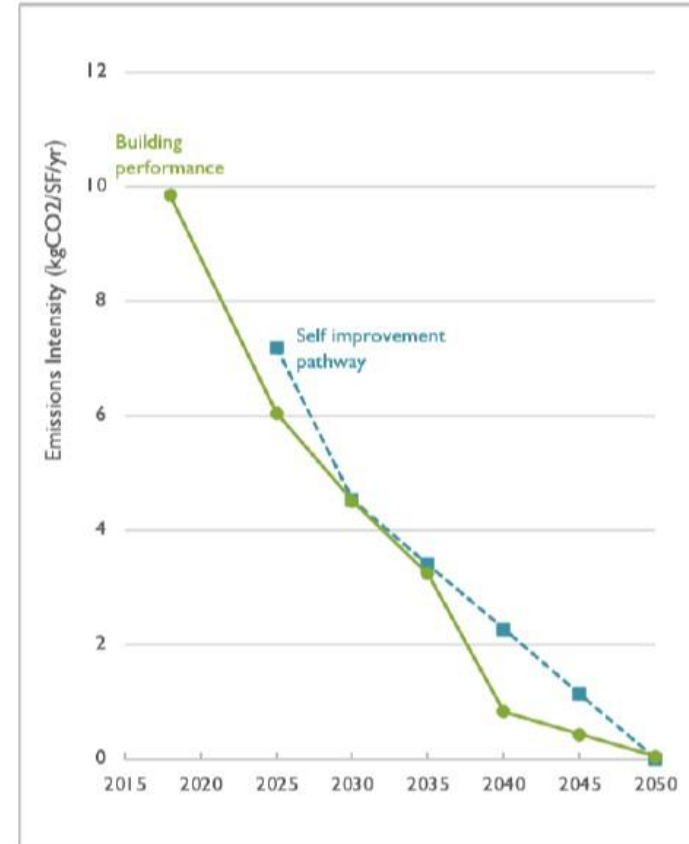


Photo credits: Conquest, PVHVAC, Patterson-Kelley

# 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)

| 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                            |
| <b>Total</b>   |                         |          | <b>\$4,755,008</b> | <b>\$1,904,018</b> | <b>18,027,165</b> | <b>73%</b> | <b>\$83,218</b> | <b>\$1,434,490</b> | <b>1,481</b>      | <b>100%</b> | <b>\$22</b>                    |

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

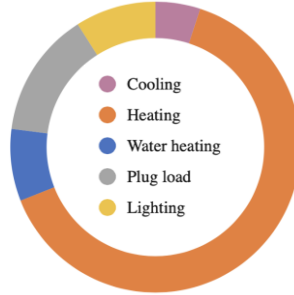
# CASE STUDY: MULTIFAMILY (LOW EMISSIONS)

## 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



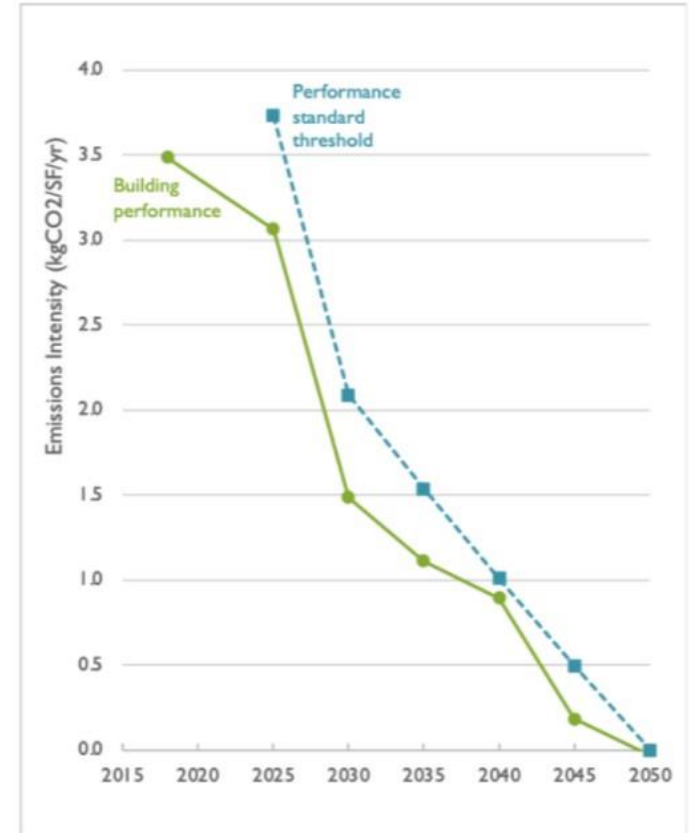
Central steam boiler



# 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                            |
| <b>Total</b>  |                         |          | <b>\$1,643,781</b> | <b>\$1,113,675</b> | <b>7,331,369</b> | <b>58%</b> | <b>-\$5,791</b> | <b>-\$17,661</b>  | <b>799</b>        | <b>100%</b> | <b>\$191</b>                   |

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