The Thompson Elementary School

This building is a case study that is part of the MassCEC BETA: Project Planning Pilot, committed to helping a representative selection of commercial building types in Massachusetts reach net zero emissions by 2050.

Building type: School/Education
Location: Arlington, MA
Year built: 2013
Stories: 3
Building Area: 69,786 SF (square foot)
EUI: 55.8 kBtu/sf/yr
CEI: 3.0 CO2e kg/sf/yr

Project Triggers & Goals:

- Occupant thermal comfort
- Utility cost savings
- Regulatory compliance

Decarbonization Performance Target

The optimized decarbonization pathway for the Thompson Elementary School prioritizes the installation of an all-electric heating and cooling system within the next 20 years, aligned with building enclosure air sealing and reconfiguration of an existing rooftop solar photovoltaic (PV) system, upon its contract expiration (2035). When including additional energy efficiency and load reduction upgrades, the recommended measures enable the property to reach a 58% EUI reduction and a 56.1% greenhouse gas emissions (GHG) reduction (with existing solar) in the next 20 years , while being mindful of Arlington's Net Zero Action Plan and recent Decarbonization Roadmap, in alignment with Massachusetts' Carbon Neutral goals by 2050.

Energy Efficiency & Load Reduction:
Lighting (LED), air sealing and weatherproofing, advanced HVAC and lighting controls

Electrification of Systems:
GSHP heating and cooling, DOAS ventilation with heat recovery, Heat Pump DHW heater

Renewable Energy:
Existing ~100kW Solar PV Array (PPA)

Existing Conditions

The Thompson Elementary School was completed in 2013, with a classroom wing addition in 2018. The building enclosure, a concrete and steel structure with insulated metal stud/masonry veneer, is in good condition and exceeded 2013 Massachusetts Energy Code code requirements at the time of construction. Approximately 9% of the building is currently air conditioned through an ASHP/VRF system, primarily serving the administrative spaces. A primary concern is the lack of cooling in the academic wings, which causes discomfort and limits classroom use during warmer weather. Heating is provided by natural gas condensing boilers. The school has taken steps to reduce on-site emissions with an existing power purchase agreement (PPA) solar PV system and is currently conducting a feasibility study with the Town of Arlington to explore neighborhood-scale geothermal (ground source) network system.

Existing Envelope

Walls: Medium performance
Roof: Medium performance
Windows: Medium performance

Existing Mechanical Systems

HVAC: Perimeter hot water (HW) heat, single zone rooftop air handler units with HW heating. Limited cooling in select areas: VRF heat pumps, ASHP (split systems) and DX cooling in select spaces. Ventilation is supplied by rooftop DOAS and AHU units.

Domestic hot water: 125-gal direct-fired natural gas tank, two 400-gal indirect storage tanks.

Existing Process/Plug Loads/Lighting

A majority of fluorescent light fixtures, full commercial kitchen with gas appliances.

Optimized Decarbonization Recommendations

Energy Efficiency & Load Reduction

Foundational Efficiency and Load Reduction:

- LED lighting upgrade
- Lighting system controls upgrade
- Demand control ventilation

Advanced Load Reduction:

- Enclosure air sealing and weatherproofing

Electrification of Systems

System Electrification:

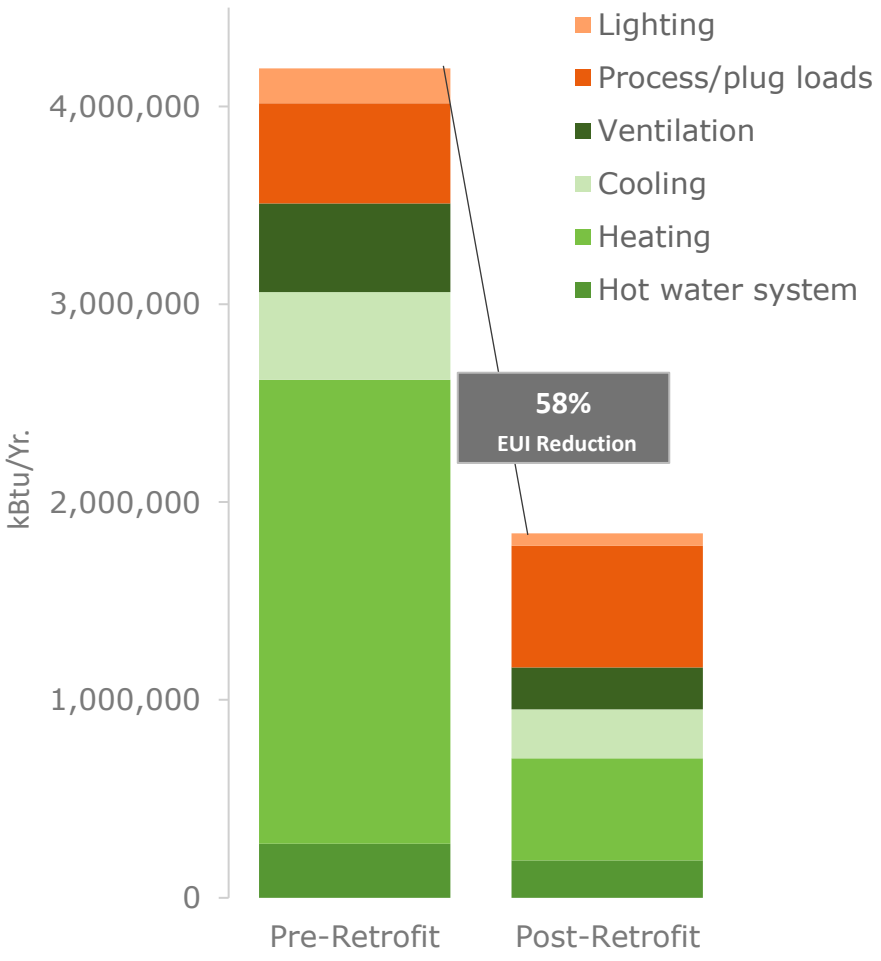
- Ground source heat pump (GSHP) HVAC system
- Dedicated outdoor air system (DOAS) with heat recovery
- Heat pump DHW system

Renewable Energy

SOLAR PV:

- Solar PV array installed during 2015
- ~100kW system producing about 104,000 kWh annually
- PPA contract ending in 2035

Annual Energy Savings Projections



Annual Utility Savings Impacts

Measure description	Electricity costs	Fossil fuel costs	Net total impacts
Lighting	-$10,938	-	-$10,938
Process/plug loads	$10,475		$10,475
Ventilation	-$22,869	-	-$22,869
Cooling*	-$33,148	-	-$33,148
Heating	$44,414	-$34,322	$10,093
Hot water system	$20,813	-$4,104	$16,709
Renewable energy	-	-	-
Total utility bill impact	**$8,747**	**-$38,426**	**-$29,679**

24% of post-retrofit load expected to be served by existing renewables

*Note: The existing energy use and costs includes the Town's planned addition of an air conditioning system to the academic wings.

Optimized Decarbonization Pathway

The following graphic depicts the proposed decarbonization measures and order of implementation for the Thompson Elementary School. The decarbonization measures are grouped into bundles, based on which measures must be implemented at the same intervention point. While it outlines a maximum number of intervention points, an all at once approach may be advantageous for accessing incentives, minimizing upfront costs, and reducing disruptions.

Considerations

2025-2040: Foundational efficiency improvements are not time dependent and are being implemented based on the end-of-life of systems.

2035: Solar PV PPA expires. Removal or new/reconfiguration of solar PV system.

2033-2035: Renewable energy tax credits from the IRA expires.

2040-2045: End of service life for existing mechanical equipment. Electrification of heating systems implementation.

2040-2045: Air sealing and weatherproofing is not time dependent. Best implementation time is prior to the electrification of heating upgrade to allow right sizing of HVAC equipment.

2040-2045: Align removal of existing HVAC system and infrastructure to allow space on roof and in mechanical room for new GSHP system.

2040-45: Partial replacement of gas fired cooking equipment at the time of the removal of the existing HVAC systems.

Order of Implementation

LED Lighting Upgrade

Lighting System Controls Upgrade

Demand Control Ventilation

Solar PV System
Reinstall existing or new solar PV System

GSHP System
Install ground source heat pump and DOAS for space heating and cooling

Heat Pump DHW Heater
Install heat pump domestic hot water heater to replace current DHW heater

Air Infiltration Sealing and Weatherproofing
Support right szing of HVAC equipment

Existing Boiler
Remove existing gas-fired boiler
Existing HVAC Infrastructure
Remove existing DOAS, AHUs, and air source heat pump VRF system

Kitchen Electrification
Partial replacement of gas fired cooking equipment during GSHP installation

Cumulative GHG Reduction Potential

11%

56%

Zero on-site combustion

*GHG calculations are based on emissions factors outlined by BERDO. Full decarbonization will be achieved as the electrical grid decarbonizes. GHG calculations include Scope 1 and Scope 2 emissions only.

LCCA Cost Analysis

Incentives

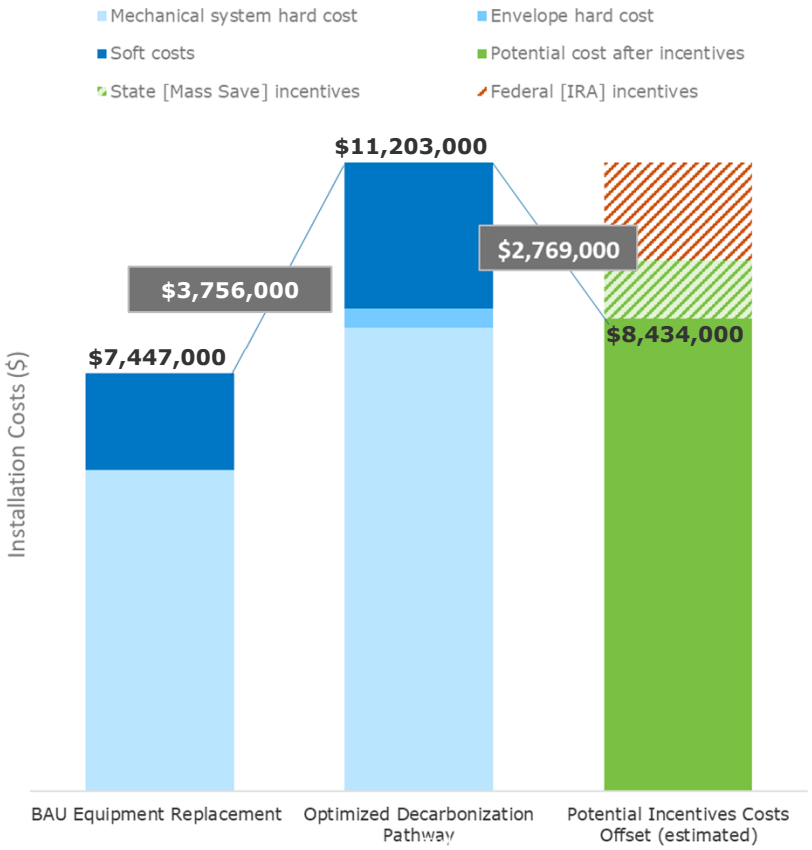
Various funding opportunities, including utility incentives, federal tax credits, and competitive grant programs (among others) are currently available to help offset the costs of decarbonization upgrades. Maximizing the use of outside funding sources while leveraging decarbonization-relevant financing tools can help offset costs and accelerate implementation. Construction timelines and measure consolidation plans should incorporate considerations such as incentive availability (as some funding sources may be time-limited), opportunities to reduce soft costs, and loss of cash flow due to disruptions.

Relevant Incentives

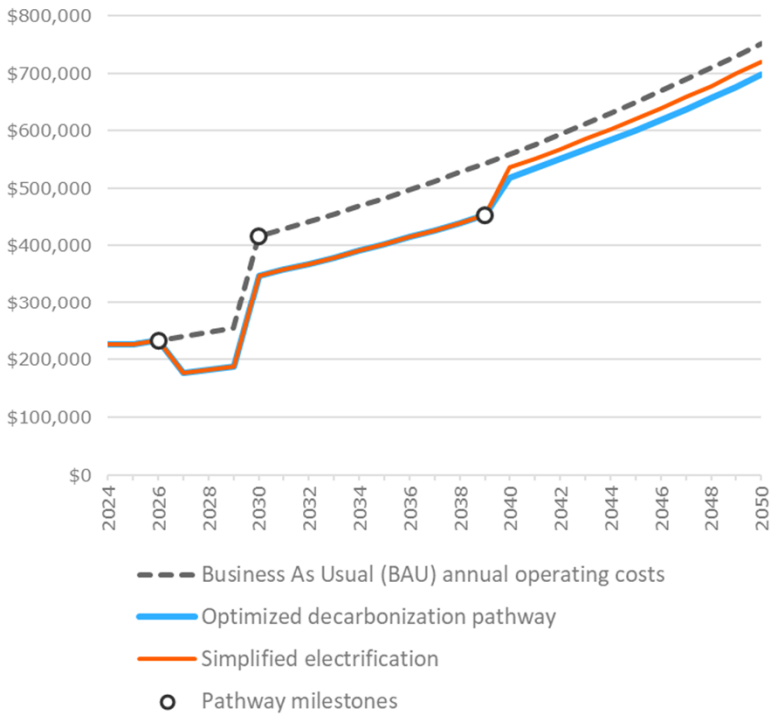
- Mass Save Commercial Incentives covering the following measures:
  - GSHP (HVAC system replacement)
  - DOAS/Heat Recovery/DCV
  - Heat Pump DHW
  - LED Lighting
  - Air Sealing-Weather proofing
  - Enclosure Upgrades (roof/windows)
- IRA Renewable Investment Tax Credit: GSHP
- DOER Alternative Energy (AEC) Program: GSHP

Installation/Implementation Costs

Estimated cost of optimized decarbonization pathway	$11,203,000
Estimated value of State (utility) incentives (2024-2029)	$1,044,000
Estimated value of Federal incentives (2024-2029)	$1,725,000
NET cost of optimized decarbonization pathway	$8,434,000



Total Operating Cash Flow*

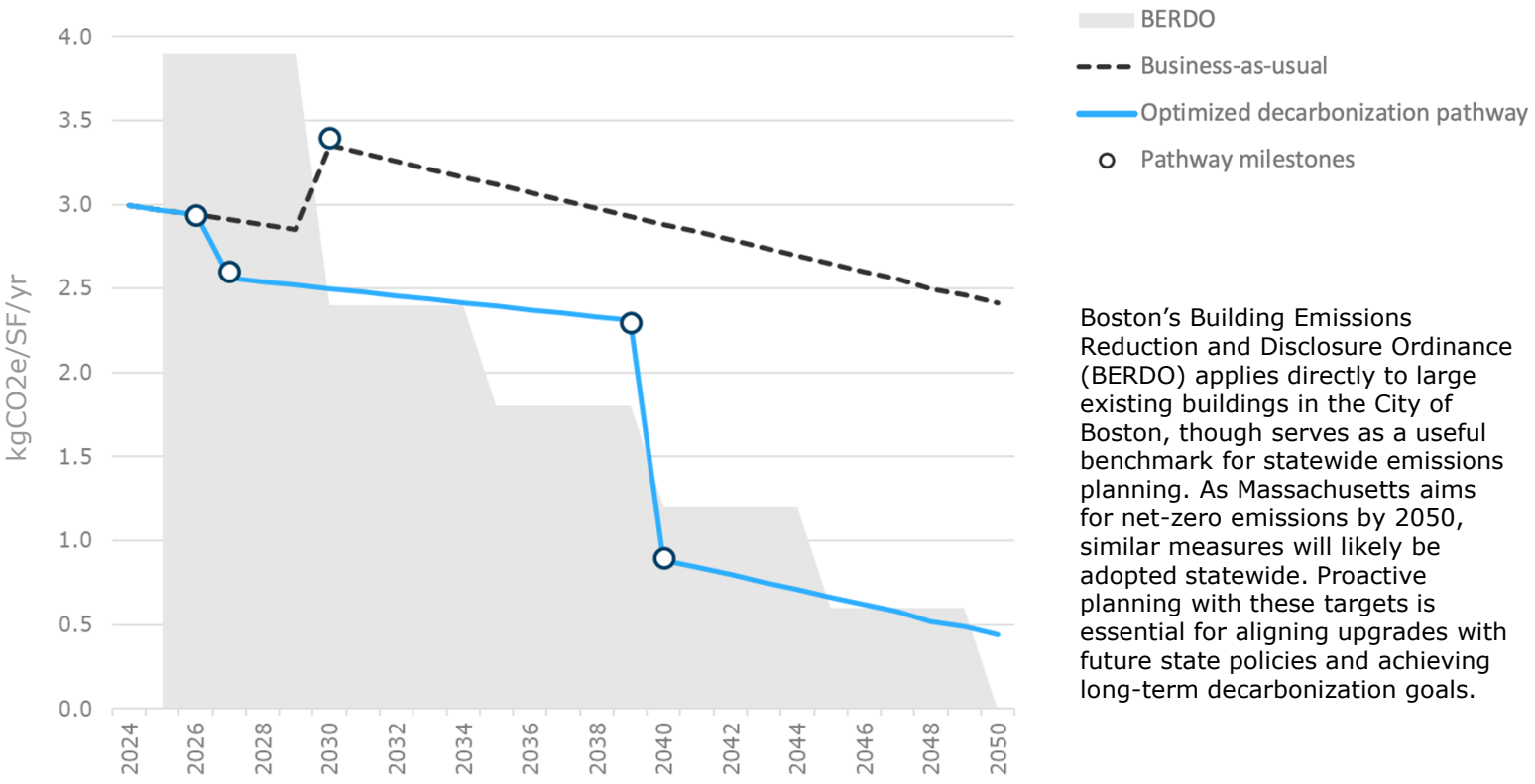


The business as usual (BAU) was developed based on direction from the owner and necessary repairs and replacements that meet code compliance, including added cooling by 2030 and an upgraded gas boiler in 2040. Compared to BAU renovations, decarbonization measures can offer long-term benefits such as avoided fines for emissions, significant energy savings, and potentially lower utility expenses.

*Forecasted operating costs look at current operating expenses and factor in changes in utility costs and maintenance costs based on the measures and targets of each trajectory. Utility and maintenance costs reflect a 3% annual escalation rate.

Decarbonization Benefits

Emissions Goals and Benchmarking



Boston's Building Emissions Reduction and Disclosure Ordinance (BERDO) applies directly to large existing buildings in the City of Boston, though serves as a useful benchmark for statewide emissions planning. As Massachusetts aims for net-zero emissions by 2050, similar measures will likely be adopted statewide. Proactive planning with these targets is essential for aligning upgrades with future state policies and achieving long-term decarbonization goals.

Resiliency Considerations

The school is located outside of but relatively close to the current FEMA flooding zones (Mystic River area). Considering the potential for intense weather events, including extreme rainfalls in short timeframes, a climate change vulnerability assessment is recommended, including flood proofing measures for both the site and the facility, such as the electrical service, generator and other energy systems equipment located at ground level. The existing solar PV provides for 9.2% of the annual energy use. Future solar PV expansion (with battery storage) on site may be of consideration, as it would provide for additional resiliency.

Next Steps and Best Practices

- [x] Existing building conditions
- [x] Decarbonization assessment
- [ ] Supplemental assessments
  - Electric load study
  - Climate change vulnerability assessment
- [ ] Assemble project team
- [ ] Structure financing stack

Within the scope of this decarbonization assessment, this building has completed an energy audit and feasibility study for the outlined decarbonization measures. Owners should have a better understanding of their existing baseline, property goals between now and 2050, and the steps needed to get there. The data and scoping from this assessment can be used by design teams, including architects and engineers, to begin drafting project plans and construction timelines which will also help bolster financing and incentive applications.