The Thompson Elementary School

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

Building type	Education
Location	Arlington
Year built	2013
Stories	3
Square footage	69,786
Energy use intensity (EUI)*	55.8 kBtu/sf/yr
Carbon emission intensity (CEI)*	3.0 CO2e kg/sf/yr
Decarbonization goals	Occupant thermal comfort, lower utility costs, regulatory compliance

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 slightly exceeded energy code requirements at the time of construction. Approximately 9% of the building is currently air conditioned, primarily serving the administrative spaces. The lack of cooling in the academic wings causes discomfort and limits classroom use during warmer weather.

Existing Conditions

Enclosure	**Walls**	**Roof**	**Windows**
	Good	Good	Good
Heating	Gas condensing boilers. Perimeter hot water (HW) heat, single zone rooftop air handler units (AHUs) with HW heating.		
Cooling	Limited cooling in administrative areas: Variable refrigerant flow (VRF) heat pumps, air source heat pump (ASHP) split systems, and direct expansion (DX) cooling. No cooling in classrooms.		
Ventilation	Ventilation is supplied by rooftop dedicated outdoor air system (DOAS) and AHUs		
Hot water	125-gal direct-fired gas tank, two 400-gal indirect storage tanks		
Lighting	A majority of fluorescent light fixtures		
Controls	Thermostats set between 68-72 degrees F during occupied hours, and 65 (heating) and 75 (cooling) during unoccupied hours		
Other	Gas appliances in commercial kitchen		
Renewable energy	Existing ~100kW rooftop solar PV system under power purchase agreement (PPA)		

*EUI represents the annual energy usage of the building divided by the total area. CEI is the amount of greenhouse gas (GHG) emissions divided by the total area.

Key Challenges & Solutions

Lack of cooling limits classroom use during warmer weather

Install a new heat pump system for cooling at classrooms by 2030, aligned with building enclosure air sealing. Stage the full heating and cooling system upgrade with ground source heat pump (GSHP) leveraging available tax credits

Aligning with Arlington's Net Zero's Action Plan

Implementing foundational energy efficiency and load reduction measures and GSHP upgrade will enable the property to meet the Town's greenhouse gas emission (GHG) reduction targets in the next 15 years.

Core Decarbonization Strategy

- Existing hydronic heating systems allows for GSHP or air-to-water heat pump (AWHP) replacements while also cost-effectively adding cooling
- Energy systems upgrades align with the end-of-life and the reconfiguration of the solar PV system to reduce upfront costs
- Air sealing addresses air leakage to lower utility costs while minimizing costly upgrades to the building envelope

Retrofit Measures and Energy Impacts

Measures

Energy Efficiency & Load Reduction

Foundational Efficiency and Load Reduction:

- LED lighting upgrade
- Lighting system controls upgrade
- Demand control ventilation (DCV)

Advanced Load Reduction:

- Enclosure air sealing and weatherproofing

System Electrification

Electrification Enablers:
Further assessment required

System Electrification:

- GSHP HVAC system
- DOAS with heat recovery
- Heat pump domestic hot water (DHW) system

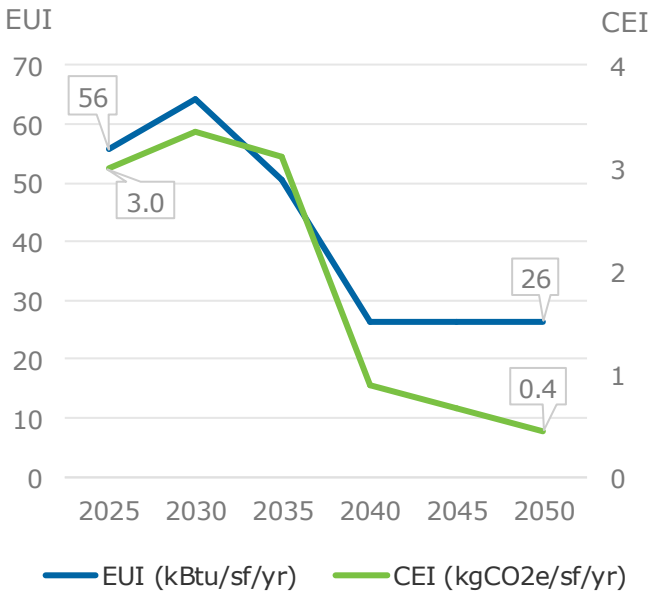
Renewable Energy

Solar:

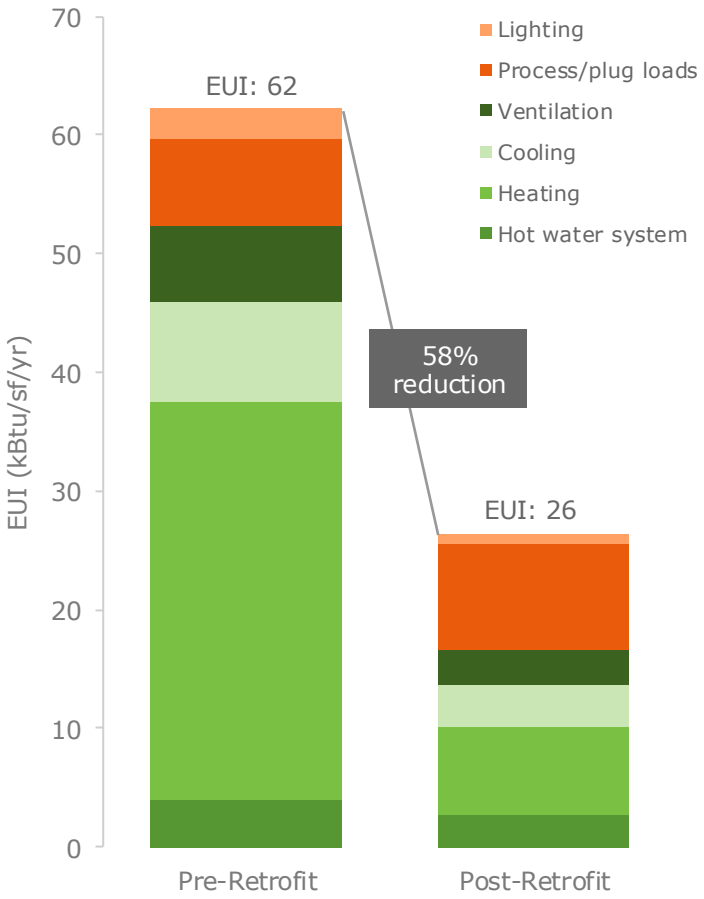
- Existing ~100kW system solar PV array installed during 2015, producing ~104,000 kWh/yr. PPA contract ending in 2035

Performance Targets

The decarbonization approach prioritizes end-of-life equipment replacement, including LED lighting and DCV upgrades, enclosure air sealing, and a GSHP system over a 15-year timeline (2025 - 2040). The recommended measures enable a 58% EUI reduction and up to 56% GHG reduction. These efforts would yield the following results over time:



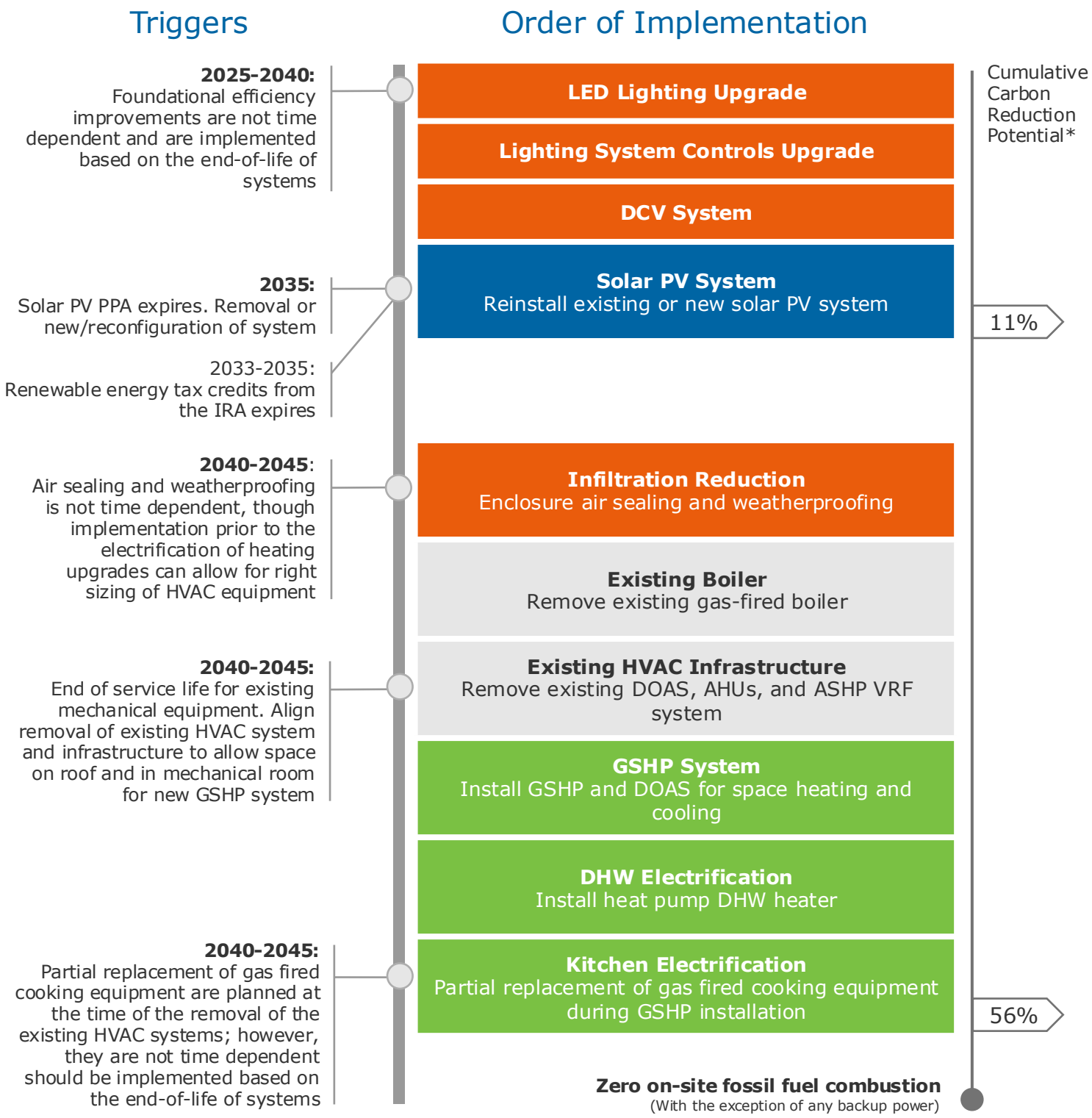
Annual Energy Use Impacts*



*The annual energy use impacts graphic illustrates an EUI before and after once all recommended measures are implemented, except for any existing renewable energy under the PPA. The existing EUI includes added air conditioning energy use, in order to best compare to a fully air-conditioned school under the optimized decarbonization pathway. The CEI and EUI shown in the performance targets in the graphic on the left account for the added benefits of renewable energy.

Project Planning

The graphic below presents a decarbonization pathway, organizing measures into bundled actions that are best implemented together. The expected cumulative carbon reduction potential from each bundle is noted on the right. The strategy to reach zero GHG emissions by 2050 focuses on maximizing energy efficiency, electrifying on-site combustion systems within a cleaning grid, and cost-effective on-site renewables. Key considerations or triggers are listed along a timeline to support informed decision-making, with bolded dates indicating recommended implementation years.



*GHG calculations are based on BERDO Version 2.3 emissions factors. Full decarbonization is dependent on statewide renewable energy adoption. GHG calculations include direct onsite combustion (Scope 1) and purchased electricity (Scope 2). For any renewable energy measures included in this plan, it is assumed that the owner will retain the Renewable Energy Credits (RECs) to claim the GHG reduction for reporting.

Cost Analysis

Annual Utility Impacts

Measure description	Changes in annual utility costs		
	Electricity	Fossil fuel	Net total changes
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
Total from recommended measures	**$8,747**	**($38,426)**	**($29,679)**
Renewable energy	The Solar PV system is a PPA. The utility saving are built in the PPA contract and existing utility costs.		

The existing energy use and estimated utility costs include the Town's planned addition of a cooling system to the academic wings by 2030. Applying for the Massachusetts DOER Alternative Energy Program (AEC) may qualify the Town for Renewable Energy Certificates (RECs) for the GSHP system. A preliminary AEC RECs calculation estimated up to $40,000+/yr., pending the RECs annual value/rate. The RECs revenues would further benefit the annual operating costs and likely improve the ROI/payback for the GSHP system.

Lifecycle Costs*

Realizing the full value of decarbonization requires a long-term outlook that weighs upfront investments, operating costs, and financial incentives. BETA assessments identify the retrofit pathway that most effectively reduces emissions, maintains comfort, and improves performance relative to upgrades an owner would already make (the business-as-usual (BAU) scenario). This comparison highlights long-term avoided costs and risks, as well as opportunities—such as incentives—that support pursuing the optimized pathway.

Costs	BAU retrofit	Optimized decarbonization pathway	
Base building and envelope costs	$0	$1,214,000	Foundational efficiency and load reduction
		$349,000	Advanced load reduction
Mechanical costs	$5,728,000	$0	Electrification enablers
		$7,054,000	System electrification
Renewable energy costs	$0	$0	Renewable energy
Soft costs	$1,719,000	$2,585,000	
Total upfront costs	**$7,447,000**	**$11,202,000**	
Utility incentive opportunities	($700,000)	($2,769,000)	
25-year total accrued utility costs	$8,722,000	$7,203,000	
25-year accrued total operating costs	$13,151,000	$11,632,000	
25-year LCCA	**$19,898,000**	**$20,065,000**	

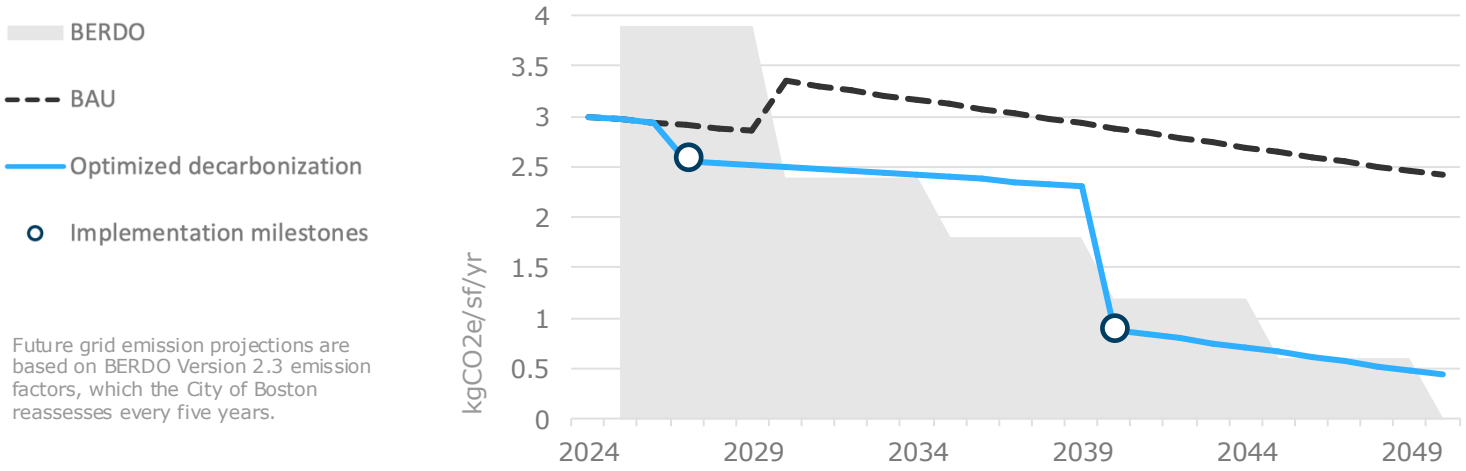
BAU scope:
- Boiler replacement
- Existing cooling (ASHP/VRF), and ventilation (DOAS) replacement
- DHW replacement
- Added cooling (ASHP/VRF) to academic wings in 2030
- Gas kitchen appliances

*All cost and incentive values are estimated based on industry data and rounded to the nearest $1,000. All incentives values are based on currently available programs and are subject to change over time. Forecasted operating costs include utility costs, maintenance costs, and noncompliance fees if relevant. Utility and maintenance costs reflect a 3% annual escalation rate. The BAU approach assumes necessary repairs and replacements that meet code compliance. In this case study, BAU represents the conventional gas or code-compliant versions of the decarbonization measures listed.

Decarbonization Benefits

Emissions Goals and Benchmarking

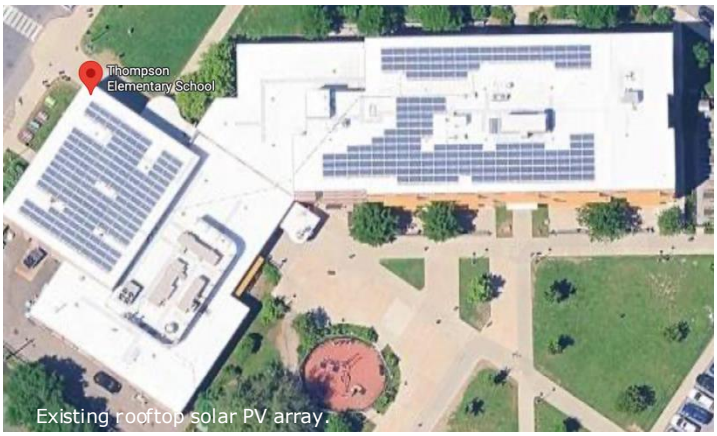
Boston's Building Emissions Reduction and Disclosure Ordinance (BERDO) applies to large existing buildings in the city and, outside Boston, serves as a useful benchmark for owners to proactively align upgrades with statewide goals. As Massachusetts targets net-zero emissions by 2050, similar policies may be adopted statewide. Achieving "zero" depends on the pace of statewide renewable energy adoption, with any remaining gaps addressed through RECs or clean electricity aggregation programs.



Future grid emission projections are based on BERDO Version 2.3 emission factors, which the City of Boston reassesses every five years.

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.



Existing rooftop solar PV array.

Next Steps and Best Practices

There are many potential strategies to reduce the operational GHG emissions of buildings. As a starting point, owners are encouraged to have a solid understanding of base building information, including current energy use, carbon emissions, and long-term property goals through 2050. The data and scoping developed through this assessment can be used by design teams, including architects and engineers, to begin shaping project plans and construction timelines, while also strengthening financing strategies and incentive applications. To move from assessment to action and ensure a clear, strategic path toward decarbonization, the following next steps are recommended.

- [x] Existing building conditions
- [x] Decarbonization assessment
- [ ] Supplemental assessments
  - Mechanical assessment for academic wings
- [ ] Emergency protocols
- [ ] Assemble project team
- [ ] Structure financing stack