Temple Israel

Building Performance Exchange

MASS CLEAN ENERGY CENTER

This case study is part of the MassCEC Building Electrification and Transformation Accelerator (BETA): Project Planning program, committed to helping a representative selection of commercial building types in Massachusetts reach net zero emissions by 2050. This MassCEC funded resource and more are available via the Building Performance Exchange.

Building type	Religious building
Location	Boston, MA
Year built	1927, 1955, 1975
Stories	3
Square footage	110,000
Energy use intensity (EUI)*	90 kBtu/sf/yr
Carbon emission intensity (CEI)*	4.8 CO2e kg/sf/yr
Decarbonization goals	Utility cost savings, Regulatory compliance, Tenant improvements

Temple Isreal in Boston, MA is a 3-story religious worship building. The building comprises three connected structures built in 1927, 1955, and 1975. The original sanctuary is wood-framed with stone veneer and glazing; the newer additions feature granite or stone veneer and black rubber roofs. Power is supplied by a 750 kVA transformer feeding an aged 3,000A switchboard. HVAC systems include a centralized hydronic system for AHUs and radiators, plus 22 RTU.

Existing Conditions

Enclosure	Walls	Roof	Windows
	Poor	Fair	Poor
Heating	Boiler serves centralized hydronic system for AHUs and radiators, plus 22 gas fired RTUs		
Cooling	Chiller serves hydronic cooling system. DX cooling within RTUs		
Ventilation	Ventilation is supplied by rooftop & AHU units		
Hot water	The heating plant feeds a 200-gallon uninsulated DHW storage tank		
Lighting	Majority LED installed in 2021 with some fluorescent		
Controls	Central BMS system		
Other	Full commercial kitchen with gas appliance		
Renewable energy	None		

*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

Aging high-temperature hydronic infrastructure

Upgrade old radiators to low-temperature fan coil units and radiators before electrifying hydronic plant.

Limited solar potential, aging roof

Consider small solar array installed at time of old sanctuary roof replacement to offset meter electricity bills

Old single-pane windows and Sky lights

Replace with triple pane low e windows

Core Decarbonization Strategy

- RTU heating creates an opportunity for cost effective heat pump replacements
- New equipment is staged over long run to align with system end-of-life and optimize upfront costs
- Air sealing and new windows addresses reported draftiness and air leakage while minimizing costly overhaul of envelope

Retrofit Measures and Energy Impacts

Measures

Energy Efficiency & Load Reduction

Foundational Efficiency and Load Reduction:

- Air sealing
- Weatherstripping
- BMS Optimization

Advanced Load Reduction:

- Skylight replacement
- Roof Replacement
- Window Replacement

System Electrification

Electrification Enablers:
Existing service capacity to be evaluated

System Electrification:

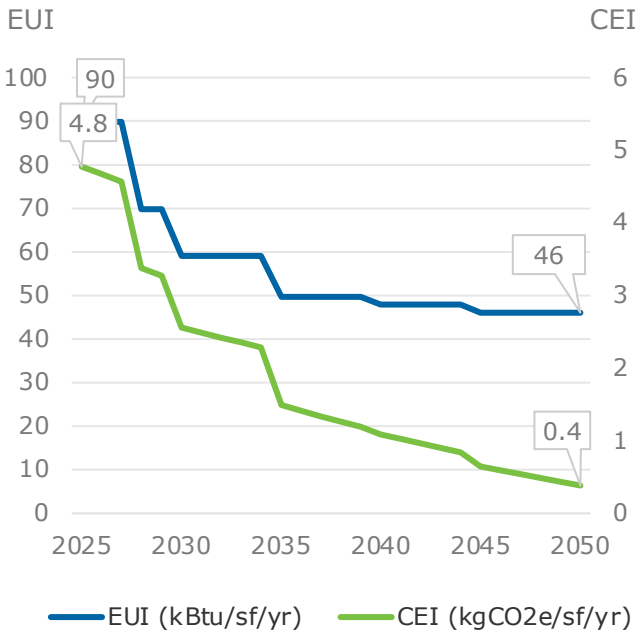
- Replace boiler and chiller with AWHP
- RTU to HP RTU
- Heat Pump DHW system
- Electrify kitchen equipment

Renewable Energy

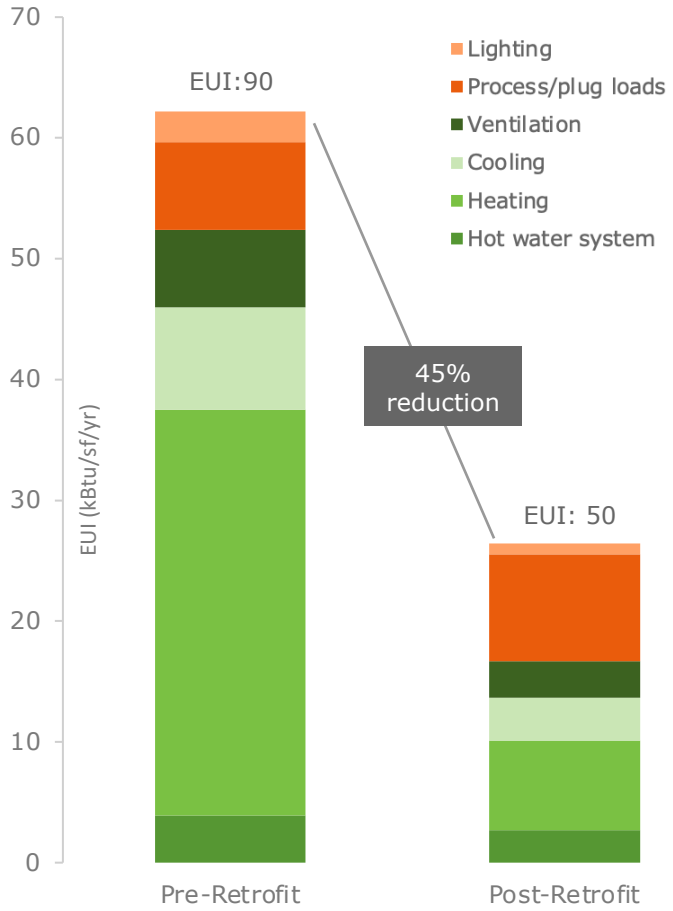
Solar:
Install 45-50 kW PV array on Levi Auditorium roof

Performance Targets

The decarbonization approach prioritizes immediate energy efficiency measures and heat recovery while looking long term at heat pumps and more efficient all-electric mechanical system replacement at end-of-life. These efforts would yield the following results over time:



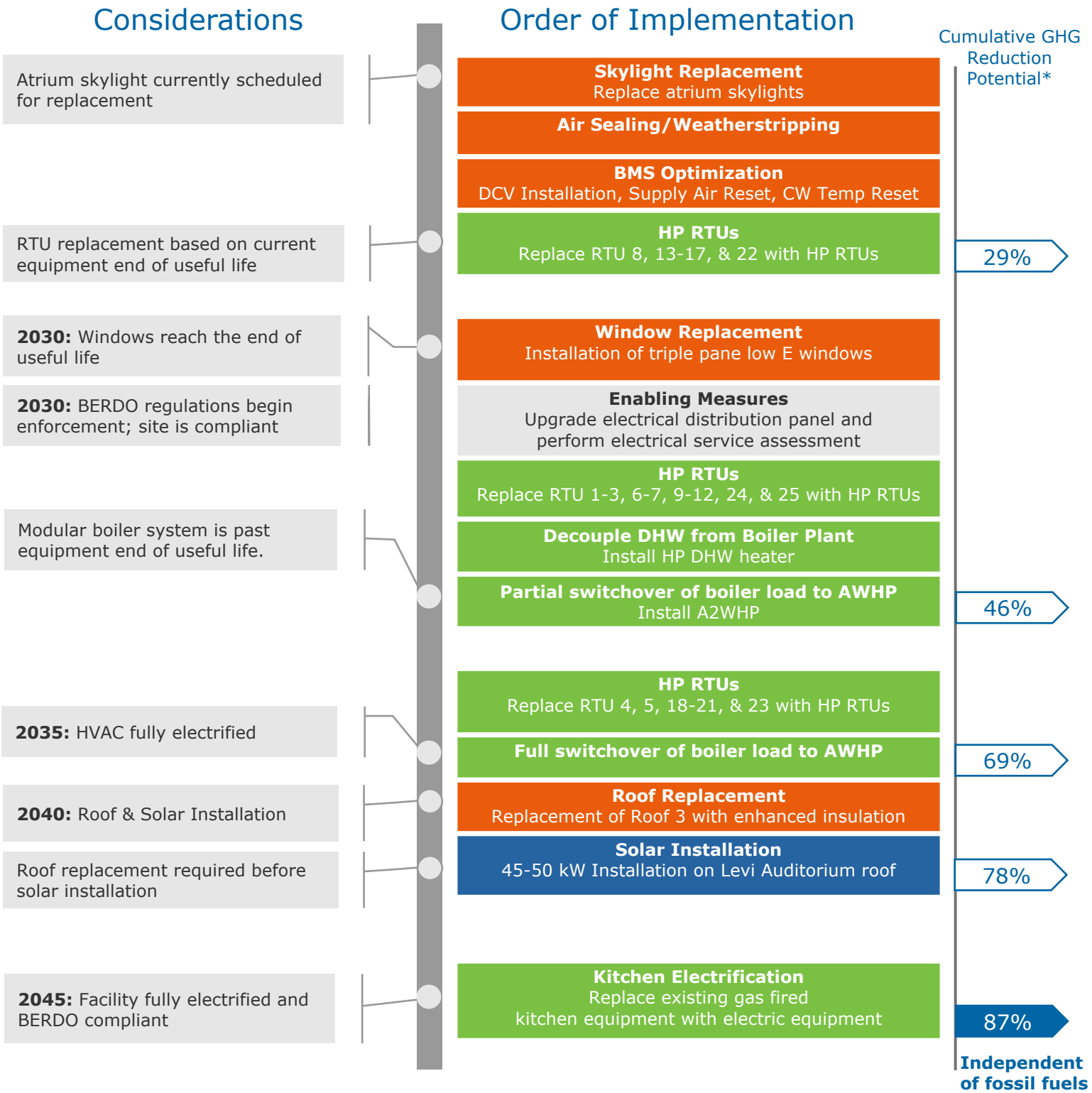
Annual Energy Use Impacts*



*The annual energy use impacts graphic illustrates an EUI before and after once all recommended measures are implemented, except for any renewable energy. The CEI and EUI shown in the performance targets 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. 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 emissions factors outlined by BERDO. It is reasonable to expect full decarbonization as the electrical grid decarbonizes. GHG calculations include direct onsite combustion (Scope 1) and purchased electricity (Scope 2). For renewable energy, it is assumed that the owner will retain the Renewable Energy Credits 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
Process/plug loads	$6,500	($4,400)	$2,100
Ventilation	($16,800)	-	($16,800)
Cooling	(19,000)	-	($100)
Heating	$176,100	($88,500)	$87,600
Hot water system	$4,000	($2,900)	$1,100
Total from recommended measures	**$150,800**	**($95,800)**	**$55,000**
Renewable energy	($14,000)	-	($14,000)

Due to inconsistent data on the CHP system's operational performance, it is not modeled in this analysis. However, a rough estimate of the CHP system's annual electricity and hot water production suggest it reduces utility costs by approximately $52,100 with the current hot water system and should be considered when assessing changes in utility costs.

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	$606,000	$49,000	Foundational efficiency and load reduction
		$955,000	Advanced load reduction
Mechanical costs	$2,568,000	TBD	Electrification enablers
		$2,679,000	System electrification
Renewable energy costs	$0	$188,000	Renewable energy
Soft costs	$317,000	$387,000	
Total upfront costs	**$3,492,000**	**$4,258,000**	
Utility incentive opportunities	($3,000)	($907,000)	
25-year total accrued utility costs	$12,905,000	$14,046,000	
25-year accrued total operating costs	$22,110,000	$22,312,000	
25-year LCCA	**$25,599,000**	**$25,663,000**	

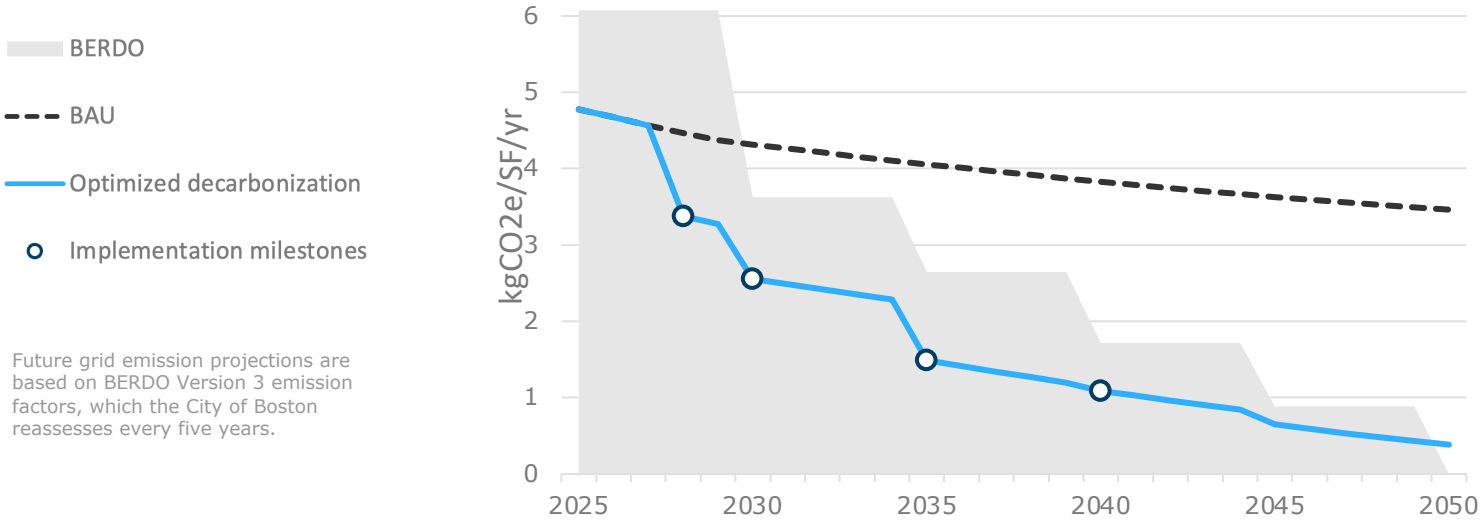
BAU scope:
- Electric resistance baseboards and PTAC replacements
- MAUs
- Gas kitchen and laundry appliances
- Double-pane windows
- Boilers replacement

*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 3 emission factors, which the City of Boston reassesses every five years.

Resiliency Considerations

Temple Israel is located outside of, but relatively close to, current FEMA flooding zones (Muddy River area). Considering the potential for intense weather events, including extreme rainfalls in short time frames, a climate change vulnerability assessment may be warranted, 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.



Analyzed Solar Rooftop Array Locations

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
  - Structural roof assessment
- [ ] Emergency protocols
- [ ] Assemble project team
- [ ] Structure financing stack