Danesh Residences

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	Multifamily housing
Location	Brookline
Year built	1972
Stories	12
Square footage	130,860
Energy use intensity (EUI)*	78 kBtu/sf/yr
Carbon emission intensity (CEI)*	4.1 CO2e kg/sf/yr
Decarbonization goals	Occupant comfort, lower utility costs

The Danesh Residences, located in Brookline, MA, is a 212-unit multifamily building that provides independent senior living apartments to its residents and various services throughout the building. There are conference rooms and offices on the first floor with a commercial kitchen on the top floor.

Existing Conditions

	Walls	Roof	Windows
Enclosure	Good	Good	Fair
Heating	Electric resistance baseboards, heat pumps in first floor common areas		
Cooling	Packaged terminal air conditioners (PTACs) in residential units. Heat pumps in first floor common areas		
Ventilation	Make-up air units (MAUs) supply fresh air with pre-conditioning coils from the combined heat and power (CHP) plant and integrated direct expansion (DX) cooling system. Units have bathroom exhaust fans.		
Hot water	Hot water produced by CHP plant, with backup gas fired boilers and storage tanks		
Lighting	LED lighting throughout		
Controls	Resident thermostats are set between 68 and 72 without set-backs		
Other	Gas appliances in commercial kitchen and gas dryers in laundry rooms on every floor. Residential units have electric kitchen appliances. CHP plant used for domestic hot water (DHW), MAU heat, and electricity production		
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

New systems installed recently

Install interim energy recovery ventilator (ERV) system to capture savings from new MAUs, while planning out larger system upgrades and electrification at end-of-life of CHP plant

Limited solar potential, aging gable roof

Consider small solar array installed at time of gable roof replacement to offset house meter electricity bills

Reported draftiness from windows

Prioritize air sealing around windows and PTAC units during window replacement and packaged terminal heat pump (PTHP) installation

Core Decarbonization Strategy

- Electric resistance 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 in apartments while minimizing costly overhaul of envelope

Retrofit Measures and Energy Impacts

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Measures

Energy Efficiency & Load Reduction

Foundational Efficiency and Load Reduction:
- Air sealing around PTAC sleeve and window perimeters

Advanced Load Reduction:
- High performance double-pane windows
- Interim ERV system

System Electrification

Electrification Enablers:
Further assessment required

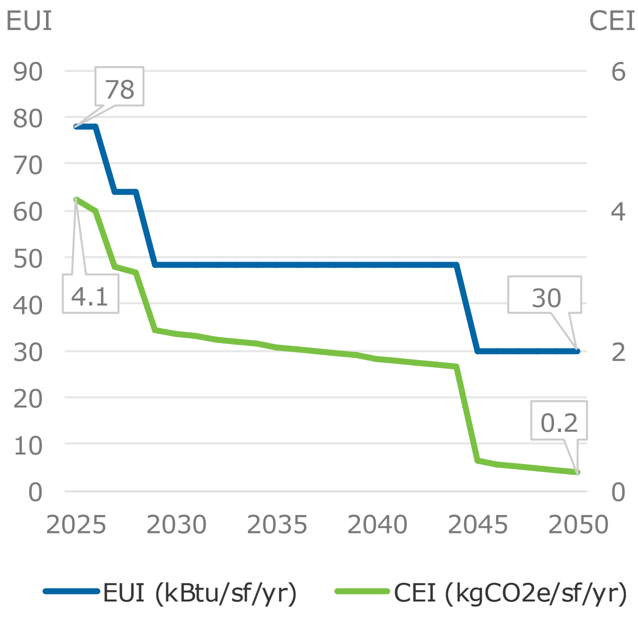
System Electrification:
- PTHP installation in units
- DHW electrification
- Dedicated outdoor air system (DOAS) with integrated ERV
- Electric laundry & kitchen appliances

Renewable Energy

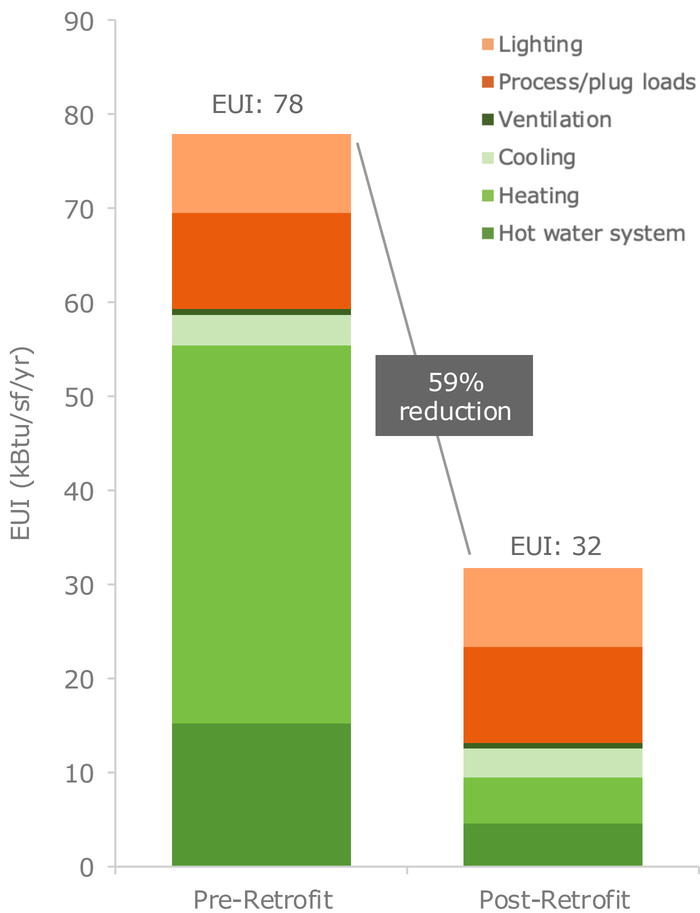
Solar:
- Install ~68kW fixed tilt solar PV array on gable roof

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. 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.

Triggers

Order of Implementation

Cumulative Carbon Reduction Potential*

2027: Foundational efficiency improvements and advanced load reduction measures to address immediate envelope leakiness and drafts

Targeted Air Sealing
Targeted air sealing around PTAC and window perimeters

Window Replacement
Install high-performance, double-pane window replacement

PTHP Installation
Install PTHPs in place of existing electric resistance and PTAC systems

23%

2029: Install ERV system as an interim step for recovering energy from existing, newly installed MAUs

ERV System
Install interim ERV system for heat recovery of existing MAUs

Solar installation is not time dependent but should be considered with planned gable roof replacement

Solar PV System
Install new solar PV system

45%

2045: End of service life for existing MAUs and CHP plant

Existing MAUs
Remove existing MAUs at end-of-life

Existing CHP Plant
Remove existing CHP plant at end-of-life

Electrify remaining mechanical systems. Electrical infrastructure may have to be reevaluated during this stage

Combined DOAS & ERV System
Install DOAS with integrated ERV

DHW Electrification
Electrify DHW with central heat pump water heater

Appliance Electrification
Electrify existing gas equipment in laundry rooms and commercial kitchen

90%

Zero on-site fossil fuel combustion
(With the exception of any backup power)

*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

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Annual Utility Impacts

Measure description	Changes in annual utility costs		
	Electricity	Fossil fuel	Net total changes
Process/plug loads	$12,200	($4,400)	$7,800
Cooling	($100)	-	($100)
Heating	($104,300)	($46,500)	($150,800)
Hot water system	$29,600	($36,500)	($6,900)
Total from recommended measures	**($62,600)**	**($87,400)**	**($150,000)**
Renewable energy	($12,500)	-	($12,500)

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	$1,669,000	$260,000	Foundational efficiency and load reduction
		$1,838,000	Advanced load reduction
Mechanical costs	$2,636,000	$0	Electrification enablers
		$3,330,000	System electrification
Renewable energy costs	$0	$212,000	Renewable energy
Soft costs	$430,000	$564,000	
Total upfront costs	**$4,735,000**	**$6,204,000**	
Utility incentive opportunities	$0	$140,000	
25-year total accrued utility costs	$13,755,000	$8,141,000	
25-year accrued total operating costs	$16,750,000	$11,137,000	
25-year LCCA	**$21,485,000**	**$17,201,000**	

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.

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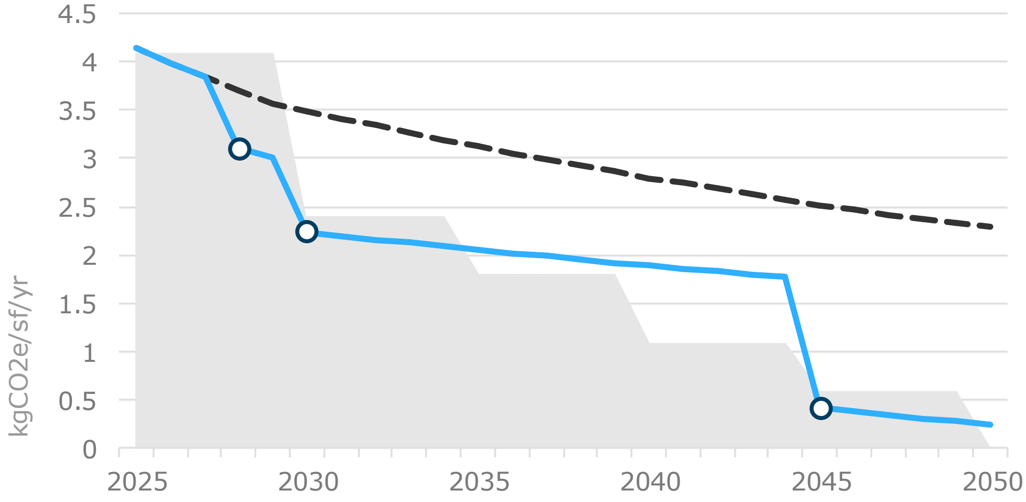
Emissions Goals and Benchmarking

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

Brookline sits at a relatively higher elevation than the surrounding area, so future flood risk is expected to remain low. Future weather patterns are likely to affect electricity consumption, system loads, and peak demand. As temperatures are projected to rise by 2050, analysis indicates that heating demand could decrease by approximately 17%, while cooling loads may increase by about 30%. In the event of extreme weather, building enclosure improvements and on-site solar generation are expected to help moderate energy demand during periods of extreme heat and extreme cold.

Gable roof for proposed solar.

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