

Carol Avenue Apartments

Boston, MA

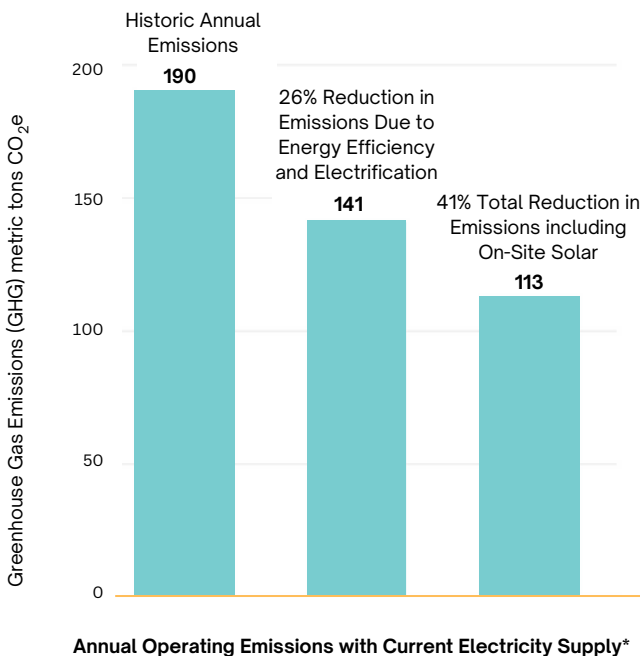
Carol Avenue Apartments, Boston, is undergoing a deep energy retrofit due to be complete in late 2024. The 33-unit, two-building affordable housing property is estimated to reduce energy use by 55 percent with envelope improvements, electrification, and other efficiency measures.



Carol Avenue Apartments, prior to renovations.

As part of the transformation, the aging fossil fuel-based heating and hot water systems will be substituted with high-efficiency, fully electric mechanical systems, which will also incorporate central air conditioning. Enhancements to the building envelopes which aim to lower energy consumption include window replacements, new roofs with improved thermal performance, added wall insulation, and preservation of the historic brick façade. In addition, renewable energy from rooftop solar panels will further reduce total energy consumption. These renovations not only address long-standing deferred maintenance issues but also significantly enhance tenant wellbeing through renovated interiors, improved thermal comfort, and the elimination of on-site fossil fuel combustion byproducts.

Deep Energy Retrofit Analysis



Without Solar

Anticipated energy reduction from energy efficiency and electrification	55 percent
Energy use intensity (EUI) before retrofit	80 kBtu/sf
Modeled EUI after retrofit	36 kBtu/sf
Anticipated greenhouse gas (GHG) emissions reduction with current electricity supply	26 percent*

With Solar

Total load served by renewables	19 percent
Solar PV system	65.3 kW
Anticipated energy reduction with solar	64 percent
Modeled EUI with solar	29 kBtu/sf
Anticipated GHG emissions reduction with solar with current electricity supply	41 percent**

*Annual operating emissions are calculated using state-specific long-run marginal emission rates (LRMER) for electricity instead of average historical emissions rates. This method is justifiable when projecting emissions savings over longer periods of time, because LRMER more accurately reflect the current and future electric grid supply.

*As with the indirect greenhouse gas footprint continuing to fall to zero as the regional electric grid becomes greener.
 **Assumes the Renewable Energy Credits (RECs) from on-site solar remain with the property and are not sold to a third party.

Building Envelope Strategy

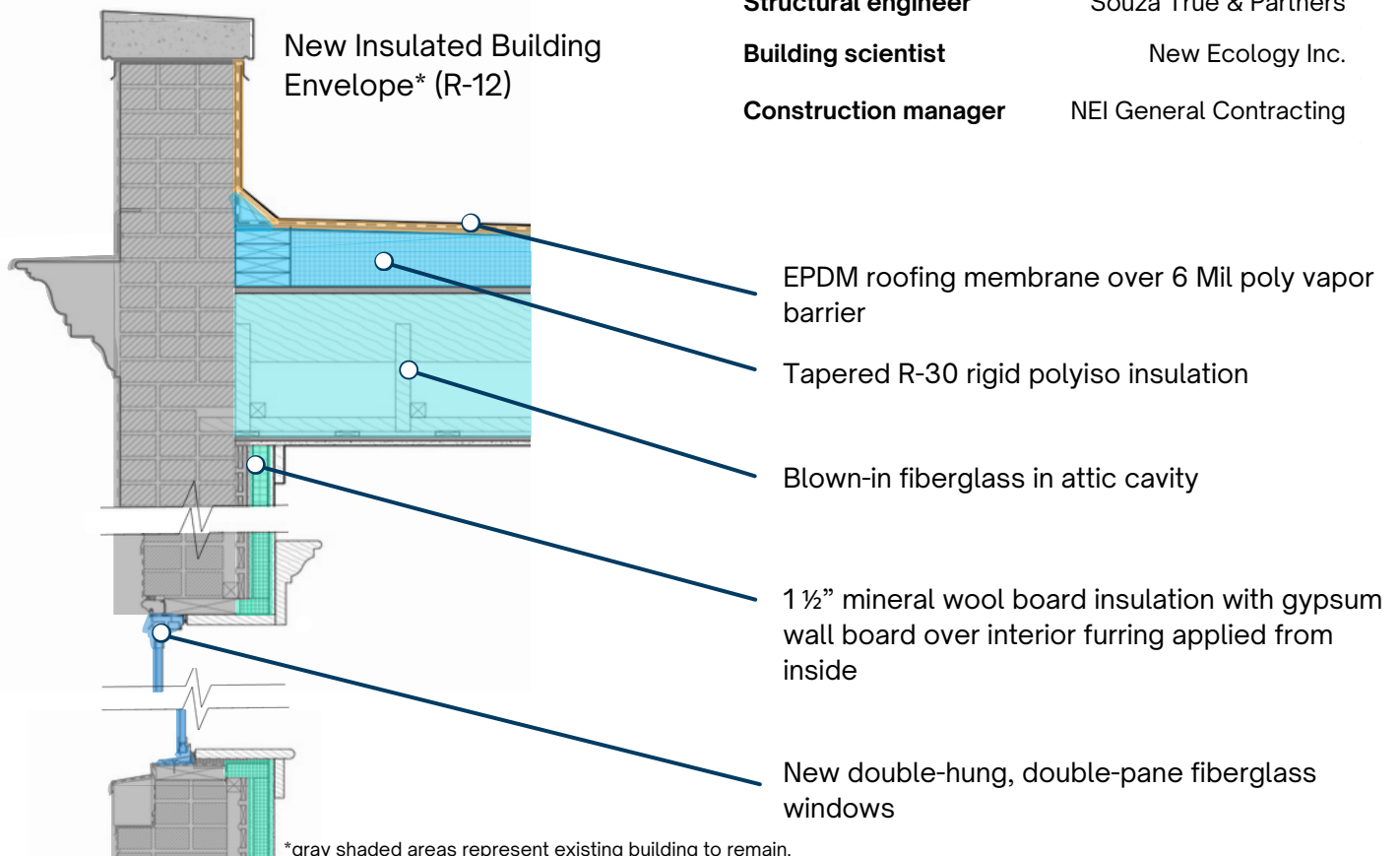
Like many existing buildings in the Northeast, Carol Avenue has a historic brick façade and is subject to zoning restrictions that precluded the possibility of substantially retrofitting the envelopes from the exterior. Therefore, the energy retrofit approach at Carol Avenue will be primarily executed from within the buildings. On all exterior-facing walls, new furring with 1 ½ inch mineral wool board insulation and gypsum board will be installed on the interior, increasing the thermal resistance of the wall from R-5 to R-12. To improve air sealing and energy efficiency on the roofs, the attic cavities will receive blown-in fiberglass and polyiso insulation on the flat roofs on top of new sheathing, raising the total thermal resistance to R-65. While this project faced limited opportunities to maximize insulation from the exterior, the retrofit approach at Carol Avenue represents a relevant strategy for other historic, cold-climate buildings seeking to achieve deep energy savings targets while preserving their exterior façade.

Building Overview

Project name	Carol Avenue Apartments
Building type	Multifamily residential
Location	Boston, MA
Year built	1910
Status of renovation	Under construction; 2024 completion
Number of stories	3
Number of apartments	33
Floor area	34,883 square feet

Building Team

Building owner	Allston Brighton CDC
Architect	Davis Square Architects
MEP engineer	BLW Engineers Inc.
Structural engineer	Souza True & Partners
Building scientist	New Ecology Inc.
Construction manager	NEI General Contracting



Exterior Wall System

Wall Insulation

R-value before	R-5
R-value after	R-12

Roof

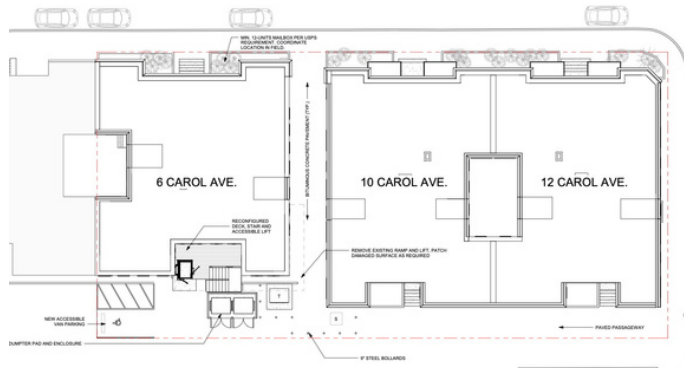
R-value before	R-17
R-value after	R-65

Windows

U-value before	U-3.0
U-value after	U-0.25
Solar heat gain coefficient (SHGC) before	0.8
SHGC after	0.28

General maintenance and aesthetic improvements prompted plans for targeted repairs on the exterior façade, including the replacement of rotten window and door frames, as well as the replacement of steel lintels and sills. Masonry at the base of the building and select areas will be restored, stabilized, and protected with a three-part breathable styrene-butadiene rubber (SBR) polymer finish system. The existing single-pane windows will be replaced with new ENERGY STAR fiberglass double-hung, double-pane windows featuring low-emissivity coating and argon-filled glazing. This scope highlights how the integration of general renovations with energy efficiency upgrades positions Carol Avenue to effectively address indoor air quality, comply with current and future GHG regulations, and reduce overall energy consumption.

Target Airtightness 0.40 CFM50



Images: Davis Square Architects.

Site drawings of 10-12 Carol Avenue (top) and 6 Carol Avenue (bottom right).

Scope of Work

Interior Insulation (Walls)

- 1 ½” mineral wool board applied from inside
- 5/8” gypsum wall board
- Interior furring

Exterior Insulation (Roof)

- Blown-in fiberglass in attic cavity
- 5” tapered R-30 rigid polyiso insulation
- 6 mil poly vapor barrier
- EPDM roofing membrane

Mechanicals

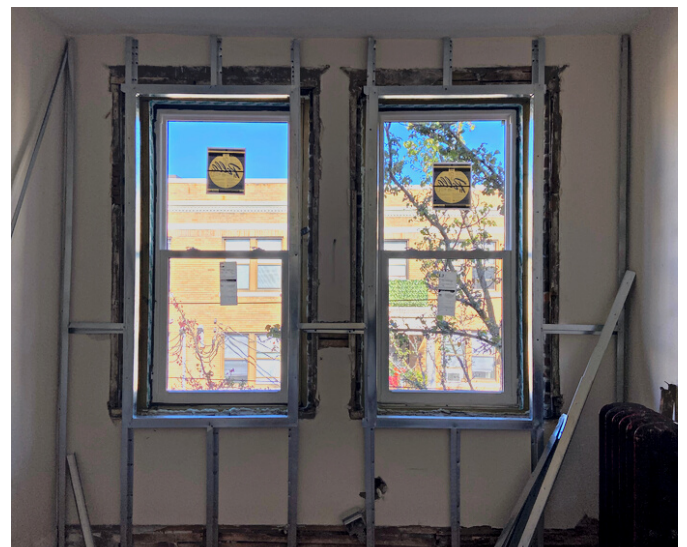
- Heating and cooling: Centralized, all-electric Variable Refrigerant Flow (VRF) system
- Ventilation: Central fresh air distribution through common areas paired with in-unit bathroom exhausts
- Domestic hot water: Electric resistance water heaters (future plans to convert to heat pump water heater)

Solar PV

- Two rooftop solar PV systems (one at each building);
 - 22.6 kW system at 6 Carol Avenue
 - 42.7 kW system at 10-12 Carol Avenue

HVAC Strategy

Built in 1910, these apartments currently rely on gas-fired systems for heating and hot water, with no cooling or ventilation. The aging and inefficient heating systems will be replaced with an all-electric, central VRF cassette system with condensers located on the roof, which will supply both heating and cooling to all the apartments. Due to the buildings’ characteristics and age, implementing an energy recovery ventilation (ERV) system is not feasible for this project. Instead, ventilation will rely on fresh air distribution in common areas, drawn into the apartments through 20–cubic feet per minute (cfm) bathroom exhausts. A central electric resistance domestic hot water system will replace gas water heaters that are nearing the end of their service life, eliminating all on-site gas consumption, and transitioning the buildings to full electric. Carol Avenue plans to integrate heat pump water heaters in the future to align with impending GHG emissions compliance. As part of making modernization improvements and to bolster overall efficiency, each apartment will also undergo bathroom and kitchen upgrades, including low-flow plumbing fixtures and all-electric, energy-efficient kitchen appliances.



Carol Avenue Apartments, during renovations.

Renewables

The flat roofs will accommodate two solar PV systems, a 22.6 kW system on one building and a 42.7 kW system on the other. The solar installation requires structural upgrades to the roofs, creating the opportunity for easier insulation upgrades. With new, highly efficient, and electrified mechanical systems and supplemental roof and wall insulation, the buildings can achieve 55 percent energy savings before solar, bringing down the existing EUI from 80 kBtu/sf to 36 kBtu/sf. The solar array will supply 19 percent of energy demands, helping Carol Avenue reduce overall energy consumption by 64 percent and emissions by 40 percent.



Planned rooftop solar PV at 10-12 Carol Avenue (left) and 6 Carol Avenue (right) by Resonant Energy.

Cost Breakdown*

Total hard construction cost of deep energy retrofit scope (envelope improvements and mechanical)	\$9,322,500
Cost per square foot of floor area	\$267
Cost per apartment	\$282,500
Total cost of installed insulated envelope assembly (walls, windows, and roofs)	\$4,383,000
Cost of insulated envelope assembly per apartment	\$132,800
Additional tenant relocation costs	\$908,000

*Based on preliminary construction cost estimates from January 2023. Estimates subject to escalation and scope of work revisions.