City Of Sommerville – 42 Cross

42 Cross Street, Somerville, MA 02145

Phase 1 - Two Year Planning

February 29, 2024

Prepared for:
Capital Projects
City of Somerville
Department of Infrastructure and Asset Management
Somerville, MA 02145

Prepared by:
SOCOTEC AE Consulting, LLC
75 Hood Park Drive, Suite 300
Charlestown, MA 02129
617.464.6931

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1. EXECUTIVE SUMMARY

SOCOTEC AE Consulting, LLC (SOCOTEC) analyzed the energy performance of City of Somerville's 42 Cross Street, a one-story commercial building built in 1920. 42 Cross Street houses the Office of Immigrant Affairs, and document storage for the City of Somerville, in approximately 3,600-square feet of gross area.

From conversations with the Office of Immigrant Affairs, we understand that the building is open Monday through Friday, and that most staff are in the office 2-days each week. Building hours are 8:30am – 4:30pm Mondays through Wednesdays, 8:30am-7:30pm on Thursdays, and 8:30am-12:30pm on Fridays.

The building envelope is a triple-wythe brick masonry wall on the street-facing West elevation, and single-wythe concrete masonry unit (CMU) construction on the North, East, and South elevations (Photo 1)*. The existing roof membrane is an EPDM rubber roof, with rigid insulation above the roof deck and spray-foam insulation at the interior underside of the roof deck. The fenestration consists of punched windows and plastic pyramid skylights in the office space, a storefront window in the Community Room, and a sloped glazing skylight extending through the Electrical/IT Room, entry vestibule, and Community Room. There is an entrance door to the building on the West elevation, and an egress door on the East elevation.

The building is served by two gas-fired roof top air handlers (RTU 1 and 2) with direct expansion (DX) cooling. The Electrical/IT Room is served by a Mitsubishi mini-split air conditioning unit. The domestic hot water is provided by an electric hot water heater in the Storage Room.

SOCOTEC was contracted to provide on-call short/near term energy consulting and planning services, to be completed in two phases:

- **Phase 1: Perform a condition assessment and develop a subsequent implementation plan to identify energy and emissions reduction measures for the near term.**
- Phase 2: Conduct air leakage infiltration testing via blower door in general accordance with ASTM E779 (conducted January 26, 2024; results provided in Appendix D).
- Phase 3: Develop construction documents for envelope (roofing, skylights) and mechanical, electrical, and plumbing improvements; assist in Construction Administration phase; and compile information to submit for the Green Communities grant. Some observations from our 2/12/2024 test cuts are incorporated into this report.

This report summarizes the findings and recommendations for Phase 1 of this effort, which are based on a January 4, 2024 site visit, a January 26, 2024 blower door test, and review of documents provided by City of Sommerville. A full list of documents used in this analysis can be found in Appendix A. Photos from the site visit can be found in Appendix B. Findings are compared against the 2023 225 CMR 23.00 Massachusetts Commercial Stretch Energy Code (MA Stretch Code) and Appendix CC Municipal Opt-in Specialized Code, which are based on IECC 2021 with Massachusetts Amendments. The City of Somerville has opted into the Specialized Code; we refer to both as MA Stretch Code throughout.

The Phase 1 study analyzes both the existing carbon emissions as well as eleven (11) energy efficiency measures (EEMs) identified in Table 1. These measures were reviewed with the City of Somerville in a meeting held on February 8, 2024 and a memo issued on February 8, 2024, titled *2024-02-08 42 Cross EEM Memo.*

**Assumptions for wall composition are based on visual assessment during site visit, and record photographs – see Section 2 of this report.*

Table 1 – Recommended energy efficiency improvement measures.

Energy Efficiency Measures (EEMs)	
Measure 1	Replace existing EPDM roof (U-0.056) with reflective membrane roof to meet MA Stretch Code thermal performance (U-0.032)***
Measure 2	Replace pyramid skylights (U-1.21, SGHC-0.77)** to meet MA Stretch Code skylight thermal performance (U-0.5, SHGC-0.4)
Measure 3	Replace east-facing egress door with fiber reinforced polymer (RFP) insulated door that meets MA Stretch Code (U-0.37)***
Measure 4	Replace storefront window (U-0.9, SHGC 0.68)** to meet MA Stretch Code thermal performance (U-0.30, SHGC-0.38)
Measure 5	Overclad exterior walls (North, South, and East elevations – currently U-0.218)* to meet MA Stretch Code thermal performance (U-0.09)***
Measure 6	Replace entry skylight (U-1.36, SHGC 0.82)** to meet MA Stretch Code skylight thermal performance (U-0.5, SHGC-0.4)
Measure 7******	Replace fluorescent lights with LED – improve lighting power density to MA Stretch Code lighting power densities (LPDs)
Measure 7 ALT******	Replace fluorescent lights with LEDs – 25% better than Mass Stretch Code LPDs
Measure 8	Replace non-EnergyStar equipment with EnergyStar-rated equipment to lower electrical plug loads
Measure 9	Replace existing gas-fired RTUs with MA Stretch Code-minimum heat-pump (HP) RTUs coupled with energy recovery wheels (ERWs)
Measure 9 ALT	Replace existing gas-fired RTUs with 10% better than MA Stretch Code-minimum HP RTUs coupled with ERWs
Measure 10	Replace the domestic hot water heater with point source heaters
Measure 11	Upgrade temperature controls systems when new RTUs are installed

**Assumptions for wall composition are based on visual assessment during site visit, and record photographs – see Section 2 of this report.*
***Values are estimated using ASHRAE Appendix A for the purposes of energy modeling only. Appendix A values are derated for clear wall thermal bridges – see Section 2 Exterior Walls for further explanation.*
****U-Values from table 402.1.4 Opaque Thermal Assembly Maximum Requirements, U-factor Method of MA Stretch Code for Massachusetts Climate Zone 5A. Derating for thermal bridges is applied prior to showing compliance with U-values.*
***** Measure 7 and 7 ALT have been omitted from recommendation as discussed with City of Somerville on February 27, 2024.*

For reference throughout this report, U-value describes the thermal transmittance through a building material (in the case of window and door assemblies) or systems (for opaque assemblies), equal to the time rate of heat flow per unit area and unit temperature difference between the warm and cold side air films (BTU/hour*ft^2*°F). U-values are the inverse of R-values, which describe the thermal resistance of a material or assembly (hour*ft^2*°F/BTU). Solar heat gain coefficient (SHGC) describes the fraction of incident solar radiation admitted through a skylight, expressed as a number between 0 and 1 (a lower SHGC means less solar heat transmittance).

The existing building energy model performance, as well as the energy, cost, and carbon emissions savings for each proposed measure, can be found in Table 2.

Table 2 – Performance of existing building and recommended efficiency measures.

	Annual Site Energy		Annual Energy Cost		Annual Carbon Emissions (2023)	
	MMBTU	% Savings	$	% Savings	kgCO2e	% Savings
Existing Conditions	221	-	$ 8,340	-	13,640	-
Measure 1: Replace EPDM Roof with Reflective Membrane System	208	6%	$ 8,205	2%	12,950	5%
Measure 2: Replace Pyramid Skylights	217	2%	$ 8,220	1%	13,390	2%
Measure 3: Replace East-facing Egress Door	220	0%	$ 8,325	0%	13,590	0%
Measures 1 through 3	204	8%	$ 8,080	3%	12,700	7%
Measure 4: Replace Storefront Window	219	1%	$ 8,300	0%	13,530	1%
Measures 1 through 4	201	9%	$ 8,030	4%	12,570	8%
Measure 5: Overclad Exterior Walls (North, South, East)	211	4%	$ 8,180	2%	13,100	4%
Measures 1 through 5	190	14%	$ 7,860	6%	11,940	12%
Measure 1 through 4, 6	195	12%	$ 7,790	7%	12,150	11%
Measure 6: Replace Entry Skylight	216	2%	$ 8,110	3%	13,295	3%
Measures 1 through 6: All Envelope Measures	185	16%	$ 7,650	8%	11,630	15%
Measure 7: Replace Lighting with LED (Code) *	217	2%	$ 7,780	7%	13,270	3%
Measure 7 ALT: Replace lighting with LED (25% better than Code) *	215	3%	$ 7,480	10%	13,050	4%
Measure 8: Replace Equipment with EnergyStar-rated Equipment	220	0%	$ 8,225	1%	13,565	1%
Measure 9: Replace RTU with HP and ERW (Code)	133	40%	$ 11,260	-35%	10,220	25%
Measure 9 ALT: Replace RTU with HP and ERW (10% better than Code Heating and Cooling Efficiency)	128	42%	$ 10,920	-31%	9,910	27%
Case 1*: Measures 1 through 4, 6, 8, 9 ALT, 10, 11	119	46%	$ 10,070	-21%	9,140	33%
Case 2*: Measures 1 through 6, 8, 9 ALT, 10, 11	111	50%	$ 9,450	-13%	8,570	37%

** Measure 7 and 7 ALT have been omitted from recommendation as discussed with City of Somerville on February 27, 2024.*

Figure 1 below shows the energy consumption of the existing condition by end use. This metric outlines high energy use categories, and points out potential high impact solutions.

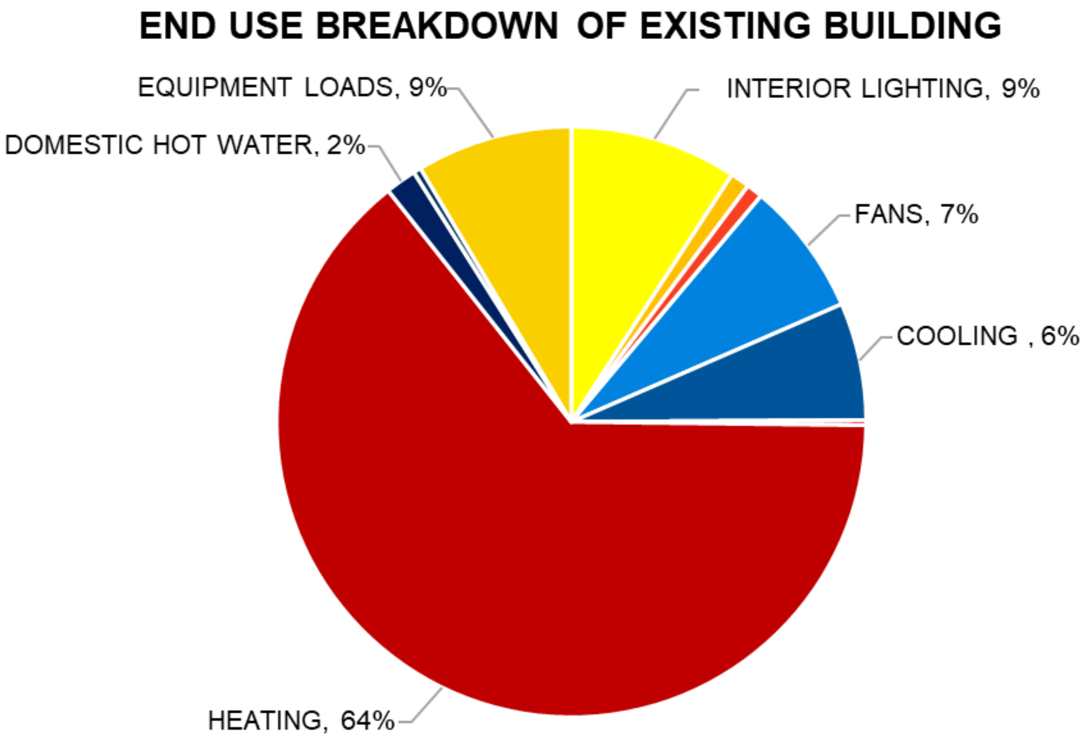

Figure 1 – Energy end use breakdown for existing building operations.

SOCOTEC performed energy modeling of the project using EQuest, a DOE 2.2 software. The model evaluates the existing conditions of the building, along with a series of low-cost improvements that could be implemented in the next one-to-two-years. The energy model was developed for the sole purpose of calculating the energy savings relative to the existing conditions, and cannot be used for predicting the actual energy use or energy cost of the building as detailed in the NOTE at the end of the report.

2. EXISTING CONDITIONS

2.1. Carbon Emissions

Annualized energy consumption and carbon emissions were calculated for 42 Cross Street based on utility bills provided by City of Somerville from the last twelve months (December 2022 – November 2023).

Carbon emission rates are calculated using rates provided by City of Boston published Projected Grid Emission Factors (see Figure 2 below) and Energy Star Portfolio Manager Building Emissions Calculator Technical Reference Document.

> Electricity Carbon Emissions Rates (MA 2023):	0.263 kgCO2e/kWh
> Electricity Carbon Emissions Rates (MA 2024):	0.256 kgCO2e/kWh
> Electricity Carbon Emissions Rates (MA 2026):	0.242 kgCO2e/kWh
> Electricity Carbon Emissions Rates (MA 2030):	0.213 kgCO2e/kWh
> Electricity Carbon Emissions Rates (MA 2040):	0.142 kgCO2e/kWh
> Electricity Carbon Emissions Rates (MA 2050):	0.071 kgCO2e/kWh
> Natural Gas Carbon Emissions Rates (USA):	53.11 kgCO2e/MMBTU

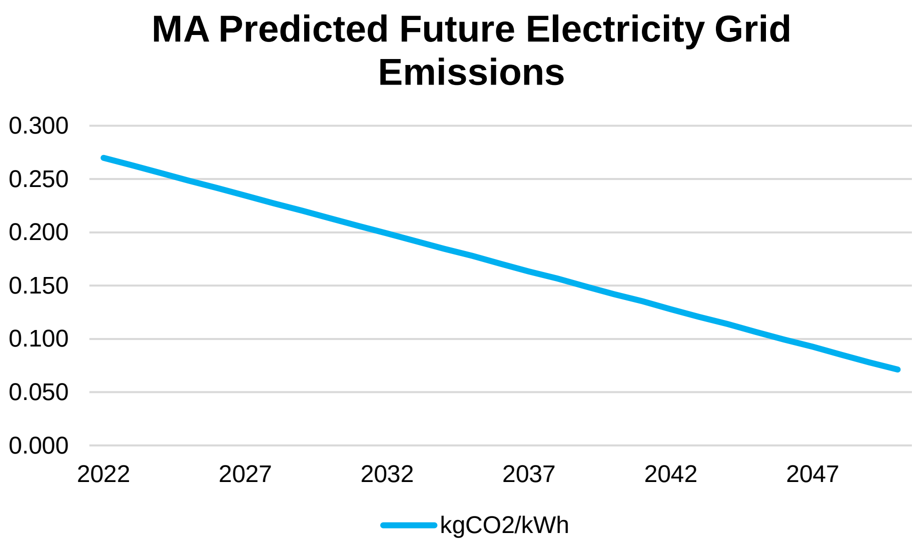

Figure 2 Future Electricity Grid Emissions

Figure 3 below shows the annual carbon emissions from November 2022 – December 2023 based on provided utility bills for the same period. 2023 electricity emission rates were used to calculate electricity emissions. Natural gas consumption and correlated emissions are highest in the winter during the heating season. Electricity emissions are consistent during the winter and shoulder seasons, representing base plug loads. There is an increase in the summer due to electric space cooling.

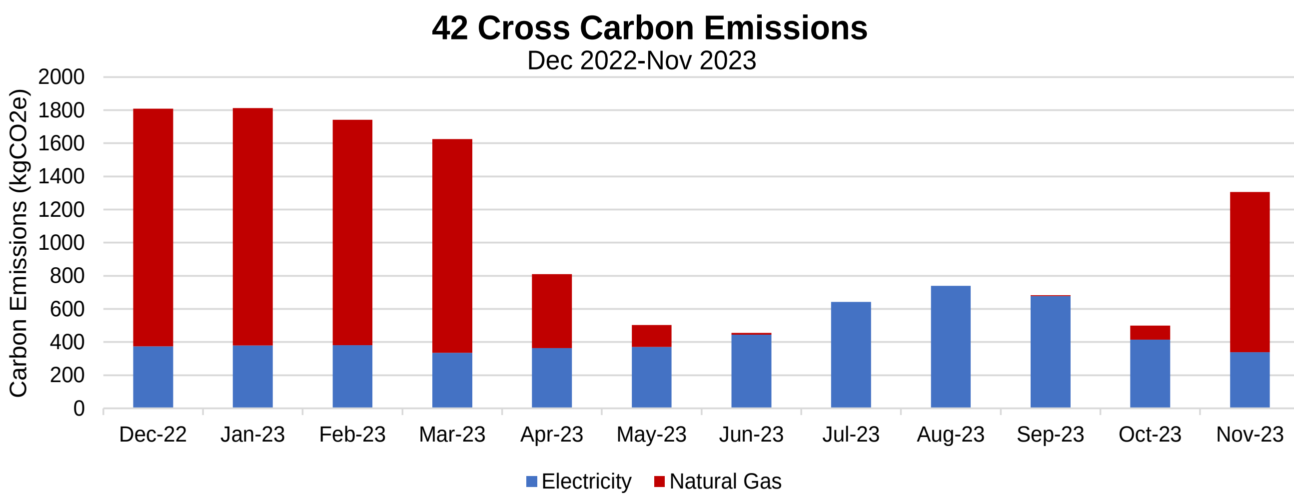

Figure 3 – 42 Cross Street carbon emissions from December 2022 to November 2023 based on provdied utiltiy bills.

Throughout the report, each case will report the carbon emissions intensities (in kgCO2e/SF/yr) by fuel source and total. The emissions intensities will be reported for the following years:

> **2023** – to compare to 2023 existing case
> **2024** – current year and starting point of improvement efforts
> **2026** – year improvements will be complete
> **2030** – 50% emissions reduction goal below 1990 levels set by Massachusetts Clean Energy and Climate Plan for 2050 (2050 CECP)
> **2040** – 75% emissions reduction goal set by 2050 CECP
> **2050** – 100% emissions reduction goal below 1990 levels set by 2050 CECP

Local jurisdictions, including Boston, have passed building emissions reduction and disclosure ordinances (BERDO). The goal of these ordinances is to set requirements for existing buildings to reduce their greenhouse gas emissions over time, reaching net-zero emissions by 2050. The energy efficiency measures' performance, as reviewed in Section 3 Recommendations, are reported in units of kilograms of carbon dioxide equivalent (CO2e) per square foot per year (kgCO2e/sf/yr), aligning with the City of Boston's BERDO emissions limits metric. This metric measures global warming potential by expressing how many kilograms of carbon dioxide emissions warm the climate equally as 1 kg of another greenhouse gas per square foot per year. The intensities are compared to Boston's published BERDO limits and timeframes, for reference.

2.2. Recent Improvements

42 Cross Street has undergone various interior and exterior repairs and renovations. SOCOTEC has records of a 2010 interior renovation, and a 2016 envelope renovation.

TBA Architects, Inc, along with Verne G. Norman Associates Electrical Engineers and AKAL Engineering Inc., previously completed primarily interior renovations at 42 Cross Street. All investigative work performed as part of this scope was done by visual assessment, or review of best available documents.

As documented in their June 22, 2010 100% Bid Drawings set, these renovations were completed in accordance with the Massachusetts State Building Code 780CMR, Seventh Edition and included:

- New interior layout and partitions
- Insulating entire underside of roof deck with spray foam insulation to a depth of 4-inches
- Removing exterior door at Workstations A, and replacing with a new storefront window
- At the exterior walls, removing mortar, cleaning joints, and repairing joints and crack with grout
- New acoustic tile and gypsum wall board ceiling, including new lighting
- Mechanical system upgrades that included new flexible ducts, dampers, diffusers, return grilles, and exhaust fans in select locations
- New exhaust ductwork through existing roofing curb, terminated with weather-proofed hood
- New programmable thermostats in Reception and Workstations A areas
- Cleaning, refurbishing, and rebalancing RTUs 1 and 2 to bring minimum 350CFM from each unit
- New lighting fixtures, light switches, electrical outlets, and occupancy sensors
- New emergency batteries (EBA-Emergilite Model LSM81-V and LSM81-2V-ZD)
- New photocell (Tork Model 2101 or equal, by Intermatic or Paragon)
- New telecommunications data wiring
- New heat/smoke detectors, duct smoke detectors, and fire alarm devices at the interior and exterior
- New exterior lighting (Square “D” model 8903-LG40-V02C or equal)
- New plumbing fixtures in select locations, including 3/4-inch cold water and 1/2-inch hot water supply to new fixtures
- New 4-inch underground sanitary line, to connect to existing 4-inch sanitary line

Russo Barr Associates (now SOCOTEC) previously completed waterproofing and window renovations Waterproofing work. As documented in their June 23, 2016 design documents, these renovations included:

- Removing and replacing (and in certain locations, relocating) windows, including replacing glass block with windows. Work included replacing the above-mentioned storefront window in Workstations A with a new punched window.
- Repairing CMU masonry walls, including removal and replacement of failed sealant joints, repointing, cracks repaired, and any deteriorated CMU
- Demolition, including removal of ivy and other plant growth
- Applying a sealer for masonry waterproofing to prepared CMU walls
- Applying sheet waterproofing and sheet flashing at the base of prepared CMU walls
- Removing and relocating, or reinstalling, exterior electrical equipment
- Preparing and applying fill materials
- Installing three catch basins and related below grade piping and connection to an Owner-provided manhole
- Installing exterior asphalt paving
- Installing two solid sections of fence, and one double set of swing gates

2.3. Envelope Site Observations/ Document Review

ROOF

The roof at 42 Cross Street is planned for replacement during the Phase 3 scope of work. Its year of installation is unknown. From a roof test cut taken in 2016, Russo Barr determined the existing roof assembly is an adhered EPDM system (Figure 4) and consists of, from outside to inside: non-reinforced Carlisle EPDM FR membrane; mechanically-fastened 1/2-inch wood fiber cover board; EPDM membrane; 1 1/2-inch foam insulation (approximately R-8.6), which we assume to be mechanically-fastened; steel roof deck; and spray foam insulation applied during 2010 renovation, observed to be 2-3-inches at the time of the test cut (approximately R-9). It should be noted that this test cut represents the typical roof composition only; it is not inclusive of all construction configurations.

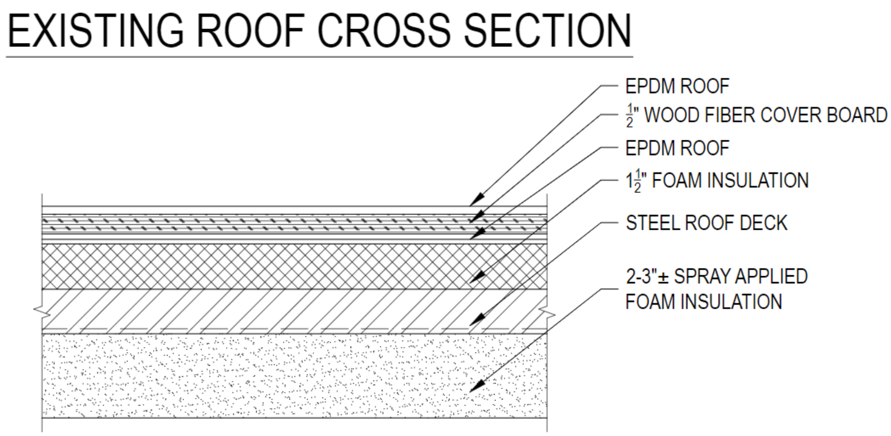

Figure 4 – Existing EPDM Roof Assembly, Russo Bar Existing Roof Construction Drawing

The R-value of the roofing assembly is approximately R-17.6, which is approximately U-0.056. For reference, MA Stretch Code requires a maximum roof assembly U-value of U-0.032 (Table C402.1.4) when the insulation is entirely above the roof deck (thus excluding the interior-side spray foam insulation), which is approximately R-31.25.

EPDM is a common roofing material for low-slope commercial roofs. The top-layer EPDM membrane and 1/2-inch wood fiber cover board were installed in a go-over configuration, which is the installation of a new roof covering over an existing roof covering. Section 1511.3.1.1 of the 9th Edition of the Massachusetts State Building Code, which is based on the 2015 Edition of the International Building Code, does not allow additional roof coverings where the existing roof has two or more applications of any type of roof covering.

From our on-site visual observations, there were areas of ponding water and residual dirt staining at the roof membrane (Photo 2). Ponding water for short durations is unavoidable and typically considered acceptable by roof manufacturers, however water that stagnates on a roof for more than 48-hours is considered detrimental to the roofing assembly. Ponding water typically occurs because the roofing drainage system is not adequate for the structure, or because of high-low variations within the roofing assembly. Test cuts taken on February 12, 2024 revealed that the flutes in the steel deck are filled with gravel surfacing, which can cause the deck to deflect, along with roofing paper, which may be asbestos-containing. Ponding at the East edge of the building is occurring because the roof blocking is too high, and not allowing water to drain; we noted on our February 12, 2024 site visit that the roof has a 1/8” slope to the East side of the building. The gooseneck penetrations are rusted, and the roof hatch does not have interior access or exterior safety railing.

There are isolated areas repair patches throughout the roof areas, indicating that these repairs have been made to locate/stop leaks or seal punctures (Photo 3). At the brick parapet, the rough edges of the flashing are touching the roof, which can cause punctures in the EPDM membrane; the flashing is also not tied into the skylight assembly, relying only on sealant at the joint interface and creating potential for water penetration at the joint (Photo 4). At the sloped skylight curb, the EPDM appeared to be delaminating from the curb (Photo 8). The spray foam insulation installed at the underside of the roof deck, as viewed in the Electrical/IT room, is peeling in some locations and is not continuous (Photo 6).

Dark roof membranes absorb heat and transfer it into the building, and do not reflect the UV rays responsible for membrane deterioration. A full roof replacement utilizing a "tear-off" application would improve the thermal performance and reflectivity of the roof. Refer to Section 3 Recommendations.

FENESTRATION

There are four dual-layer acrylic pyramid skylights in the office spaces that have cracks in their outer layers (Photo 7). From conversation with the Office of Immigrant Affairs, we understand these cracks are a result of impact damage from rocks. We also observed uncured EPDM at the skylights, likely installed to stop leaking through the skylight at the metal frame/pyramid skylight interface. The blower door test showed a minimal amount of air leakage, 34 cubic feet per minute (CFM), across the four skylights when the building was depressurized to -50 pascals (Pa) – refer to Appendix D. Skylight replacement will occur with the roof replacement as part of the Phase 3 work to ensure a continuous tie-in between the curb of the skylights and the field of the roofing membrane. MA Stretch Code requires maximum U-0.50 and SHGC-0.40; using ASHRAE Appendix A, we estimate the existing skylights are U-1.21 and SHGC-0.40.

There is also a sloped skylight along the West elevation extending through the Electrical/IT Room, entry vestibule, and Community Room (Photo 8). We presumed this is single glazing for the energy model; using ASHRAE Appendix A, we estimate this system is U-1.36 and SHGC-0.82. At the exterior, we observed cracking and crazing at the sealant joints of the glazing and mullions, and at a film installed at the exterior face of the skylight that was peeling. SOCOTEC was not able to assess its performance during blower door testing – refer to Appendix D.

The occupant sitting near the East-facing egress door (Photo 9) noted draftiness in their work space. The blower door test showed a high amount of air leakage at this door, 123 CFM, when the building was depressurized to -50Pa – refer to Appendix D. There are no drawings available showing how this door is tied into its surrounding conditions, however it is likely not an airtight seal. Evidence of moisture damage at the door head indicates potential condensation within the wall cavity.

There is a large storefront window in the Community Room (Photo 10) on the street-facing West facade. The storefront is a muntin grid holding double-pane glazing. Using ASHRAE Appendix A, we estimate this system is U- 0.9 and SHGC-0.68. For comparison, MA Stretch Code requires maximum U-0.30 and minimum SHGC-0.38. From conversation with the Office of Immigrant Affairs, we understand the Community Room is always cold in the winter; this could be because of the lower insulative value of the glazing, or because of air infiltration at the window perimeter – small gaps were observed in the masonry at the window perimeter. The blower door test showed 68 CFM air leakage at the storefront when the building was depressurized to -50Pa. The infrared thermography photos taken during this test showed active air infiltration around the rough opening. Refer to Appendix D.

There are fifteen punched windows throughout the office space that were installed as part of the 2016-2017 Russo Barr renovations (Figure 5, Photo 11). These are thermally broken Winco 8250 operable windows with mesh security screens. They consist of, from outside to inside: 1/4-inch tempered exterior glass (PPG Solargray); 1/2-inch cavity with 90% argon-filled air space and warm-edge spacer; 1/4-inch interior tempered glass (with PPG Solarban 60 Low-e on #3 surface).

The center-of-glass winter U-value is 0.24; the whole-window U-value is roughly U-0.33 and the SHGC is 0.28. For comparison, current MA Stretch Code requires maximum U-0.30 and SHGC-0.38. These windows are in good condition; the blower door test showed a minimal amount of air leakage, 35 CFM, across nine of the fifteen windows (the windows behind archives stacks remained sealed for the duration of the test) when the building was depressurized to -50Pa. Refer to Appendix D.

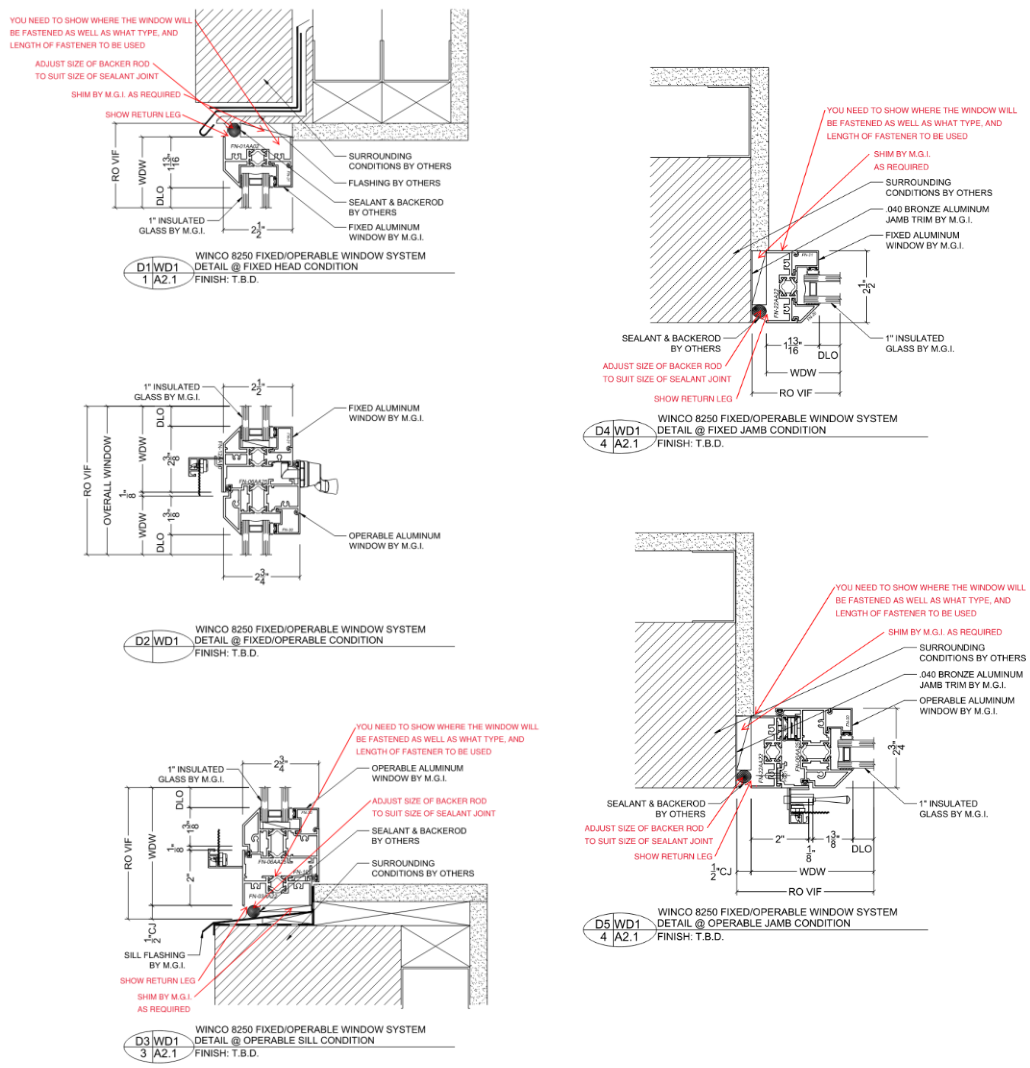

Figure 5 – Aluminum Window Shop Drawings, Folan Waterproofing and Construction Co., Inc.

EXTERIOR WALLS

SOCOTEC did not complete investigative openings as part of our condition assessment on January 4, 2024. There are also no design documents available that depict the exterior wall construction. Our understanding of the exterior walls is based upon Russo Barr's findings during the 2016-2017 renovation work.

From Photo 12, we assume the walls to consist of, from exterior to interior: 8-inch by 16-inch CMU coated in sealer; 1 1/2-inch metal furring strips; and 2-inches of extruded polystyrene (XPS) insulation.

The XPS insulation does not appear to be continuous, installed only between the furring strips. The insulation material is approximately R-10. Using ASHRAE Appendix A, we estimate the total wall assembly has an R-value of R-0.48 (which includes derating for clear wall thermal bridges). For reference, 225 CMR 23 requires a lower U-value of U-0.090 for mass masonry walls, after derating for thermal bridges and assuming continuous insulation, which is approximately R-11.11.

The lack of continuity in the insulation layer, which is interrupted by metal studs, creates thermal bridges at each stud. Thermal bridges are interruptions in the envelope assembly that cause unwanted heat transmission because they bypass the surrounding assembly insulation. Clear field thermal bridges are a type of thermal bridge that is uniformly distributed throughout the assembly. Steel framing and concrete both have high thermal conductivity, allowing for conduction through the CMU and each metal furring strip because there is no continuous insulative barrier and thus less thermal resistance. In the winter, unwanted heat loss can occur as heat flows outward through the thermal bridges, creating cold spots on the interior wall along the metal stud locations; in the summer, heat flows inwards from the hot exterior to the cooler interior through the thermal bridges. This unwanted transfer of heat increases energy costs and occupant discomfort, and creates risk of condensation within a wall assembly.

The thermal performance of the exterior walls would be improved with continuous insulation, which would mitigate the effects of thermal bridging.

3. RECOMMENDATIONS

SOCOTEC's Phase 3 work will include developing construction documents, cost estimating for order of magnitude budget planning, and reviews during the bidding and construction administration phases for the following measures:

- New reflective roofing membrane system, including roof insulation to meet or exceed MA Stretch Code requirements (Measure 1)
- Replace pyramid skylights (Measure 2)
- Replace East-facing egress door (Measure 3)
- Replace West-facing storefront window (Measure 4)
- Replace entry skylight (Measure 6)
- Install new RTU with heat pumps and energy recovery (Measure 9 ALT)
- Install electric point source DHW (Measure 10)
- Install new controls system that is bacNET compatible (Measure 11)

Overcladding of East, South, North-facing exterior walls (Measure 5) will be evaluated in Phase 3.

The impacts of additional recommended measures focused on thermal barrier continuity and MEP energy efficiency are noted below. These impacts will be reported in carbon emission intensity, in units of kgCO2e/SF/yr, and compared against Boston's published BERDO limits.

3.1. MEASURE 1: Replace EPDM Roof with Reflective Membrane

We recommend full roof replacement utilizing a "tear-off" application, which includes complete removal of all roofing down to the roof decking level followed by the installation of a new singe-ply reflective roofing system. This work will require removal of the vines that are on the North and West elevations (Photo 1) for roof edge access. The gravel surfacing and roof paper installed in the steel flutes will also need to be removed, as they cause the deck to deflect.

According to the MA Stretch Code, insulation is required to be installed continuously above the roof deck with a maximum roof assembly U-value of U-0.032, which is approximately R-31.25. We recommend using flat polyisocyanurate (polyisio) insulation and tapered insulation crickets to provide positive slope to gutters. Skylight curbs will need to be addressed when the insulation thickness is increased – insulation could be added to the curbs, or insulated metal curbs could be installed, for thermal continuity across the assembly. At the brick parapet, a reglet will need to be saw-cut into the masonry walls on both sides of the skylight to install new flashing following the insulation height increase (Photo 4)0. Mechanical lines at rooftop equipment would also need to be extended with the added insulation thickness.

The City of Somerville should determine whether they would like to keep the roof hatch, which would require a safety railing; if it should be abandoned during roof replacement and covered with steel decking; or if they would like to replace with a thermally-broken roof hatch to maintain thermal continuity. Gutters appear to be undersized, and their capacity may need to be increased. Given the age of the building, hazardous materials testing will be required prior to roof replacement.

The roof can be designed in a way to allow for tie-in to the exterior overcladding system, should overcladding the exterior facade be considered for future renovations.

- **Reflective Roofs:** Reflective roofs reflect the sun's UV rays and direct the heat away from the building, lowering local air temperatures and thus reducing energy bills by decreasing air conditioning needs (conversely, some elements of winter heating may be lost). The recommended reflective roof membranes for a low-sloped roof are white thermoplastic polyolefin (TPO) and polyvinyl chloride (PVC) membranes. These are comparable products in terms of puncture-resistance and lifespan. Both systems can be adhesively applied or mechanically attached, but adhesive application provides a membrane that is fully bonded to the roof substrate whereas mechanically attached systems are only fastened at the seams.

  Of the two systems, we recommend PVC for its ease of installation as it is a more flexible, workable, and weldable material than TPO. PVC sheets range in thickness from 60 to 90 mils, and contain plasticizing additives to impart flexibility to the membrane. Thicker membranes have greater impact resistance, and are required for longer roofing warranties. Manufacturers have specific requirements if solar panels are installed. Many reinforced PVC roofing membranes perform with a lifespan of 30-years and possibly longer.
- **Insulation:** The rigid insulation commonly used at single-ply roof assemblies is polyiso insulation. Polyiso is the most thermally efficient rigid board insulation available with the highest R-value per inch of thickness. It has a moisture-resistant foam core, and has excellent dimensional stability. Standard polyiso systems may be susceptible to puncture from falling objects, and sometimes can be crushed if uneven weight is applied (under heavy foot traffic and/or rooftop mechanical equipment loading).

SOCOTEC recommends that a cover board be fully adhered over the attached polyisocyanurate insulation to provide a more durable substrate for the roof membrane, as well as reduce the potential of damage to the roof membrane.

Energy Performance: Measure 1

This measure improves the thermal performance and airtightness of the roof. Bringing the roof to code minimum insulation values helps to reduce annual heating energy. Including a reflective roof membrane reduces solar heat gains, and annual cooling energy. The installation will reduce overall air infiltration through the roof, roof penetrations, and connections between the exterior walls and the roof.

Table 3 below details the existing conditions and the proposed roof.

Table 3 – Thermal performance of existing roof compared to proposed roof.

Roof	Existing Condition	Proposed Roofing Condition (MA Stretch Code)
U-Value	U-0.090	U-0.032
Construction	R-8.9 above deck. Table A.2.2.3*	R-30 above deck
Reflectivity	Non-Reflective Roof membrane	Reflective Roof Membrane

** Not accounting for spray foam below deck*

Measure 1 is expected to save 6% annual site energy consumption, 2% on annual utility cost, and 5% on annual carbon emissions using 2023 emission rates. This measure reduces annual natural gas consumption of the building by 10%. The carbon emission intensities compared to BERDO limits are detailed below in Table 4.

Table 4 – Carbon emissions intensities for Measure 1.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measure 1: Replace Roof System	*Electricity*	1.70	1.65	1.56	1.38	0.92	0.46
	Natural Gas	1.90	1.90	1.90	1.90	1.90	1.90
	Total	**3.60**	**3.55**	**3.46**	**3.27**	**2.81**	**2.36**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

Incentives: Measure 1

Currently there are the following incentives and tax credits for replacing roof systems.

- Mass Save – Attic Insulation: $0.10 per R-value added per square foot.
- Mass Save – Attic Air Sealing: $115 per hour of air sealing work.
- EnergyStar – Tax credit: Bulk insulation products can qualify for 10% of material cost up to $500.

3.2. MEASURE 2: Replace Pyramid Skylights

The existing pyramid skylights are cracked from impact damage and need to be replaced to achieve a watertight tie-in to the roofing system. To protect from further damage, safety screens – which are primarily intended for fall protection – can be installed around each pyramid skylight. Alternatively, a different skylight configuration can be installed to minimize the surface area of exposed glazing, such as a roof monitor.

Sloped, arched, dome and pyramid skylights are pitched, making them more effective at draining water. Reconfiguring the skylight orientation can be considered; north-facing skylights provide constant but cool illumination; east-facing skylights provide light and solar gain in the morning; west-facing skylights provide afternoon sunlight and heat gain; south-facing skylights provide the best potential for winter solar heat gain, but may create unwanted heat gain in the summer.

To meet MA Stretch Code, the skylights will need to be installed with maximum U-0.50 and SHGC-0.40. Skylights are typically plastic or glass. Plastics (typically acrylic or polycarbonate) offer higher impact resistance, but naturally deteriorate over time and become more brittle and yellow with age. Glazing is more durable over time and does not discolor – glass used for skylights must be safety glazing. The selected skylight frames should be thermally broken, meaning that heat cannot be conducted from the interior to the exterior through the frame. A UV coating can be considered for adding UV resistance; shades could also be installed at the interior. The thermal performance of a skylight can be further improved with insulated glazing units, and an air gap filled with argon or krypton. EnergyStar labeled skylights should be considered.

Energy Performance: Measure 2

Replacing the pyramid skylights will help to reduce both heating and cooling loads. The improved U-value will help to reduce heat losses through the windows. Improving the connection with the roof will reduce infiltration losses. The improved SHGC will reduce solar gains and lower the overall cooling loads. The thermal performance of the existing conditions and proposed skylight can be seen below in Table 5.

Table 5 – Pyramid skylight replacement thermal performance metrics.

Pyramid Skylight	Existing Condition	Proposed Skylight (MA Stretch Code)
U-Value	U-1.21*	U-0.50
SHGC	0.77*	0.40

**Values from Table A8.1-1 and Table A8.1-2 for unlabeled skylights*

Measure 2 is expected to reduce annual site energy consumption by 2%, annual energy costs by 1% and annual carbon emissions, using 2023 emission factors, by 2%. The future projected carbon emissions intensities, compared to BERDO set limits, can be seen below in Table 6.

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Table 6 – Carbon emissions intensities for Measure 2.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measure 2: Replace Pyramid Skylights	*Electricity*	1.68	1.63	1.54	1.36	0.90	0.45
	Natural Gas	2.04	2.04	2.04	2.04	2.04	2.04
	Total	**3.72**	**3.67**	**3.58**	**3.40**	**2.95**	**2.50**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

Incentives: Measure 2

Currently there are the following incentives and tax credits for replacing skylight systems.

- Mass Save – Attic Air Sealing: $115 per hour of air sealing work.
- EnergyStar – TaxCredit: EnergyStar labeled skylights installed are eligible for 10% of material cost up to $200.

3.3. MEASURE 3: Replace East-Facing Egress Door

The existing East-facing egress door is drafty and should be replaced with a fiber-reinforced polymer (FRP) fire-rated door. MA Stretch Code requires that insulated doors do not exceed U-0.37. FRP doors are moisture-resistant, rust-resistant, and are durable. EnergyStar products should be considered.

The door should be air sealed to minimize air leakage and water intrusion. This can be accomplished by installing a continuous gasket, such as weatherstripping, around the interior perimeter of the door frame. The rough opening can also be air sealed with non-expanding spray foam or backer rod and caulk. The exterior of the door should be flashed with a waterproof flashing integrated with the wall drainage plane, and a tight-fitting door sweep should be installed along the bottom of the door.

Energy Performance: Measure 3

Replacing the East-facing egress door is expected to reduce air infiltration. This will help with both heating and cooling loads. Measure 3 is an important part of the overall envelope improvements; however it alone does not make a significant impact on the annual performance. The future projected carbon emissions intensities, compared to BERDO set limits, can be seen below in Table 7.

Table 7 – Carbon emissions intensities for Measure 3.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measure 3: Replace Egress Door	*Electricity*	1.70	1.65	1.56	1.38	0.92	0.46
	Natural Gas	2.08	2.08	2.08	2.08	2.08	2.08
	Total	**3.77**	**3.73**	**3.64**	**3.45**	**2.99**	**2.54**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

Cost Estimate: Measures 1-3

Following is a cost estimate for Measures 1-3, which are included in the Phase 3 scope of work. These costs include labor and material.

Table 8 – Cost estimate for Measures 1-3/ Phase 3.

Measures 1-3 (Phase 3 Scope)	SF/Unit Count	Cost per SF or Unit	Total Cost
New PVC Roof	3600 SF	$40/SF	$144,000
New Unit Skylights	4 Units	$1,500/Unit	$6,000
New FRP Insulated Egress Door	1 Unit	$5,000/Unit	$5,000
Total Phase 3 Cost			**$155,000**

Incentives: Measure 3

Currently there are the following incentives and tax credits for replacing the back door.

> Mass Save – Exterior Door Weatherstripping: $11 per linear foot of door weatherstripping.

> EnergyStar – TaxCredit: EnergyStar labeled doors installed are eligible for 10% of material cost up to $500.

3.4. MEASURE 4: Replace Storefront Window

The storefront window had high air infiltration at the perimeter rough opening, and can be considered for replacement. The insulating value of the glass can also be improved – MA Stretch Code requires a maximum U-value of U-0.30 and SHGC of 0.38. When selecting new windows, the window frame materials, glazing features, and gas fill and spacers should all be considered for energy efficiency. EnergyStar labeled products should be considered.

Massachusetts State Building Code considers the storefront to be in a hazardous location as it is within 36-inches of a walking surface, thus it will require safety glazing. Double or triple-pane glazing can be considered for improved thermal performance, and argon or krypton gas can be considered for better thermal insulation. Non-metallic thermally broken spacers and warm-edge spacers between the glass should be used, as they will lower the window U-factor and reduce risk of condensation. The selected glazing should have a low-e coating, which will lower the U-value of the window and manage daylight transmittance and solar heat gain through the glazing.

The selected window frame should be thermally broken; it is possible to use muntins on the storefront to hold the glass and maintain the current visual appearance of the storefront, or alternatively decorative muntins can be used. New windows that are installed should have a continuous tie-in to the air barrier of the surrounding wall structure, to ensure an air-tight and water-tight assembly.

Energy Performance: Measure 4

Replacing the storefront window is expected to reduce overall infiltration as well as improve heating and cooling loads. The improved tie-in to the surrounding wall will improve infiltration. The reduced U-value will help reduce thermal losses through the glazing, and the reduced SHGC reduces the solar gains. Overall the heating and cooling loads will be reduced across the year with this measure. The thermal performance metrics for this measure can be seen below in Table 9.

Table 9 – Thermal performance of storefront replacement measure compared to existing condition.

Storefront	Existing Condition	Proposed storefront window (MA Stretch Code)
U-Value	U-0.90*	U-0.30
SHGC	0.68*	0.38

**Values from Table A8.2*

Measure 4 is predicted to reduce annual site energy consumption by 1%, and annual carbon emissions by 1%. The future projected carbon emissions intensities, compared to BERDO set limits, can be seen below in Table 10.

Table 10 – Carbon emission intensities for Measure 4.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measure 4: Replace Storefront Window	*Electricity*	1.69	1.65	1.56	1.37	0.91	0.46
	Natural Gas	2.07	2.07	2.07	2.07	2.07	2.07
	Total	**3.76**	**3.71**	**3.62**	**3.44**	**2.98**	**2.52**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

Cost Estimate: Measure 4

The labor and material cost estimate for Measure 4 is shown in Table 11.

Table 11 - Cost estimate for Measure 4.

Measure 4	SF	Cost per SF or Unit	Total Cost
Storefront Window	118 SF	$150/SF	$17,700

Incentives: Measure 4

Currently there are the following incentives and tax credits for replacing the storefront window.

> EnergyStar – TaxCredit: EnergyStar labeled windows installed are eligible for 10% of material cost up to $200.

3.5. MEASURE 5: Overclad Exterior Walls (North, South, East)

The existing building does not have continuous exterior insulation. Overcladding can be installed at the CMU walls on the East, South, and West elevations to achieve continuous insulation and to create a continuous air/vapor and thermal barrier. MA Stretch Code requires a maximum U-0.09 for mass masonry buildings with continuous insulation.

The biggest advantage to overcladding is reduced disruption to building occupants compared to demoing/rebuilding the envelope from the interior or exterior, and a reduced disruption to plumbing, mechanical, or electrical work that may be located at exterior walls. If there are existing hazardous materials at the exterior walls, these can be encapsulated with overcladding, therefore reducing abatement costs.

Materials that can be considered for overcladding include exterior insulation and finishing systems (EIFS) with mineral wool or XPS insulation, or rainscreen aluminum composite material (ACM) panel with thermally broken girts. EIFS can be reinforced for more durability. An embodied carbon comparison using Payette's Kaleidoscope tool is as follows:

Table 12 – Kaleidoscope Embodied Carbon Comparison of EIFS vs Metal Panel.

Entrance Skylight	Initial Carbon ($kgCO_2eq/sf$)	60-year Lifespan with Module D and Biogenic Carbon ($kgCO_2eq/sf$)	60-year Lifespan with Biogenic Carbon ($kgCO_2eq/sf$)
EIFS with Mineral Wool*	3.2	4.12	5.76
EIFS with XPS**	13.08	26.88	28.52
ACM Panel***	10.5	7.64	15.11

** Not including building structure or fenestrations. Assumes latex/acrylic based stucco on fiberglass reinforcement mesh, 3.5-inch mineral wool insulation set to reach system R-value 15.625, and service life of exterior materials Tally default of 60 years or higher.*

*** Not including building structure or fenestrations. Assumes latex/acrylic based stucco on fiberglass reinforcement mesh, 2.5-inch XPS insulation set to reach system R-value 15.625, and service life of exterior materials Tally default of 60 years or higher.*

**** Not including building structure or fenestrations. Assumes 5" continuous mineral wool insulation to reach system R-value 15.625, fiberglass mat gypsum sheathing, 4mm aluminum facings bonded to thermoplastic core, and service life of exterior materials Tally default or adjusted to 60 years or higher.*

It is unlikely that the depth added by overcladding the exterior walls would impact the daylight received or views through the punched windows, which would be slightly recessed. However, it is important to perform thermal and hygrothermal analyses when designing overcladding to determine the dewpoint within the new wall assembly, and accurately locate air/vapor and thermal barriers to reduce condensation risk within the wall cavity. Structural analysis is also critical; the addition of the new facade not only introduces new gravity loads, but also introduces structural connections to the existing building which may deflect, or thermally contract and expand, different than the existing wall. Once the existing facade is captured within the overcladding, it becomes weather-tight and significantly less prone to climate-related damage or failure over time.

Energy Performance: Measure 5

Overcladding the North, South, and East exterior walls will help to reduce infiltration as well as thermal losses through the envelope. The proposed wall performance for the North, South, and East facades can be seen below in Table 13. The West facade and existing punched windows will remain in place.

Table 13 – Exterior wall improvement recommendations thermal performance compared to existing condition.

Exterior Walls		Existing Condition	Proposed Wall Conditions (MA Stretch Code)
North, South, East	U-Value	U-0.218	U-0.032
	Construction	8in CMU block, 1.5" metal furring strip, R-10 cavity rigid insulation, gypsum board.	Overclad System. 8in CMU block, 1.5" metal furring strip, R-10 cavity rigid insulation, gypsum board.
West	U-Value	U-0.25	U-0.25
	Construction	3 Wythe Brick	3 Wythe Brick
Punched Windows	U-Value	U-0.33	U-0.33
	SGHC	0.28	0.28

Measure 5 is expected to reduce annual site energy consumption by 4%, annual energy costs by 2% and annual carbon emissions by 4%. The future projected carbon emissions limits, compared to BERDO set limits, can be seen below in Table 14.

Table 14 – Carbon emission intensities for Measure 5.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measure 5: Overclad exterior walls (North, South, East)	*Electricity*	1.68	1.64	1.55	1.36	0.91	0.46
	Natural Gas	1.96	1.96	1.96	1.96	1.96	1.96
	Total	**3.64**	**3.59**	**3.50**	**3.32**	**2.86**	**2.41**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

Cost Estimate: Measure 5

The labor and material cost estimate for Measure 5 is shown in Table 15. EIFS is the less costly material.

Table 15 – Cost estimate for Measure 5.

Elevation	SF	EIFS*		ACM Metal Panel	
		Cost/SF	Total Cost	Cost/SF	Total Cost
North	900	$50	$45,000	$75	$67,500
South	600	$50	$30,000	$75	$45,000
East	900	$50	$45,000	$75	$67,500
West	-	-	-	-	-
Total Cost			**$120,000**		**$180,000**

**Costs consider XPS insulation. EIFS with mineral wool insulation likely has higher material and labor costs.*

Incentives: Measure 5

Currently there are the following incentives and tax credits for improving wall thermal performance.

- Mass Save – Wall insulation: $0.17 per R-value added per square foot.
- EnergyStar – Tax credit: Bulk insulation products can qualify for 10% of material cost up to $500

3.6. MEASURE 6: Replace Entry Skylight

Refer to Measure 2 Skylight discussion if the skylight is desired for replacement. If the existing skylight remains in place, the skylight should be re-caulked for watertight seals around the glazing during roof repairs. A new UV coating could also be installed, or interior skylight shades.

Energy Performance: Measure 6

Replacing the entry skylight will help reduce infiltration by improving the connections between the wall, skylight, and roof. The reduced U-value will reduce thermal losses through the glazing unit, and the reduced SHGC will reduce solar gains in the space. Overall heating loads and cooling loads will be reduced through this measure. The thermal performance metrics for Measure 6 can be seen below in Table 16.

Table 16 – Thermal performance metrics for Measure 6.

Entrance Skylight	Existing Condition	Proposed Skylight (MA Stretch Code)
U-Value	U-1.36*	U-0.50
SHGC	0.82*	0.40

**Values from Table A8.1-1 and Table A8.1-2 for unlabeled skylights*

Measure 6 is expected to save 2% in annual site energy, 3% in annual utility cost, and 3% in annual carbon emissions using 2023 rates. The future projected carbon emissions intensities, compared to BERDO Limits, can be seen below in Table 17.

Table 17 – Carbon emission intensities for Measure 6.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measure 6: Replace entry skylight	*Electricity*	1.65	1.60	1.52	1.34	0.89	0.45
	Natural Gas	2.04	2.04	2.04	2.04	2.04	2.04
	Total	**3.69**	**3.65**	**3.56**	**3.38**	**2.93**	**2.49**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

Cost Estimate: Measure 6

The labor and material cost estimate for Measure 6 is shown in Table 18.

Table 18 - Cost estimate for Measure 6.

Measure 4	SF	Cost per SF or Unit	Total Cost
Entry Skylight	210 SF	$100/SF	$21,000

Incentives: Measure 6

Currently there are the following incentives and tax credits for replacing the front entrance skylight.

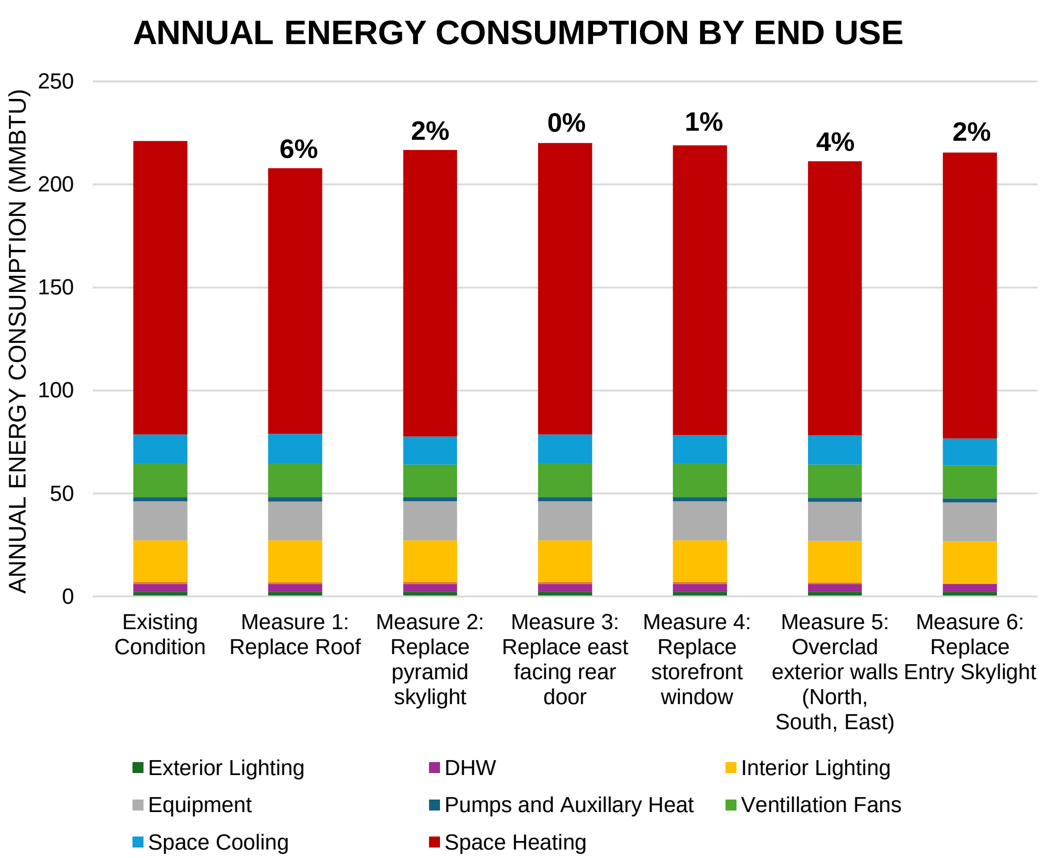
- Mass Save – Attic Air Sealing: $115 per hour of air sealing work.
- EnergyStar – TaxCredit: EnergyStar labeled skylights installed are eligible for 10% of material cost up to $200.

3.7. All Envelope Measures

Energy Performance: Measures 1-6

Measures 1 through 6 as detailed above help reduce overall infiltration rates, solar heat gains, and thermal heat losses. They help to reduce heating and cooling loads, which is an important first step in decarbonization and electrification, in alignment with meeting future BERDO-type emission limits.

Figure 6 Annual energy consumption of envelope measures broken down by end use.



The annual energy consumption, in units of MMBTU/yr for each measure (1-6) can be seen above in Figure 6, broken down by end use. As seen below, heating is the major end use of energy for this building. Improving the envelope helps to reduce heating and cooling loads, however the other loads in the building remain nominally the same. Percent annual energy reduction compared the existing building is marked above each measure.

Different combinations of Measures 1 through 6 carbon emissions intensities, compared to BERDO limits, can be seen below in

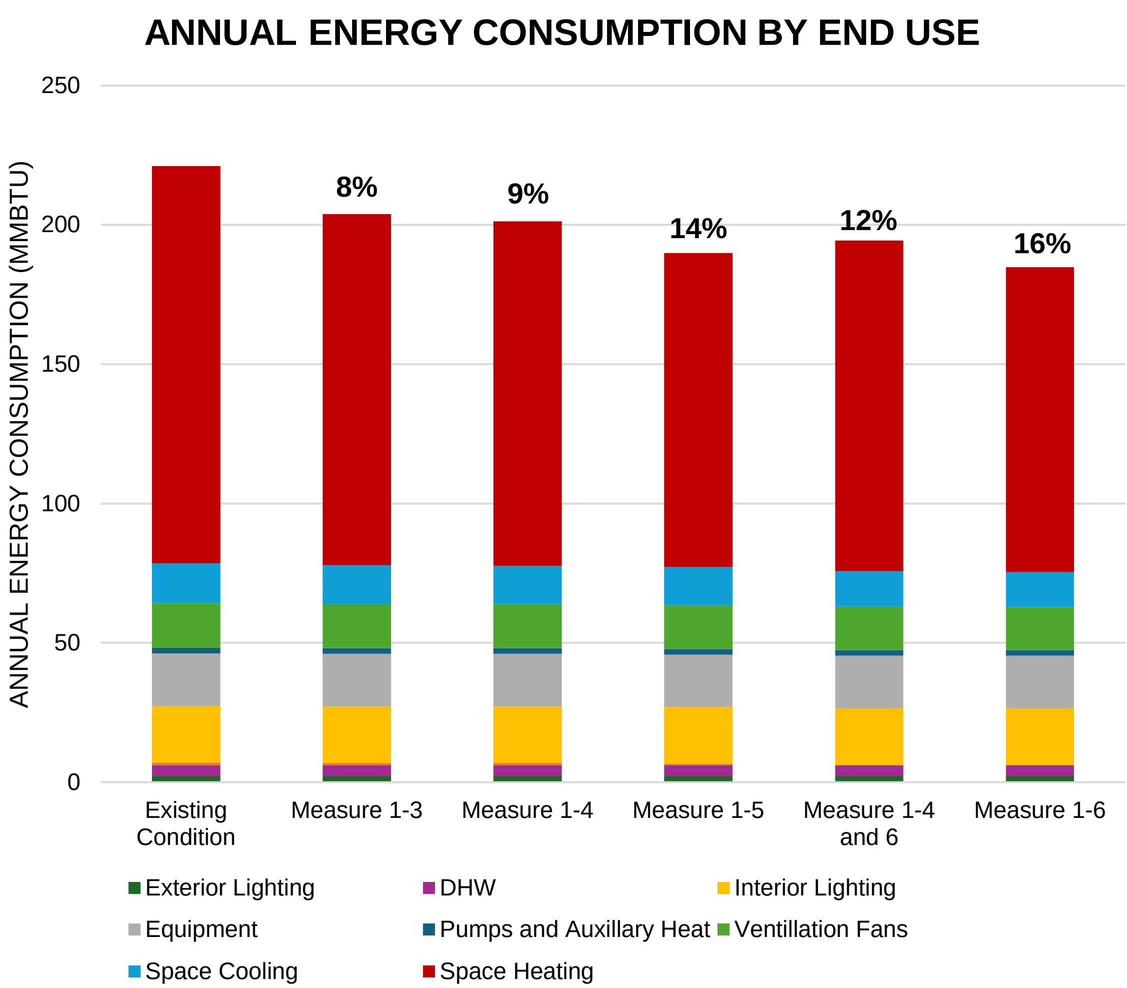
Table 19. Measure 1 through 6, combined, saves a 2% on annual site energy, and 3% on annual cost and carbon emissions.

Table 19 – Carbon emissions intensities for the combined envelope measures.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measures 1-3	*Electricity*	1.68	1.63	1.54	1.36	0.91	0.45
	Natural Gas	1.85	1.85	1.85	1.85	1.85	1.85
	Total	**3.53**	**3.48**	**3.39**	**3.21**	**2.76**	**2.30**
Measures 1-4	*Electricity*	1.67	1.63	1.54	1.36	0.9	0.45
	Natural Gas	1.82	1.82	1.82	1.82	1.82	1.82
	Total	**3.49**	**3.45**	**3.36**	**3.17**	**2.72**	**2.27**
Measures 1-5	*Electricity*	1.66	1.62	1.53	1.35	0.9	0.45
	Natural Gas	1.66	1.66	1.66	1.66	1.66	1.66
	Total	**3.32**	**3.27**	**3.18**	**3.00**	**2.55**	**2.11**
Measures 1-4, 6	*Electricity*	1.63	1.58	1.49	1.32	0.88	0.44
	Natural Gas	1.75	1.75	1.75	1.75	1.75	1.75
	Total	**3.37**	**3.33**	**3.24**	**3.07**	**2.63**	**2.19**
Measures 1-6	*Electricity*	1.62	1.57	1.49	1.31	0.87	0.44
	Natural Gas	1.61	1.61	1.61	1.61	1.61	1.61
	Total	**3.23**	**3.18**	**3.10**	**2.92**	**2.48**	**2.05**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

The combinations of the envelope measures annual energy performance can be seen below in Figure 7. The results are broken down by end use. The annual heating energy decreases significantly when the envelope measures combine- infiltration is reduced and U-values increase. The percent annual energy savings is marked above each measure.

Figure 7 Annual energy consumption of the combined envelope measures broken down by end use



Cost Estimate: Measures 1-6

The labor and material cost estimate for Measures 1-6, all envelope measures, is shown in Table 20.

Table 20 – Cost estimate for all envelope measures.

Measures 1-6 (All Envelope Measures)	SF/Unit Count	Cost per SF or Unit	Total Cost
New PVC Roof	3600 SF	$40/SF	$144,000
New Unit Skylights	4 Units	$1,500/Unit	$6,000
New FRP Insulated Egress Door	1 Unit	$5,000/Unit	$5,000
Storefront Window	118 SF	$150/SF	$17,700
Overcladding – EIFS or ACM	2400 SF	$50-75/SF	$120,000-$180,000
Entry Skylight	210 SF	$100/SF	$21,000
Total Phase 3 Cost			**$313,700-$373,700**

3.8. MEASURE 7: Replace Existing Lights with LEDs

This measure has been removed from the recommendation, as per site visits by BLW on February 22, 2024, it was observed that LED lights had already been installed. This is aligned with the utility bills reviewed by the SOCOTEC team and plug loads in the modeling. The results for the remaining measures continue to be accurate as an improved lighting power density was used for analysis of all measures.

The existing fluorescent lighting was installed in 2010, as noted in 42 Cross Street Renovations 100% Bid Drawings. The calculated lighting power densities of the existing lighting system were considerably higher than the 2023 MA Stretch Code allowable lighting values. Measure 7 recommends replacing the existing lights with code-compliant LEDs. SOCOTEC also studied an alternative (Measure 7 ALT) for a lighting system that is designed to 25% better than code lighting power density (LPD) allowances. The values can be seen below in Table 21.

Table 21 – Lighting Power Densities.

Space	Existing LPD	2023 MA Stretch LPD	25% better than 2023 MA Stretch LPD
Enclosed Office	1.02	0.74	0.56
Open Office	1.63	0.61	0.46
Storage Stacks	1.39	1.18	0.89
Storage Room	0.95	0.38	0.29
Community Room	2.23	0.97	0.73
Corridor	2.00	0.41	0.31
Copy	1.10	0.31	0.23
Teledata	0.57	0.43	0.32
Toilets	0.80	0.63	0.47
Breakroom	0.64	0.59	0.44

Energy Performance: Measure 7

Reducing lighting power densities and installing LEDs instead of the existing fluorescent helps lower electrical usage associated with lighting equipment, as well as cooling loads in the summer. There is often

a small heating load increase due to a reduced lighting power design. Measure 7 saves an annual 2% of energy, 7% on annual energy costs, and 3% of annual carbon emissions using 2023 carbon emission rates. Measure 7 ALT increases the savings to 3%, 10%, and 4% respectively. The annual carbon emissions intensities compared to BERDO emission limits can be seen below in Table 22.

Table 22 – Carbon emission intensities for Measure 7.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measure 7: Replace Lighting with LED (Code)	*Electricity*	1.55	1.50	1.42	1.25	0.84	0.37
	Natural Gas	2.14	2.14	2.14	2.14	2.14	2.14
	Total	**3.69**	**3.64**	**3.56**	**3.39**	**2.97**	**2.51**
ALT: Replace Lighting with LED (25% Better than Code)	*Electricity*	1.47	1.43	1.35	1.19	0.79	0.36
	Natural Gas	2.16	2.16	2.16	2.16	2.16	2.16
	Total	**3.63**	**3.59**	**3.51**	**3.35**	**2.95**	**2.52**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

Cost Estimate: Measure 7

The cost of each fixture will vary based on chosen lighting design. Roughly given the 2500 Watts accounted for in Measure 7, the total cost will be $7,000-$9,000 to replace the existing lighting with LEDs.

Incentives: Measure 7

Currently there are the following incentives and tax credits for installing LED lighting:

1. Mass Save - Instant Lighting Incentives: Linear Replacement Lamps – up to $15
2. Mass Save - Instant Lighting Incentives: Linear fixtures with and without controls – up to $15
3. Mass Save - Instant Lighting Incentives: Exterior fixtures with and without controls – up to $205
4. Mass Save - Partner incentive – Eversource: Occupancy-controlled step-dimming systems, wall-mounted occupancy sensors, wall-mounted vacancy occupancy sensors.

3.9. MEASURE 8: Replace Equipment with EnergyStar-Rated Equipment

Measure 8 recommends replacing equipment in the office, conference, and breakroom with EnergyStar-rated equipment. This equipment can include: computer monitors; large TVs/ presentation screens/projectors; and kitchen equipment. This is an effective measure to lower electrical plug loads and annual energy consumption. Equipment can be replaced in an as-needed fashion, or all at once.

Energy Performance: Measure 8

This measure is expected to save 1% annual utility costs and 1% annual carbon emissions. The annual energy consumption of this measure compared to the existing condition can be seen below in Figure 8. The annual energy end use is broken down by end use. The equipment end use reduces as well as the cooling energy. There is a slight increase in heating energy associated with this measure. The annual carbon emissions intensities compared to BERDO emission limits can be seen below in Table 23.

Figure 8 Annual energy consumption of Measure 8 compared to existing condition broken down by end use.

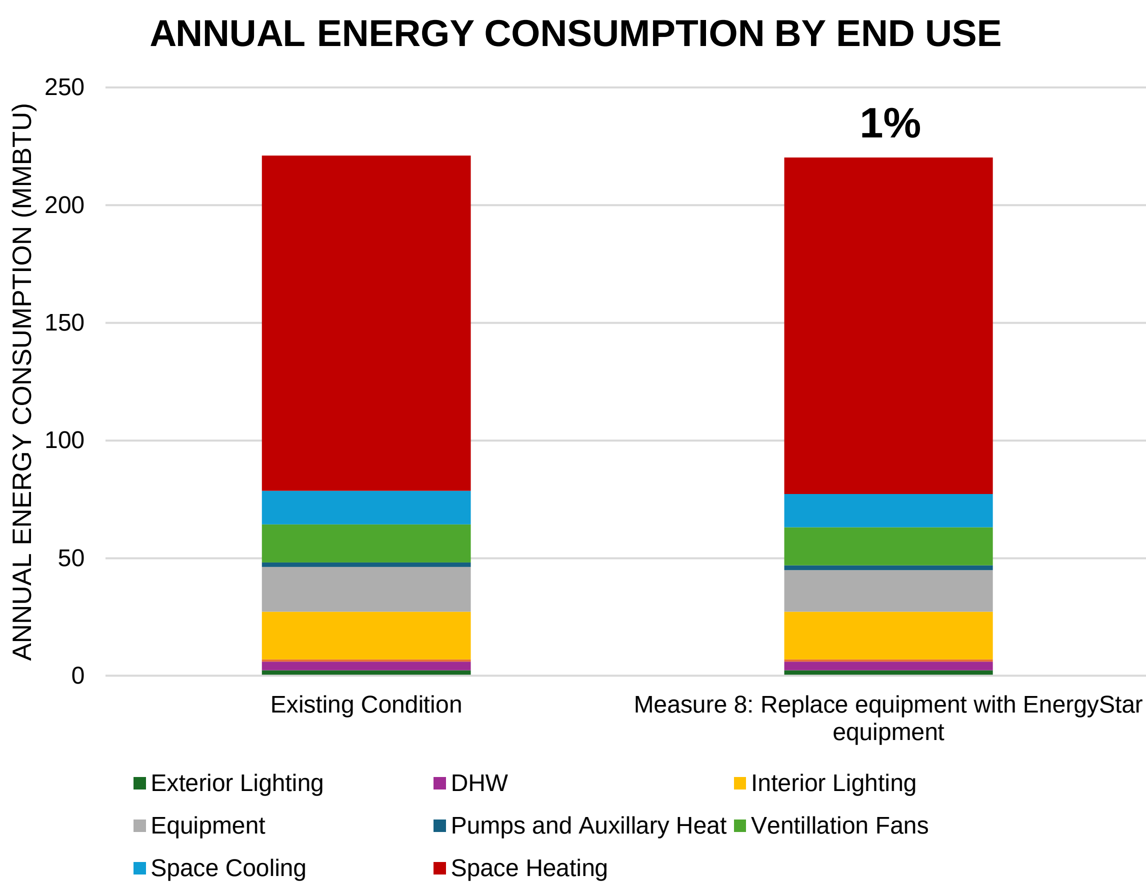


Table 23 – Carbon emission intensities for Measure 8.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measure 8: Replace Equipment with EnergyStar- rated Equipment	*Electricity*	1.67	1.62	1.53	1.35	0.90	0.45
	Natural Gas	2.10	2.10	2.10	2.10	2.10	2.10
	Total	**3.77**	**3.72**	**3.63**	**3.45**	**3.00**	**2.55**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

Cost Estimate: Measure 8

EnergyStar-rated equipment can be found on *energystar.gov/productfinder*. A tabulated cost of sample equipment is located below in Table 24.

Table 24 – EnergyStar equipment costs.

EnergyStar Equipment	**Desktop Monitor**	$ 100-200
	Large TV	$2,000-5,000
	Printer/Copy Machine	Smaller units: $200-500 Larger units: $500-1000
	Fridge	$1,000-3,000

Incentives: Measure 8

Currently there are no incentives and tax credits for installing EnergyStar equipment.

3.10. MEASURE 9: Replace RTUs with Heat Pump and Energy Recovery Wheels

The main use of energy in the existing condition is space heating (see Section 2). Measure 9 outlines a recommendation to significantly reduce the energy used for space heating, as well as remove natural gas from the building's operation. Measure 9 recommends replacing existing gas-fired RTUs with heat pump RTUs, coupled with an energy recovery wheel. Two options were studied, a MA Stretch Code minimum RTU, and an alternative with heating and cooling efficiencies 10% better than MA Stretch Code requirements. Per Massachusetts State Building Code, serviceable equipment within 10-feet of the roof ledge will require a guard.

Energy Performance: Measure 9

Table 25 below has the existing RTU efficiencies as well as the efficiencies studied under Measure 9. Replacing the existing gas fired RTUs with heat pumps will improve the heating efficiency from 81%, to a COP of at least 2.21. This will both remove natural gas from the building operation, as well as meet the heating load more efficiently. The cooling efficiency will also improve from a seasonal energy efficiency ratio (SEER) of 13 to a SEER (as converted from SEER2) of at least 13.94. The energy recovery wheel, with an efficiency of at least 70% for both sensible and latent loads, will help to reduce the overall heating and cooling energy as it captures/rejects heat to/from the exhaust stream.

Table 25 – Measure 9 RTU efficiencies.

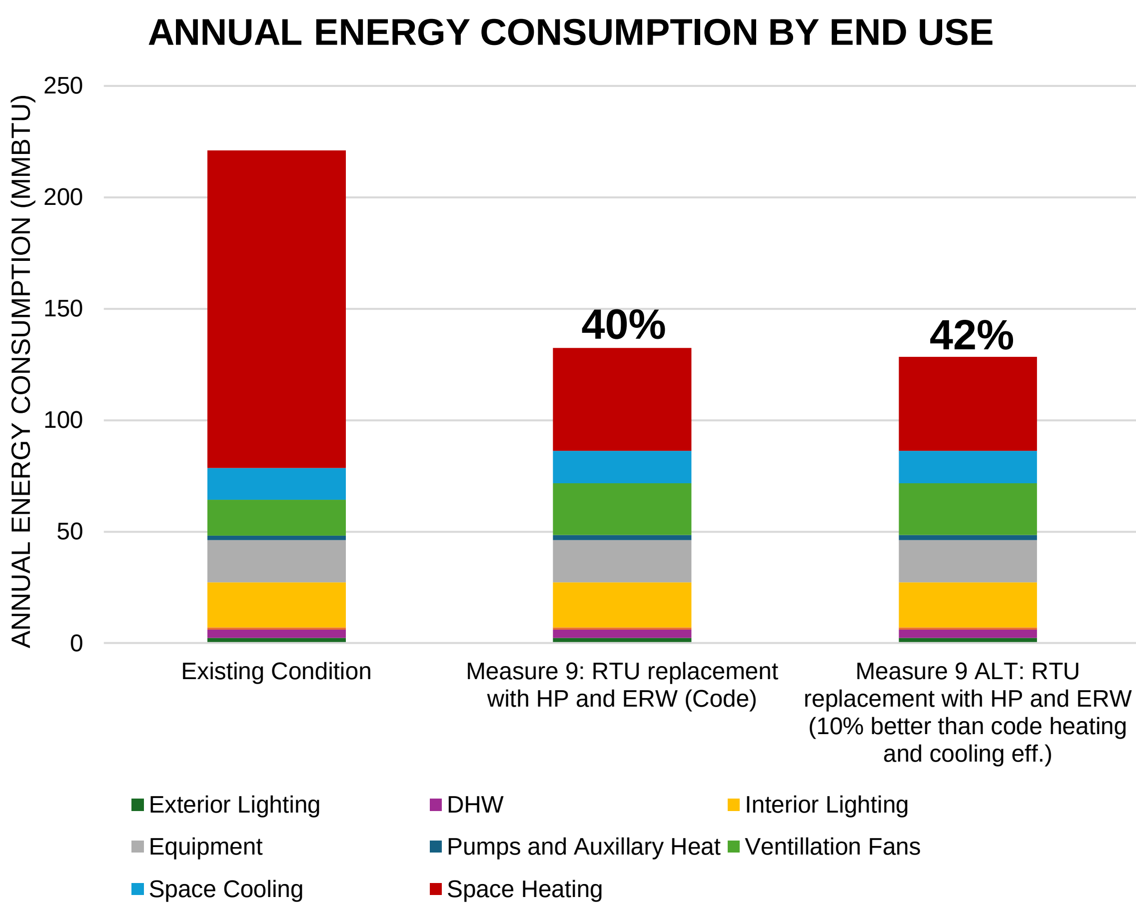
	EXISTING RTU	CODE MINIMUM HP RTU	ALT RTU
Cooling Source	DX	HP	HP
Cooling Efficiency	SEER-13	SEER2-13.4	SEER2-14.7
Heating Source	NG Furnace	HP	HP
Heating Efficiency	81%	HSPF2-6.7	HSPF2-7.37
Energy Recovery	No	Yes -ERW	Yes -ERW
Energy Recovery Effectiveness	N/A	70% Sensible and Latent	70% Sensible and Latent

This measure reduces the annual site energy consumption by 40%, and the annual carbon emissions by 25%. The alternative outlined above saves 42% annual energy consumption and 27% of carbon emissions. The annual carbon emissions intensities compared to BERDO emission can be seen below in Table 26. Figure 9 below shows the annual energy consumption for Measure 9 and 9 Alt compared to the existing condition. The ventilation energy increases due to the increased pressure drop associated with the energy recovery wheel. The space heating energy decreases significantly due to the switch from an 81% efficient natural gas furnace to a heat pump heating source with a HSPF2 of over 6.

Table 26 – Carbon emission intensities for Measure 9.

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Measure 9: RTU replacement with HP and ERW (Code)	*Electricity*	2.84	2.76	2.61	2.30	1.53	0.77
	Natural Gas	-	-	-	-	-	-
	Total	**2.84**	**2.76**	**2.61**	**2.30**	**1.53**	**0.77**
ALT: 10% better than code heating and cooling eff.	*Electricity*	2.75	2.68	2.53	2.23	1.48	0.74
	Natural Gas	-	-	-	-	-	-
	Total	**2.75**	**2.68**	**2.53**	**2.23**	**1.48**	**0.74**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

Figure 9 Annual energy consumption for Measure 9 and Measure 9 Alt compared to existing condition, broken down by end use.



Cost Estimate: Measure 9

To replace the existing RTUs with heat pump RTUs, there will be three main costs to consider: (1) demolition, (2) material, and (3) installation. Based on costing data provided by RSMeans, Measure 9 is expected to cost approximately $200,000, not including any incentives. The cost estimate breakdown can be seen below in Table 27.

Table 27 – Cost estimate breakdown for Measure 9.

10-ton Heat Pump (RSMeans -D30502451010)	**Quantity**	2
	Removal	$1,500
	Material per unit	$85,200
	Installation per unit	$14,200
	Total per unit	$100,900
	Total Cost	$201,800

Incentives: Measure 9

Currently there are the following incentives and tax credits for installing air source heat pumps

- Federal Tax credit: Installing Energy Star certified heat pumps - $300
- Mass Save: Heat Pump Qualified Products List (PHQPL) – Air Source Heat Pump - up to $2,500/ton
- IRA Federal Tax Credit: Heat pump installation credit up to $2,000 per year.

3.11. MEASURE 10: Replace Domestic Hot Water Heater with Point-Source Heaters

Measure 10 is to replace the existing electric hot water heater with storage tank with an electric point-source water heater. This measure is not expected to save any additional energy as the domestic hot water consumption of the building is very small. Using point-source water heaters is more efficient than storage tank water heaters as it removes standby heat loss. Point heating systems also typically have a longer life of 20+ years compared to 10-15 years for standard storage tank systems. Point-source water heaters are more expensive than storage tanks water heater systems.

Cost Estimate: Measure 10

To install a point-source water heater, the two main considerations are material cost and installation. It is expected that per unit installed, this measure would cost approximately $700. The cost breakdown can be seen below in Table 28. To remove the existing water heater is estimated to cost approximately $900, for 6.5 hours of labor.

Table 28 – Cost estimate breakdown for Measure 10.

Point Source Water Heater (RSMeans -223313208970)	**Material per unit**	$250
	Installation per unit	$450
	Total per unit	$700

Incentives: Measure 10

Currently there are the following potential incentives and tax credits for installing improved point-source water heaters:

> Federal Tax credit – installing Energy Star certified water heaters with a thermal efficiency of at least 90% - $300

3.12. MEASURE 11: Upgrade Temperature Controls Systems

Measure 11 is to replace the existing thermostat and temperature control systems when the new RTUs are installed. The existing thermostats, per discussion with the Office of Immigrant Affairs, are not accurate and do not properly control the temperature in the space. When replacing the RTUs it is recommended to replace the thermostat system to ensure that the space temperature can be controlled more accurately. This will improve occupant comfort and overall performance of the system. Per discussion with the City of Somerville this system is to be compatible with JCI controls systems which other buildings in the City of Somerville portfolio currently use.

Cost Estimate: Measure 11

To install an upgraded temperature controls system, there are a range of costs. To install new thermostats with timed temperature setbacks, there is a unit cost of $230, including installation. The full control system depends on the system and integration into existing networks. The cost breakdown for this measure can be seen below in Table 29.

Table 29 – Cost estimate breakdown for Measure 11.

Thermostats with Control Capability (RSMeans- 230953105040)	**Material per unit**	$130
	Installation per unit	$100
	Total per unit	$230

Incentives: Measure 11

Currently there are the following incentives and tax credits for installing or commissioning control systems:

> Mass Save – Smart Thermostat installation.
> Mass Save – ESPO: low-cost tuning measures or targeted systems tuning.

3.13. Combined Measures

The measures detailed above help to reduce overall infiltration rates, solar heat gains, envelope thermal heat losses, plug loads, cooling loads, and improve equipment efficiency. Two "combined" cases were studied: Case 1* includes all envelope improvements except the wall overclad (Measure 5) + energy star equipment, improved HP RTU, updated controls, and point source DHW; the other, Case 2* includes all measures in Case 1* as well as the wall overclad (Measure 5).

Overall Case 1* saved 46% in annual site energy consumption, and 33% in annual carbon emissions using 2023 emissions factors. Case 2* saved 50% in annual site energy consumption, and 37% in annual carbon emissions using 2023 emissions factors. The annual energy use of Case 1* and Case 2* can be seen below in Figure 10. Annual energy is broken down by end use, with the percent annual savings marked for each measure. The heating energy decreases significantly, due to the improved envelope and heat pump heating source; while the ventilation energy increases due to the increased pressure drop from the energy recovery wheels. Different combinations of Case 1* and Case 2* carbon emissions intensities, compared to BERDO limits, can be seen below in Table 30.

* *Case 1* and Case 2* measures are enumerated in Table 30 below. The v01 Case 1 and Case 2 have been removed as they have been superseded by Case 1* and Case 2* per request by City of Somerville on February 27, 2024 in report v01 review meeting.*

Figure 10 Annual energy consumption of Case 1* and Case 2*: combined EEMS, broken down by end use.

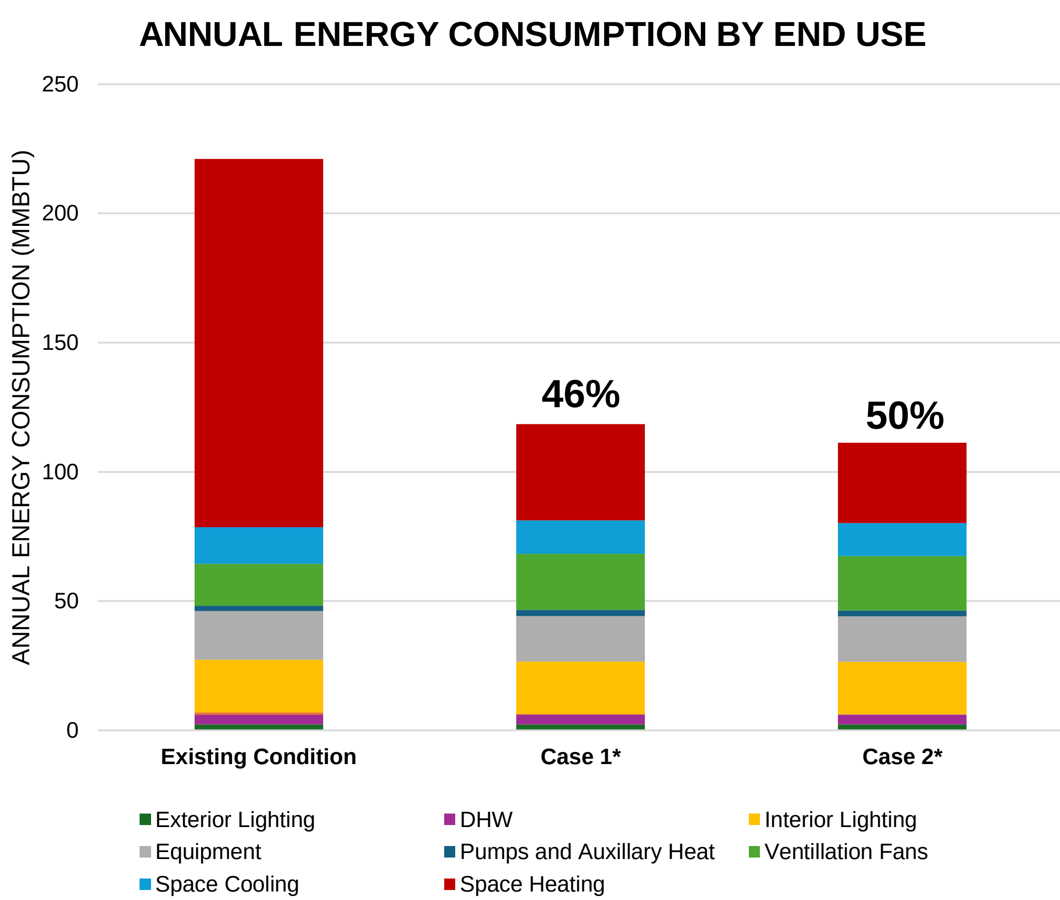


Table 30 – Carbon emission intensities for combined measures Case 1 and Case 2*.*

		2023	2024	2026	2030	2040	2050
		kgCO2e/SF/yr					
Case 1*: Measure 1-4, 6, 8, 9 ALT, 10, 11	*Electricity*	2.54	2.47	2.33	2.06	1.37	0.69
	Natural Gas	-	-	-	-	-	-
	Total	**2.54**	**2.47**	**2.33**	**2.06**	**1.37**	**0.69**
Case 2*: Measure 1-6, 8, 9 ALT, 10, 11	*Electricity*	2.38	2.32	2.19	1.93	1.29	0.64
	Natural Gas	-	-	-	-	-	-
	Total	**2.38**	**2.32**	**2.19**	**1.93**	**1.29**	**0.64**
BERDO LIMIT				**5.3**	**3.2**	**1.6**	**0**

4. ROOF ASSESSMENT AND PV STUDY

2023 MA Stretch Code states a requirement that buildings less than five stores with low-slowed roofs or roofs oriented between 110º and 270º of North must have a minimum of 40% total unoccupied roof area designed to be solar ready, with a 2’x4’ space designated as electrical energy storage ready. Pursuant to the 2023 MA Stretch Code, and owner interest, a solar feasibility study was conducted.

Assuming a 40% roof area availability, 16% efficient PV modules, 42 cross roof top can support a 21 kW system. This equates to a 28,400 kWh annual generation. This is more than 90% of the total kwh projected under Case 1 and Case 2 above, 31,300 kWh/yr and 30,000 kWh/yr respectively. The average PV system costs approximately $3.13/Watt. A system this size would cost approximately $67,000 before incentives. This does not include storage cost. Any reductions in annual energy costs due to offsetting demand charges is also not included in this analysis.

Pairing photovoltaic systems with storage is a great option for participation in demand response programs, offsetting peaks, as well as resiliency. Installing a bank of battery storage units can help to provide resiliency in the case of a utility outage. Especially when paired with generators, PV systems and battery storage can help to keep a building operational for longer in an islanded condition.

Solar PV and storage can also help to mitigate risk and future cost associated with future improvements to the building. As carbon regulations become increasingly stringent and the push to fully electrify grows, generation and distribution of electricity will be in higher demand and may contribute to increased costs. Installation of solar PV and battery storage can help insulate the building from rising utility costs by reducing reliance on the grid.

The full NREL PV Watts calculation can be found in Appendix B.

Incentives:

> **IRA:** The Inflation Reduction Act (IRA) updated the Solar Investment Tax Credit (ITC). For commercial solar larger than 1 MW, projects would need to pay prevailing wage and have 10%-15% of labor hours filled by apprentices to qualify for the 30% ITC. Otherwise, the credit is 6%. This is only available for projects beginning construction 60 days after the Department of Treasury outlines the labor metrics.

Technologies eligible for the ITC are standalone battery systems, batteries paired with solar, microgrid controllers connected to systems smaller than 5MW, and solar water heating.

> **SMART:** Solar Massachusetts Renewable Target (SMART) program offers incentives for commercial projects throughout Massachusetts. The DOER sets the regulatory framework for the program. The tariff-based incentive is paid directly by the utility company to the system owner, following the approval of the application by the Solar Program Administrator and DOER.

  The SMART Program is a 3,200 MW declining block incentive program. Eligible projects must be interconnected by one of three investor-owned utility companies in Massachusetts: Eversource, National Grid and Unitil. Each utility has established blocks that decline in incentive rates between each block.

  The steps are (1) Agreement – requiring a signed contract for small projects, (2) application, (3) Qualify – receive preliminary statement of qualification.

5. ENERGY MODELING SOFTWARE

5.1. eQuest

SOCOTEC used the computer software eQuest, running on DOE-2.2 to model the building design and evaluate energy efficiency measures. DOE-2.2 is a computer program for detailed energy use analysis of residential and commercial buildings. DOE-2.2 calculates the hour-by-hour energy use of a building based on information on the building's location, construction, HVAC systems, central plant, occupancy and operation.

It was developed primarily through a partnership between Lawrence Berkeley Laboratories and James J. Hirsch & Associates. Support for its development over its decades long development has come from individuals, and institutions, both public and private, worldwide. However, primary financial support was funded by the US Department of Energy (USDOE), and United States gas and electric utilities.

A 2022 and 2023 Logan Airport weather file was used to approximate performance of the energy model as compared to provided utility data.

A TMY3 weather file for Logan Airport, Boston was used in the analysis.

The following annualized utility rates were used as calculated per provided utility bills :

- Electricity: 29.00 cents/kWh
- Natural Gas: $1.13/Therm

6. NOTE

This report is developed for the purpose of calculating the energy performance for the analysis in the decarbonization of 42 Cross Street. Actual energy use and carbon emissions can vary, since the modeling rules do not account for many real-life issues, such as quality of construction, equipment functionality, building operation and other factors. Reasons include, but are not limited to the following:

- Energy models assume perfection, as noted in the bullets below:
  - The HVAC equipment is manufactured per standards. The design of the HVAC systems is such that each individual piece of equipment performs optimally. The installation is flawless, and the operation optimum.
  - Lighting and lighting controls are perfectly manufactured/installed and function as such.
  - The insulation is installed perfectly. There are no gaps and no rips caused by pipes and wiring. The windows are put in place with perfect caulking.
- Certain real-life effects are not included in the baseline calculations, and therefore are not included in the design calculations either. For instance, the three-dimensional heat loss effect that occurs at the roof parapet.
- Occupant behavior is idealized.
- Other effects, such as uncertainties in equipment (plug load) operation.

The cost estimations included in this study are rudimentary and are included for rough analysis and comparison between measures. Before the City of Somerville commits to or implements any measures, SOCOTEC recommends getting a formal cost estimation and engaging in a formal bidding process.

APPENDIX A – REFERENCED DOCUMENTS

	Document Name	Company	Date
1.	42 Cross Street Renovations – 100% Bid Drawings	TBA Architects, Inc.	2010-06-22
2.	Existing Roof Construction - Drawing	Russo Barr (now SOCOTEC)	2015-11-30
3.	42 Cross Street Waterproofing and Associated Work - Drawings	Russo Barr (now SOCOTEC)	2016-06-10
4.	42 Cross Street Waterproofing and Associated Work - Specifications	Russo Barr (now SOCOTEC)	2016-06-10
5.	Aluminum Window Shop Drawings	Folan Waterproofing and Construction Co., Inc.	2016-09-30
6.	Winco 8250 Series Window Product Information	Folan Waterproofing and Construction Co., Inc.	2016-10-03
7.	Window Glass Colors Submittal	Folan Waterproofing and Construction Co., Inc.	2016-10-19
8.	RTU Nameplate Photographs	City of Newton	2023-12-15

APPENDIX B – PV WATTS

NREL

NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at //sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

28,430 kWh/Year*

System output may range from 27,288 to 29,465 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	3.12	1,738
February	3.94	1,964
March	4.92	2,649
April	5.37	2,668
May	6.20	3,066
June	5.95	2,794
July	6.43	3,088
August	5.90	2,837
September	5.51	2,619
October	4.02	2,065
November	2.90	1,527
December	2.57	1,416
Annual	**4.74**	**28,431**

Location and Station Identification

Requested Location	42 cross somerville
Weather Data Source	Lat, Lng: 42.37, -71.1 1.3 mi
Latitude	42.37° N
Longitude	71.10° W

PV System Specifications

DC System Size	21.4 kW
Module Type	Standard
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	20°
Array Azimuth	180°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss

Jan	Feb	Mar	Apr	May	June
0%	0%	0%	0%	0%	0%

July	Aug	Sept	Oct	Nov	Dec
0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	15.2%

APPENDIX C – SITE VISIT PHOTOS

Photo 1 - West (top-left), South (top-right), East (bottom-left), and North (bottom-right) building elevations. Triple-wythe brick masonry wall on West elevation, and single-wythe CMU construction on other elevations. Vines need to be removed prior to roof replacement for roof edge access.

Photo 2 – Overview of Roof with Carlisle EPDM FR membrane. There is active ponding and residual dirt staining on the center of the roof, as well as areas of active ponding on the East roof edge. Rusted gooseneck penetrations should be wire-brushed and painted. The roof hatch has no interior access or exterior safety railing.

Photo 3 - Isolated areas of repair patches on EPDM roof.

Photo 4 - Metal flashing at parapet. Low flashing height. Rough edges of flashing are touching the roof, which may cause punctures in the EPDM membrane. Flashing is not tied into skylight, relying only on sealant, and creating potential for water penetration at corner joint.

Photo 5 – Sloped skylight at West elevation. EPDM membrane is delaminating at skylight curb.

Photo 6 - Spray-foam insulation installed at underside of roof deck, as shown in the Electrical/IT room, is peeling and not continuous.

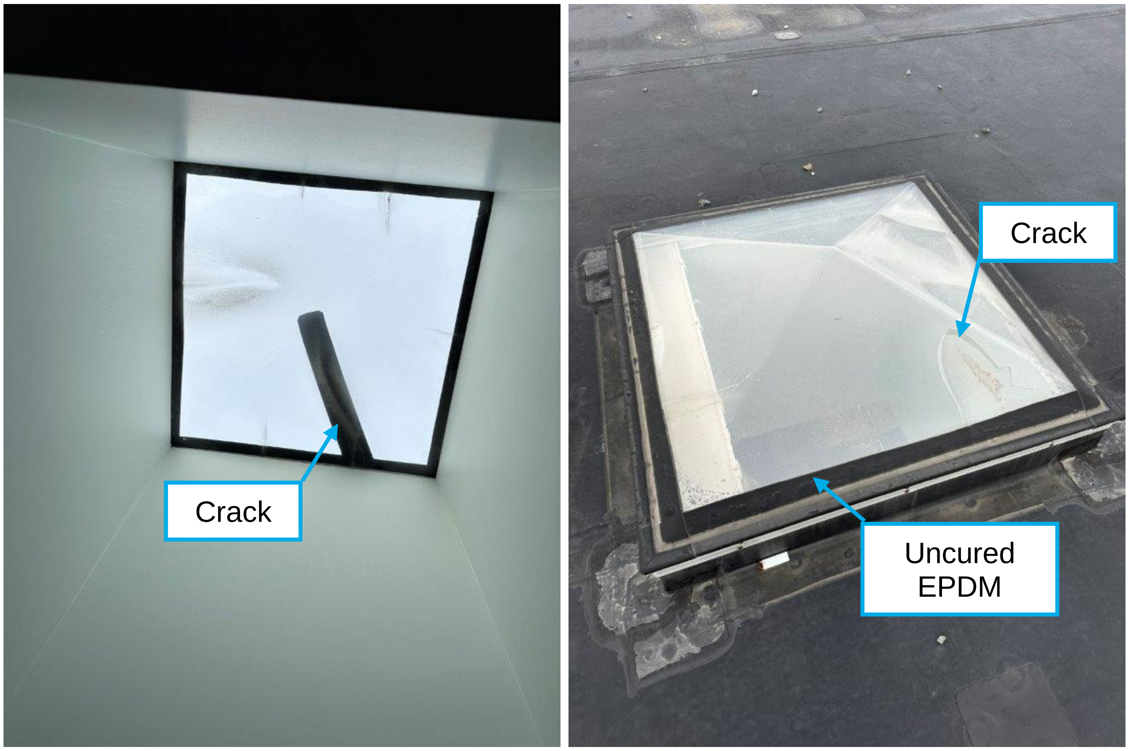


Photo 7 – Cracks in pyramid skylights. Uncured EPDM was installed at pyramid skylights, likely to stop leaking through the skylight at the metal frame/pyramid skylight interface. Blower door test showed 34 CFM air leakage when tested @-50Pa. Refer to Appendix D.

Photo 8 – Sloped skylight at West elevation. Cracking and crazing of sealant joints at glazing. Film on glazing is peeling.

Photo 9 - Back egress door. Occupant seated near egress door has noted draftiness. Evidence of moisture damage is apparent at door head. Blower door test showed 123 CFM air leakage at egress door when tested at @-50Pa. Refer to Appendix D.

Photo 10 - Storefront window in Community Room. Blower door test showed 68 CFM air leakage at storefront when tested @-50Pa. Refer to Appendix D.

Photo 11 - Typical Winco window opening in open office area, installed in 2017. Blower door test showed 35 CFM air leakage across all punched windows (except for the windows located behind the archives storage, which remained sealed) when tested @-50Pa. Refer to Appendix D.

Photo 12 – Exterior wall composition, from Russo Barr records dated March 22, 2016.

Photo 13 – Mitsubishi heat pump serving Electrical/IT Room.

Photo 14 – Carrier RTU 2. Blower door test showed 460 CFM air leakage at both RTUs when tested @-50Pa. Refer to Appendix D.

Photo 15 – Carrier RTU 2. Blower door test showed 460 CFM air leakage at both RTUs when tested @-50Pa. Refer to Appendix D.

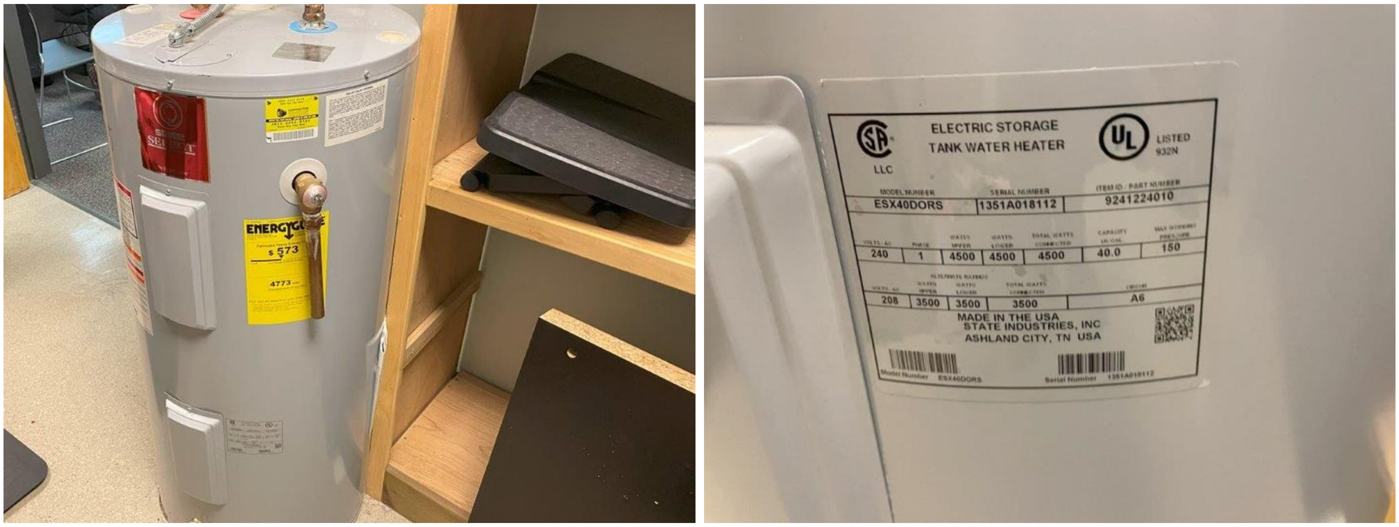


Photo 16 – State Select hot water heater in Storage D.

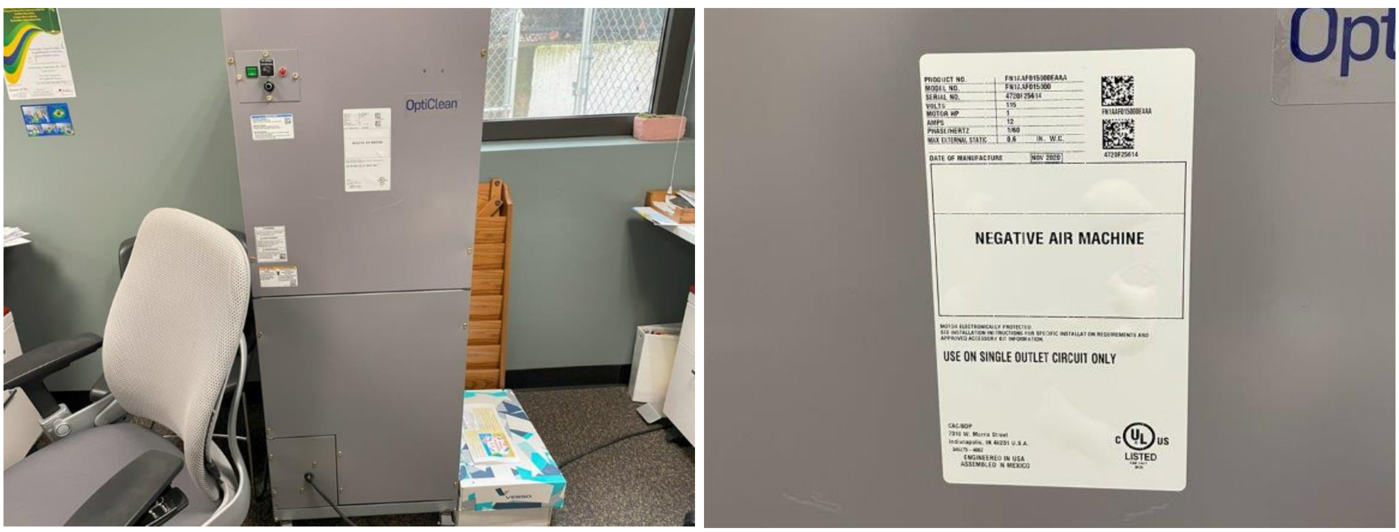


Photo 17 - Typical OptiClean negative air machine, one of two observed.

Photo 18 – NSTAR/Eversource Meter on South elevation and in Electrical/IT Room.

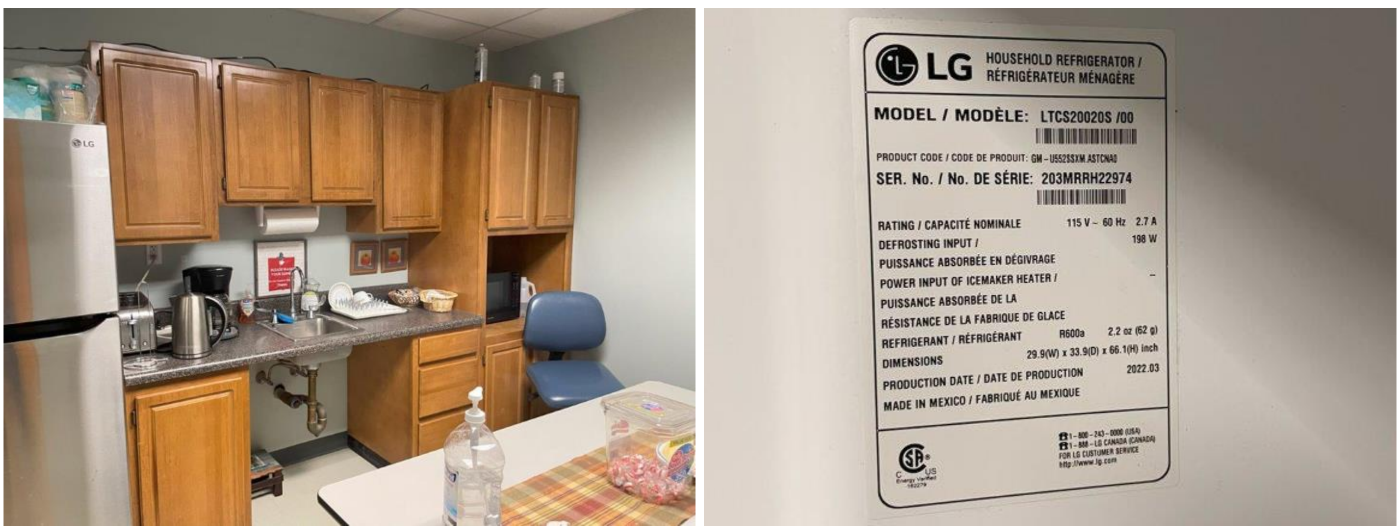


Photo 19 – Kitchen appliances (toaster, tea kettle, coffee machine, microwave) and LG refrigerator model.

Photo 20 - Honeywell thermostats and settings at reception (left) and open office area (right).

APPENDIX D – AIR LEAKAGE TESTING

1. SUMMARY

SOCOTEC was contracted to provide a blower door test at the property located at 42 Cross Street, aiming to identify areas within the building most susceptible to air infiltration.

2. METHODOLOGY

Utilizing a multi-point depressurization blower door test, SOCOTEC systematically assessed the vulnerability of various components in the building envelope to air infiltration. The test sequence involved covering all potential air leakage pathways, including the roof top units (RTUs) on the roof, back egress door, punched windows, four pyramid skylights, and a large storefront window. Adverse weather conditions prevented the coverage of the entry vestibule's large skylight.

The blower door was placed at the West street-facing entrance (Figure 1, Photos 1-2). A baseline for subsequent evaluations was provided by sealing off and testing all components. The building was tested with typical 10 pascal (Pa) increments, to a depressurization of 50 pascals. Following that, coverings from individual components were individually removed one at a time, allowing for a comparative analysis of cubic feet per minute (CFM) differences against the established baseline. This approach facilitated a nuanced understanding of the extent of air leakage associated with each specific component. Notably, the multi-point blower door test generally adhered to the standards outlined in ASTM E779, with all interior doors open and all exterior doors/windows closed. The following components were sealed shut for the baseline of the test:

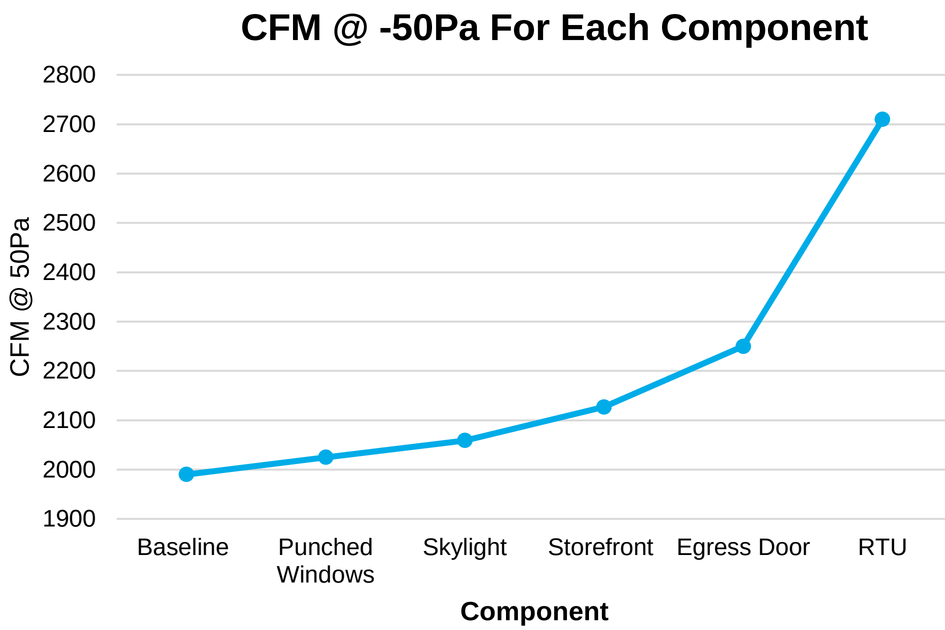
- (2) Roof top units (RTUs) (Photos 3-4)
- (4) Skylights (Not counting large skylight at entry) (Photo 5)
- Back egress door (Photos 6-7)
- (15) Punched windows (Photo 8)
- Storefront window in Community Room (Photos 9-13)

3. METHODOLOGY

Following are the results of the blower door testing.

Results (the following is displayed @ -50Pa):	
Measure 1	All Components Sealed Off: 1990 CFM
Measure 2	Punched window seals removed: 2025 CFM*
Measure 3	Skylight seals removed: 2059 CFM
Measure 4	Storefront seal removed: 2127 CFM
Measure 5	Egress door seal removed: 2250 CFM
Measure 6	RTU seals removed: 2710 CFM

** Punched windows behind the archive stacks were inaccessible during testing and remained sealed throughout the tests.*



Difference in CFM between each component (displayed @ -50Pa):	
Punched window seals removed:	35 CFM
Skylight seals removed:	34 CFM
Storefront seal removed:	68 CFM
Egress door seal removed:	123 CFM
RTU seals removed:	460 CFM

Taking the difference from each test and the baseline shows the components with the most significant amount of air leakage are the **storefront, back egress door and RTU units.** This can also be seen through the infrared camera at the storefront and egress door where the cold air leaks around the rough opening (see Photos 6-7 and 10-13).

A series of depressurization tests with typical 10 Pa increments were performed to arrive at regression analysis on the Function: ASTM E779 → Qcfm = C*(ΔP)n Where C = flow coefficient n = flow exponent (0.5 ≤ n ≤ 1.0) and ΔP in Pascals.

The building achieved 0.35 cfm/ft2 @ 75 Pa.

(CFM @ 75 Pa was calculated using Slope and Intercept data from tests performed at 10,20,30,40 and 50 Pa)

Based on the data gathered, and with the caveat that some windows remained sealed for the duration of the test, the measured air leakage at 42 Cross generally aligns with the allowable limits in Section C402.5.2 of the MA Stretch Energy Code (Figure 2): “The measured air leakage shall not be greater than 0.35 cfm/ft2 (1.8 L/s × m2) of the building thermal envelope area at a pressure differential of 0.3 inch water gauge (75 Pa) with the calculated building thermal envelope surface area being the sum of the above- and below-grade building thermal envelope.”

Sample floor plans, photographs and result graphs are shown in the following pages.

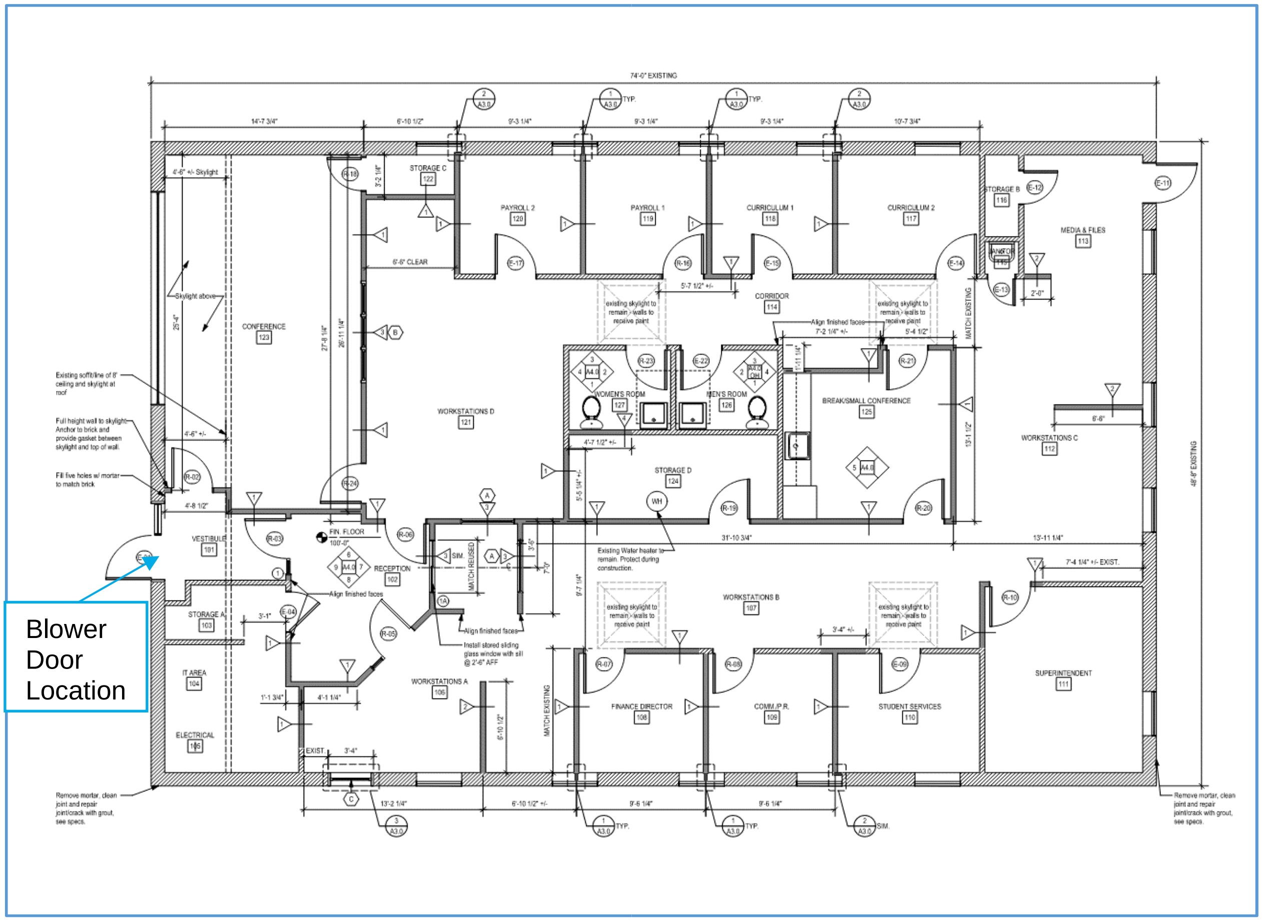
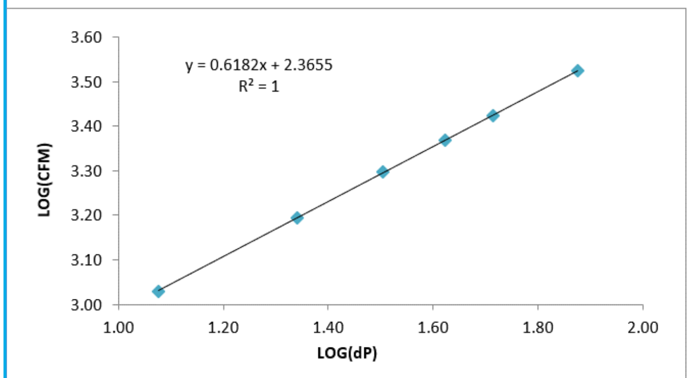


Figure 1: Area Plan

Differential Pressure (Pa)	Flow Rate (cfm)	Temp Corc Flow (cfm)	Log (dP)	Log (cfm)
12	1092	1071	1.076	3.030
22	1593	1562	1.340	3.194
32	2020	1981	1.504	3.297
42	2386	2340	1.622	3.369
52	2710	2658	1.715	3.424
75	3343	3343	1.875	3.524



Slope: 0.6163
Intercept: 2.3686

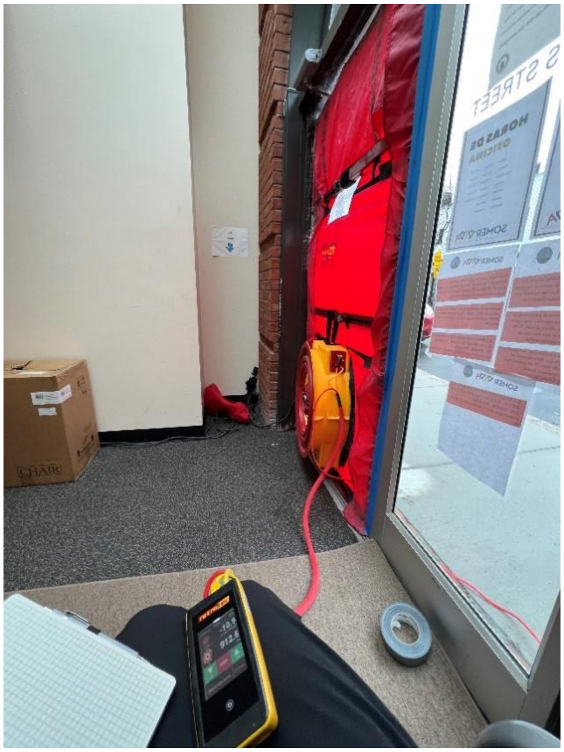
C: 233.6487
n: 0.6163
R: 0.9998

From Regression:
CFM_{50}: 2604
ACH_{50}: 3.721

ELA: 155.7 in^2 (4 Pa)
EqLA: 283.9 in^2 (10 Pa) - Canada

0.35 cfm/ft2 (1.8 L/s × m2) @ 75Pa **<------THIS NEED TO BE BELOW 0.35**

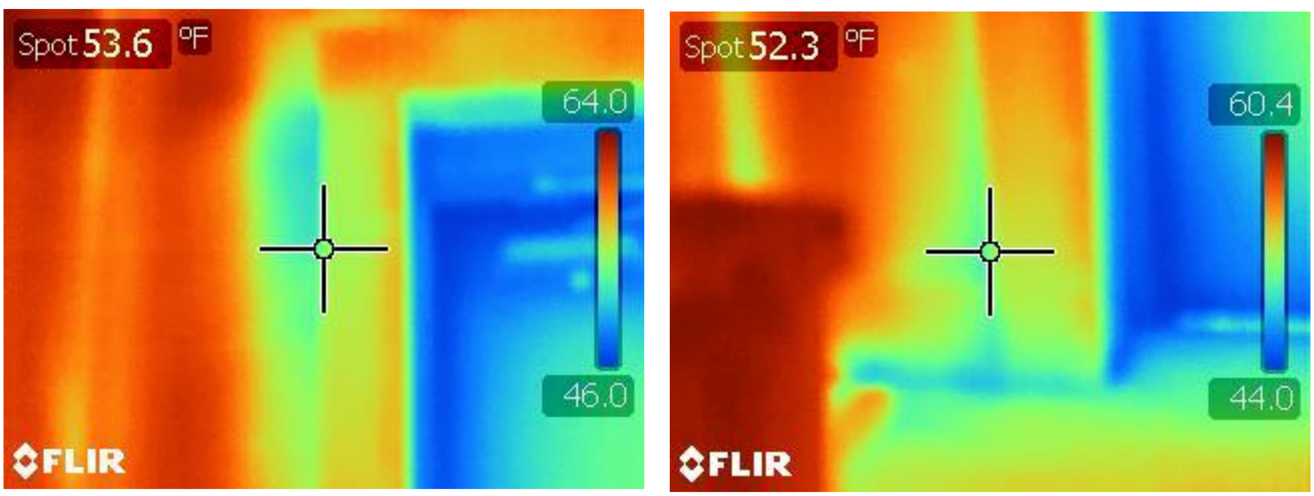
Figure 2: Results show good correlation with measured data – mode depressurization.



Photos 1-2: Blower Door Set-up at Front Entrance

Photos 3-4: RTU Sealing

Photo 5: Skylight Seals



Photos 6-7: Infrared Photos of Back Egress Door

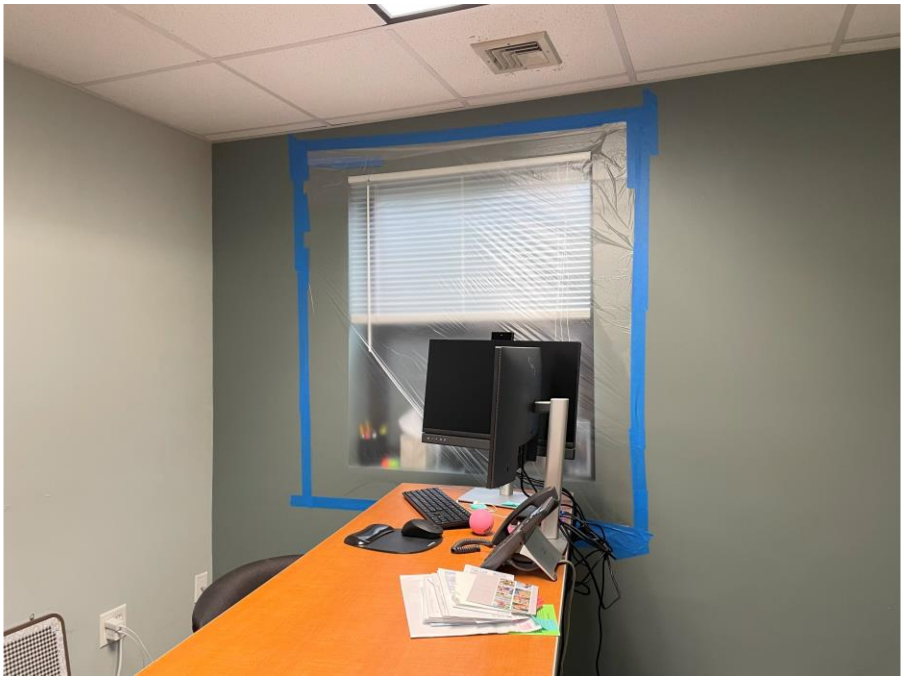
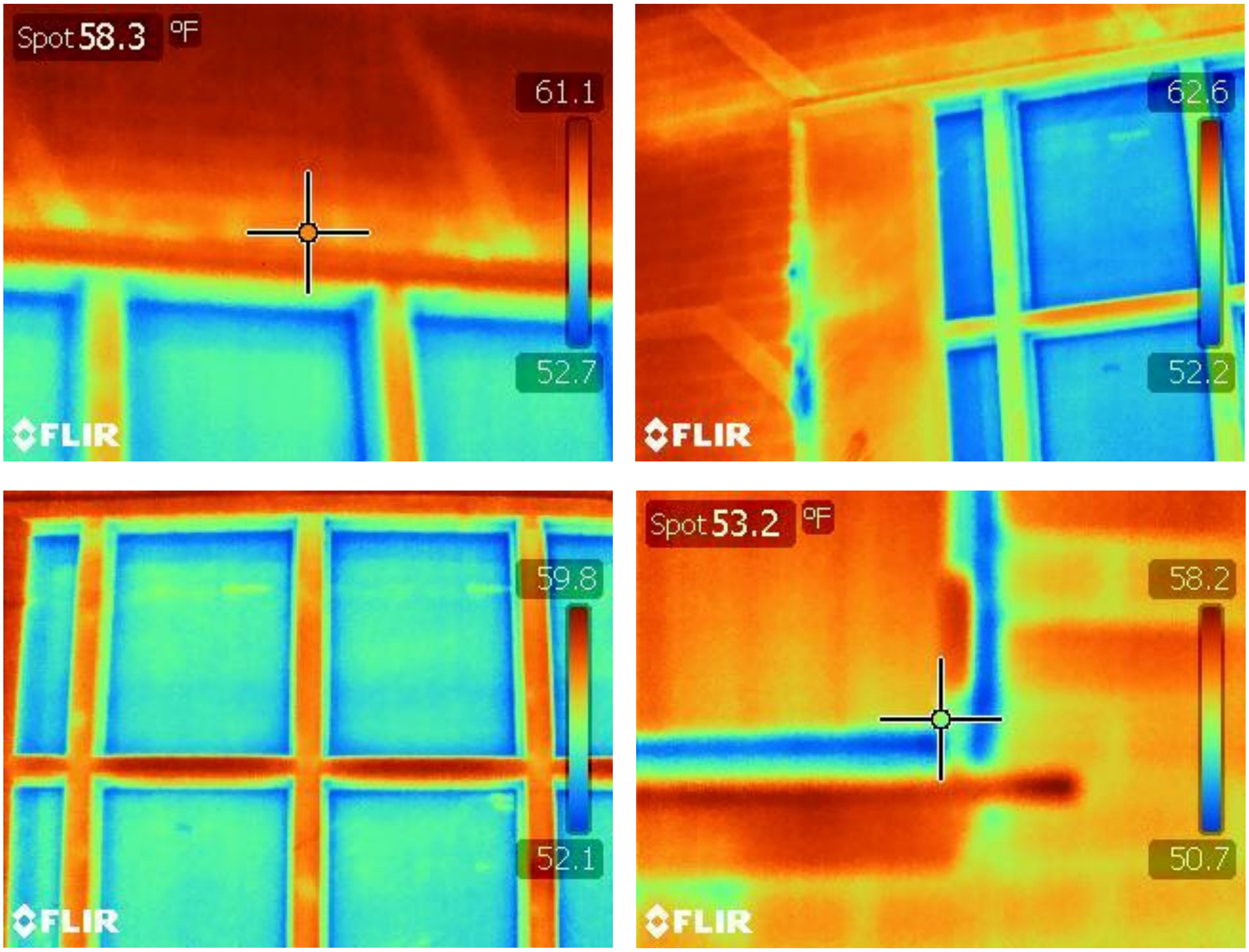


Photo 8: Punched Window Seal

Photo 9: Storefront Window in Community Room



Photos 10-13: Infrared Photos of Storefront Window in Community Room