RETROFIT STRATEGIES

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RDH evaluated what we learned from our studies of existing documentation, field observations and existing building energy analysis to compile recommended lists of both Mechanical and Enclosure system retrofit options that make sense for the specific practical and technical considerations of the existing West Tisbury School building. Our assessment considers both the mechanical system and building envelope relative to carbon and energy savings after implementing the recommended retrofits.

The following pages highlight the recommended retrofit strategies for Building Enclosure and Mechanical systems. The retrofit strategies are then combined in two packages of options, weighing the potential benefits and challenges. The packages of options also consider the sequence and associated costs of implementing the retrofits, highlighted in the **Scheduler Tool** in this section.

This Section of the report outlines two retrofit paths:

- **Option 1**: This retrofit strategy focuses on achieving net zero carbon-readiness immediately. The strategies include replacing the mechanical system, including new ventilation and performing a building enclosure deep-energy retrofit, all at once.
- **Option 2**: This retrofit strategy implements the same energy conservation and carbon reduction measures as the Retrofit Option 1, replacing the mechanical systems and performing limited enclosure upgrades initially. The implementation of building enclosure retrofits by each wing of the building, from oldest to newest, are then phased over time in line with the life cycle of the installed components. This “zero over time” approach achieves net zero carbon-readiness by 2040.

In addition to reducing energy consumption and greenhouse gas emissions, both recommended retrofit paths will provide the following benefits:

- A correctly operating building that minimizes extraneous efforts by custodial staff to maintain operation of building systems.
- Superior thermal comfort and indoor air quality for students and teachers that creates a healthy indoor environment and promotes learning.
- Improved resiliency against extreme weather events and future climate impacts ensuring the long-term continued operation of the building, allowing it to function as a space to educate children and potentially serve as a shelter for the island during extreme events.
- A cooling system for the whole building that does not exist today, allowing year-round operation, flexibility in summer programming and futureproofing against hotter future temperatures anticipated with climate change.
- Materials that have come to end of life will be replaced.
- Demonstrated leadership in sustainable building practices.

BUILDING ENCLOSURE RETROFIT STRATEGIES

BUILDING ENCLOSURE

Improvements to the building enclosure performance will be achieved by:

→ Adding a vapor barrier to the crawlspace floor.

→ Adding 5 inches of high-density EPS and metal panel fascia, in a frost-skirt configuration, at the exterior side of the crawlspace and slab on grade foundation walls to increase the thermal performance of this assembly from R-2.9 to R-20.0.

→ Adding a continuous air barrier to all walls and roofs, that transition from foundation to above-grade wall, around window openings and other sealed wall penetrations, and wall to roof.

→ Adding 4 inches of mineral wool continuous insulation outboard of existing wall sheathing and replacing all existing wood shingle wall cladding with new cedar shingles.

→ Replacing the existing curtain wall (R-1.3) with triple glazed, thermally broken curtain wall (>R-5).

→ Replacing all existing Anderson composite clad wood windows (R-3.7) with fiberglass framed windows with triple-glazed insulated glazing units (IGUs) (R-5.6).

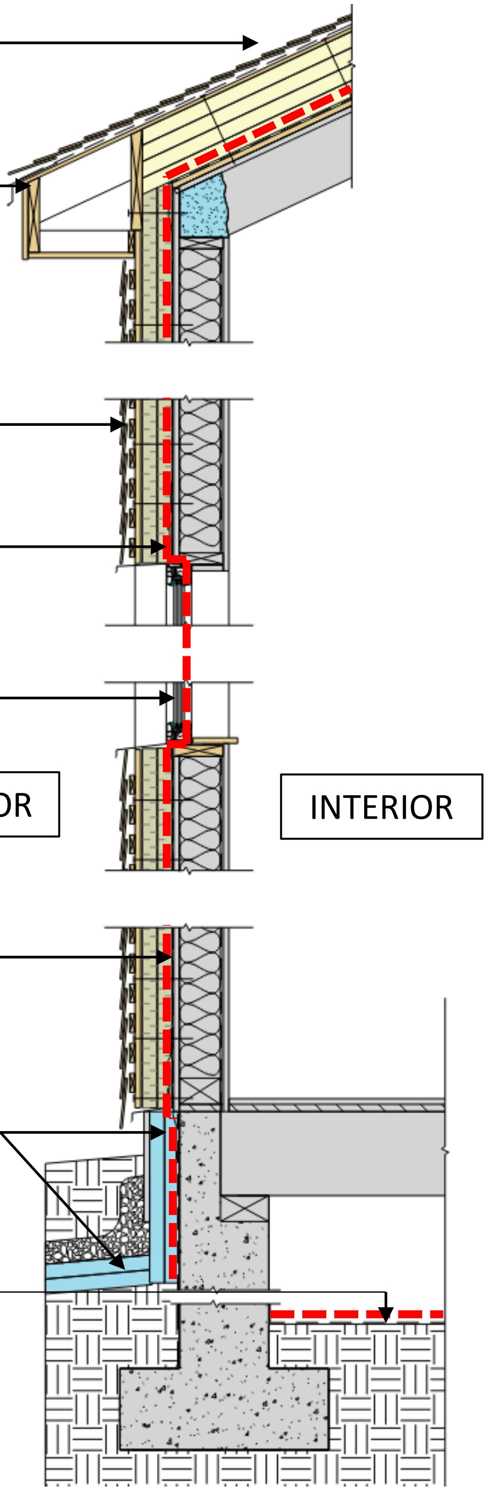
→ Replacing all existing Anderson window wall at the courtyard (R-3.7) with fiberglass framed, triple-glazed windows and opaque insulated spandrel panels in window wall configuration (R-5.6).

→ Changing the existing steel exterior doors and hollow metal frames (R-0.8) to insulated doors, fully gasketed with thermally broken frames and thresholds (R-5.6).

→ Adding new vapor retarder, insulation and roofing over the existing roof deck at the existing pitched roof assemblies, and adding vapor retarder on deck, additional insulation and new EPDM roofs at existing low-slope roofs.

The goal of this enclosure package is to improve the thermal efficiency of the enclosure to lower the enclosure heat loss. In addition to the increased thermal performance through added exterior insulation, the addition of a continuous air barrier which also functions as the weather resistant barrier, combined with careful design and implementation, will result in mitigation of water infiltration, and reduction in air leakage across the building enclosure. Air leakage was one of the largest contributors to enclosure heat loss and providing continuity of exterior air barriers, particularly at transitions between assemblies, will reduce air leakage. A vapor barrier for the crawlspace floor will reduce the amount of water vapor reaching the interior, where it can contribute to uncontrolled interior humidity.

In general, the existing windows and doors should be replaced in conjunction with the walls and roofs for better continuity of control layers between the component interfaces. This enclosure package would upgrade the windows and doors' thermal performance to increase their thermal resistance, or R-value, to further reduce the enclosure heat loss. The existing roof assembly is the second highest contributor to the enclosure heat loss as some of the older roofs lacked insulation in the drawing details. There is a great benefit to adding insulation to the roofs, above-grade walls, and foundation walls, as insulation will reduce the heat loss through the building enclosure and reduce the heating and cooling loads of the building's mechanical system.



ROOFING OVER EXTERIOR INSULATION OVER AIR/VAPOR BARRIER ON ROOF SHEATHING OVER EXISTING ROOF DECK

EXISTING EAVE CUT OFF AND RE-FRAMED TO ALLOW CONTINUITY OF AIR BARRIER AND INSULATION FROM WALL TO ROOF AND NEW EAVE FRAMED OUTISDE OF INSULATION

CEDAR SHINGLE SIDING OVER BATTENS WITH LONG SCREWS OVER EXTERIOR INSULATION

CONTINUOUS EXTERIOR INSULATION

HIGH PERFORMANCE, THERMALLY BROKEN, TRIPLE GLAZED WINDOWS

CONTINUOUS AIR BARRIER, TRANSITIONING BETWEEN FOUNDATION TO ABOVE-GRADE WALL, AROUND WINDOW OPENINGS AND OTHER SEALED WALL PENETRATIONS, AND WALL TO ROOF (DASHED RED LINE)

INSULATION "FROST SKIRT" OVER FOUNDATION WALL AND BELOW GRADE WITH METAL PANEL FASCIA

CONTINUOUS VAPOR BARRIER AT EXISTING CRAWLSPACE FLOOR

TYPICAL WALL SECTION
BUILDING ENCLOSURE RETROFIT STRATEGIES

*Refer to Building Enclosure Retrofit section of report for more detailed information.

BUILDING ENCLOSURE RETROFIT SUMMARY

		EXISTING BUILDING	RETROFIT
Walls	**Above Grade Walls**	2x4 and 2x6 wood framed walls with fiberglass batt cavity insulation (R-9 - R-20)	New air barrier, lapped over rim joist/foundation below. New insulation and cladding outboard of sheathing/air barrier.
	Below Grade Walls	Uninsulated concrete foundation walls. Stem wall at slab-on grade, full height wall at basement and crawlspaces (R-2)	Add High Density EPS continuous insulation at foundation walls below grade with frost skirt at basements and crawlspaces.
Glazing	**Curtain wall**	Original (1974) curtain wall at two entrance locations (U-0.8)	Replace with triple glazed curtainwall U<0.20 (BOD: Schuco USA FWS 60 SI)
	Window Wall	Andersen window wall at courtyard from 1985 (U-0. 28 – 0.34)	Replace with fiberglass triple glazed windows and opaque insulated spandrel panels in window wall configuration U<0.18 (BOD: Alpen Tyrol Series)
	Windows	Andersen composite clad wood windows replaced in 2011 (U–0.28)	Replace with fiberglass triple glazed windows U<0.18 (BOD: Alpen Tyrol Series)
	Doors	Steel exterior doors and hollow metal frames	Replace with insulated doors, fully gasketed with thermally broken frame and threshold U-0.36 (BOD: Ceco Trio E)
Roof	**Pitched Roofs**	Asphalt shingles over discontinuous air barrier on deck, some rigid insulation over decking in newer wings (R-1 – R-11)	New Insulation and roofing assembly over existing roof sheathing (R40 – R-50)
	Low Slope Roofs	EPDM assembly installed 2022 (R-30)	Add vapor retarder on deck and additional insulation to assembly, over the roof deck detailed at penetrations to provide airtightness (R-40 – R-50 Option 2, R-30 to remain for option 1)
Whole Building Airtightness		0.65 cfm75/sf	0.10 cfm75/sf (Option 1) 0.30 cfm75/sf (Option 2 day 1)

*Refer to Building Enclosure Retrofit section of report for more detailed information.

MECHANICAL SYSTEMS RETROFIT STRATEGIES

VENTILATION

The ventilation strategy for the West Tisbury School focuses on right-sizing the ventilation, ensuring it's delivered to all the spaces in the buildings, and utilizing heat recovery with as much of the building ventilation as possible:

→ Replace all classroom unit ventilators with a vertical integrated fan coil units integrated with energy recovery ventilators

→ Replace air handling units, and integrate with energy recovery ventilators

→ Size the ventilation to current code ventilation rates based on the space type and occupancy per space

MECHANICAL PLANT

The existing building has hydronic heating. It makes the most sense from a cost and implementation perspective to continue to use this infrastructure for the mechanical system retrofit. An air-to-water heat pump (AWHP) transfers heat from the outdoor air to water in a closed hydronic loop, which is then distributed to terminal units throughout the building for heating. It also transfers heat from the indoors to the water loop, to the outdoor air for cooling. This equipment can be installed on the roof, or at ground level to serve as primary heating for the building, providing an efficient heating source with a significant reduction in greenhouse gas emissions. The air-to-water heat pump can also be used to provide chilled water for summer cooling. Cooling would use the same hydronic piping but include a seasonal switchover from heating to cooling mode (likely May) and cooling to heating mode (likely October). If the existing distribution piping is used for a cooling application, the insulation on the pipes would need to be checked to ensure appropriate continuous insulation thickness and the inclusion of an air and vapor barrier outside of the insulation to prevent warm moist air from reaching the distribution pipes when in cooling to limit condensation. Investigating the current condition of the piping and assessing the implementation strategy to upgrade piping, or improve or add insulation needs to be addressed in the future phases of the engineering design.

Air-to-water heat pump technology is constantly improving, especially for cold climate applications. However, in the winter, the Coefficient of Performance (COP) and capacity of the unit can drop significantly at low outside temperatures which can impact its ability to meet the peak heating load of the building. As a result, a “top up” or “back up” boiler is sometimes required in very cold climates to make up the difference on the coldest days. In rare scenarios where the ambient temperature is below the heat pump's operating range, the boiler is required to act as the sole heat source.

RDH assumed that no "back up" boiler would be required in this case, and that the air-to-water heat pump would be sufficient to meet the heating demands of the building. We assumed a heat pump cutoff temperature of 5°F. As the retrofit planning progresses, a more detailed analysis should be completed with a mechanical designer to determine whether a back-up heating system is necessary.

In a cooling application, air-to-water heat pumps are more costly and are slightly less efficient compared to dedicated air-cooled chillers. A cost-effective strategy would be to appropriately size the air-to-water heat pump to balance the operational cost in both heating and cooling. This will allow the air-to-water heat pump to cover a reasonable amount of wintertime heating and summertime cooling. An air-cooled chiller can be provided for peak cooling conditions. For this study, we have not included an air-cooled chiller.

TERMINAL HEATING & COOLING

The existing boilers serve hydronic perimeter unit ventilators and hydronic coils in the air handling units. Currently the classrooms do not have a dedicated cooling systems. Some spaces do have small air conditioning units – like the admin area, the computer lab, and the library.

As temperatures rise due to climate change, cooling is increasingly becoming an important consideration for occupant comfort, health, and safety.

Replacing the existing boilers with AWHPs will require an upgrade to the classroom unit ventilators and air handling units to accommodate a low temperature central plant and include cooling. A vertical integrated fan coil unit in each classroom would replace the existing unit ventilators, incorporate heat recovery with the ventilation, and allow for cooling in the warmer shoulder season months, and in the summer if the school is occupied.

DOMESTIC HOT WATER

The existing main service hot water system is heated with oil-fired heating in the winter with supplemental electric resistance hot water heating. We have assumed point-of-use electric tanks for individual washrooms, to ensure hot water is available from the fixtures located farthest from the service hot water tank.

The existing kitchen service hot water is provided by propane fired water heaters and are assumed to be replaced with heat pump hot water heaters. These are preferred to electric resistance water heaters as they have a higher coefficient of performance and use less electricity.

MECHANICAL SYSTEMS RETROFIT SUMMARY

		EXISTING BUILDING	RETROFIT
HEATING COOLING	PLANT	3 oil-fired boilers (959MBH Gross Output each, w/ two running) Peak cap = 1,918 MBH	Air to water heat pump (Aermec NRB or similar). Assume two units - each unit is 117 tons.
	CLASSROOMS	Unit Ventilators and perimeter hydronic baseboards	Replace unit ventilators w/ vertical fan coil unit integrated w/ an ERV (Changeair Freshman unit or similar)
	CAFETERIA	AHU w/ hydronic heating	AHU w/ hydronic heat/cool
	GYM	Two AHUs w/ hydronic heating	Option 1: AHU w/ hydronic heat/cool Option 2: Separate heating from ventilation. Includes a balanced AHU for ventilation + 3-4 VRF heads in the ceiling for heating/cooling
	MUSIC ROOMS	One AHU per classroom w/ hydronic heating	AHU w/ hydronic heat/cool
	SCIENCE ROOMS	One AHU per classroom w/ hydronic heating	AHU w/ hydronic heat/cool
VENTILATION	CLASSROOMS	Direct ventilation through the unit ventilator	Ventilation through ERV in vertical fan coil unit
	CAFETERIA	Through AHU	Through upgraded AHU w/ ERV
	GYM	Through AHU	Through upgraded AHU w/ ERV
	MUSIC ROOMS	Through AHU	Through upgraded AHU w/ ERV
	SCIENCE ROOMS	Through AHU	Through upgraded AHU w/ ERV
DOMESTIC HOT WATER	GENERAL (LAVATORIES)	Electric water heater in central mechanical room	Assume replacement with electric DHW system of same size, OR point of use electric tanks in each bathroom. Heat pump water heaters also an option.
	KITCHEN	Two AO Smith tankless propane-fired 199 kBTUh hot water heaters	Replace w/ Heat Pump Water Heater
RENEWABLES		Some PV panels on pitched roof (non-operational)	658,400 KWH ground mounted PV array

RETROFIT OPTIONS

RETROFIT OPTION 1

The first Retrofit Option takes a holistic approach where the building enclosure and mechanical systems are upgraded within the same timeframe. In the design and construction phase of the project, consideration should be given to the exact schedule of this retrofit work with consideration to the school year schedule. The use of temporary modular classrooms may allow for work to occur during the school year.

The Benefits of Retrofit Option 1 are:

→ Full enclosure performance on day 1 for the most efficient mechanical system sizing.

→ Net zero carbon is achieved sooner.

The Challenges of Retrofit Option 1 are:

→ Higher up-front costs for doing the work all at once

→ Some building enclosure components may be replaced prior to the end of their expected life span.

→ If construction occurs during the school year, modular classrooms may need to be utilized.

RETROFIT OPTION 2

The second Retrofit Option incorporates the same carbon reduction measures as Retrofit Option 1 but implements them over time, based on age and expected life-span of the equipment or building component.

The Benefits of Retrofit Option 2 are:

→ The project cost is spread out.

→ Some of the building components are replaced closer to the end of their lifespan.

The Challenges of Option 2 are :

→ New mechanical systems implemented first must be sized for higher enclosure losses of the existing enclosure.

→ Net zero carbon-readiness is reached later.

→ Full enclosure performance is incrementally achieved and enclosure detailing needs to anticipate future retrofits tying into previous enclosure retrofits.

→ There will be escalation of construction costs each year construction is deferred.

→ There will be added cost in multiple Contractor mobilizations.

→ There will be added cost in multiple phases of design fees.

→ If construction occurs during the school year, modular classrooms may need to be utilized.

SCHEDULER

The Scheduler was developed to illustrate the lifespans of the components and equipment in comparison to when they would be replaced according to each retrofit option. The life span is divided into two sections:

1. The initial period, where the equipment or component is functioning as intended, and
2. The maintenance period, where maintenance is required to ensure the equipment or component continues to function as intended.

RDH has assumed that the maintenance periods occurs halfway through the lifespan of the building component or equipment. The period after the building component or equipment's assumed lifespan is shown in red, indicating repair or replacement will be needed.

RDH compiled the Scheduler based on information from building drawings, and site visit notes and pictures. Where such information wasn't available, the component or equipment's age was assumed.

The X's within the Scheduler indicate when the component or equipment will be replaced based on the retrofit option. The hatched pattern on the Scheduler specify a phase during which specific retrofits will take place.

The cost of each component was obtained through a cost estimator based on quantity takeoffs from the drawings provided.

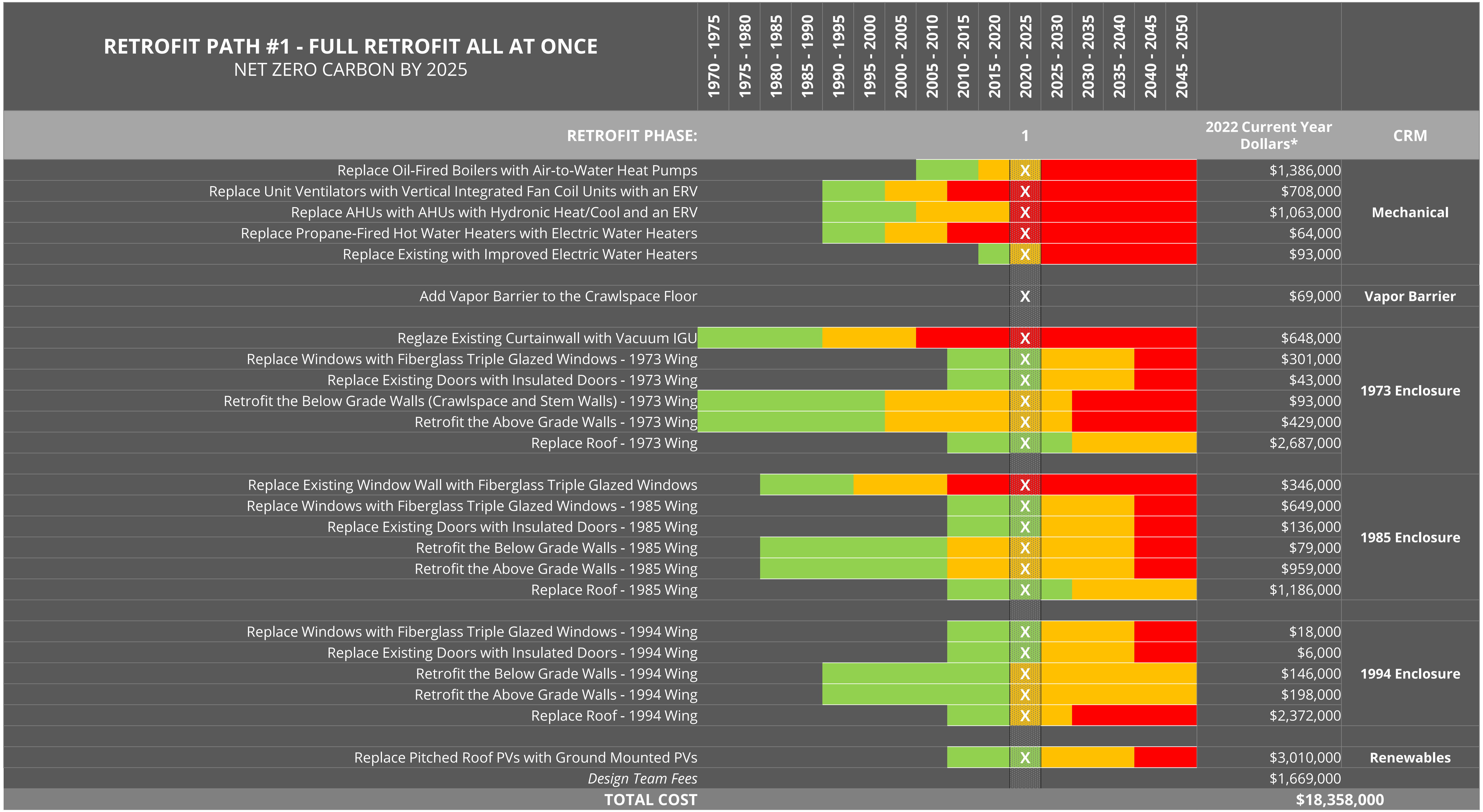
The costing for Retrofit Option 1 does not include contractor mobilization as it is assumed to be included in the contractor fee.

For Retrofit Option 2, line items for design team fees (10%) and contractor mobilization (5%) costs were included for each phase. Additionally, the first phase is priced in current, 2022, dollars while subsequent phases include an estimated inflation of 3% compounded per year from 2022, for the time period in which the phase will be implemented.

Potential increased carbon cost over time was not included in the scheduler. The cost of carbon-based fuel sources could increase over time, and future carbon taxes or penalties could be implemented locally, at the state level or federally.

A full Life Cycle Cost Analysis over time was not prepared as part of RDH's scope for this study.

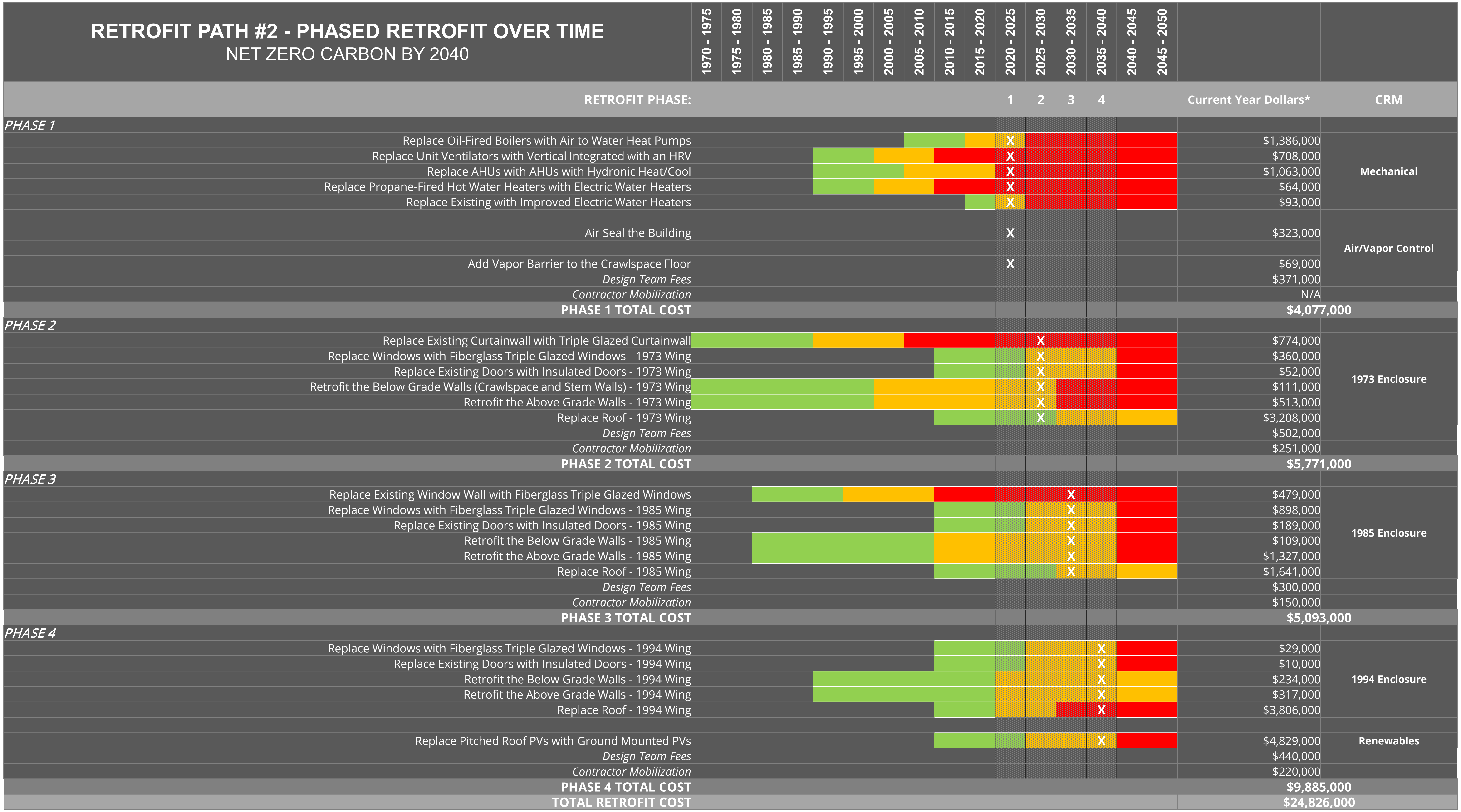
RETROFIT SCHEDULER – OPTION 1



RETROFIT PATH #1 - FULL RETROFIT ALL AT ONCE NET ZERO CARBON BY 2025	1970 - 1975	1975 - 1980	1980 - 1985	1985 - 1990	1990 - 1995	1995 - 2000	2000 - 2005	2005 - 2010	2010 - 2015	2015 - 2020	2020 - 2025	2025 - 2030	2030 - 2035	2035 - 2040	2040 - 2045	2045 - 2050		
RETROFIT PHASE:											1						**2022 Current Year Dollars***	**CRM**
Replace Oil-Fired Boilers with Air-to-Water Heat Pumps								🟩	🟩	🟨	X	🟥	🟥	🟥	🟥	🟥	$1,386,000	**Mechanical**
Replace Unit Ventilators with Vertical Integrated Fan Coil Units with an ERV					🟩	🟩	🟨	🟨	🟥	🟥	X	🟥	🟥	🟥	🟥	🟥	$708,000	
Replace AHUs with AHUs with Hydronic Heat/Cool and an ERV					🟩	🟩	🟩	🟨	🟨	🟨	X	🟥	🟥	🟥	🟥	🟥	$1,063,000	
Replace Propane-Fired Hot Water Heaters with Electric Water Heaters					🟩	🟩	🟨	🟨	🟥	🟥	X	🟥	🟥	🟥	🟥	🟥	$64,000	
Replace Existing with Improved Electric Water Heaters										🟩	X	🟥	🟥	🟥	🟥	🟥	$93,000	
Add Vapor Barrier to the Crawlspace Floor											X						$69,000	**Vapor Barrier**
Reglaze Existing Curtainwall with Vacuum IGU	🟩	🟩	🟩	🟩	🟨	🟨	🟨	🟥	🟥	🟥	X	🟥	🟥	🟥	🟥	🟥	$648,000	**1973 Enclosure**
Replace Windows with Fiberglass Triple Glazed Windows - 1973 Wing									🟩	🟩	X	🟨	🟨	🟨	🟥	🟥	$301,000	
Replace Existing Doors with Insulated Doors - 1973 Wing									🟩	🟩	X	🟨	🟨	🟨	🟥	🟥	$43,000	
Retrofit the Below Grade Walls (Crawlspace and Stem Walls) - 1973 Wing	🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟨	🟨	🟨	X	🟨	🟥	🟥	🟥	🟥	$93,000	
Retrofit the Above Grade Walls - 1973 Wing	🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟨	🟨	🟨	X	🟨	🟥	🟥	🟥	🟥	$429,000	
Replace Roof - 1973 Wing									🟩	🟩	X	🟩	🟨	🟨	🟨	🟨	$2,687,000	
Replace Existing Window Wall with Fiberglass Triple Glazed Windows			🟩	🟩	🟩	🟨	🟨	🟨	🟥	🟥	X	🟥	🟥	🟥	🟥	🟥	$346,000	**1985 Enclosure**
Replace Windows with Fiberglass Triple Glazed Windows - 1985 Wing									🟩	🟩	X	🟨	🟨	🟨	🟥	🟥	$649,000	
Replace Existing Doors with Insulated Doors - 1985 Wing									🟩	🟩	X	🟨	🟨	🟨	🟥	🟥	$136,000	
Retrofit the Below Grade Walls - 1985 Wing			🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟨	X	🟨	🟨	🟨	🟥	🟥	$79,000	
Retrofit the Above Grade Walls - 1985 Wing			🟩	🟩	🟩	🟩	🟩	🟩	🟨	🟨	X	🟨	🟨	🟨	🟥	🟥	$959,000	
Replace Roof - 1985 Wing									🟩	🟩	X	🟩	🟨	🟨	🟨	🟨	$1,186,000	
Replace Windows with Fiberglass Triple Glazed Windows - 1994 Wing									🟩	🟩	X	🟨	🟨	🟨	🟥	🟥	$18,000	**1994 Enclosure**
Replace Existing Doors with Insulated Doors - 1994 Wing									🟩	🟩	X	🟨	🟨	🟨	🟥	🟥	$6,000	
Retrofit the Below Grade Walls - 1994 Wing					🟩	🟩	🟩	🟩	🟩	🟩	X	🟨	🟨	🟨	🟨	🟨	$146,000	
Retrofit the Above Grade Walls - 1994 Wing					🟩	🟩	🟩	🟩	🟩	🟩	X	🟨	🟨	🟨	🟨	🟨	$198,000	
Replace Roof - 1994 Wing									🟩	🟩	X	🟨	🟥	🟥	🟥	🟥	$2,372,000	
Replace Pitched Roof PVs with Ground Mounted PVs									🟩	🟩	X	🟨	🟨	🟨	🟥	🟥	$3,010,000	**Renewables**
Design Team Fees																	$1,669,000	
TOTAL COST																	**$18,358,000**	

Initial Condition 🟩 Maintenance 🟨 Smaller Repairs or Replacement 🟥

RETROFIT SCHEDULER – OPTION 2



RETROFIT PATH #2 - PHASED RETROFIT OVER TIME

NET ZERO CARBON BY 2040

	1970 - 1975	1975 - 1980	1980 - 1985	1985 - 1990	1990 - 1995	1995 - 2000	2000 - 2005	2005 - 2010	2010 - 2015	2015 - 2020	2020 - 2025	2025 - 2030	2030 - 2035	2035 - 2040	2040 - 2045	2045 - 2050		
RETROFIT PHASE:											**1**	**2**	**3**	**4**			**Current Year Dollars***	**CRM**
PHASE 1																		
Replace Oil-Fired Boilers with Air to Water Heat Pumps								🟩	🟩	🟧	🟧 X	🟥	🟥	🟥	🟥	🟥	$1,386,000	
Replace Unit Ventilators with Vertical Integrated with an HRV					🟩	🟩	🟧	🟧	🟥	🟥	🟥 X	🟥	🟥	🟥	🟥	🟥	$708,000	
Replace AHUs with AHUs with Hydronic Heat/Cool					🟩	🟩	🟩	🟧	🟧	🟧	🟥 X	🟥	🟥	🟥	🟥	🟥	$1,063,000	**Mechanical**
Replace Propane-Fired Hot Water Heaters with Electric Water Heaters					🟩	🟩	🟧	🟧	🟥	🟥	🟥 X	🟥	🟥	🟥	🟥	🟥	$64,000	
Replace Existing with Improved Electric Water Heaters										🟩	🟧 X	🟥	🟥	🟥	🟥	🟥	$93,000	
Air Seal the Building											X						$323,000	
																		Air/Vapor Control
Add Vapor Barrier to the Crawlspace Floor											X						$69,000	
Design Team Fees																	$371,000	
Contractor Mobilization																	N/A	
PHASE 1 TOTAL COST																	**$4,077,000**	
PHASE 2																		
Replace Existing Curtainwall with Triple Glazed Curtainwall	🟩	🟩	🟩	🟩	🟧	🟧	🟧	🟥	🟥	🟥	🟥	🟥 X	🟥	🟥	🟥	🟥	$774,000	
Replace Windows with Fiberglass Triple Glazed Windows - 1973 Wing									🟩	🟩	🟩	🟧 X	🟧	🟧	🟥	🟥	$360,000	
Replace Existing Doors with Insulated Doors - 1973 Wing									🟩	🟩	🟩	🟧 X	🟧	🟧	🟥	🟥	$52,000	
Retrofit the Below Grade Walls (Crawlspace and Stem Walls) - 1973 Wing	🟩	🟩	🟩	🟩	🟩	🟩	🟧	🟧	🟧	🟧	🟧	🟧 X	🟥	🟥	🟥	🟥	$111,000	**1973 Enclosure**
Retrofit the Above Grade Walls - 1973 Wing	🟩	🟩	🟩	🟩	🟩	🟩	🟧	🟧	🟧	🟧	🟧	🟧 X	🟥	🟥	🟥	🟥	$513,000	
Replace Roof - 1973 Wing									🟩	🟩	🟩	🟩 X	🟧	🟧	🟧	🟧	$3,208,000	
Design Team Fees																	$502,000	
Contractor Mobilization																	$251,000	
PHASE 2 TOTAL COST																	**$5,771,000**	
PHASE 3																		
Replace Existing Window Wall with Fiberglass Triple Glazed Windows			🟩	🟩	🟩	🟧	🟧	🟧	🟥	🟥	🟥	🟥	🟥 X	🟥	🟥	🟥	$479,000	
Replace Windows with Fiberglass Triple Glazed Windows - 1985 Wing									🟩	🟩	🟩	🟧	🟧 X	🟧	🟥	🟥	$898,000	
Replace Existing Doors with Insulated Doors - 1985 Wing									🟩	🟩	🟩	🟧	🟧 X	🟧	🟥	🟥	$189,000	
Retrofit the Below Grade Walls - 1985 Wing			🟩	🟩	🟩	🟩	🟩	🟩	🟧	🟧	🟧	🟧	🟧 X	🟧	🟥	🟥	$109,000	**1985 Enclosure**
Retrofit the Above Grade Walls - 1985 Wing			🟩	🟩	🟩	🟩	🟩	🟩	🟧	🟧	🟧	🟧	🟧 X	🟧	🟥	🟥	$1,327,000	
Replace Roof - 1985 Wing									🟩	🟩	🟩	🟩	🟧 X	🟧	🟧	🟧	$1,641,000	
Design Team Fees																	$300,000	
Contractor Mobilization																	$150,000	
PHASE 3 TOTAL COST																	**$5,093,000**	
PHASE 4																		
Replace Windows with Fiberglass Triple Glazed Windows - 1994 Wing									🟩	🟩	🟩	🟧	🟧	🟧 X	🟥	🟥	$29,000	
Replace Existing Doors with Insulated Doors - 1994 Wing									🟩	🟩	🟩	🟧	🟧	🟧 X	🟥	🟥	$10,000	
Retrofit the Below Grade Walls - 1994 Wing					🟩	🟩	🟩	🟩	🟩	🟩	🟧	🟧	🟧	🟧 X	🟧	🟧	$234,000	**1994 Enclosure**
Retrofit the Above Grade Walls - 1994 Wing					🟩	🟩	🟩	🟩	🟩	🟩	🟧	🟧	🟧	🟧 X	🟧	🟧	$317,000	
Replace Roof - 1994 Wing									🟩	🟩	🟧	🟧	🟥	🟥 X	🟥	🟥	$3,806,000	
Replace Pitched Roof PVs with Ground Mounted PVs									🟩	🟩	🟩	🟧	🟧	🟧 X	🟥	🟥	$4,829,000	**Renewables**
Design Team Fees																	$440,000	
Contractor Mobilization																	$220,000	
PHASE 4 TOTAL COST																	**$9,885,000**	
TOTAL RETROFIT COST																	**$24,826,000**	

*Phase 1 is in 2022 dollars; future phases include estimated cost escalation for the time period indicated for that phase.

Initial Condition 🟩 Maintenance 🟧 Smaller Repairs or Replacement 🟥

POTENTIAL INCENTIVE PROGRAMS

CAPE LIGHT COMPACT

The Cape Light Compact is the Utility Company for Martha's Vineyard that oversees applicable incentive programs and rebates for energy reduction related building projects. RDH has been in contact with Margaret Song from the Cape Light Compact and has reviewed potentially applicable incentive programs for future phases of the West Tisbury School project. Based on the information currently available, the following programs may be applied for, and further coordinated with the Cape Light Compact, in design and construction phases of the project and may be able to provide the following estimated incentives:

MASS SAVE INCENTIVES

Heat Pump Rebate

The Mass Save program is offering a rebate for the purchase and installation of energy-efficient heat pumps for the heating and cooling of buildings. The amount of the rebate awarded depends on the heat pump type and sizing of the system in tons. The current requirements of this program pertain to the 2022 calendar year and are subject to modification in the future.

→ $2,500 per ton (the sizing) of heating and cooling for Air Source Heat Pumps

DER Program

The Deep Energy Retrofit (DER) program is a program in development that has not been rolled out yet, but is likely to be in place by the time the West Tisbury School is considering design and construction phase incentives. It is composed of two tiers based on greenhouse gas (GHG) reductions relative to existing conditions, excluding renewables. Tier 1 addresses 25% GHG reductions. Tier 2 addresses 40% GHG reductions.

→ Tier 1: Projects that achieve 25% GHG reduction receive an incentive of$0.40/$ft^2$ of building area.

→ Tier 2: Projects that achieve 40% GHG reduction receive an incentive of$0.60/$ft^2$ of building area.

→ Enclosure: Based on correspondence with the Cape Light Compact representative, an enclosure rebate is available and would provide an incentive of $181 per mmBTU of energy loss reduction through the building enclosure versus the baseline.

GREEN COMMUNITIES GRANT PROGRAM

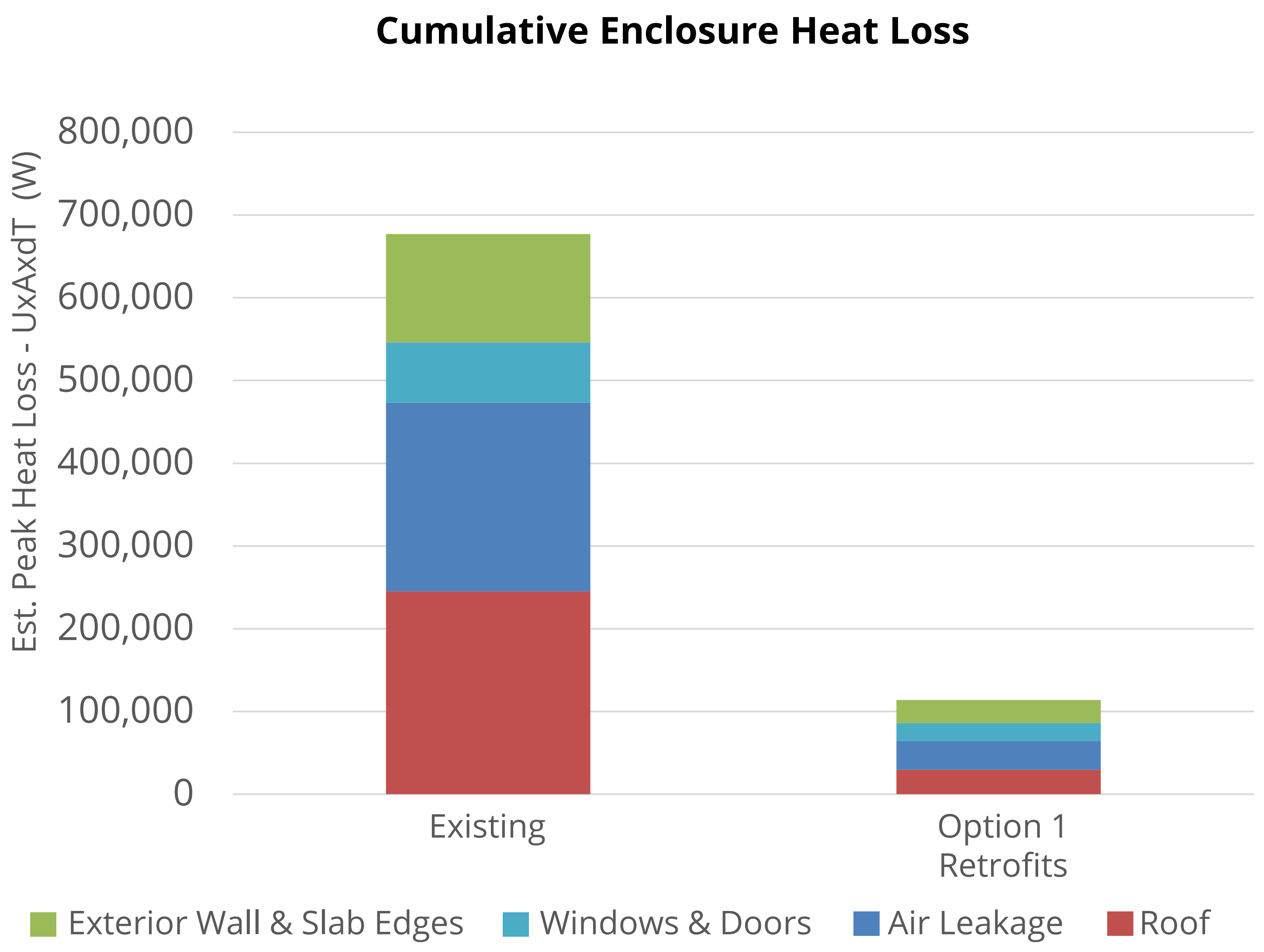
Funded by the Massachusetts Department of Energy Resources, the Green Community provides competitive grant funding to municipalities to support all or a portion of the cost to implement energy efficiency and greenhouse gas reduction measures. West Tisbury recently added the West Tisbury School to the Green Communities baseline. The West Tisbury Elementary School could be eligible for up to $500,000 as a building decarbonization project. It is recommended to contact the Green Communities Regional Coordinator to discuss the proposal with Department of Energy Resources (DOER) staff. This grant makes the School ineligible for other competitive grants for 2 years after award in the Green Communities program.

Incentive	Evaluation Criteria	Potential Funding Estimate
Mass Save Heat Pump Rebate	$2,500 per ton per heat pump x 117 tons x 2	$585,000
Mass Save DER Tier 1 (25% GHG Reduction)	$0.40 /$ft^2$ of building area	$24,400
OR		OR
Mass Save DER Tier 2 (40%GHG Reduction)	$0.60 /$ft^2$ of building area	$36,600
Mass Save Enclosure Rebate	$181 per mmBTU reduction of heat loss through building enclosure x 740 mmBTU	$133,940
Green Communities	Minimum 25% match, must demonstrate greenhouse gas emission reductions, and be completed within 3 years of grant contract execution	TBD - Up to $500,000

RETROFIT RESULTS – OPTION 1

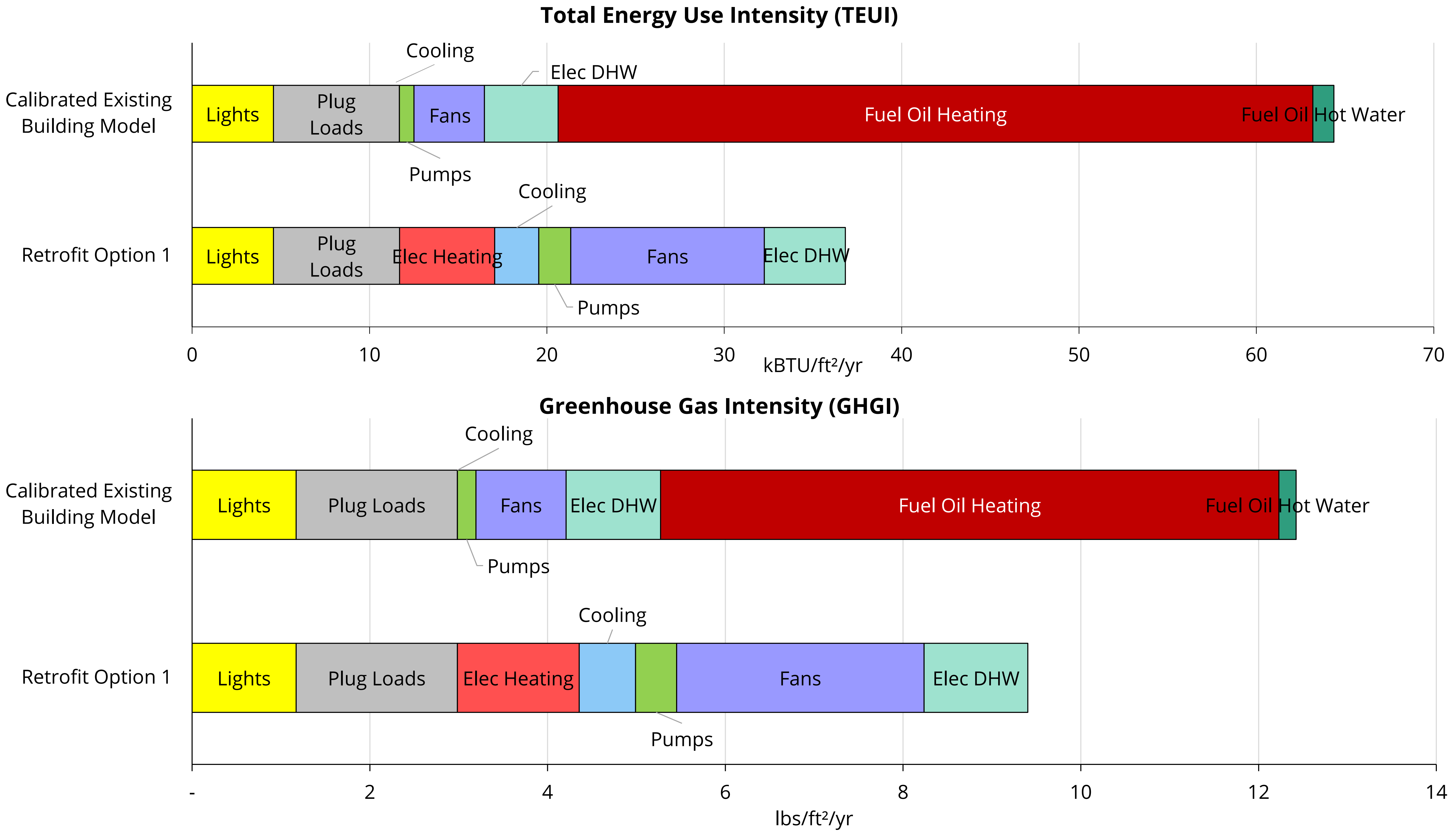
The Total Energy Use Intensity (TEUI) and Greenhouse Gas Intensity (GHGI) for both the calibrated existing building model and Retrofit Option 1 are shown in the figures on the following page. The table below also includes the absolute consumption of fuel oil and electricity. Retrofit Option 1 focuses on achieving net zero carbon ready immediately. The strategies in this retrofit option include replacing the mechanical system and performing a building enclosure deep-energy retrofit immediately. The upgrade of the mechanical systems and the improved enclosure results in an overall TEUI reduction of 43% and an overall GHGI reduction of 24% compared to the calibrated existing building model. The oil-fired boilers are replaced with air-to-water heat pump and electric hot water tank, and the energy consumption from space heating is greatly reduced due to the enclosure retrofit and inclusion of heat recovery for all mechanical ventilation. It is important to note that if cooling were to be removed from the retrofit, energy consumption by both cooling and fan power would decrease and the GHG emissions would be reduced further.

The cumulative enclosure heat loss is the loss or heat through building envelope components such as air leakage, roof, door, glazing, slab edge, and exterior walls. In Retrofit Option 1, the reduction of heat loss through the enclosure is experienced at once time with a simultaneous installation of continuous vapor, air, and thermal layers.



ANNUAL METRICS	CALIBRATED EXISTING BUILDING MODEL	RETROFIT OPTION 1
GHGI (LBS/FT²/YR)	12	9
TEUI (kBTU/FT²/YR)	64	37
TEDI (kBTU/FT²/YR)	31	12
FUEL OIL (MBTU)	2,700	-
ELECTRICITY (kWh)	369,000	658,400
CO2E (TONS)	380	290

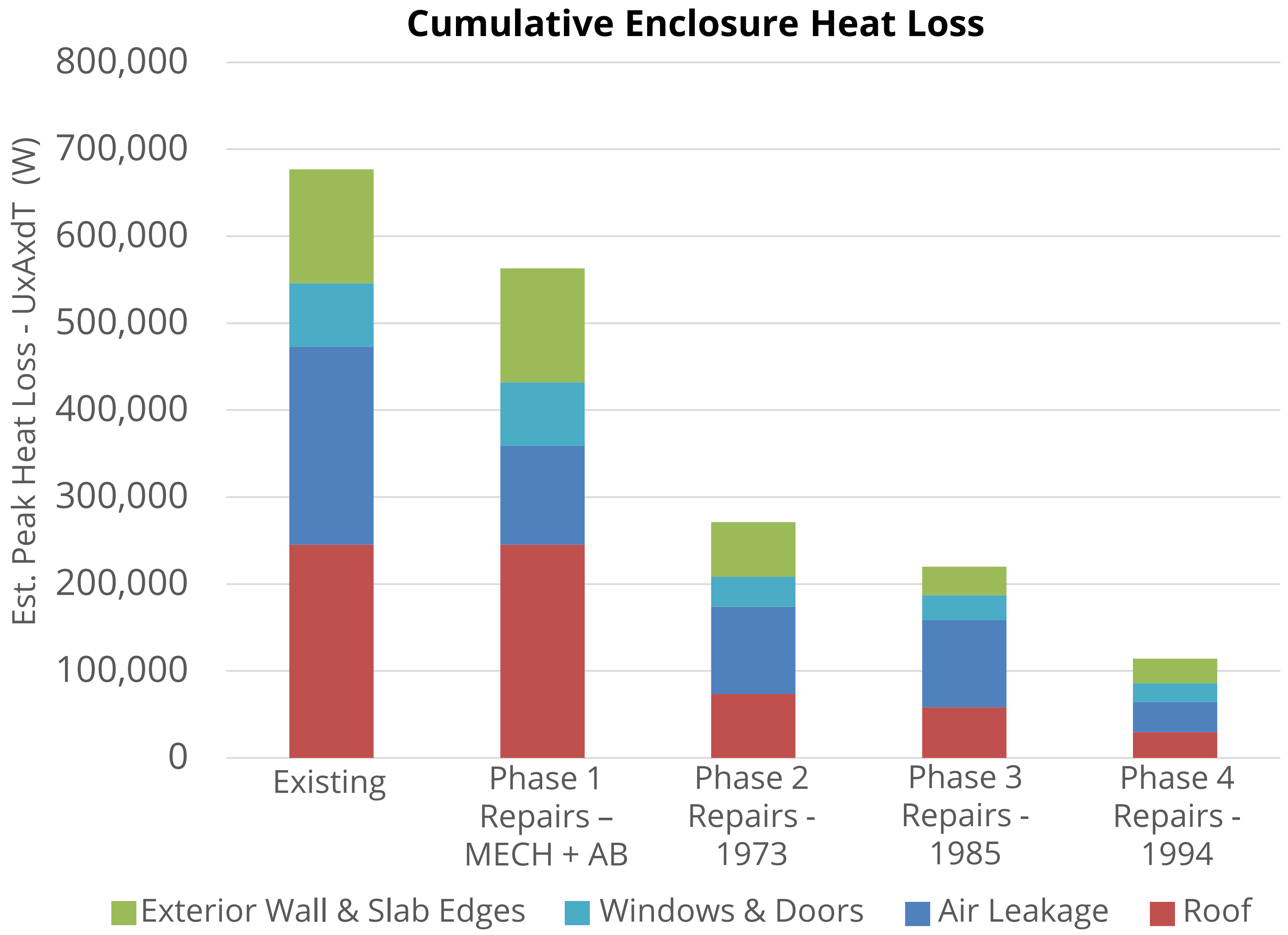
RETROFIT RESULTS – OPTION 1



RETROFIT RESULTS – OPTION 2

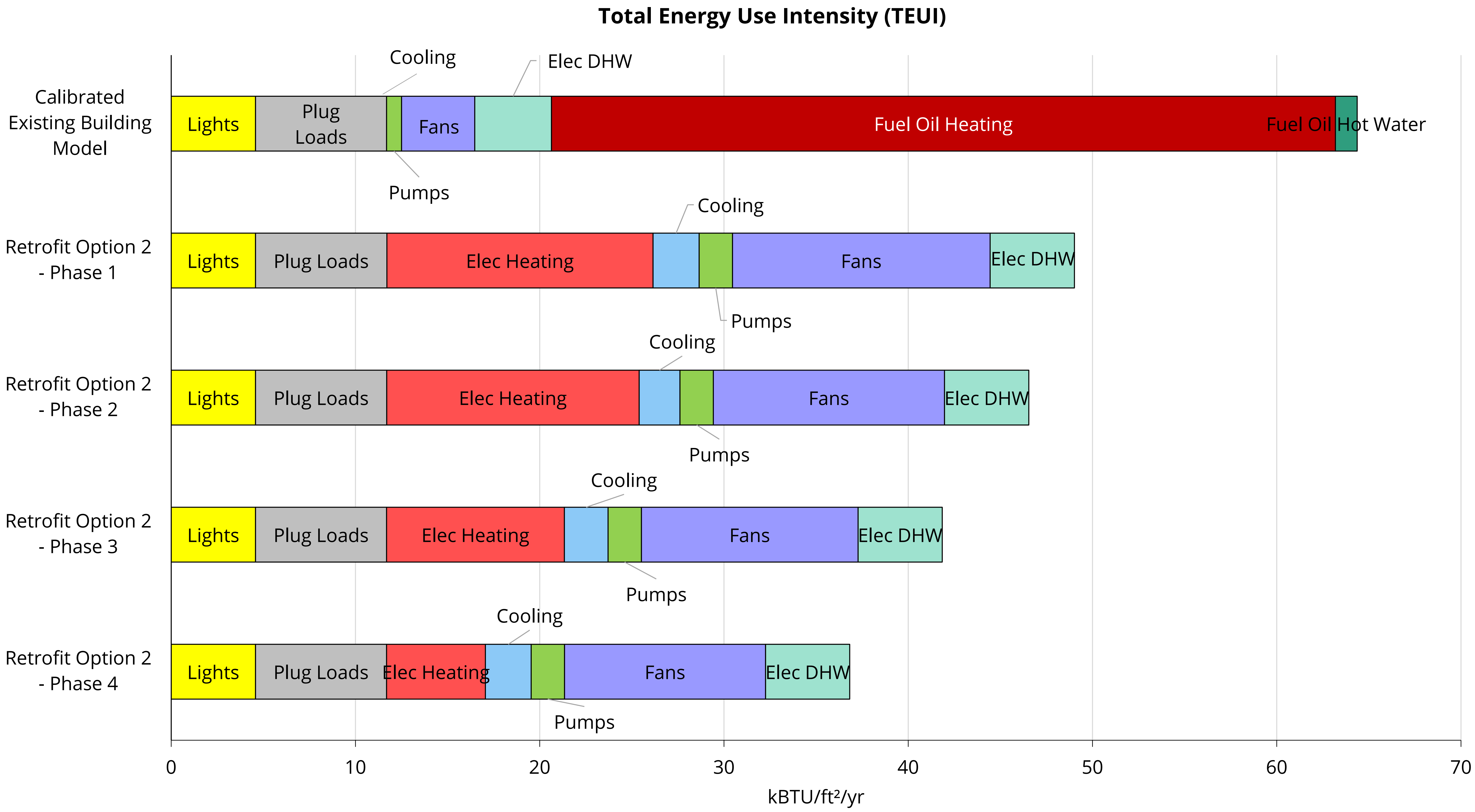
The (TEUI) and (GHGI) for the calibrated existing building model, and each of the four phases in Retrofit Option 2 are shown in the figures on the following pages. This retrofit strategy implements the same energy conservation and carbon reduction measures as the Option 1 Retrofit, replacing the mechanical systems and performing limited enclosure upgrades on “Day-1”, but phases the implementation of building enclosure retrofits by each wing of the building, from oldest to newest. Similar to Retrofit Option 1, the replacement of the oil-fired boilers and the propane hot water heaters with an air-to-water heat pump and electric DHW system reduces the reliance on combustion equipment. Phase 1 see a slight increase in GHG emissions due to the increased electricity and fan power required when all systems are turned on and due to the high emission factor of Massachusetts’ electricity grid. After Phase 1, each phase of the retrofit provides further reductions in energy use and GHG emissions due to the reduced heating requirements and improved airtightness from the enclosure upgrades. As this strategy phases the enclosure retrofit, the cooling plant will likely be undersized after Phase 1. This will still allow for some cooling on the hottest days, and will still improve comfort with the cooling and dehumidification the system is able to provide.

Each phase of the retrofit strategy aims to reduce the enclosure heat lost through the installation of continuous vapor, air, and thermal layers. Phase 1 repairs are not shown below as they focus on mechanical repairs which would not impact the reduction of heat through the enclosure. While attempting to reduce air infiltration in Phase 1 of option 2, the air-sealing measures will not eliminate all air infiltration, such as that which RDH observed through the wall assembly, or at all rough openings.



ANNUAL METRICS	CALIBRATED EXISTING BUILDING MODEL	PHASE 1	PHASE 2	PHASE 3	PHASE 4
GHGI (LBS/FT²/YR)	12	13	12	11	9
TEUI (kBTU/FT²/YR)	64	49	47	42	37
TEDI (kBTU/FT²/YR)	31	30	27	20	12
FUEL OIL (MBTU)	2,700	-	-	-	-
ELECTRICITY (kWh)	369,000	876,500	832,200	748,200	658,400
CO2E (TONS)	380	380	360	330	290

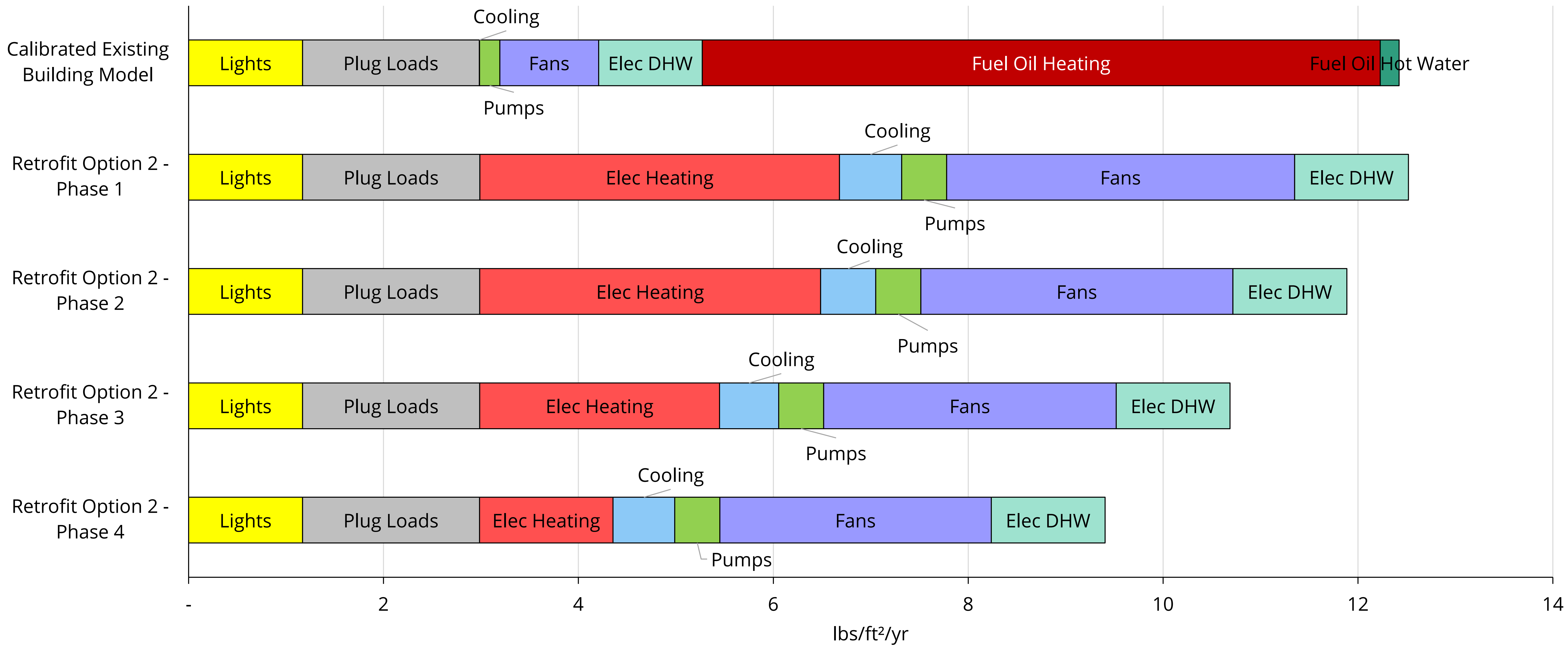
RETROFIT RESULTS – OPTION 2



RETROFIT RESULTS – OPTION 2

The GHGI values for each phase shown below are based on the current 2022 Massachusetts grid emissions rate. As previously stated, the emission rate is high due to the use of natural gas to produce the majority of the electricity in the state. As the grid shifts to cleaner electricity generation, the GHGI per phase has the potential to decrease n the future as more renewable energy sources are incorporated into the grid.

Greenhouse Gas Intensity (GHGI)

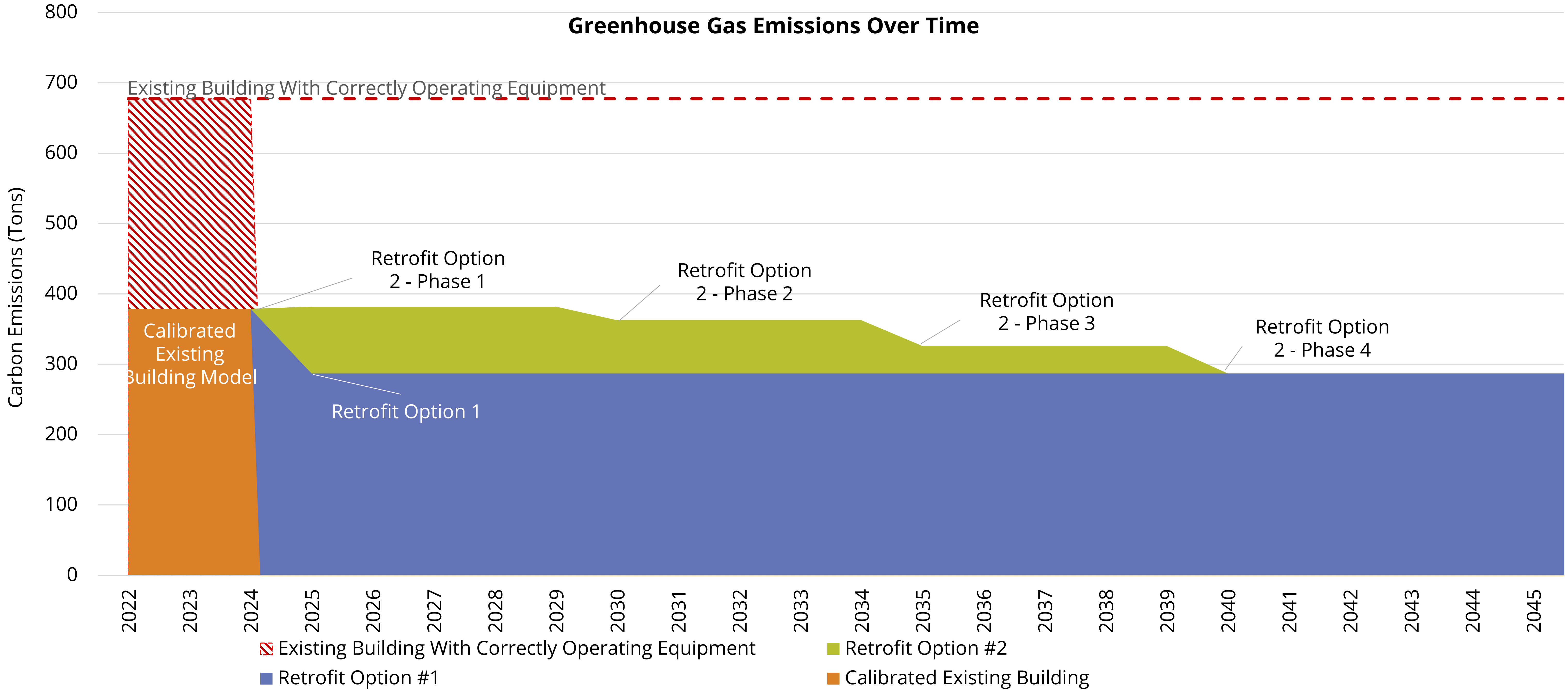


RETROFIT ENERGY PROJECTIONS

The GHG emissions over the next 30 years are shown in the figure below. They were calculated using the emission factors shown on page 30 of this report. The orange bar represents the calibrated existing building model which is **currently operating with most of the air handlers turned off because they are broken or are too noisy for the function of the spaces they are in**. The red bar represents the building if it were functioning under normal operations (Existing Building With Correctly Operating Equipment).

Retrofit Option 1 (blue) presents the retrofit strategy that focuses on achieving net zero carbon ready immediately and achieves 24% GHG reductions relative to the calibrated existing building model by 2025 and 56% relative to the Existing Building With Correctly Operating Equipment. By 2025, the energy conservation and carbon reduction measures have been implemented and the building is considered net zero after offsetting the remaining emissions with renewable energy generation or paying for carbon offsets.

Retrofit Option 2 (green) implements the same energy conservation and carbon reduction measures as the Retrofit Option 1 but is implemented over four phases and achieves net zero carbon ready by 2040, with the same requirements to offset the remaining emissions with renewable energy generation or paying for carbon offsets.



UTILITY COST RESULTS

Estimated annual utility costs associated with the calibrated existing building model, as well as Retrofit Option 1, and each phase of Retrofit Option 2 are provided in the table below. The table also includes the utility cost savings compared to the calibrated existing building model, as well as the total capital investment and the dollars of capital investment per GHG avoided. For Retrofit Option 2, Phases 2 and 3 see no dollars of capital investment per GHG avoided because GHG emissions either increase or stay the same compared to the calibrated existing building model.

The utility costs were assumed to be $0.157/kWh, a blended annual rate for electricity, and $2.97/gallon for fuel oil. Electricity costs are based on Cape Light Compact's (CLC) 2022 Power Supply Rates for commercial buildings, calculated as a blended annual rate. It is unclear from the CLC website if this rate includes both supply and distribution, but we have assumed both are included. Fuel oil costs are estimated based on averages from the utility bills provided. A full life-cycle cost analysis (LCCA) was not part of the base scope of this report; therefore, all values are calculated using 2022 rates, and presented in current dollars. It should be noted that the utility costs will vary significantly in the future due to increases in inflation.

ANNUAL METRICS	CALIBRATED EXISTING BUILDING MODEL	RETROFIT OPTION 1	RETROFIT OPTION 2			
			PHASE 1	PHASE 2	PHASE 3	PHASE 4
FUEL OIL COST ($/yr)	$62,000	-	-	-	-	-
ELECTRICITY COST ($/yr)	$58,000	$103,000	$138,000	$131,000	$118,000	$103,000
TOTAL UTILITY COST ($/yr)	$120,000	$103,000	$138,000	$131,000	$118,000	$103,000
SAVINGS COMPARED TO CALIBRATED EXISTING BUILDING MODEL ($/yr)	-	$17,000	$(18,000)	$(11,000)	$2,000	$17,000
TOTAL CAPITAL INVESTMENT ($)	-	$18,358,000	$4,077,000	$5,771,000	$5,093,000	$9,885,000
$ OF CAPITAL INVESTMENT/GHG AVOIDED ($/TONS)	-	$204,000	-	-	$102,000	$110,000

UTILITY COSTS	
ELECTRICITY ($/kWh) [3]	0.157
FUEL OIL ($/gallon)[4]	2.97

[3] Cape Light Compact blended commercial rate for December 2021 – June 2022 and June 2022 – December 2022 (https://www.capelightcompact.org/power-supply/)
[4] Based on utility bills provided by Up-Island Regional School District

ENERGY AND CARBON SUMMARY

	Calibrated Existing Building Model	Retrofit Option 1	Retrofit Option 2 - Phase 1	Retrofit Option 2 - Phase 2	Retrofit Option 2 - Phase 3	Retrofit Option 2 - Phase 4
GHGI (LBS/FT2/YR)	12	9	13	12	11	9
TEUI (KBTU/FT2/YR)	64	37	49	47	42	37
TEDI (KBTU/FT2/YR)	31	12	30	27	20	12
FUEL OIL (MBTU)	2,700	-	-	-	-	-
ELECTRICITY (kWh)	369,000	658,400	876,500	832,200	748,200	658,400
CO2E (TONS)	380	290	380	360	330	290
GHG SAVINGS COMPARED TO EXISTING (TONS)		90	-	20	50	90
FUEL OIL COST ($)	$62,000	-	-	-	-	-
ELECTRICITY COST ($)	$58,000	$103,000	$138,000	$131,000	$118,000	$103,000
TOTAL UTILITY COST ($)	$120,000	$103,000	$138,000	$131,000	$118,000	$103,000
SAVINGS COMPARED TO EXISTING ($)	-	$17,000	$(18,000)	$(11,000)	$2,000	$17,000
TOTAL CAPITAL INVESTMENT ($)	-	$18,358,000	$4,077,000	$5,771,000	$5,093,000	$9,885,000
$ OF CAPITAL INVESTMENT/GHG AVOIDED ($/TONS)	-	$204,000	-	-	$102,000	$110,000

MEP SYSTEM UPGRADES

PROPOSED MEP SYSTEM UPGRADES

For the air-to-water heat pump, two 117-ton units have been costed based on the annual heating and cooling loads modelled for the building. Two units would meet the building loads for both Retrofit Option 1 and each phase of Retrofit Option 2 and would be more than sufficient for the final phase of the retrofit. It is important to note that these sizes are estimated based on outputs from the energy model and that as the project moves through design, sizing will be refined by the mechanical designer during the design phase. For Retrofit Option 1, however, it is possible that the building loads could be met by one 117-ton units and one smaller unit. For Retrofit Option 2 Phase 1, two 117-ton units should be sufficient, however, there is the risk that if there is no back up boiler and winter temperatures drop too low, the controls may turn off the equipment and the school would be left without heating. More units or a larger unit could be added increase capacity, but the benefit of this increased capacity for occupant comfort would need to be weighed against cost.

The images on this page provide a reference for what the different mechanical systems proposed for the retrofit may look like.

Aermec NRB1600XH air-to-water heat pump. This is the “plant” where heat is acquired from or rejected to the outdoors, and distributed to or taken from the terminal units in the spaces inside the building.   Source: Aermec air-to-water heat pump cutsheet.

Changeair Freshman Vertical Fan Coil Unit. This is the type of vertical “terminal unit” being proposed for use in existing classrooms where there are horizontal through-wall units under the windows. Source: Systemair website.

RENEWABLE ENERGY OPPORTUNITIES

The Up-Island Regional School District has set a target of the school becoming **net zero operational carbon ready/net zero energy ready.** Through the retrofit strategies laid out in this report, the carbon emissions of the school will be reduced, however, in order to achieve zero carbon emissions, the remaining emissions will need to be offset through the implementation of renewable energy generation (solar photovoltaic or PV) or by purchasing carbon offsets. We understand some of the West Tisbury School's electricity presently comes from photovoltaic arrays at the landfill on the island. That renewable source was not included in this analysis and can be considered in future analyses of renewable energy sources.

RDH carried out an analysis to estimate the amount of solar PV that would be required to offset the remaining emissions from the school after the retrofit, the results of which are shown in the table below. After the retrofits are complete, approximately 658,400 kWh of annual energy generation will remain. The peak DC size needed to meet 658,400 kWh is determined based on the full sun hours for the location of the building. For Martha's Vineyard the full sun hours are 1290, which requires a **peak DC size of 525 kW***. Assuming a typical panel efficiency of 16.7 W/ft², approximately 30,500 ft² of solar PV panel area or collector area would be required and could be mounted over top of the parking lot or in an adjacent field . Assuming not every square foot of roof area is useable, a roof mounted system would require more roof area than the system mounted over a parking lot. If 65% of the roof could be covered in solar PV panels, a solar collector area of around 50,400 ft² would be required.

The array sizes provided in the table below are assumed to provide 100% of the 658,400 kWh annual energy generation required to bring the school to net zero. Other sources of renewables have not been explored, however, if other sources, such as the town's landfill solar array site are considered, the array sizes and subsequent costs have the potential to decrease.

**Based on panel sizing due South and with no shading.*

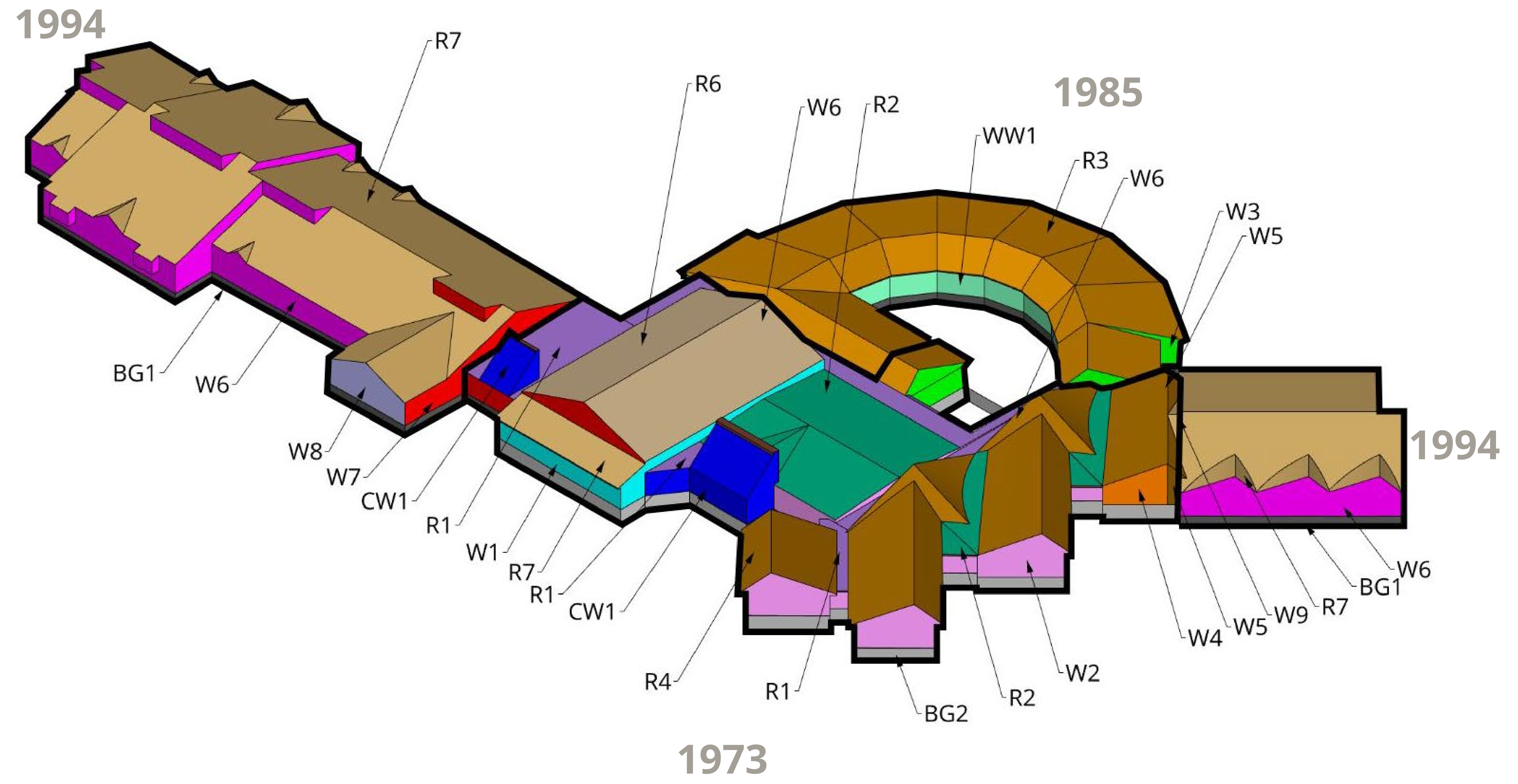
PV SYSTEM TYPE	AREA REQUIRED (FT²)
GROUND MOUNTED Can also be mounted in a canopy configuration over parking spaces in the parking lots to minimize area on ground required.	30,500
ROOF MOUNTED *For reference only, there is not enough south facing roof on the existing building for this much PV.	50,400

Ground mounted solar PV system. Canopy mounted PV over parking lot is also an option. Source: Adobe

Roof mounted solar PV system. Source: Adobe

BUILDING ENCLOSURE RETROFIT

ASSEMBLY TYPES



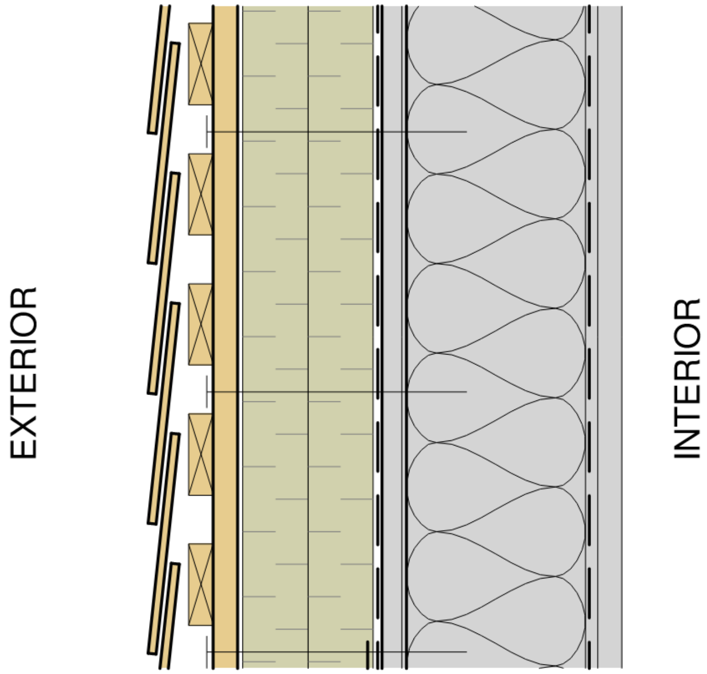
Assembly	Area (sqft)
W1, W3, W6	15,535
W2, W4	5,006
W5, W9	539
W7, W8	3,003
BG1	5482
BG2	7028
CW1	1,691
WW1	1,007
R1, R2	10,232
R3	13,404
R4, R5, R6	22,263
R7	26,817

GLAZING & DOOR TYPES

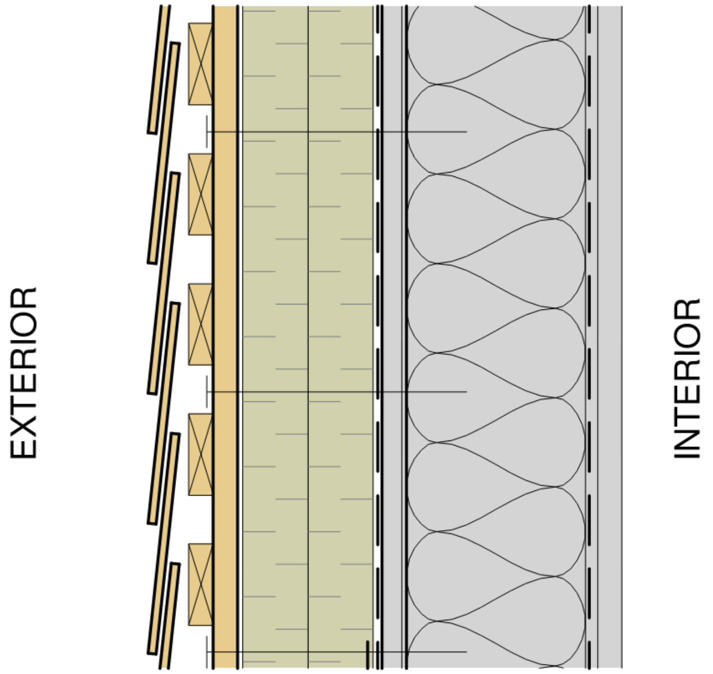
Glazing Type	Area (sqft)	Count	Existing	Proposed
CW1	**1691**	**N/A**	**Curtain wall at two entrance locations from 1974**	**Option 1: Reglaze existing curtainwall with an R14+ Vacuum Insulated IGU (BOD* Vitroglazing)** **Option 2: Replace with triple glazed curtainwall U<0.18 (BOD*: Shuco USA FWS 60 SI)**
WW1	**1007**	**N/A**	**Andersen window wall at courtyard from 1985**	**Replace with fiberglass triple glazed windows U<0.18 (BOD*: Alpen Tyrol Series)**
GL-1	**2414**	**111**	**Andersen composite clad wood punched windows replaced in 2011**	**Replace with fiberglass triple glazed windows U<0.18 (BOD*: Alpen Tyrol Series)**
GL-2	**400**	**20**	**Existing windows from 1974**	**Replace with fiberglass triple glazed windows U<0.18 (BOD*: Alpen Tyrol Series)**
DOORS	**756**	**36**	**Existing Steel Exterior doors**	**Replace with insulated doors, fully gasketed with thermally broken frame and threshold U 0.36 (BOD*: Ceco Trio E)**

**Note: BOD stands for Basis of Design*

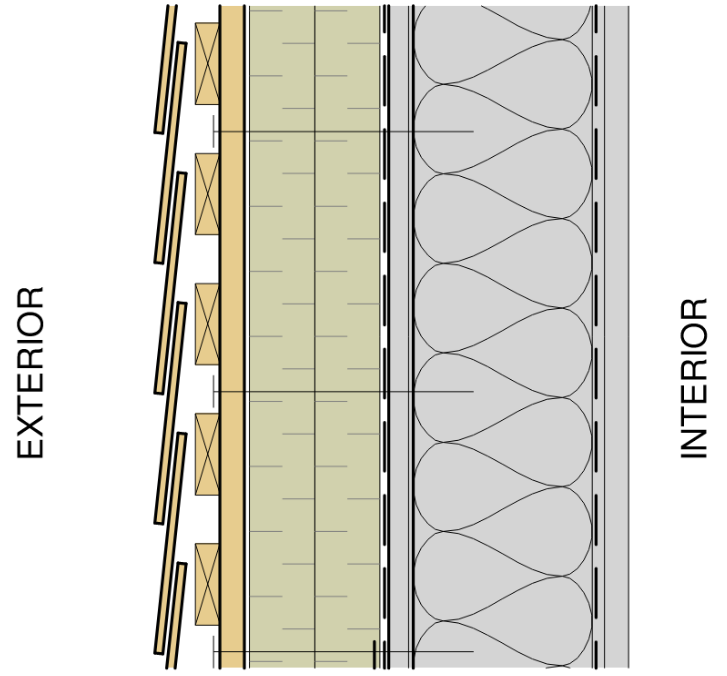
WALL ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
W2, W4 (1973) 	*Exterior*			**Proposed assembly R-value: R-25-30**
	New cedar shingles		Vertical and horizontal 1x3 battens with long screws	
	New continuous insulation	Thermal	Add 4” of mineral wool continuous insulation	
	New vapor permeable self adhered air barrier	Air	BOD Siga Majvest 500 SA	
	Exterior plywood sheathing			**Existing assembly approx. R-value: R-9**
	2x4 wood stud w/ fiberglass batt insulation	Thermal	Review condition of batts and provide infill where required	
	Vapor barrier	Vapor		
	Gypsum wallboard			
	Interior			

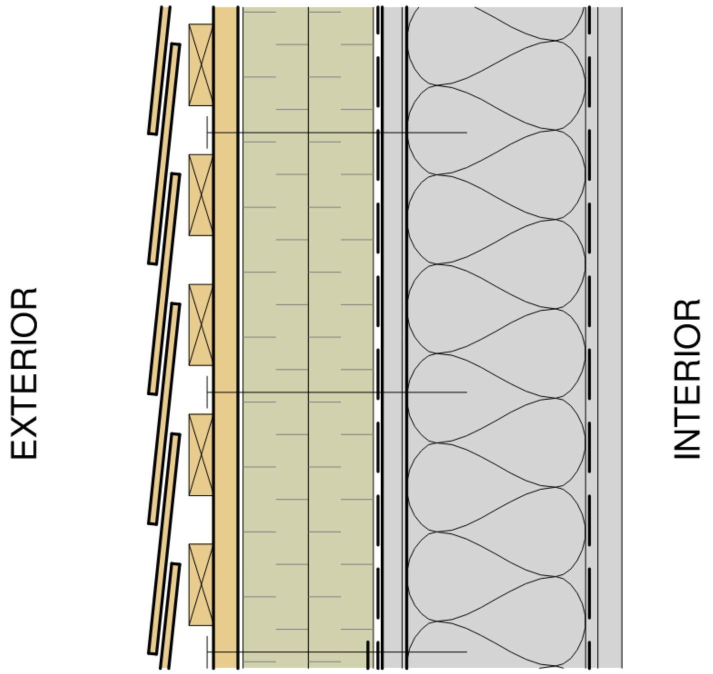
WALL ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
W5, W9 (1973)  SIM	*Exterior*			**Proposed assembly R-value: R-25-30**
	New cedar shingles		Vertical and horizontal 1x3 battens with long screws	
	New continuous insulation	Thermal	Add 4” of mineral wool continuous insulation	
	New vapor permeable self adhered air barrier	Air	BOD Siga Majvest 500 SA	
	Exterior plywood sheathing			**Existing assembly approx. R-value: R-14**
	2x4 wood stud w/ fiberglass batt insulation	Thermal	Review condition of batts and provide infill where required	
	Vapor barrier	Vapor		
	2x4 wood stud with airspace or additional sheathing	Fire Separation		
	Gypsum wallboard			
	Interior			

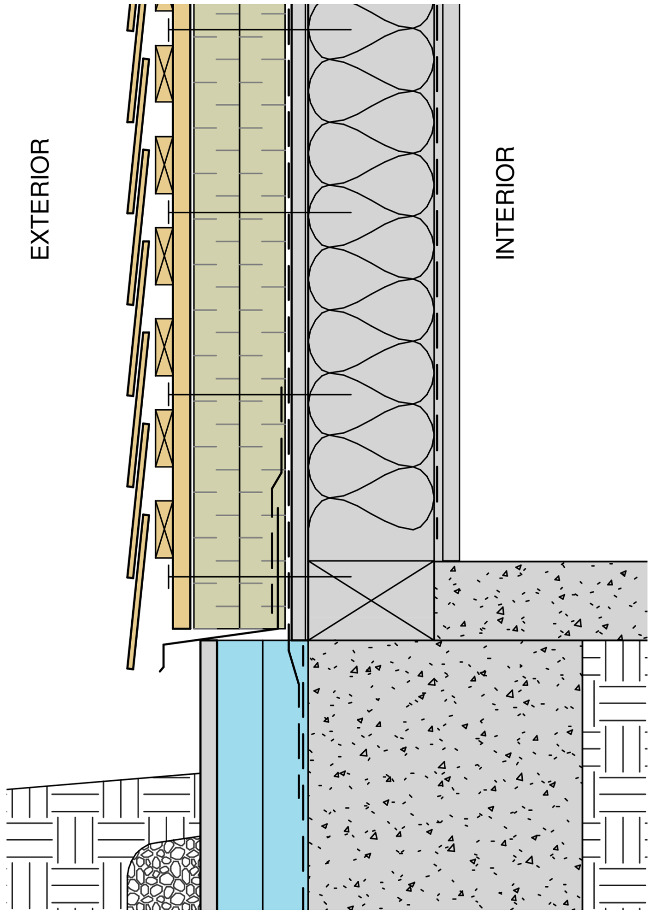
WALL ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
W1, W3, W6 **(1973, 1985, 1994)**  SIM	*Exterior*			**Proposed assembly R-value: R-25 – R-30**
	New cedar shingles		Vertical and horizontal 1x3 battens with long screws	
	New continuous insulation	Thermal	Add 4" of mineral wool continuous insulation	
	New vapor permeable self adhered air barrier	Air	BOD Siga Majvest 500 SA	
	Exterior plywood sheathing			**Existing assembly approx. R-value: R-16**
	2x6 wood stud w/ fiberglass batt insulation	Thermal	Review condition of batts and provide infill or replace batts where required	
	Vapor barrier	Vapor		
	Gypsum wallboard			
	Interior			

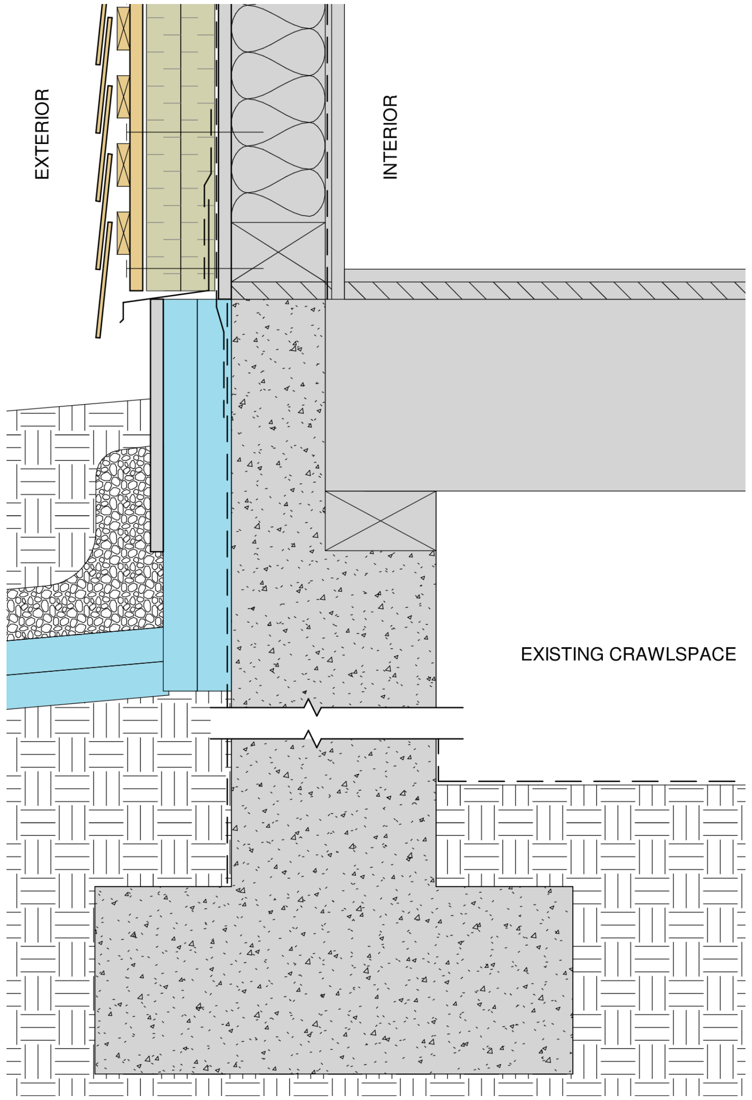
WALL ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
W7, W8 (1994)  SIM	*Exterior*			**Proposed assembly R-value: R-25**
	New cedar shingles		Vertical and horizontal 1x3 battens with long screws	
	New continuous insulation	Thermal	Add 4" of mineral wool continuous insulation	
	New air barrier	Air	BOD Siga Majvest 500 SA	
	Exterior plywood sheathing			**Existing assembly approx. R-value: R-20**
	2x6 or 2x8 wood stud w/ fiberglass batt insulation	Thermal	Review condition of batts and provide infill where required	
	Vapor barrier	Vapor		
	Gypsum wallboard			
	Interior			

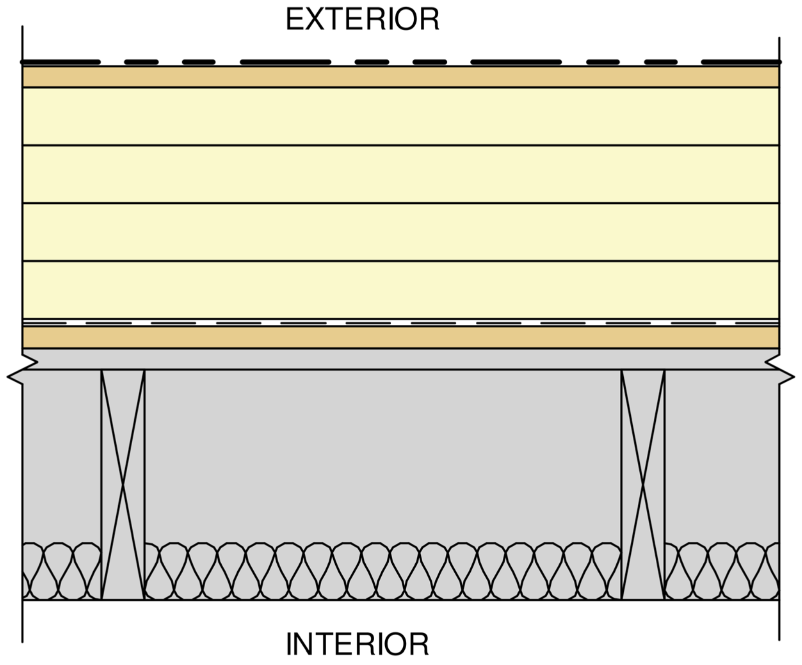
BELOW GRADE WALL ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
BG1- Slab on Grade Foundation Wall  	*Exterior*			**Proposed assembly R-value: R-20-25**
	New metal panel fascia		Covers new exterior insulation	
	New high-density EPS insulation	Thermal	Add 5" of high-density EPS continuous insulation 3' down foundation below grade. Air barrier from wall above to lap over rim joist and onto foundation wall.	**Existing assembly approx. R-value: R-2**
	Concrete foundation wall	Air/vapor		
	Interior			

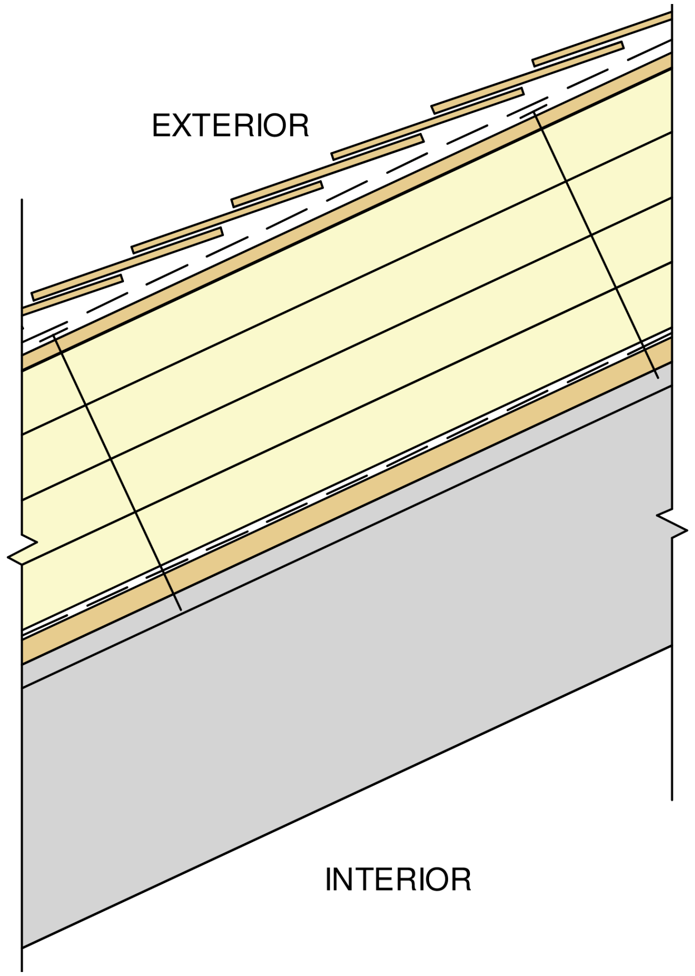
BELOW GRADE WALL ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
BG2 – Crawlspace Wall (1974) 	*Exterior*			**Proposed assembly R-value: R-20 - 25**
	New metal panel fascia		Covers new exterior insulation	
	New high-density EPS insulation	Thermal	Add 5" of high-density EPS continuous insulation 3' down foundation below grade with frost skirt 4' out, sloped away from building. Air barrier from wall above to lap over rim joist and onto foundation wall.	**Existing assembly approx. R-value: R-2**
	Concrete foundation wall	Air/ Vapor	Add new vapor barrier at crawlspace floor, TYP.	
	Interior			

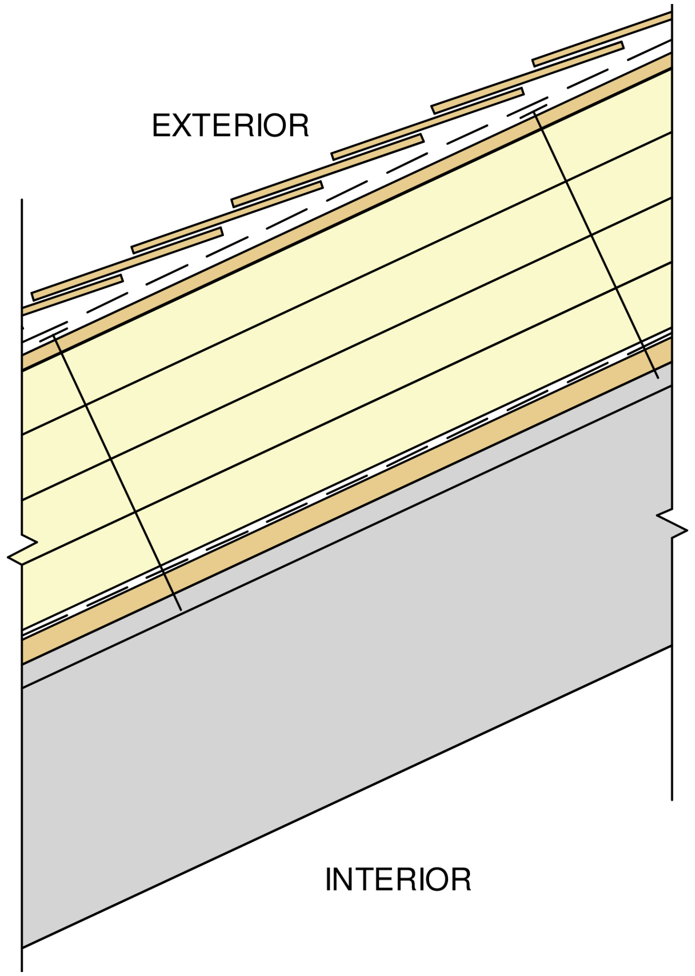
ROOF ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
R1, R2 (2022) 	*Exterior*			**Proposed assembly R-value: R-40-R-50**
	New EPDM membrane	Water, air		
	New coverboard			
	New polyisocyanurate insulation	Thermal	8 inches of polyisocyanurate insulation, mechanically fastened (add 3” to existing)	**Existing assembly approx. R-value: R-30**
	New vapor barrier	Air/ Vapor	Self-adhered vapor barrier	
	New plywood sheathing			
	Tongue and groove wood deck			
	Roof Joists			
	Interior			

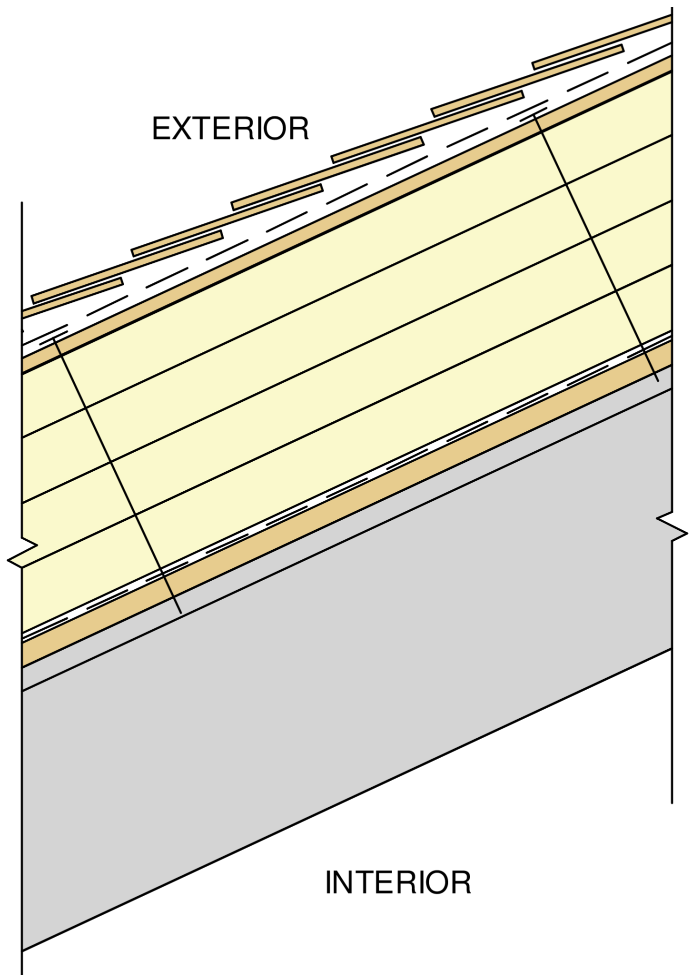
ROOF ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
R3 (1985)  	*Exterior*			**Proposed assembly R-value: R-40-R-50**
	New asphalt shingles	Water		
	New roof underlayment			
	New plywood sheathing			
	New polyisocyanurate insulation	Thermal	8 inches of polyisocyanurate insulation, mechanically fastened	**Existing assembly approx. R-value: R-10**
	New vapor barrier	Air/ Vapor	Self-adhered vapor barrier	
	New plywood sheathing			
	Roof deck			
	Roof joists			
	Interior			

ROOF ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
R4, R5, R6 (1974) 	*Exterior*			**Proposed assembly R-value: R-40-R-50**
	New asphalt shingles	Water		
	New roof underlayment			
	New plywood sheathing			
	New polyisocyanurate insulation	Thermal	Add 8 inches of polyisocyanurate insulation, mechanically fastened	
	New vapor barrier	Air, Vapor	Self-adhered vapor barrier	
	New plywood sheathing			**Existing assembly approx. R-value: R-1, R-1, R-5**
	Roof deck			
	Roof joists			
	Interior			

ROOF ASSEMBLY MATRIX

Assembly	Assembly Components	Control Layer	Comments	Assembly R-value
R7 (1994) 	*Exterior*			**Proposed assembly R-value: R-40-50**
	New asphalt shingles	Water		
	New plywood sheathing			
	New polyisocyanurate insulation	Thermal	Add 8 inches of polyisocyanurate insulation, mechanically fastened	**Existing assembly approx. R-value: R-11**
	New vapor barrier	Air, Vapor	Self-adhered vapor barrier	
	New plywood sheathing			
	Roof deck			
	Roof joists			
	Interior			

CONCLUSION

CONCLUSION

WHY DOES THIS MATTER?

All children deserve a healthy learning environment. According to the EPA, “Substandard environmental conditions in schools, such as… inadequate ventilation can cause serious health problems for children…Studies demonstrate that improved IAQ (indoor air quality) increases productivity and improves the performance of mental tasks, such as concentration and recall in both adults and children.” [5]

The custodial staff of the West Tisbury School are extremely diligent in maintaining and operating the school to the best of their ability, but are challenged with a mechanical system that does not work properly, which prevents the ventilation systems in the school from operating. The desire for additional ventilation, particularly in this post-covid environment, leads to staff opening windows, which causes the thermostats of the heating system to malfunction, leading to the heating system operating incorrectly and wasting energy. Implementing the rennovations outlined in this report will contribute to creating a healthy indoor environment that promotes learning with a correctly operating building and proper ventilation.

The addition of a cooling system to the building will also allow for year-round operation of the building which will allow flexibility in summer programming and continued thermal comfort for teachers and students as outdoor temperatures continue to climb as a result of climate change.

The proposed building enclosure upgrades will allow the building mechanical systems to operate at maximum efficiency with minimized energy use.

The proposed rennovations will also futureproof building against future climate change so that it remains inhabitable and can serve its function as a space to educate children, as well as potentially serve as an emergency shelter for the island capable of withstanding extreme weather events.

Renovating and utilizing an existing building can have a lower carbon footprint and lower cost than constructing a new building. According to the Carbon Free Boston report published in 2019, “85% of projected building square footage in Boston in 2050 exists today. For carbon neutrality, nearly all of the existing buildings in the city will need to undergo deep energy retrofits that are designed and implemented with a ‘whole building’ approach.” [6] This emphasized the need to address rennovations of existing buildings throughout the commonwealth to achieve the stated 2050 carbon reduction mandate, signed into law in 2021.

NEXT STEPS

This report presents conceptual-level recommendations with respect to retrofit options. It is important to understand that these recommendations do not provide a basis for implementing retrofit work.

RDH anticipates that the findings and recommendations in this report will be used by the UIRSD committee and other stakeholders (town’s people, individuals like Marc Rosenbaum, members of the Environmentally Friendly School Building Task Force) to assess the viability of this project in the context of other major capital projects, such as the Martha’s Vineyard Regional High School, Tisbury Elementary School and the Chilmark School. Their feedback is certain to raise questions about the timing, sequence and costs that we have not anticipated as part of this preliminary effort.

During the design phase, the conceptual recommendations contained in this report will need to be developed, refined, and specified in detail before the construction work can be put out to bid to contractors.

The Design Phase typically begins with the Owner’s Project Manager and the Consultant assisting in the decision-making process related to the proposed retrofit options. Once decisions are made by the Owner, the selected design is developed and documented in greater detail with drawings and specifications by the Design Team. These contract documents describe the exact extent and nature of the proposed renovation work. Specific energy targets should be defined during the beginning of the design process, with the energy consultant updating the energy model to reflect changes to the design as they occur, ensuring design compliance with the established energy targets.

The drawings and specifications are used to obtain bids from pre-qualified contractors and to obtain a building permit to commence the construction process.

During the Construction Phase the retrofit work that has been designed is constructed by the Contractor. The Consultant administers the construction contract and undertakes periodic field review of construction as the work proceeds. The Consultant should continue to update the energy model through construction to track construction progress against the project goals and energy targets.

Post-Construction, Measurement and Verification services are required to ensure the building is performing and operating as designed.

[5] “EPA Student Health and Academic Performance Quick Reference Guide”. November, 2012, https://www.epa.gov/sites/default/files/2014-08/documents/student_performance_findings.pdf

[6] “Carbon Free Boston” . 2019, https://www.boston.gov/sites/default/files/file/2020/08/CFB_SummaryRpt_FEB19_0.pdf

CONCLUSION

CLOSURE

The energy calculations completed for this report were based on information provided by the UIRSD team through the drawings and documents identified in the References section, as well as correspondence with the study committee.

Where required information was not explicitly defined in the information provided, assumptions were made based on previous experience. We can discuss these assumptions upon request.

RDH was retained to assess the performance of the building based on the information provided and develop retrofit options. Once the retrofit plan is implemented, it is the responsibility of the designers of record and the contractor to review the construction and materially maintain the intended energy performance of as-constructed retrofit projects.

The following staff at RDH contributed to this report:

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→ Project Manager: Andrew Steingiser, RA, CPHC, LEED AP

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→ Energy Analyst: Sarah Bozoian, GIT, LEED Green Associate

We trust this report summarizes the building retrofit paths to meet your planning needs. Please do not hesitate to contact us if you require any further information.