Deep Retrofit Study | Project 27803.000

54 Jackson Road, Dartmouth, Nova Scotia

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Submitted December 12, 2023 by
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Executive Summary

RDH was retained by zzap Architecture and Planning ("zzap") to assess retrofit options for 54 Jackson Road in Dartmouth, Nova Scotia. This is a 2-storey low-rise residential rental building with 19 suites that was built in the 1960s. The retrofit study has the following goals:

→ Develop a high-level plan for exterior enclosure retrofit strategies and mechanical system upgrades that will help reduce energy consumption, associated costs, and carbon footprint.
→ Comment on the scopes, costs, and energy savings associated with whole building retrofits of an occupied building.

Our assessment considers both the mechanical system and building envelope, with carbon and energy savings after implementing our recommended retrofits.

RDH completed a preliminary energy assessment to summarize energy consumption and carbon emissions using approximately two years of utility data. Our work demonstrates carbon and energy reduction potential for the two retrofit pathways.

The existing building has wood-framed walls clad primarily with brick veneer. The glazing consists of aluminum framed double pane sliding windows. The roof has a conventional assembly with fibreglass insulation in frame cavities. The suites are currently heated by hot water baseboard heaters served by a natural gas boiler located on the lower level. The natural gas boiler also serves the building's domestic hot water use.

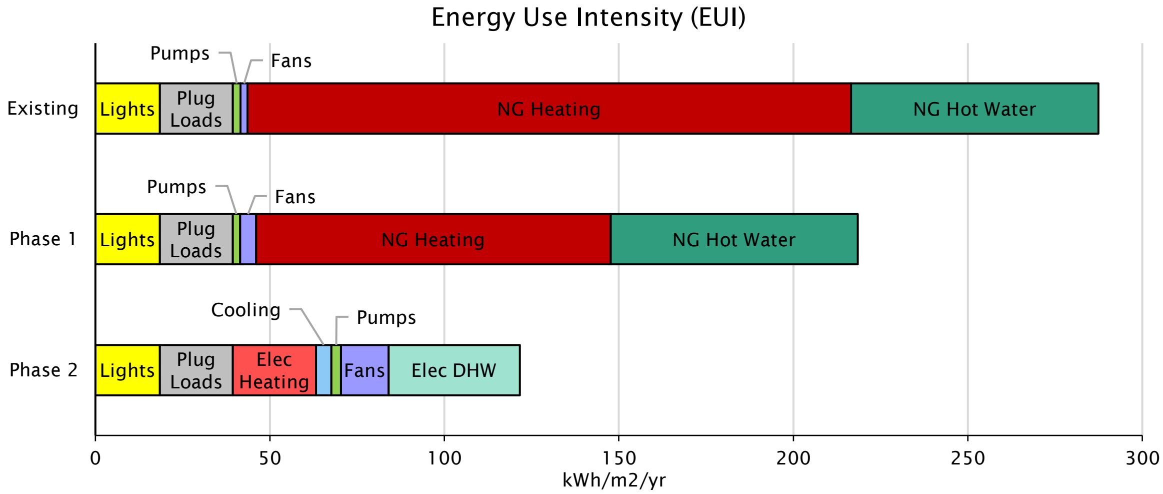
We gathered the inputs for the existing building energy model using information and documents provided by zzap. When required information was not explicitly stated in the provided documentation, we made assumptions based on our previous experience.

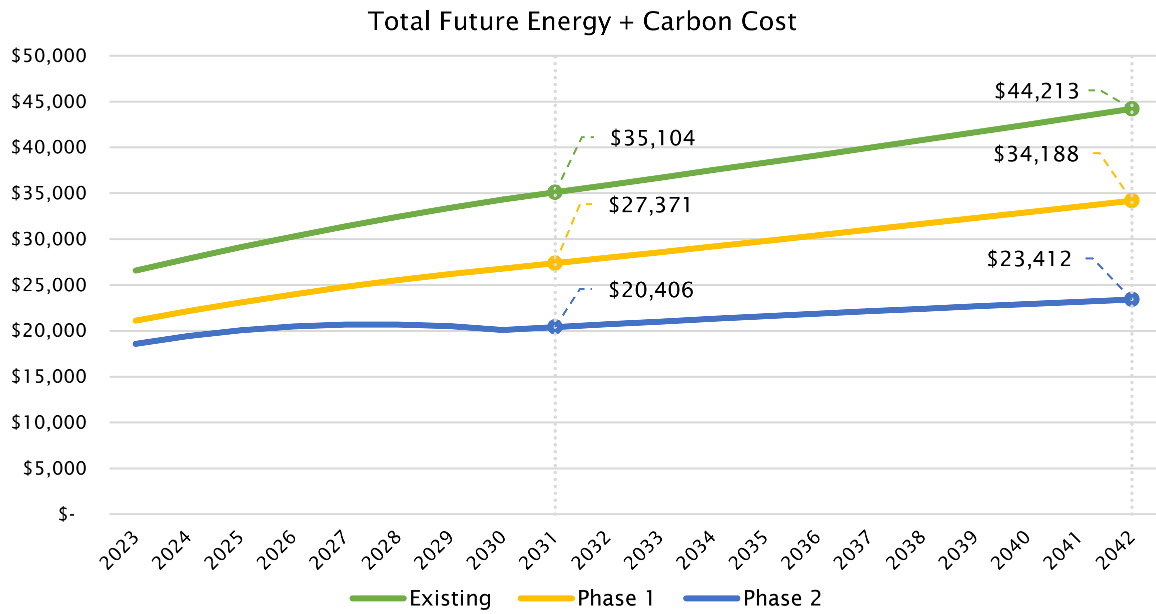
The existing building has a Greenhouse Gas Intensity (GHGI) of 65 $kgCO_2/m^2$, an Energy Use Intensity (EUI) of 285 kWh/m^2, and a Thermal Energy Demand Intensity (TEDI) of 135 kWh/m^2.

This document outlines two retrofit options that can be implemented in phases:

→ **Phase #1 Retrofit**: This strategy focuses on enclosure and ventilation, including insulation, air tightness, and window upgrades with prefabricated wall panels, and in-suite heat recovery ventilation.
→ **Phase #2 Retrofit**: This option builds on Phase 1 and includes upgrading the HVAC system to electric heat pumps to provide heating and cooling. The addition of cooling requires installation of in-suite fan coil units.

The energy model and future energy cost analysis results are presented below. The results show a staged reduction of energy use and operations cost for Phase 1 and Phase 2 retrofits. Based on our Class D costing estimates and the reduced operating costs shown in the figures on the following page, the Phase #2 retrofit is estimated to have a positive Net Present Value compared to the existing building in **40-70 years**. This means that the capital costs (construction costs) of the building retrofit will be offset by the savings in energy and carbon usage in 40-70 years.





Our report summarizes the proposed enclosure and mechanical retrofit pathways. Alternative options were considered, but we consider the retrofit measures presented to be the most effective and feasible options. Potential benefits and drawbacks are provided for each retrofit path considered.

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

→ Improved resiliency against extreme events and future climates (e.g., added cooling)
→ Superior occupant comfort and health due to indoor environmental quality (e.g., added ventilation)
→ Demonstrate leadership in sustainable buildings
→ Updated exterior aesthetics

Once a retrofit path is selected, the next steps include choosing the specific elements of the rehabilitation program, designing, and tendering the repair package, conducting the repairs, verifying operational performance, and implementing ongoing maintenance.

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Appendices

1 Introduction & Background

1.1 Project Description

Location 54 Jackson Road, Dartmouth, Nova Scotia

Building Use Residential Apartments

Number of Storeys 2 storeys above/ 1 storey below-grade

Number of Suites 19 suites

Floor Area 1087 m^2

Construction Date 1960s

1.2 Document Scope

RDH was retained by zzap Architecture and Planning (zzap) to assess net zero energy and panelized deep retrofit options at 54 Jackson Road in Dartmouth, Nova Scotia. This building is a 2-storey low rise residential building with 19 units built in the 1960s.

The retrofit study has the following goals:

- → Develop a high-level plan for exterior enclosure and mechanical system upgrades that will help reduce energy consumption, associated costs, and carbon footprint.
- → Comment on the potential scopes, costs, and energy savings associated with whole building retrofits of an occupied building
- → Provide a holistic assessment that considers the mechanical system and building envelope, with a stated payback model for efficiencies gained
- → **Phase #1 Retrofit**: This strategy focuses on enclosure only, including cladding and window replacements, and in-suite ERVs.

→ **Phase #2 Retrofit**: This option builds on the Phase 1 strategy and includes deeper retrofit strategies such as electrifying the heating and domestic hot water plants.

RDH completed a preliminary energy assessment to summarize energy consumption and carbon emissions using approximately 2 five years of utility data. Our work provides carbon and energy reductions for the two retrofit pathways, including Class D cost estimates.

1.3 Methodology

RDH reviewed the documents listed in the references. These documents, in addition to communications with zzap, allowed RDH to complete a preliminary energy assessment of the existing building using a building energy model. We compared the model to the utility data provided by zzap and adjusted our energy analysis to align. Our scope did not include visiting the site for visual review nor for conducting test openings.

RDH does not endorse specific products even if they are mentioned by name in this report. Product references are provided as technology examples; however, the stated efficiency and performance of the references are integral to the evaluated energy performance, not the specific product.

This retrofit study is intended as a tool to facilitate communication between the property management team, sustainability group, asset management group, investors, and future project design team members. This document represents the energy retrofit design intent and should be carefully minded by the design team during the development of the design and construction documents, should retrofit projects be undertaken.

1.4 References

Zzap provided the following documents to us for our assessment:

→ Electrical utility data from 2019 to 2023

→ Natural Gas usage data from 2021 to 2023

→ Property Condition Assessment from 2019

→ Whole Housing Energy Retrofit Envelope Nova Scotia Owner’s Report

→ 54 Jackson Rd Specifications.docx

→ HomeSol - Air Leakage Report

→ Plan and Elevation Drawings

2 Climate Change Adaption & Mitigation

2.1 Why Retrofits?

Climate change is projected to have a significant impact on society and the built environment. Shifting climate norms result in changing weather patterns. The underlying cause of this change has been identified as anthropogenic greenhouse gas (GHG) emissions.

To achieve a sustainable future, both climate change *Adaptation* and *Mitigation* are required.

→ **Adaptation** is ensuring our buildings will be able to withstand changing and ever stronger environmental loads.

→ **Mitigation** is minimizing the severity of these future environmental loads by reducing GHG emissions or increasing GHG sinks.

As all levels of government target more stringent carbon emission reduction goals, there is an increased focus on reducing emissions related to operating existing buildings. Deep energy retrofits are fast becoming a key strategy to reach carbon emission goals in Canada.

2.2 Adaptation

The projected climate for Halifax over the next few decades is summarized in the Figure 2.2 below. Extreme weather can manifest as intensified wind speeds and severe precipitation downbursts leading to flood risks and ice storms. Existing buildings must be able to effectively manage current and future environmental loads.

	1976-2005	2051-2080		
Change	**Mean**	**Low**	**Mean**	**High**
Typical hottest summer day	29.6°C	30.7°C	33.6°C	36.6°C
Typical coldest winter day	-21.3°C	-18.8°C	-14.6°C	-10.7°C
Number of +25 °C days per year	18	40	66	92
Number of +20°C nights per year	0	1	10	27
Annual precipitation	1440 mm	1324 mm	1571 mm	1849 mm
Number of below-zero days per year	145	71	92	115
Frost-free season (days)	170	191	217	243

Figure 2.2 Projected Climate Changes for Halifax, NS
From HalifACT: Acting on Climate Together Plan, 2020

2.2.1 Heating, Cooling & Thermal Comfort

Buildings require active heating and cooling systems. Passive systems such as insulation should be considered to supplement active systems for energy savings and resiliency to maintain comfort and liveability in the event of power loss.

2.2.2 Durability

Building enclosures require water control strategies that can handle higher levels of precipitation and wind loads due to increased extreme storm events. Using durable enclosure materials, assemblies, and systems extends the period between significant repairs and renewals and reduces lifecycle maintenance costs.

2.2.3 Air Quality

Providing fresh air promotes resident well-being. Adding air filtration within ventilation systems should be considered to manage contaminants from interior or exterior sources.

2.2.4 Wildfires

Wildfires are becoming more prevalent across the continent and lead to poor air quality. Buildings require less air leakage to limit smoke entering the building and available cooling when opening windows will reduce the interior air quality.

2.2.5 Water Use

Buildings should incorporate water reduction strategies such as low flow fixtures, rainwater harvesting, and water efficient landscaping.

2.2.6 Flooding

Buildings that may be exposed to flooding and elevated ground water levels should have resilient ground-level and below-grade enclosure assemblies and details.

2.3 Mitigation

The Global Status Report 2017 by the United Nations Environment Programme found that the building industry is responsible for over 28% of global GHGs due to operations and 11% due to construction and material extraction. Buildings that produce less green house gas (GHGs) during operation are critical for a sustainable future.

Tiered mitigation shown in the figure below builds off the strategy of reducing loads passively with an improved building enclosure. This strategy starts by reducing building loads with increased building enclosure performance. Next, mechanical systems with improved efficiency can be implemented to reduce energy consumption. Finally, renewable energy systems may be used to fully offset energy and carbon usage in a building.

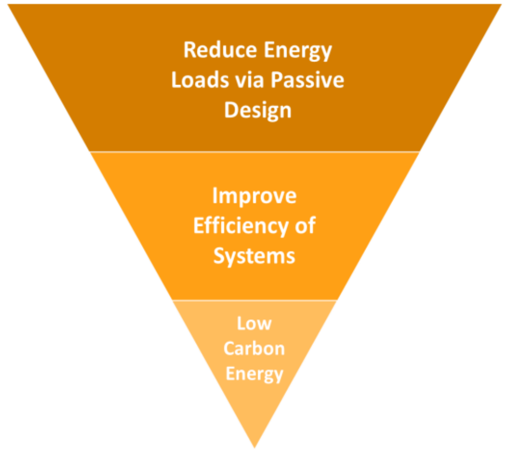


Figure 2.1 Tiered Mitigation

Windows are typically the weakest link in the building enclosure and may account for significant heat loss, cold surfaces, and air leakage (drafts). Upgrading windows can reduce loads, deliver energy savings, reduce cooling in the summer, and provide more comfortable living spaces.

Adding exterior wall/roof insulation further reduces heating demand and improves the durability of the building enclosure. Adding a continuous air barrier can significantly reduce air leakage which can improve indoor air quality, building durability, and occupant comfort. With increased airtightness, it is important to ensure adequate ventilation will be provided. Ventilation can be delivered efficiently through Energy Recovery Ventilators (ERVs).

Other retrofit opportunities to reduce energy consumption and greenhouse gas emissions include upgrading HVAC systems with higher efficiency equipment, switching to low flow water fixtures, fine tuning controls, etc.

3 Regulatory Framework for Existing Buildings

3.1 Building Codes for Existing Buildings

Currently, energy performance improvements are not mandated in existing building codes nor required when implementing base building repairs or maintenance on existing buildings. The Pan-Canadian Framework on Clean Growth and Climate Change has stated that federal, provincial and territorial governments will work to develop a model code for existing buildings by 2022; we understand that this work is still in progress.

3.2 City of Halifax Net Zero Carbon Emissions Plan

In October 2019, the Province of Nova Scotia enacted the Sustainable Development Goals Act with a long-term objective for the province to achieve sustainable prosperity. In particular, the government's greenhouse gas emission reduction goals are:

1. By 2020, reduce emissions by 10% (baseline 1990)
2. By 2030, reduce emissions by 53% (baseline 2005)

3. By 2050, achieve net-zero emissions

Further, on June 23, 2020, Halifax Regional Council adopted HalifACT (Acting on Climate Together), which outlines a comprehensive plan to reach net zero emissions by 2050. The document describes a community vision, guiding principles, outlines the opportunities for decarbonization (including business opportunities), and explicitly lists decarbonization actions with associated timelines. The document identifies retrofits of residential and non-residential buildings as the greatest opportunity for decarbonization and suggests these are the sectors which will have the greatest investment and economic stimulus. Significant decarbonization opportunities are also prevalent through implementation of rooftop solar, large-scale renewables, net-zero emission new buildings, and electrification of transportation. The top seven priority actions by 2025 are:

1. Retrofit and renewable energy programming
2. Retrofit municipal buildings to be net-zero ready and climate resilient
3. Electrification of transportation
4. Net-zero standards for new buildings.
5. Framework for assessing and protecting critical infrastructure
6. Capacity building for climate adaptation, and
7. Financing strategy to operationalize the HalifACT 2050 plan over 30 years.

HalifACT targets net-zero new construction by 2030 and aims to retrofit all existing buildings by 2040. Existing buildings are the single biggest source of GHG emissions in Halifax (77% of total GHG emissions in 2016). Halifax Regional Municipality has identified the need for deep energy retrofits, fuel switching heating systems to electricity, and implementation of green building standards.

Efficiency Nova Scotia offers incentives for retrofits based on verified energy savings, and offers feasibility study incentives for up to 100% of study cost (up to $15,000). Nova Scotia currently runs solar electricity programs for individuals and community groups; however, expanding programming for rooftop solar systems and energy storage has been identified by HalifACT as an immediate action to be undertaken. The province is also working with the region to develop a deep energy retrofit pilot program, which would be open to commercial property owners. The federal government and Canada Infrastructure Bank also have supports.

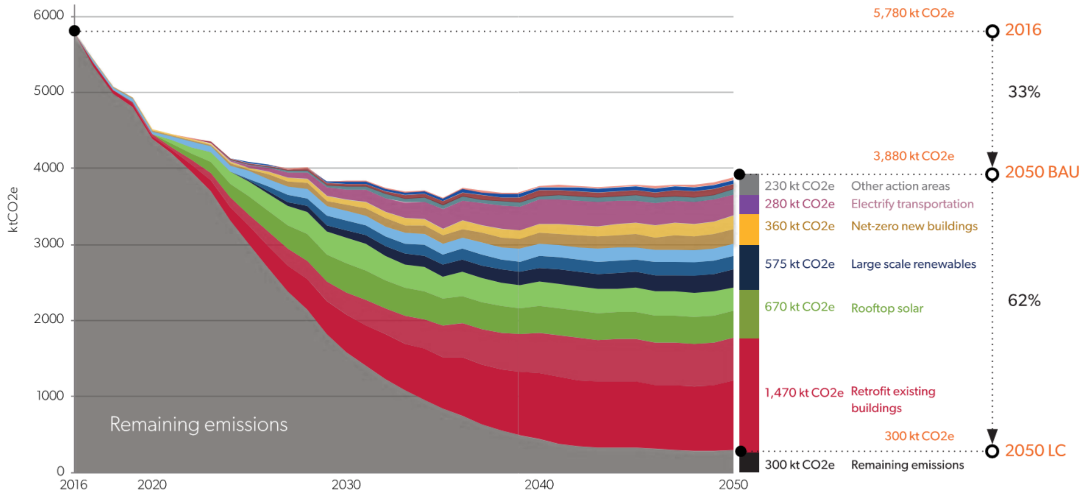


Figure 3.1 Pathway to reduce GHG emissions for Halifax, NS
From Halifact: Acting on Climate Together Plan, 2020

3.3 Nova Scotia Electricity Grid

In 2019, more than half of Nova Scotia's electricity generation was met through coal fired generation plants, followed by other fossil fuels such as natural gas, oil and diesel. Emissions will be reduced as the province has a goal of 80% renewable electricity by 2030.

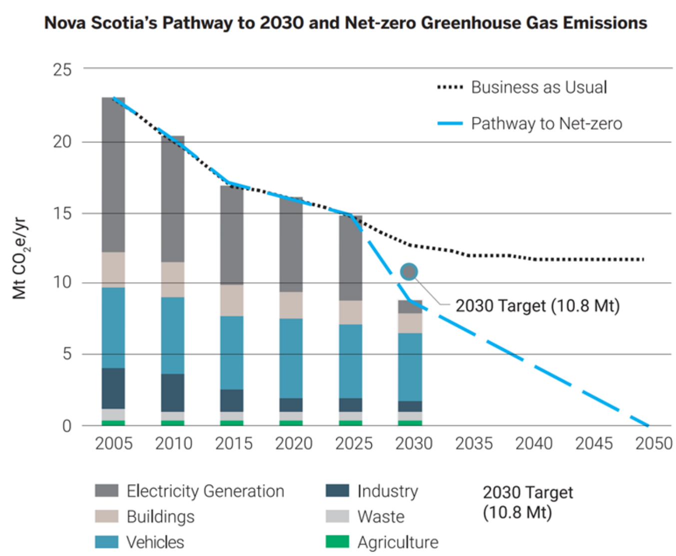


Figure 3.2 - Nova Scotia's Pathway to Net-zero GHG Emissions
from Nova Scotia Climate Change Plan Progress Report Appendix A

With Nova Scotia's current high carbon emission electricity grid, reducing overall building emissions should include an absolute reduction of energy consumption through reduction of loads combined with electrification utilizing high efficiency heating systems such as heat pumps.

3.4 Carbon Pricing

In 2019, the Government of Canada Carbon implemented carbon pricing to recognize the externalized cost of greenhouse gas pollution, incentivize reducing greenhouse gas emissions, and drive innovation for cleaner growth and a more sustainable future. Provinces and territories were allowed to develop their own pricing systems.

Since inception, Nova Scotia has operated under a cap-and-trade program to reduce greenhouse gas emissions by larger emitters, in lieu of the federal backstop. Nova Scotia's carbon price has fluctuated between $24-$36/tonne. The program is due for renewal in 2023 and may continue to follow cap-and-trade, apply a full price on carbon at point of sale, or develop a hybrid approach. If a full price on carbon is selected, a likely scenario is to utilize the Government of Canada's carbon pricing model.

The federal carbon price is set per tonne of carbon emission, and the initial price was $30/tonne (2020). The price escalates annually until 2030 when the price reaches $170/tonne. The Government of Canada is currently using an internal shadow carbon price of $300/ tonne to assess all major real property funding proposals as it is understood this level of carbon pricing is required for Canada to meet GHG reduction targets.

Buildings will pay the carbon price on their natural gas and electricity utility bills, based on the cubic meters (m3) of natural gas and kilowatt-hours (kWh) of electricity consumed where the generation of electricity results in greenhouse gas emissions. The carbon price is projected to represent a significant portion of a building's natural gas utility cost in the near future. As the Nova Scotia electricity grid turns to renewable energy, the impact of carbon pricing will weight heavier on natural gas and other fossil fuel consumption compared to electricity consumption.

The effect of carbon pricing will incentivize moving to clean-grid electricity for building space heating and domestic water heating. While electricity is currently more expensive than natural gas, this price gap is expected to close as the cost of carbon increases, the electrical grid is "cleaned up" through development of renewable energy generation, and electric heat pump technology becomes more efficient in the coming years.

4 Net Zero Carbon

RDH is seeing that more building owners have the goal to achieve net zero carbon emissions over the coming decades. The definition of **Net Zero Carbon** we commonly use for these projects is as follows:

> The amount of carbon emissions from on-site energy use has been minimized as much as possible, and the remaining carbon emitted will be offset through renewable energy generated on site or by purchasing carbon credits or offsets.

4.1 CAGBC Zero Carbon Building Standard

The carbon accounting methodology we use is adapted from the CAGBC Zero Carbon Building Standard v2. The Canada Green Building Council (CAGBC) launched the Zero Carbon Building (ZCB) Standard to assist the building industry's transition to zero carbon while being cost effective. ZCB Certification is not a priority for this project; however, the ZCB standard provides a framework for carbon accounting which we feel is important to outline, if not for this project, for future consideration.

The methodology referenced by the ZCB guide provides a carbon accounting framework to handle emissions from different fuel sources (e.g., electricity and natural gas), and accounts for on-site and off-site carbon offsets. The sources and sinks of carbon emissions are used to calculate the carbon balance, i.e., net emissions, as the embodied carbon plus the operational carbon minus the avoided emissions from exported renewable energy and carbon offsets.

4.2 Main Principles

RDH's four steps for achieving a net zero carbon building are outlined in the graphic below. Although net zero carbon is not a specifically stated goal for this building at this time, the following framework still applies to a deep energy retrofit plan that optimizes energy and cost savings. The process order may differ depending on project factors such as asset life cycles, budgets, etc.

4.2.1 Step 1: Load Reduction

To reduce energy consumption (and carbon emissions), the first area of focus is optimizing the heating and cooling needs of the building to achieve occupant comfort. Building heating and cooling demand can be reduced by improving the enclosure thermal performance, solar control, and airtightness.

Minimizing ventilation tempering (heating) will also significantly reduce the building load. This can be achieved by applying heat recovery technology to ventilation air.

4.2.2 Step 2: Energy Efficiency and Decarbonization

Reduced building loads require smaller mechanical equipment. This reduces energy consumption, capital costs, and can potentially reclaim mechanical room space. Fuel switching the heating from natural gas to electricity (i.e. with the use of heat pumps) can significantly reduce GHG emissions (assuming grid decarbonization) and increase energy efficiency.

4.2.3 Step 3: Renewable Energy

On-site renewable energy systems can offset the amount of electricity consumed from the grid, reducing indirect emissions associated with grid-supplied electricity. When excess power is generated, it can be exported back to the grid and is credited in the building's carbon balance.

4.2.4 Step 4: Carbon Offsets

Although the best efforts will be made to minimize the amount of carbon consumed on site, the building may still have operating carbon emissions. Operational carbon that has not been reduced by on-site energy generation such as solar PV must be offset with the purchase of green power, or through the purchase of carbon offsets.

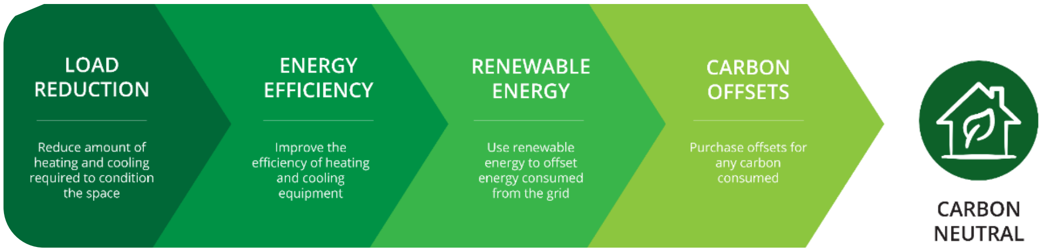


Figure 4.1 RDH's Four Steps for achieving a Net Zero Carbon Building

5 Baseline Components & Systems

5.1 Building Enclosure

The building's structure is wood framed with concrete foundations. The foundation walls which are not insulated are exposed at the east side of the building. The existing walls are clad with brick veneer and contain fiberglass insulation in the stud cavities. The exact make-up of the exterior walls is not known however, many buildings of this vintage did not include an air barrier membrane in the wall assemblies.

Aluminum framed double pane sliding windows are installed at punched openings in the brick cladding. Eight (8) of the building's 46 windows have been replaced with new, vinyl windows.

The roof is "near-flat" with an exposed roof membrane, and fiberglass insulation in the wood frame cavity.

The building includes unconditioned crawlspace under the west half of the building. The floors of the units above the unconditioned space are not insulated.

Figure 5.1 Existing Brick & Wood Panel Enclosure

5.2 Thermal Bridging

In the energy model of the existing building, the enclosure performance accounted for regular thermal bridges at cladding connections (i.e., masonry ties) as well as thermal bridging at the exposed slab edges. Thermal bridging of linear interfaces at the window and door perimeters, roof parapet, and structural transitions were not included in our analysis.

5.3 Thermal Performance

RDH calculated the existing whole wall effective thermal performance for each enclosure component (imperial units first in $ft^2 \cdot {}^{\circ}F \cdot h/BTU$, followed by metric units in $m^2 \cdot K/W$ in square brackets):

Table 5.1 Thermal Performance of Existing Constructions

Construction	Thermal Performance
Brick Clad Exterior Wall	R-9.6 [RSI-1.7]
Roof	R-13.8 [RSI-2.4]
Existing Double-Pane Windows	R-0.5 [RSI-0.1]
Foundation Walls	R-2 [RSI-0.4]

5.4 Air Leakage

According to air leakage testing conducted by HomeSol the building has an air leakage rate of 4.31 air changes per hour at a pressure differential of 50 Pascals (ACH50).

5.5 Heating & Ventilation

Heating is provided by an 80% efficient natural gas boiler. Heated water is distributed to baseboard perimeter heaters in the suites. There are baseboard heaters in the entry vestibule and a baseboard perimeter heater in the stairwell however many of the corridor spaces are unheated. There is no central cooling.

The building has no direct source of fresh air ventilation. The suites contain kitchen and bathroom exhaust fans controlled by tenants via operable switches. Exhaust fans can depressurize the building allowing air infiltration directly through the building enclosure.

5.6 Domestic Hot Water

The natural gas boiler used for heating also serves the domestic hot water load in the existing building.

5.7 Electrical

The lighting and plug loads (electrical outlets) for the building are unknown. We have assumed that the lighting fixtures are not LED. We have estimated the following electrical loads associated with lighting and other miscellaneous loads.

Table 5.2 Assumed Lighting Power Density

Zone	Lighting Power Density (W/m^2)
Suites	5.0
Corridors	7.10

Table 5.3 Assumed Plug Loads

Zone	Plug Load (Outlets) (W/m^2)
Suites	5.0

6 Energy Analysis & Modelling Process

6.1 Overview

Using data collected from the documents provided and our conversations with zzap, we performed a preliminary energy assessment of the existing building using a simplified energy model.

6.2 Enclosure Heat Loss

The pie chart in figure 6.2 shows the breakdown of the existing building enclosure and infiltration heat losses. The largest contributor to the building's heat loss is the air infiltration which accounts for 50% of the heat loss.

Approximately 20% of the heat loss is due to the exterior walls and foundation thermal bridge ("below grade"). The aluminum windows and doors contribute 12% of heat loss. The roof contributes only 8% and finally exhaust fan ventilation contributes 8%.

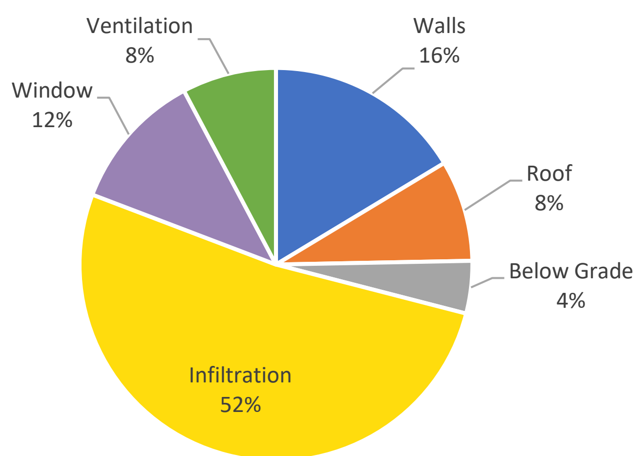


Figure 6.2 - Enclosure Heat Loss Breakdown

6.3 Utility Bill Analysis

The average monthly electricity and natural gas consumption in equivalent kilowatt hours is shown in Figure 6.3 below. The electrical data spans from 2019 to 2023 while natural gas data is from 2021 to 2023. The electrical usage data was provided as a yearly total. We have assumed that loads remain relatively constant year-round as there is no electric space conditioning, and the electrical loads are driven by occupants (lighting and outlet (plug) loads). The natural gas heating contributes to most of the yearly energy consumption and will be the most impactful system to tackle to reduce GHG emissions.

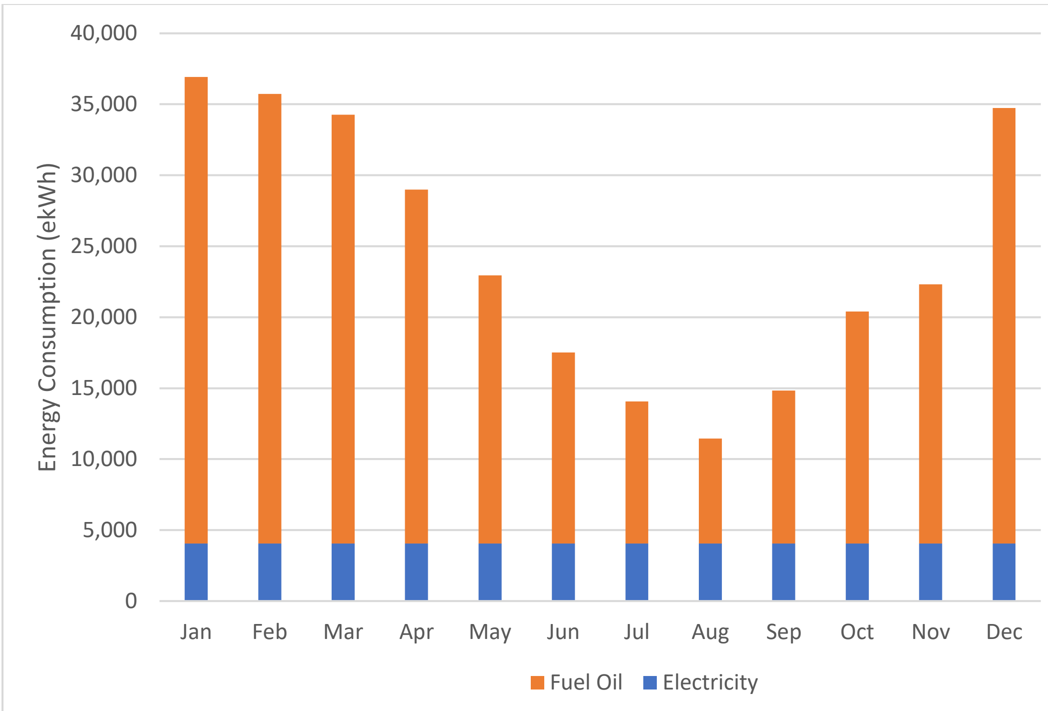


Figure 6.3 – Average monthly energy use for the 54 Jackson Building

From our review of the electricity and natural gas utilities, we have determined the cost of electricity and natural gas at the site as follows in Table 6.3.

Table 6.3 – Utility per unit costs

Source	Cost ($/ekWh)
Electricity	0.157
Natural Gas	0.081 [$0.85/m^3]

We performed a high-level calibration of the representative energy model to align with the building's electricity and natural gas utility data. Inputs for the energy model were adjusted to approximate the reported consumption of the building. This preliminary energy analysis is intended to quantify opportunities to improve energy performance with retrofit strategies.

7 Existing Building Results

7.1 Energy Model Results

The energy model generates the results presented on this page, based on the components and systems discussed previously in this report. The modelled Greenhouse Gas Intensity (GHGI), Energy Use Intensity (EUI), and Thermal Energy Demand Intensity (TEDI) are defined as:

→ **GHGI**: The total greenhouse gas emissions associated with the use of all energy utilities on site divided by the conditioned floor area.

→ **EUI**: The sum of all energy used on site (i.e. electricity, natural gas, and district heating and cooling), minus all Site Renewable Energy Generation, and divided by the conditioned floor area.

→ **TEDI**: The annual heating delivered to the building for space conditioning and conditioning of ventilation air divided by the conditioned floor area.

The intensity (dividing by floor area) of each of these factors is critical to compare similar building types of different size. We have included the EUI of average multi-unit residential buildings (MURBs) surveyed by NRCan conducted in 2018 for comparison.

The end-use breakdown for GHGI and EUI are shown in Table 7.1 and Figure 7.1 below.

The EUI of 285 kWh/m^2 for the existing building is higher than the NRCan Survey of existing MURBs in 2018. It is likely that the high level of air infiltration causes the variance between the 54 Jackson building and typical values.

Table 7.1 Summary of Existing Building Energy Model Results

ANNUAL METRICS	EXISTING
GHGI (KGCO$_2$/M^2/YR)	65
EUI (KWH/M^2/YR)	285
TEDI (KWH/M^2/YR)	135
NATURAL GAS (MBTU)	840
ELECTRICITY (kWh)	44,000
CO$_2$E (TONNES)	65
NATURAL GAS COST PER YEAR	$19,900
ELECTRICITY COST PER YEAR	$7,200
TOTAL UTILITY COST PER YEAR	$27,100

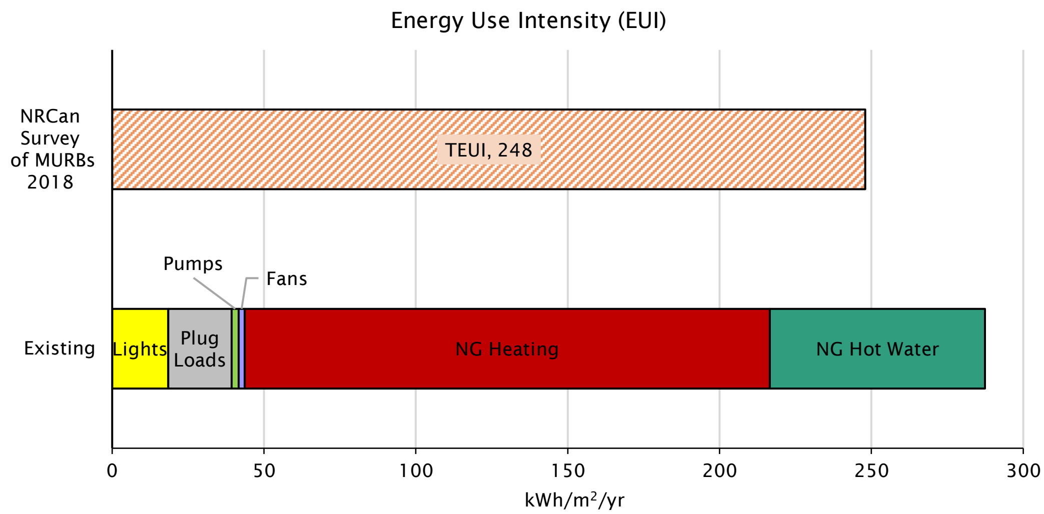


Figure 7.1 – Existing building energy model EUI

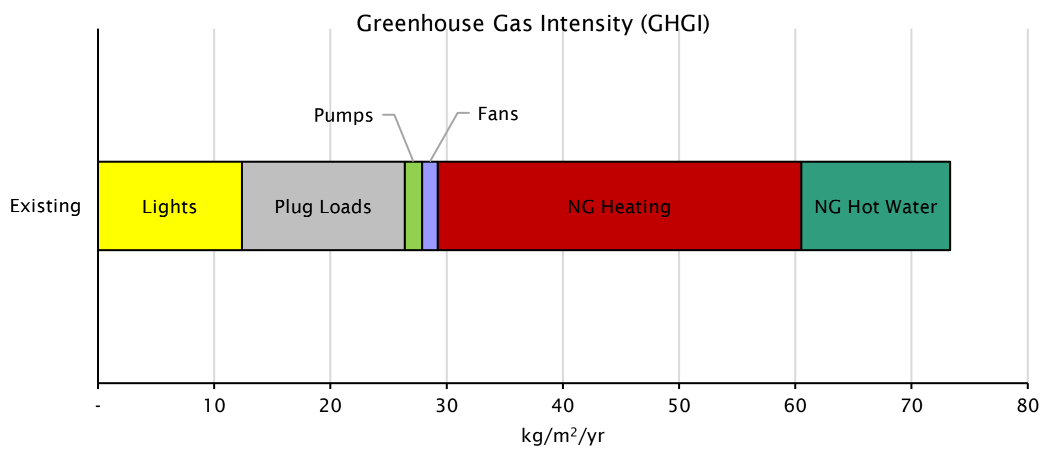


Figure 7.2 – Existing building energy model GHGI

8 Retrofit Strategies

The goal of this retrofit is to provide the maximum cost and carbon savings. Our recommendations include the best-practice upgrades increasing occupant comfort and well-being where possible.

As discussed in section 2.3, retrofit strategies should first target load reduction, then increase the efficiency of systems and finally implement low-carbon sources. We have also tailored our retrofit strategies to target minimal interior work required in tenants living spaces.

The retrofit packages recommended in this report are categorized as a deep retrofit addressing most aspects of the building and include addressing the building enclosure system.

Our retrofit recommendations are categorized as **Phase 1 Retrofit** and **Phase 2 Retrofit** strategies. We recommend implementing both phases of the retrofit. The phases were broken up into two separate phases to show incremental savings from the incorporated measures. The implementation of these phases could be staggered based on available funding or timing. For the purposes of this study, each phase of the retrofit was conducted in the same year.

8.1 Enclosure

The **Phase 1 Retrofit** strategy improves the whole building enclosure performance by installing prefabricated wall and roof panels over the existing assemblies. Installing prefabricated panels vs. a cladding replacement can reduce the construction time required and minimize disturbance to tenants. We evaluated the following panelized systems and will include our analysis in a separate report:

- → Nexii – Nexiite concrete sandwich panel
- → Trimo QBiss One – Insulated metal panel
- → Dextall – Metal framed panel
- → Dryvit – Fedderlite EIFS panel

All evaluated panelized systems can increase the existing wall insulation value by an approximate R-20. Including the existing walls an effective R-30 retrofitted wall is achievable. In addition to the increased thermal performance through added insulation, the addition of a dedicated air/water barrier, combined with careful design and implementation, will result in increased durability, and reduction in air leakage across the building enclosure. It is challenging to quantify the air leakage values prior to post-retrofit air leakage testing, but we have made assumptions using standard industry values. Roof insulation can be increased with panels or removal and replacement of the roof membrane with additional insulation.

In general, the existing windows and doors are at the end of their useful service life and should be replaced. This enclosure package would upgrade the windows and doors thermal performance with new vinyl windows and thermally broken entryway doors.

Due to the reduced fresh air from air leakage through the building enclosure, dedicated ventilation is required to be installed in addition to the building enclosure upgrades.

8.2 Ventilation

We recommend installing in-suite energy recovery ventilators (ERVs) to meet ventilation requirements and recover heat from the exhaust stream. Ventilation provides the units with fresh air and reduces smells in the units. Ventilation heat recovery allows the heat from the exhaust ventilation air to be transferred to the cold incoming ventilation air by conduction. Heat is transferred through a medium so that the incoming and exhaust air streams do not mix. High-effectiveness ERVs can recover approximately 80% of the energy from the exhaust air.

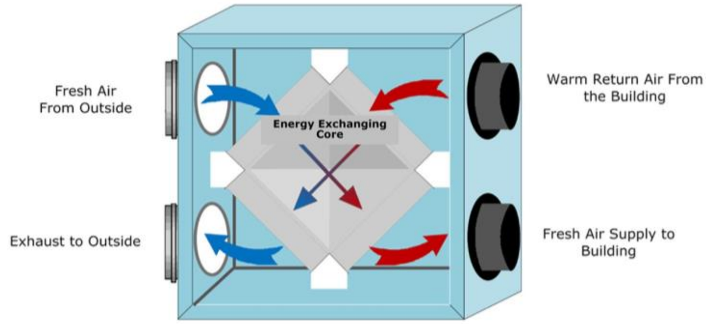


Figure 8.1 Example of Energy Recovery Ventilator

For buildings with centralized existing ductwork, ERVs can often be installed into the existing ducts. As the 54 Jackson building has no central system, we recommend installing through-wall ERVs that do not require any ducts such as the Lunos e2 system. The through-wall ERVs can be combined with the panelized retrofit; however, suite entry and resident disruption are required to create penetrations in the existing wall for the ERV installation. To meet code required ventilation levels a minimum of two (2) through wall ERVs should be installed in each unit. These ERVs would be located in the main bedroom and living area.

The existing exhaust fans in the washrooms and kitchen could be retained to provide area-specific exhaust. We recommend installing timer-controlled switches on these existing systems as energy from the existing system exhaust air would not be recovered by the ERVs.

8.3 Mechanical Systems

8.3.1 Central System

The **Phase 2 Retrofit** will build on the enclosure upgrade and include mechanical system upgrades. The reduced loads from the **Phase 1** enclosure upgrades allow more efficient and smaller sized systems to be chosen, reducing cost significantly.

The existing building has hydronic heating meaning hot water flowing through pipes to each unit to provide heat. 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) can replace the existing gas boiler to improve the efficiency and replace fossil fuel burning with electricity. The AWHP transfers heat from the ambient air to water for heating, or transfers heat from water to the ambient 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.

Air-to-water heat pump technology is constantly improving, especially for cold climate applications. However, in the winter, the efficiency and capacity of the unit can drop significantly at low outside temperatures and these systems have a cut-off temperature, below which the unit will not work. As a result, a “back up” system (typically a boiler) is required to make up the difference on the coldest days. In scenarios where the ambient temperature is below the heat pump’s operating range (typically around -15 C), the boiler is required to act as the sole heat source. It is possible to use a natural gas boiler or electrical boiler as a back-up. Having a natural gas boiler gives added redundancy of fuel sources and currently lower cost fuel. We recommend installing an electrical back-up boiler to completely switch fuel type from natural gas to electricity. As the Nova Scotia electrical grid continues to be sourced by more renewable energy sources the electrical boiler will reduce carbon emissions and provide savings on future carbon taxes. In order to serve the electrical back-up boiler and AWHP the building transformer will need to be reviewed by and electrical engineer and may need to be improved to serve the demand from the electrical systems.

As discussed in section 2.2 above, cooling is increasingly becoming an important consideration for occupant comfort, health, and safety. Halifax's future weather predictions indicate cooling will be necessary to ensure occupant comfort. 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).

8.3.2 In-Suite Systems

The existing boiler serves hydronic perimeter baseboards in the suites. Currently the suites do not have dedicated cooling systems.

Replacing the existing boilers with AWHPs will require an upgrade to the perimeter heating system to accommodate lower temperature water provided by the heat pump and include cooling. Perimeter fan-coil units (for example, the Briza unit by Jaga) can provide hydronic heating and cooling served by the AWHP. A perimeter fan coil system would be located in place of the existing perimeter baseboards in each room requiring heating or cooling. The perimeter fan coil can be installed either in wall as shown below or at the base of the wall similar to the current convectors. These systems are similar to a baseboard with a small, low energy fan recirculating air over the heating/cooling coils to heat or cool the room. Electrical service to these perimeter units would be required with the installation.

Figure 8.2 - Example of a Perimeter Fan Coil Unit Replacing a Radiator

An alternative solution for in-suite heating and cooling is ducted fan coil units. Ducted fan coil units come in either vertical or horizontal layouts. Vertical fan coils can be installed in a small (approximately 1m by 1m) closet while horizontal fan coils can be installed in existing drop ceilings such as in washrooms with overhead plumbing. The ducted fan coils require ducts to be installed throughout units to distribute the heated/cooled air.

Mini-split systems could be installed in-lieu of fan coil units to reduce resident disruption; however, these systems do not take advantage of the existing building infrastructure and would come at an increased cost.

8.3.3 Domestic Hot Water

Similar to the existing system, we recommend combining the domestic hot water system with the central heating system to provide heated water. This takes advantage of the additional heating efficiency of the heat pump and switches the fuel source to electricity. The domestic hot water system requires additional storage tanks and uses the electric boiler to "top-up" the water beyond the capability of the heat pump to 60C.

8.4 Additional Retrofit Opportunities

8.4.1 Domestic Hot Water

The existing showerheads and kitchen and washroom faucets should be replaced with low flow fixtures. This will reduce the DHW load by reducing water consumption. As existing fixtures are unknown this has not been included in the energy model upgrades.

8.4.2 Lights

All lights should be replaced with LED or LED retrofit kits. As existing lighting fixtures are unknown this has not been included in the energy model upgrades.

8.4.3 Plug Loads

Additional electrical load reduction can be achieved with Energy Star rated appliances.

9 Phase 1 Retrofit Matrix

	Existing Building		Phase 1 Retrofit	
Architectural				
Roof	"Near-flat" roof assembly with ½" gypsum board and fiberglass batt insulation	R-13.8	Increased roof insulation through re-roof or new panels	R-40
Exterior Wall Panel	Alternating brick and wood panel cladding with fiberglass batt insulation	R-9.6	Panelized walls	R-30
Exterior Glazing	Non-thermally broken aluminum framed double-glazed horizontal sliding windows	R-2	New Vinyl Double Glazed Windows	R-4
Air Leakage	Blower door test report	4.31 ACH50 (~5 L/s/m² @ 75 Pa)	U.S. Army Corps of Engineers (2012)	1.27 L/s/m² @ 75 Pa
Ventilation	Exhaust from kitchen and Bathrooms and via air leakage	N/A	Addition of in-suite energy recovery ventilators (ERVs)	~80% Effective ~50 cfm/suite

1) All R-values are effective R-values with units of ft2·F·hr/ BTU. Estimated effective R-values include the anticipated impact of thermal bridging at the slab edge based on experience. Thermal calculations have not been conducted for this study.
(2) Assumes new IGUs include low-e coating(s), argon gas fill, and warm edge spacers.

10 Phase 2 Retrofit Matrix

		Existing Building		Phase 2 Retrofit	
Mechanical					
Heating/Cooling	Central	One natural gas fired boiler No cooling	80% Efficient	Central air-to-water heat pumps (AWHPs) to provide heating and cooling with back-up electric boiler	COP 3.0 (~300% Efficiency)
Heating/Cooling	In-Suite	Hydronic perimeter baseboards	N/A	Heating and Cooling with hydronic perimeter fan-coil units	-
Domestic Hot Water	Plant	Served by heating boiler	82% Efficient	Combined with AWHPs and electric boiler	COP 3.0 (~300% Efficiency)
Domestic Hot Water	In-Suite	Normal flow water fixtures	Various flow rates	Low flow water fixtures	No savings modelled
Lighting		Unknown fixtures		Retrofit all lighting to LED	No savings modelled
Plug Loads		Unknown appliances		Consider Energy Star appliances	No savings modelled

11 Retrofit Results

Greenhouse Gas Intensity (GHGI), Energy Use Intensity (EUI), and Thermal Energy Demand Intensity (TEDI) for the existing building and both retrofit paths are summarized in table 11.1 below. Appendix A includes additional model results. The table also includes the absolute consumption of natural gas and electricity, along with the utility costs. The utility costs used were $0.16/kWh for electricity and $0.85/m3 for natural gas according to our utility bill analysis. Total greenhouse gas emissions for present day (2023) and 2030 emission rates are included. The 2030 emission rate is based on the current emission factor according to the Zero Carbon Workbook Emission Factors reduced to a level of 80% renewable sources predicted by the government of Nova Scotia. It is possible that the electrical emission factor may be reduced further if coal plants are shut down, leaving the remainder of the 20% non-renewable, electrical generation to natural gas as coal has a very high emission factor. The emission rates used in the analysis are summarized in table 11.2 below. Further discussion on emission rates and carbon cost are included in Section 12 – Future Energy Cost Analysis.

Table 11.1 – Retrofit Results

ANNUAL METRICS	EXISTING	PHASE #1	PHASE #2
GHGI ($KGCO_2/M^2/YR$)	73	62	81
EUI ($KWH/M^2/YR$)	285	220	120
TEDI ($KWH/M^2/YR$)	135	75	75
GHGI 2030 (KGCO2/M2/YR)	53	40	24
NATURAL GAS (MBTU) [ekWh]	840 [245,000]	590 [175,000]	0
ELECTRICITY (kWh)	44,000	46,000	123,000
CO2E (TONNES)	75	65	80
NATURAL GAS COST PER YEAR	$19,900	$14,100	$-
ELECTRICITY COST PER YEAR	$6,900	$7,300	$19,200
TOTAL UTILITY COST PER YEAR	$26,800	$21,400	$19,200
SAVINGS COMPARED TO EXISTING	$-	$5,400	$7,600

Table 11.2 Emission Rates used for Analysis

	2023	2030
Electricity kg CO2/ekWh	0.67	0.20
Natural Gas $kgCO2e/m^3$	1.90 (0.181 kg CO2e/ekWh)	1.90 (0.181 kg CO2e/ekWh)

The goal of an energy retrofit is to reduce energy consumption (the EUI metric) and carbon emissions (the GHGI metric). Reducing carbon emissions will limit carbon costs in the future as government carbon prices increase and will also reduce the building's contribution to climate change. The GHGI vs. TEUI graph shown in figure 11.1 below illustrates the existing and post-retrofit performance metrics for 54 Jackson.

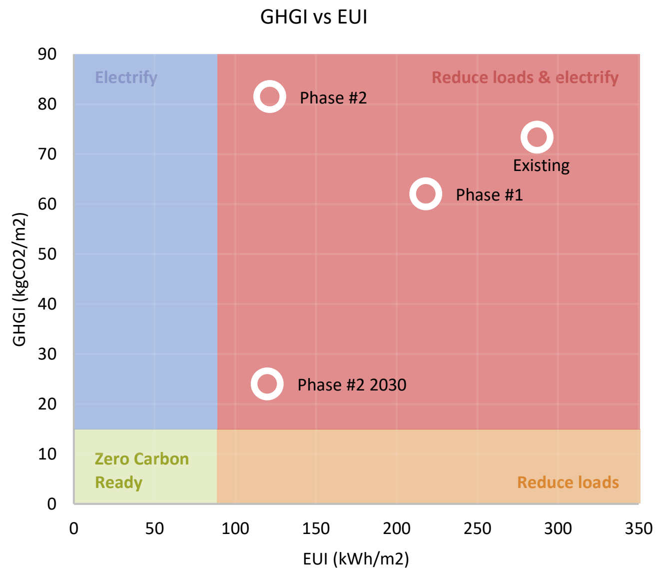


Figure 11.1 – GHGI vs. EUI for retrofit phases

The red quadrant (top right) indicates that the building improvement projects should focus on reducing loads, improving equipment efficiency and electrifying. While Nova Scotia currently has an emission-intensive electricity grid, the provincial goal of meeting 80% of electrical generation through renewable energy means that electrification of buildings systems will result in future carbon emission reduction.

The **Phase 1 Retrofit** reduces the loads through a full enclosure overclad, and window upgrades. It also includes in-suite ERVs which adds additional outdoor air that must be conditioned. Fan consumption and additional outdoor air associated with the ERVs does not reduce energy or carbon but greatly improves occupant comfort and is necessary for good indoor air quality due to the reduced air leakage following building enclosure improvements.

The **Phase 2 Retrofit** path includes everything in the **Phase 1 Retrofit** plus electrification of the heating plant, and domestic hot water (DHW) and the addition of cooling.

The **Phase 2 Retrofit** strategy reduces energy use with high efficiency electric ASHPs for heating and cooling. The addition of cooling (increasing electrical energy use) and the high carbon intensity of Nova Scotia's current electricity grid results in an increase in GHGI compared to the existing building. When compared to the estimated 2030 emissions factor of the energy grid the **Phase 2 Retrofit** provides significantly reduced GHGI.

The Energy Use Intensity (EUI) and Greenhouse Gas Intensity (GHGI) are shown in figures 11.2 and 11.3 below.

- → In the **Phase 1 Retrofit**, the EUI is reduced by 25% and the GHGI by 15%. The TEUI reduction is due to the load reduction from the enclosure replacement.
- → In the **Phase 2 Retrofit**, the EUI is reduced by 60% and the GHGI by 55% (using 2030 emissions rates). The savings compared to the **Phase 1 Retrofit** are a result of the central AWHP (even with the addition of cooling).

In the **Phase 1 Retrofit** the majority of the savings come from reduced air leakage and increased wall insulation. In the **Phase 2 Retrofit** path the majority of the savings come from increased efficiency of the central heating system.

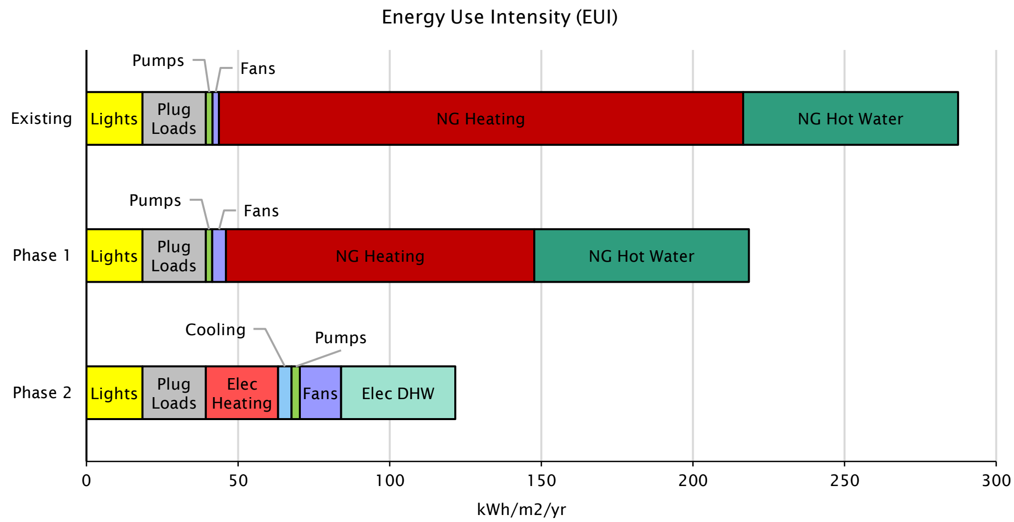


Figure 11.2 – EUI of retrofit phases

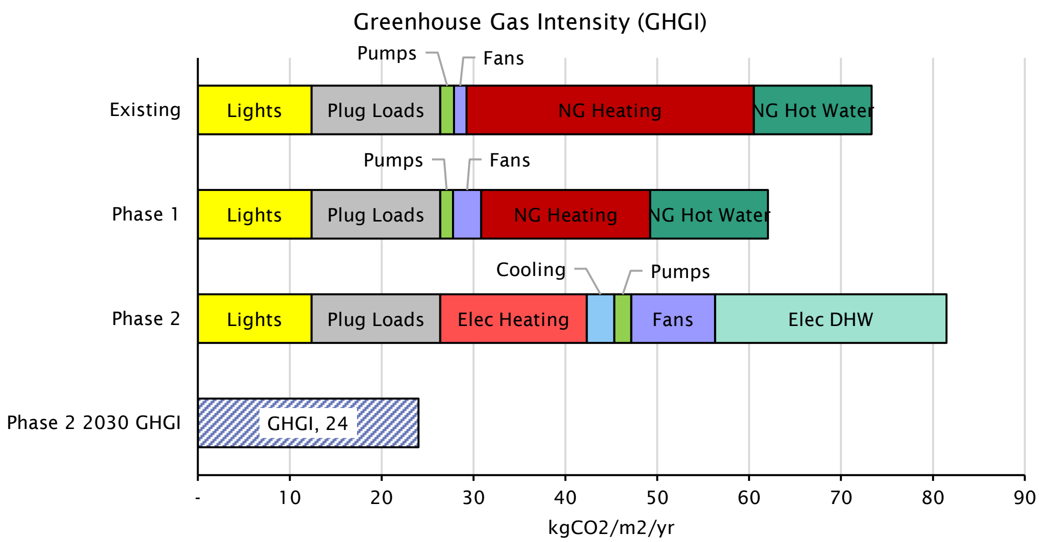


Figure 11.2 – GHGI of retrofit phases

11.1 Benefits

A future high-performance enclosure will bring the building into alignment with one of the basic principles of Passive House and Net Zero design approaches: reduce loads at the source. Enclosure improvements will not only improve building performance due to reduced heating requirements, but it will also enable a broader range of efficient space conditioning strategies for future HVAC system replacement cycles, resulting in even deeper energy and GHG savings.

Other benefits of improving the building enclosure thermal performance include:

→ Improved thermal comfort

→ Fewer “cold spots” and drafts

→ Reduced interior condensation on windows and doors in winter

- → Improved durability by keeping all structural components warm which reduces risk of concealed condensation and deterioration
- → Improved resiliency and passive survivability in the event of power loss during cold weather
- → Aesthetic improvements with new façade design
- → Extended building life and durability

The in-suite mechanical ERV units ensure that the residents get adequate amounts of ventilation after improving the enclosure's airtightness. Other benefits of ERVs include:

- → Enhanced indoor air quality
- → Enhanced thermal comfort
- → Quiet ventilation
- → Building enclosure durability due to balanced airflow

The addition of an AWHP for heating has the bonus function of cooling and also provides comfort for building occupants.

11.2 Drawbacks

The improvement of indoor air quality and occupant comfort through ventilation systems and addition of space cooling requires additional energy, and the carbon intensity of the current electrical grid means that retrofit strategies focused on electrification do not have immediate impact on carbon emissions that can be seen in other provinces. However, this analysis does not include reduced maintenance costs, potential rent increases, or enhanced resale value due to these improvements or other factors of having a high-performing and resilient building.

12 Future Energy Cost Analysis

We conducted a future energy cost analysis (FECA) for the existing building, Phase 1, and Phase 2 retrofits described above. The analysis uses RDH's energy modelling conducted for the Deep Retrofit report. For each scenario, we assumed that the operation of the building does not change year over year. For example, loss of equipment efficiency due to degradation or changes in future weather is not captured in this analysis.

This analysis is focused on energy and carbon pricing and does not include replacement cycles and maintenance costs.

The FECA uses the following parameters:

STUDY PARAMETERS	VALUE
STUDY PERIOD (YEARS)	20
FUEL COST INFLATION	2%
CARBON PRICING	See Figure 12.1
GHG EMISSION RATES	
ELECTRICITY 2023 ($kgCO_2e/kWh$)	0.67
ELECTRICITY 2030 ($kgCO_2e/kWh$)	0.20
ELECTRICITY 2050 ($kgCO_2e/kWh$)	0.05
NATURAL GAS ($kgCO2e/m^3$)	1.8277

GHG emission rates are based on the Nova Scotia Climate Change Plan Progress Report as described in section 3.2.

12.1 Federal Carbon Pricing

As described in the Deep Retrofit Report, the federal carbon price is set per tonne of carbon emission, and the current (2022) price is $50/tonne as of April 1, 2022. The price escalates annually until 2030 when the price reaches $170/tonne. After 2030, the Government of Canada uses an internal shadow carbon price of $300/ tonne, and we anticipate that this will be the carbon price by 2050.

This study linearly escalates the carbon price from $170/tonne in 2030 to $300/tonne in 2050.

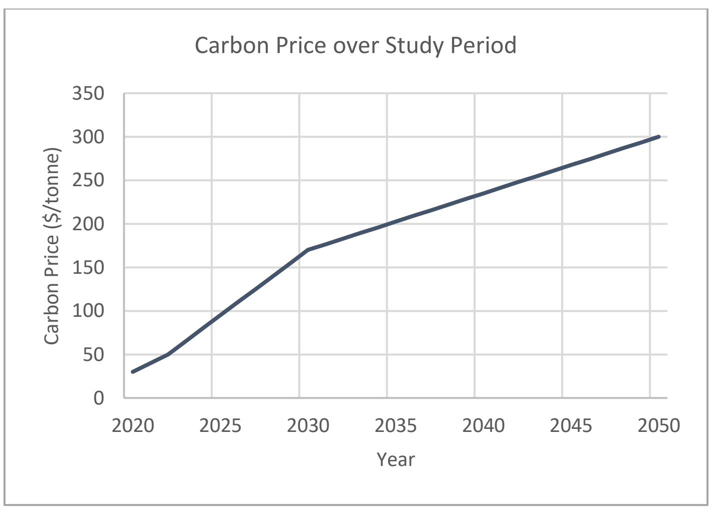


Figure 12.1 – Federal carbon price

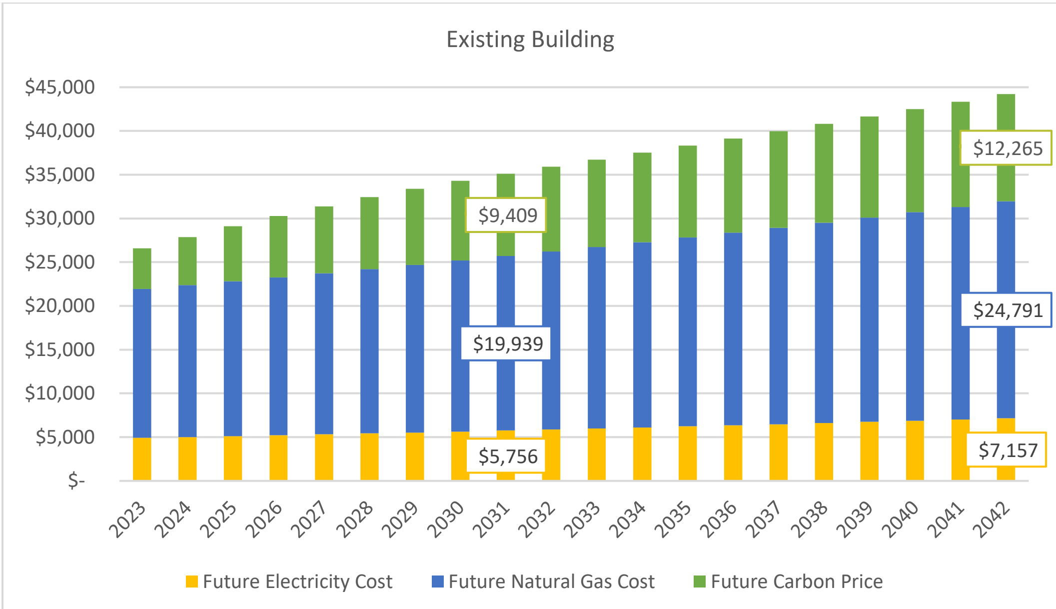
We used the following references for emission factors and carbon pricing:

- CaGBC Zero Carbon Building Standard (references Canada's National Inventory Report and ENERGY STAR)
- Pan-Canadian Approach to Carbon Pollution Pricing 2023-2030
- Federal Carbon Pricing shadow price as identified by the Treasury Board of Canada

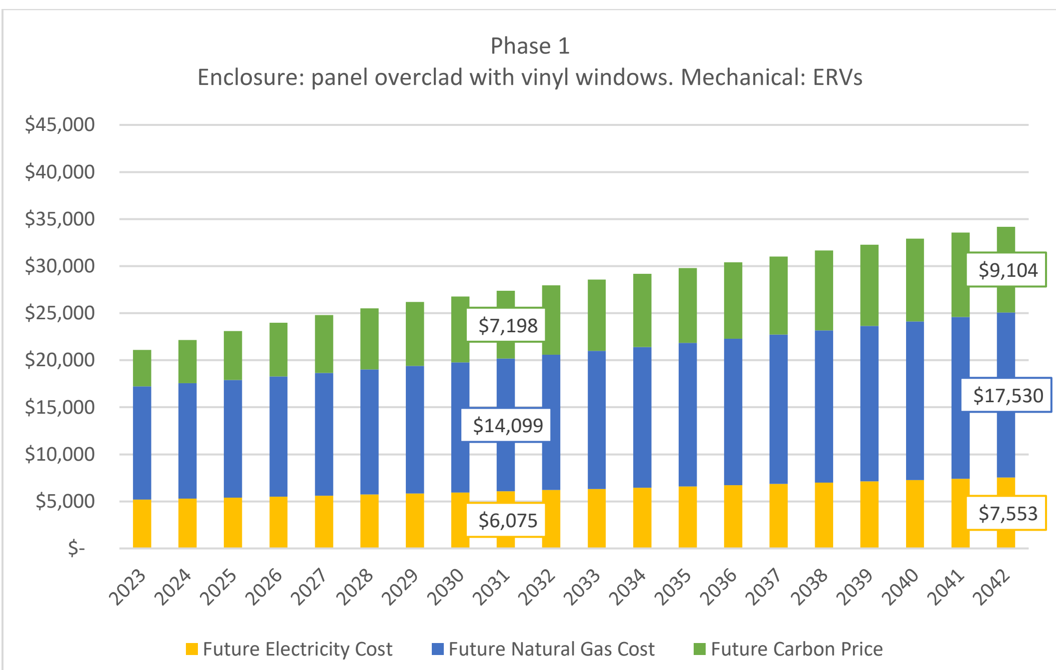
12.2 Energy + Carbon Cost Results

The following graphs illustrate the average yearly electricity, natural gas, and carbon costs for each of the three scenarios over twenty years.

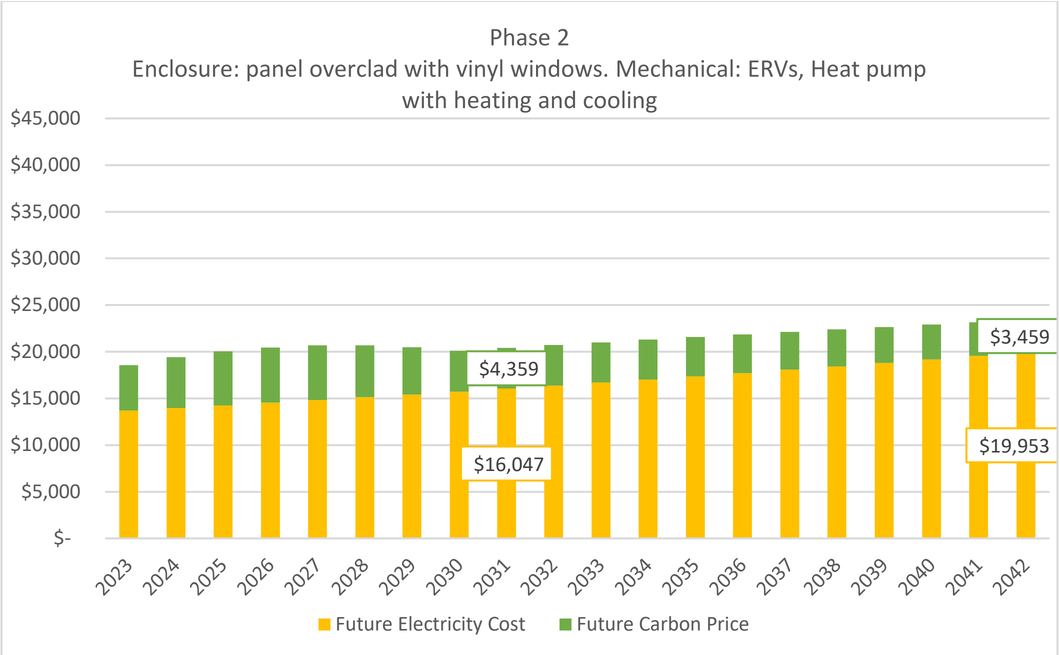
In each of the scenarios, the cost of carbon grows year on year due to the increase in carbon pricing. Where natural gas is the primary source of space heating and domestic water heating, carbon emissions due to natural gas combustion make up the bulk of the building's operating carbon emissions.



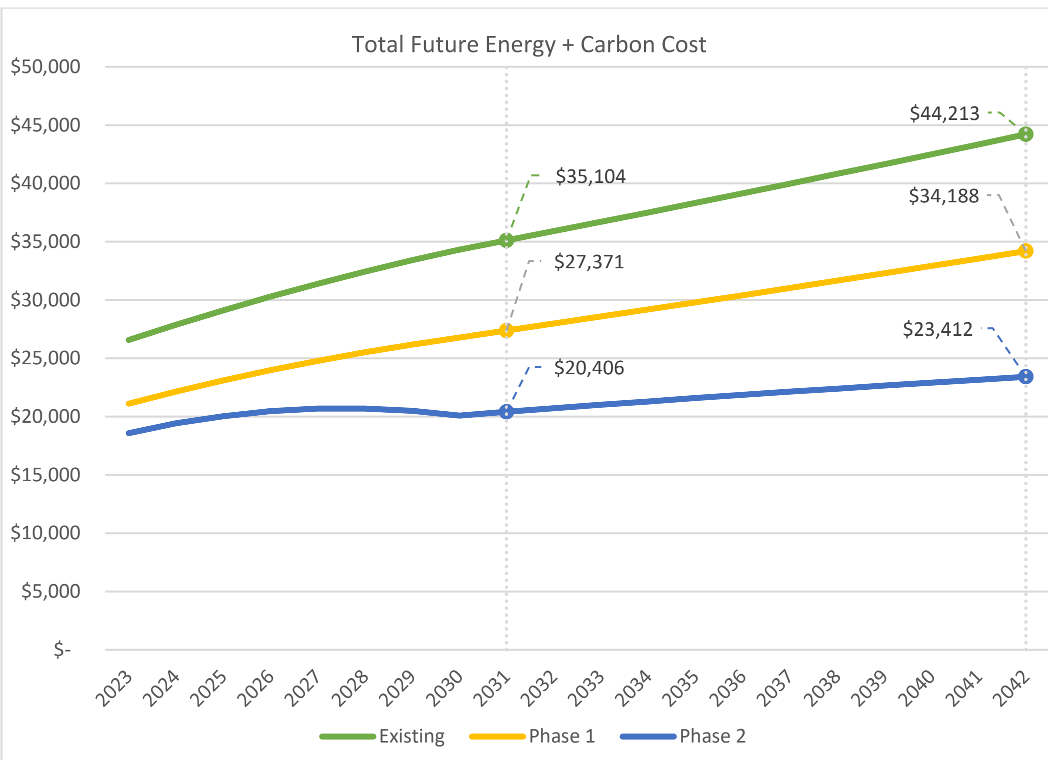
Phase 1 shows a reduction in natural gas and carbon costs with a similar electrical cost. As this option still relies on fossil fuels for heating, the future carbon price is a significant portion of the overall costs.



In the fully electrified retrofit Phase 2, the future reduction of emissions from the electrical grid and increasing carbon pricing lead to similar levels of carbon price throughout the study period.



Both retrofit strategies are predicted to result in reduced operating costs compared to the existing building.



13 Cost Analysis

Our Class D cost estimates for enclosure and mechanical retrofits are summarized in Table 13.1 below. Costs for retrofit work are highly dependent on the condition of the existing building, local labour, and local manufacturer/supplier costs. There is also currently high variability in construction pricing due to recent supply chain issues, labour availability, and interest rate increases, among other factors. Due to this variability, we have provided a range of costs for the construction project. The costs do not include information for proprietary panelized systems. Cost estimates also do not include for local applicable taxes, permit costs, zoning application costs (if required), consultant fees, or other "soft costs."

The costs for the low end of the range are based on pricing from RS Means costing software for building enclosure components. The low end of the range does not include contingencies for work that depends on integration with existing systems, and the type/condition of some existing building systems that are currently unknown (such as water pipes hidden in walls and equipment in resident suites). The mechanical system cost is based on an early estimate from a local manufacturer and installer of the proposed mechanical system.

The costs for the high end of the range include our experience with recent supply chain issues, detail conditions for the existing building, and higher aesthetics/finishes. Please note that the cost estimates are provided for initial planning purposes only. Tendering the work will provide a true reflection of costs in the market at that time.

TABLE 13.1	RETROFIT COSTS	
EXTERIOR WALL	Insulated Metal Panel System	$220,000 - $340,000
GLAZING	Double-glazed	$50,000 - $100,000
ROOF	Single-Ply Roof Membrane and Insulation	$70,000 - $100,000
VENTILATION	In-Suite ERVs	$65,000 - $100,000
HEATING & COOLING (Includes Domestic Hot Water)	Central Heat Pump and In-Suite FCUs	$120,000-360,000
CONSTRUCTION TOTAL	**$525,000 - $1,000,000**	

Based on these cost estimates and the reduced operating costs described in Section 12, there is a potential for the building retrofit to have a positive Net Present Value compared to the existing building in approximately **40-70 years**. This means that the capital costs (construction costs) of the building retrofit will be offset by the savings in energy and carbon usage in 40-70 years. The net present value calculations include a 2% inflation rate and a 2.5% interest rate applying to costs in future years.

These costs do not include maintenance costs for either of the scenarios. The maintenance costs will increase with the full retrofit package option as there is more mechanical equipment to replace. Note however that the added maintenance costs will be partially offset as the existing mechanical systems would also need to be replaced during this time frame. Further, benefits such as increased durability, climate resiliency, improved "curb appeal" (aesthetics related to tenant attraction), and occupant health and comfort are not quantified in this study and could also lead to the ability to charge higher rental rates.

14 Conclusion

14.1 Next Steps

This report presents conceptual-level recommendations with respect to retrofit activities. It is important to understand that these recommendations do not provide a basis for implementing remedial work. The conceptual recommendations will need to be developed, refined, and specified in detail before the construction work can be tendered to contractors.

The next step typically begins with the design process where the consultant assists in decision making with respect to specifics of the rehabilitation program. Once decisions are made, the selected design is developed and documented in greater detail using drawings and specifications. These documents describe the exact extent and nature of the remedial work, materials to be used, etc.

The drawings and specifications are used to obtain bids from prequalified contractors and to obtain a building permit to carry out the work. Once a contractor has been selected, the project can move into the construction stage. During this stage, the remedial work program that has been designed by the consultant (with owner involvement and agreement) is implemented, and repair and reconstruction takes place on-site. The consultant administers the construction contract and undertakes periodic field reviews of construction as the work proceeds. It is also common for the consultant to provide a maintenance and renewals plan (or update an existing plan) for the rehabilitated enclosure assemblies upon completion of the construction.

14.2 The Performance Gap

"The Performance Gap" refers to a difference between designed (intended) and actual energy performance after retrofit work is complete. Sometimes the causes can be outside of the design team's control, such as how the building is used and the occupant behaviour. Steps to reduce the risk of a performance gap can be taken through the design, construction, and operation of a building. To mitigate the performance gap, consider project goal and target setting with regards to carbon reductions and utilizing an energy consultant to develop and update an energy model to track construction progress against the project goals. Commissioning, and Measurement and Verification are valuable services once the retrofit is complete to ensure the building is performing as intended.

14.3 Closure

The energy calculations completed for this report were based on information provided by the zzap team and through the drawings and documents identified in the References section. 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.

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

Yours truly,

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Appendix A

Energy Model Inputs and Assumptions