Panelized Retrofit Toolkit

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Contents

Introduction

This toolkit is the summation of several studies on the potential for panelized retrofits in Nova Scotia, and particularly a 2-storey, 19-unit residential building in Dartmouth, owned by **VIDA Living**. **Retrofit Canada** defines a panelized retrofit as using "cutting-edge imaging technology to design pre-built panels. This toolkit can provide general information for those curious about this type of process as well as introductory technological information for more seasoned property owners, project managers and technical workers. These airtight, super-insulated panels are built offsite and attached to the outside of existing buildings." It is sometimes called a Prefabricated Exterior Energy Retrofit, or PEER. A key advantage is minimizing disturbance to tenants during retrofits.

There are thousands of similar apartments in similar buildings across the province. The buildings are simply shaped rectangular structures built before the last significant building code update in the 1990s. They are usually inefficient users of energy and collectively emit a great deal of greenhouse gas, contributing to climate change. There is therefore a significant greenhouse gas and cost reduction opportunity to retrofit such buildings, improving their envelopes and insulation, and updating their mechanical systems for electrification and greater efficiency.

To complete this study, **Ecology Action Centre** worked first on extensive scoping with **BeFreeHomes**, then with **Zzap Architecture and Planning** in Dartmouth, and **RDH**, experts in building science, design, and construction. We also enlisted **Sean Kelly Consulting** to develop contextual information about panelized retrofits across Canada: what has been done, studied, or planned in this field. So far, no panelized retrofits have been completed in Nova Scotia. Our hope is that this document will inform property owners and others considering this method about its options, important considerations, challenges, and benefits.

This work would not have been possible without the generous financial support of the **Halifax Climate Investment, Innovation and Impact Fund** (HCi3), an initiative of **Low Carbon Cities Canada** (LC3).

Completed/In-Progress Panelization Projects

Sundance Housing Co-op

The **Sundance Housing Co-operative** offers affordable housing and community living in Edmonton, Alberta. Currently, Sundance is leading the largest panelized Deep Energy Retrofit undertaken in Canada.

This retrofit will reduce the energy needs of Sundance Housing's buildings by 70-80% and eliminate the need for gas lines. The Co-op is also installing solar panels that will produce more than 75% of the remaining energy demand. The balance will be purchased from off-site renewable sources.

In 2019, the Sundance co-op members voted in favour of an Energiesprong-inspired Deep Energy Retrofit pilot; NRCan committed $2.5 million for Sundance to pilot Deep Energy Retrofit technology on two units (now complete) and future retrofits on 57 more units. Work began in 2019, and the total cost of the retrofit at completion – which, uniquely, can be considered a whole-community retrofit – will be just over $7 million. The Co-operative is dipping into its renovation fund and secured a long-term mortgage to cover the balance of costs.

Sundance is managing the project, working side-by-side with companies **Butterwick Projects** and **Communitas** as the construction progresses. Sundance wants to help pave the way for a Canadian movement for panelized Deep Energy Retrofits by sharing what they've learned with other co-ops, housing associations, and anyone else who may be interested in making their homes ready for net-zero.

Highlands Panelized Deep Retrofit

Also in Edmonton, the same design team from the Sundance Co-op project – Butterwick Projects – worked on Jim Sandercock and Melanie Harmsma's retrofit, the first panelized, Energiesprong-inspired deep retrofit of a private home in Canada.

Peter Amerongen, one of the founders of **Retrofit Canada** and a partner at Butterwick, worked with the 3D computer modelling done by Logan Gilmour on the 1,950-square-foot 1951 home to design the pre-built panels.

The panels were installed in less than a day and fit within design tolerances. The new windows were factory-installed to reduce disruptions for the owners. Butterwick and Jim Sandercock are monitoring the retrofit's energy performance.

There were a few challenges that should be considered by other homes undertaking similar panelized retrofits:

- Project management was at times complicated even with a panelized approach that required less labour and demolition.
- Due to the 1951 home's age, there were several unexpected challenges that required significant remediation.
- Adding a new, airtight, super-insulated roof right on top of the old one took more time because the home had a complex roof that included dormers (vertical windows framed in a slanted roof).

Several other single-family homes in the Edmonton area are currently duplicating this Prefabricated Exterior Energy Retrofit (PEER) process.

Ottawa Community Housing's PEER pilot

With around 6,000 townhome units built between 1960 and 1980 among their housing stock, all at a life-cycle tipping point (without maintenance they could become derelict), Ottawa Community Housing (OCH) developed a strategy for renewing these assets and bringing them to Net-Zero greenhouse gas emissions, meaning they would emit none or offset any emissions. They started in 2018 with a Prefabricated Exterior Energy Retrofit (PEER) demonstration pilot of an occupied four-unit block of townhomes.

After a year of feasibility testing, a business case was then presented to – and approved by – the OCH Finance Department. The case study showed there could be energy savings of over $500,000 if the building was to be held as a long-term asset. (They also secured a $500,000 contribution from Natural Resources Canada.)

In 2019, they engaged mechanical, electrical, and structural engineers, architects, and a dedicated panel designer to put together the retrofit specifications. Once they had an approved building permit, the team began construction and site preparation.

In 2020, The OCH team created an offsite fabrication facility and panels were delivered to the construction site. In addition to exterior panels, each unit received a heat pump domestic hot water tank, a heat pump integrated into existing ductwork, and a Heat Recovery Ventilator (HRV).

The new highly insulated air-tight building envelope reduced the overall energy requirements of the building, and a solar array was installed on the roof. This system can produce as much energy as the retrofitted home will consume in a year, making the building a Net-Zero Home.

NRCan PEER 'Proof of Concept' Construction Trailer

In 2021, **NRCan** illustrated the potential of PEER retrofits by implementing the process on a simple construction trailer in Ottawa, Ontario. This 'proof of concept' test gave researchers a first-hand opportunity to study the panelized retrofit process, test for energy performance, and better understand the practical implications for construction.

They concluded that the approach has several important advantages over other retrofitting methods:

- Reduces the time needed for deep retrofits
- Provides better energy savings and improved overall airtightness
- Provides less disruption to occupants
- Improves curb appeal
- Provides no loss of floor area

Planned Panelization Projects

Reframed Initiative – 6 pilot projects in British Columbia

The Reframed Initiative is a collaboration of the **BC Non-Profit Housing Association**, the **City of Vancouver**, **Metro Vancouver Housing Corporation**, and the **Pembina Institute**. The Reframed Initiative brings together the construction industry, building owners, policy makers, and the financial sector to scale up deep retrofits.

Specifically, their Reframed Lab is designing deep retrofit solutions for six low- to mid-rise affordable housing residential buildings in Kamloops, Coquitlam, New Westminster, North Vancouver, Vancouver, and Victoria. The six design teams will develop retrofit designs for the buildings, and integrate carbon reduction, climate adaptation, energy conservation, seismic safety, and health and wellness.

The province is supporting the design and capital costs of the project through funding from the **Capital Renewal Fund**, a 10-year, $1.1-billion investment tasked with preserving and improving B.C.'s 51,000 units of social housing. The **CleanBC Building Innovation Fund** will contribute $460,000. The City of Vancouver will be providing technical and regulatory guidance to support the work, and the other cities where the projects are taking place have agreed to give regulatory support.

Schematic designs have now been developed for all properties, and three are in the detailed designed state. Construction for these three is slated to begin in the fall of 2023 or winter of 2024. There is an RFP out at the moment for detailed designs for the other three buildings.

The buildings date from the 1960s to the 80s, and most are classic wood-frame construction. Interestingly, of the three buildings with detailed designs completed, only one of those designs recommends panelization. This is because:

- Two buildings needed re-cladding and other repairs, and traditional deep retrofits made more sense than panelization.
- There is some discomfort with contractor experience with panelization.
- There is limited panel manufacturing capacity in BC.

Other Key Initiatives and Organizations

(Note: The work of the Ecology Action Centre in panelization is not covered here.)

retrofitcanada

Retrofit Canada is an open-source project dedicated to sharing solutions, eliminating barriers, and accelerating deep retrofits in Canada. Retrofit Canada offers:

- Case studies
- Deep Retrofits 101 info
- Webinars

They have also partnered with Butterwick Construction on Deep Retrofit demonstration projects in Edmonton, Alberta. (See the Sundance Housing Co-op description in the first section of this report.)

CANMETENERGY RESEARCH CENTRES

NRCan operates **CanmetENERGY**, a leading research and technology organization in the field of clean energy.

CanmetENERGY traces its origins to the federal government's Mines Branch, which was renamed CANMET, the Canada Centre for Mineral and Energy Technology in 1975.

Canmet will soon launch a comprehensive PEER Project Guide on the nature of panelized deep retrofits in a Canadian context, team roles, panel manufacturing, technical considerations, building codes, project design, and costs. The document will provide builders, panel fabricators, design consultants and building capture specialists with step-by-step guidance to carry-out prefabricated panelized exterior retrofits, with a focus on improving the energy performance of existing housing.

It will cover pre-design, building measurement, panel design, fabrication, and installation processes, and will be a very important contribution to the panelization movement in Canada.

ReCover

Halifax-based **reCover Initiative** is an organization dedicated to research, design, and promotion of deep-retrofit solutions, primarily through panelization. They are also committed to sharing research and lessons learned; their current focus is to move from feasibility and research studies to supporting on-the-ground implementation.

Their projects include:

- Working with McGill and the Southern Alberta Institute of Technology on an open-source panelization toolkit. It will include economic and technical decision-making tools.
- Leading a feasibility study for Toronto Community Housing.
- Supporting the upcoming project guide from Canmet ENERGY.
- Panelization feasibility studies – and accompanying webinars – for six municipalities/cities: Burlington, Oakville, ON; Saskatoon, SK; Halifax, New Glasgow, Colchester County, NS. reCover is hopeful that the HRM feasibility study on a community centre will go ahead.
- Working with Retrofit Canada on an online resource library.

Sustainable Buildings Canada

Toronto-based **Sustainable Buildings Canada (SBC)** was established in 2002 as a not-for-profit organization devoted to designing, building, and operating better buildings to help reach the 'next level' of sustainability. SBC delivers a number of core activities which include education, training, research, and program services to utility, government, and agencies.

Starting in 2016, SBC undertook background research looking at what is needed to launch a national Energiesprong movement in Canada. In addition to broader analysis, they held workshops in Toronto and Ottawa, reviewing housing provider projects, and exploring the potential for PEER pilot projects.

Several key overarching recommendations that came from the SBC research are:

- The Canadian Government should fund the creation of Energiesprong Canada, joining the Energiesprong International Initiative in developing the open-source knowledge-sharing platform, and facilitating the establishment of regional Market Development Teams;
- The provinces, either solely or on a regional basis, should fund the initial establishment of Market Development Teams which will be responsible for facilitating the delivery of the Energiesprong initiative in their regions; and
- The funds derived from Provincial Cap and Trade or Carbon Tax regimes should be earmarked for the ongoing delivery of Energiesprong refurbishments.

Challenges

There are existing and potential obstacles to the broader uptake of Panelized Deep Energy Retrofits (DER) in Nova Scotia. Several key challenges specific to panelized DER are listed here.

LABOUR SHORTAGES

This is an issue facing the broader energy efficiency/clean energy sector. There are difficulties finding sufficient contractors to undertake deep retrofits in a timely manner. Labour shortages can also drive-up costs of retrofits. This is a challenge requiring the coordinated involvement of many players including government, trades schools, contractors & industry associations, energy companies, and environmental civil society.

Shortages could intensify as more affordable housing projects begin in the province, and in the wake of the spring 2023 wildfires that destroyed many homes. (Immigration to this region could help mitigate this obstacle if construction labourers are targeted. Whoever fills current labour shortages, skills training & upgrading will be needed to meet energy-efficiency challenges of all kinds.)

PRIORITIZING NEW BUILDS

Closely connected to labour shortages, there is limited incentive for existing contractors to invest in the skills needed for DER panelization, also called Prefabricated Exterior Energy Retrofit (PEER). There is considerable work available on new builds in Nova Scotia, particularly in HRM. Energy-efficiency retrofits are too often seen as an expense rather than a long-term savings opportunity.

This is particularly relevant as the average ages of contractors advances in Nova Scotia, as some contractors may not see sufficient benefit to embracing new methods for the duration of the time they plan to remain in the workforce.

TECHNICAL COMPLEXITY

Conventional methods of performing deep energy retrofits on buildings can be slow and expensive, as every project is a custom job. That's why the Energiesprong modular approach is attractive for affordable deep energy retrofits. That having been said, this is still a relatively new method of Deep Energy Retrofits (DER) in Canada, and there will be technical challenges that require problem-solving. For example, it will be critical to understand potentially unforeseen moisture control issues arising from DER panelization. Significant cost-saving opportunities can be expected if mass industrialization of panelization occurs. Economies of scale would the allow more readily available and affordable supplies. (And more and more building owners are aware of moisture issues in homes and could potentially be concerned over new energy efficiency technologies.)

There is also the challenge of 'paneling' over existing building envelope structural problems (some of which may come as surprises as the work is undertaken). Doing a retrofit with panels is more difficult than putting pre-fab panels on a new build; retrofits may require more on-site adjustments as the work progresses.

DER retrofits may require more invasive building analysis, which opens up the issue of repairing audit-stage testing damage. And this highlights the need for energy auditors with the training and experience to conduct DER panelized retrofit analysis, as well as the need for energy data on individual resident units.

FUNDING

In the current economy, panelized retrofits require a significant upfront investment to be recovered over the life of a building. This creates a social risk of inflated rents to recover costs directly, or after selling the building, and a financial risk for owners of losing the time value of investments due to significant upfront costs. This is why at this stage of adoption of this method, significant government supports will be required, not only for large but also small to medium-sized projects.

Financial support for PEER pilots and projects is insufficient, and we need more long-term 'proof of viability' examples for building owners considering panelization. Furthermore, there is a need for additional funding for new incentives and market signals to de-risk this DER approach for both contractors and building owners. (It should be noted that there are national funds targeting deep retrofits including PEER; however, it can be a challenge to find information on all available funding opportunities.)

Market signals include financing and incentives, industry training, technology & product investments, actionable data, and policies/regulations. Training must encompass not just building trades, but energy assessment, integrated design, project management, digital capture, client engagement, and off-site prefabrication.

From a homeowner/building owner perspective, walls and insulation are just part of a deep retrofit. Although a goal of PEER is to eliminate as much of the cost and time associated with traditional approaches, there's no avoiding the fact that a deep retrofit is a major construction project. As part of a deep retrofit, typical projects may also include reroofing to insulate and air seal above the existing roof deck and the addition of new mechanical systems including ventilation with heat recovery. If fuel switching is part of the project, the cost of replacing an oil furnace system can be significant.

BASELINE DATA AND THE CASE FOR PANELIZATION

Building on the above point, the case for panelized retrofits generally requires a positive cost-benefit analysis. However, accurate baseline energy data is not always available, nor is data on business-as-usual maintenance costs which should be factored into the equation. (And there may not be consistent definitions of 'business-as-usual' baselines.)

On a related note, if greenhouse-gas emissions reductions is a major goal, is lifecycle carbon assessment – i.e., embodied carbon, which is the energy already used to create the building – data readily available?

ENERGY EFFICIENCY PROGRAMS FAVOUR SHALLOW RETROFITS

Building on the above point, energy efficiency rebate and grant programs in Nova Scotia tend to offer monetary incentives that do not add up to large enough amounts to encourage deeper retrofits, especially when the money must be upfronted by building owners.

For example, neither GreenerHomes rebate caps nor HomeWarming retrofit funding limits allow for deeper retrofits. This can trap many in cycles of energy poverty, light retrofits that do not offer opportunities for deeper upgrades or fuel switching means many are still reliant on heating oil, and fossil fuel prices (and carbon taxes) will continue to rise.

This is mitigated somewhat for homeowners living in municipalities with Property Assessed Clean Energy (PACE) programs. In PACE programs (e.g. Clean Energy Financing or PACE Atlantic), the municipality pays for the upfront costs of the retrofits, and the homeowner pays the municipality back (usually over 10-15 years) through energy savings. Some municipalities have increased project financing available to over $20,000. At this time, however, PACE programs in Nova Scotia are for residential not commercial buildings.

SILOED INFORMATION

For those interested in panelization, information, toolkits, resources, case studies, etc. can be difficult to find, or spread across several online resource portals. In Nova Scotia, ReCover is widely seen as the leader on PEER in this province, although others (including EAC, zzap) are also taking leading roles. ReCover and EAC are both working on tools, research, and case studies on panelization.

Nationally, there are resource sites from Retrofit Canada and the Reframed Initiative, the latter including a Retrofit Supply Chain map. And, as mentioned in the section above, NRCan's Canmet Energy will soon launch a comprehensive PEER Project Guide on the nature of panelized deep retrofits in a Canadian context, including team roles, panel manufacturing, technical considerations, building codes, project design, and costs.

There is the risk of unnecessary duplication, and if all major panelization players in Nova Scotia create their own form of 'resource sharing site', this could lead to further market confusion and compartmentalization of tools and resources.

LOT LINE SETBACKS COULD LIMIT UPGRADES OF EXTERIOR INSULATION

Exterior envelope retrofits add wall thickness that could encroach on lot line setback limits. A related concern is that thicker panelized walls could require new windows/interior window extensions even if existing windows are in good shape. This extra expense (and apparent lost spending on windows and doors) could give some pause if considering panelization.

Case Study

54 Jackson Road, Dartmouth, Nova Scotia

Building Use: Residential Apartments

2 storeys above
1 storey below-grade

19 suites

Floor Area 1087 m2

Construction: 1960s

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-year periods of utility data. Our work provides carbon and energy reductions for the two retrofit pathways, including Class D cost estimates.

Methodology

RDH reviewed the provided utility data, previous condition assessments, building plans, and air leakage report. These documents, in addition to communications with zzap, allowed RDH to complete a preliminary energy assessment of the existing building using a representative building typology 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.

Baseline Components & Systems

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.

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.

THERMAL PERFORMANCE

RDH calculated the existing whole wall effective thermal performance for each enclosure component (imperial units first in ft2·°F·h/BTU, followed by metric units in m2·K/W in square brackets):

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-2 [RSI-0.4]
Foundation Walls	R-1 [RSI-0.2]

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.

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).

Existing brick & wood panel enclosure

DOMESTIC HOT WATER

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

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.

Assumed Lighting Power Density

ZONE	LIGHTING POWER DENSITY [W/M²]
Suites	5.0
Corridors	7.10

Assumed Plug Loads

ZONE	PLUG LOAD (OUTLETS) [W/M²]
Suites	5.0

Energy Analysis & Modelling Process

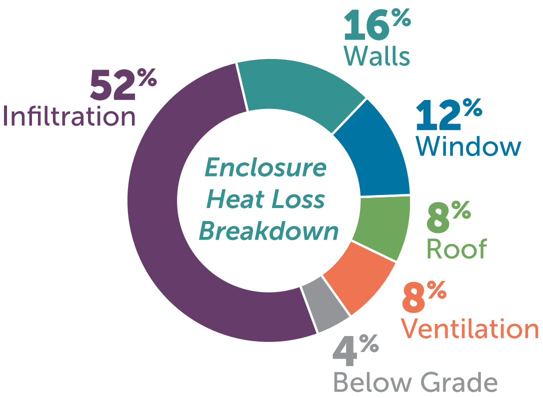
OVERVIEW

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.

ENCLOSURE HEAT LOSS

The pie chart below 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.

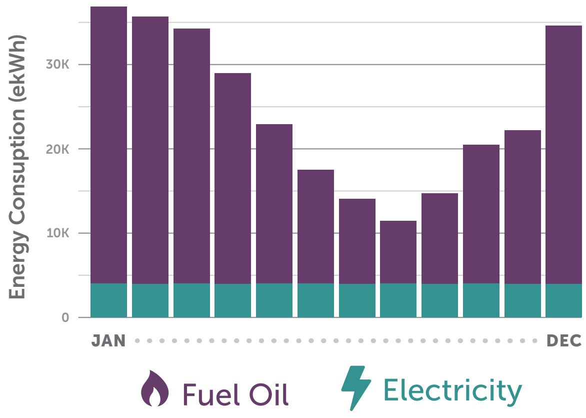
Approximately 20% of the heat loss is due to the exterior walls and foundation thermal bridge ("below grade"). The aluminum windows and doors contribute 12% of heat loss. The roof contributes only 8% and finally exhaust fan ventilation contributes 8%.



UTILITY BILL ANALYSIS

The average monthly electricity and natural gas consumption in equivalent kilowatt hours is shown 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.

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:

Assumed Lighting Power Density

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.

Existing Building Results

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 to the right.

The EUI of 285 kWh/m² 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.

Summary of Existing Building Energy Model Results

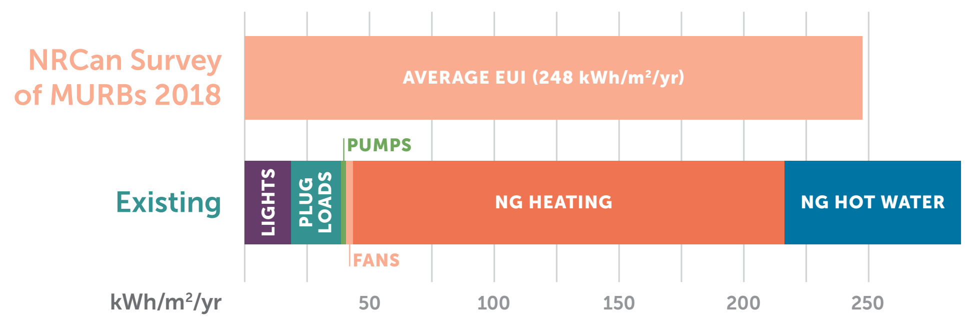
ANNUAL METRICS	EXISTING
GHGI (KGCO$_2$/m²/yr)	65
EUI (kWh/m²/yr)	285
TEDI (kWh/m²/yr)	135
NATURAL GAS (MBTU)	840
ELECTRICITY (kWh)	44,000
CO$_2$E (TONNES)	65

Natural gas cost per year
$19,900

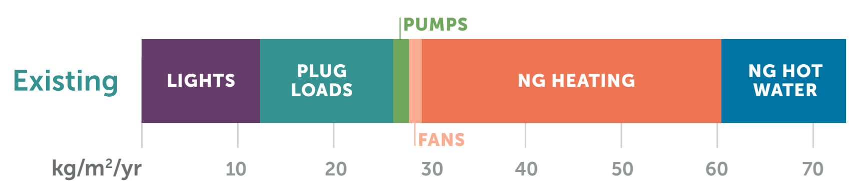
Electricity gas cost per year
$7,200

Total utility cost per year
$27,100

Energy Use Intensity (EUI)



Greenhouse Gas Intensity (GHGI)



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.

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 tenant 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.

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:

- **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.

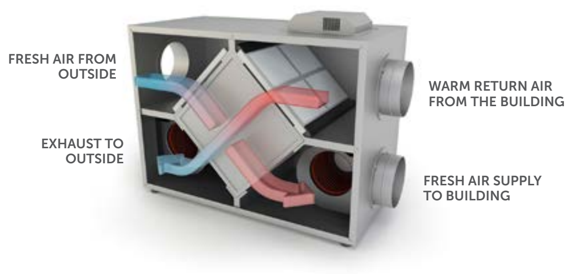
VENTILATION

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.

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.

Example of Energy Recovery Ventilator



MECHANICAL SYSTEMS

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 an electrical engineer and may need to be improved to serve the demand from the electrical systems.

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).

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 or at the base of the wall similar to the current convecting baseboards. 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.

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.

Example of a Perimeter Fan Coil Unit Replacing a Radiator

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.

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.

ADDITIONAL RETROFIT OPPORTUNITIES

Domestic Hot Water

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

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.

Plug Loads

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

Phase 1 Retrofit Matrix

ARCHITECTURAL

	EXISTING BUILDING		PHASE 1 RETROFIT	
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

Phase 2 Retrofit Matrix

MECHANICAL

		EXISTING BUILDING		PHASE 2 RETROFIT	
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)
	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)
	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

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 here. 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 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 below.

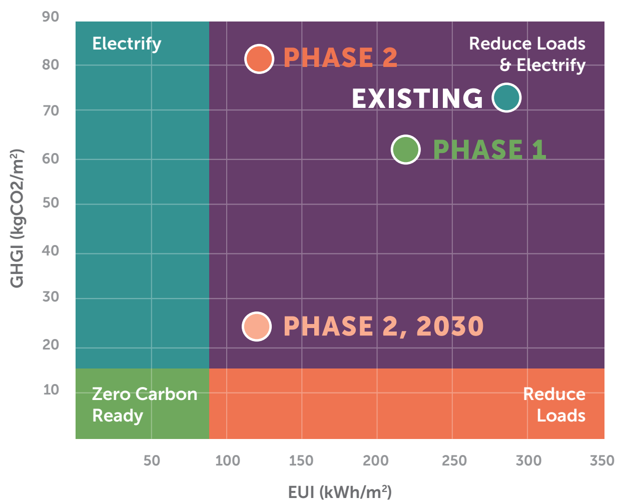
Emission Rates used for Analysis

	2023	2030
Electricity kg CO_2/ekWh	0.67	0.20
Natural Gas kgCO_2e/m^3	1.90 (0.181 kg CO_2e/ekWh)	1.90 (0.181 kg CO_2e/ekWh)

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 (KGCO_2/M^2/YR)	53	40	24
NATURAL GAS (MBTU) [ekWh]	840 [245,000]	590 [175,000]	0
ELECTRICITY (kWh)	44,000	46,000	123,000
CO_2E (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

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 below illustrates the existing and post-retrofit performance metrics for 54 Jackson.

GHGI vs. EUI for retrofit phases



The purple 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.

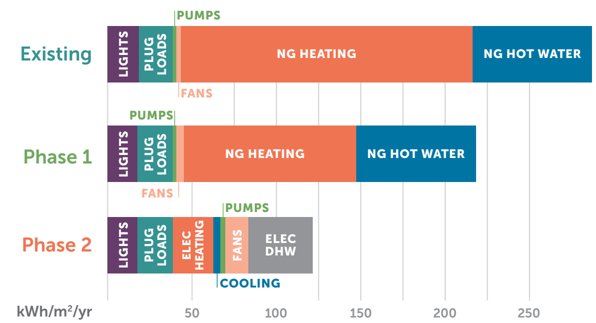
The **Phase 2 Retrofit** strategy reduces energy use with high efficiency electric heat pumps for heating and cooling. The addition of cooling (increasing electrical energy use) and the high carbon intensity of Nova Scotia's current electricity grid results in an increase in GHGI compared to the existing 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 to the right.

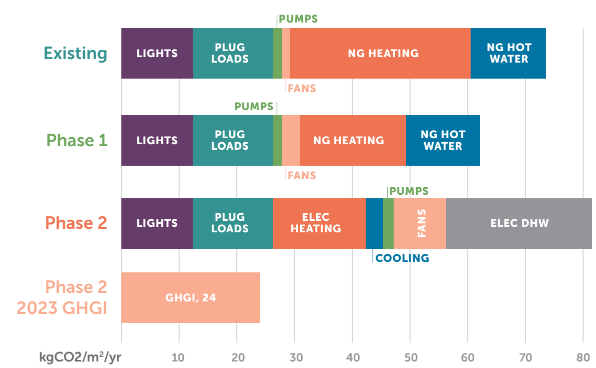
- In the **Phase 1 Retrofit**, the EUI is reduced by 25% and the GHGI by 15%. The TEUI reduction is due to the load reduction from the enclosure replacement.
- In the **Phase 2 Retrofit**, the EUI is reduced by 60% and the GHGI by 55% (using 2030 emissions rates). The savings compared to the **Phase 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.

EUI of retrofit phases



GHGI of retrofit phases



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 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 and protection from wildfire smoke
- 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.

DRAWBACKS

- The improvement of indoor air quality and occupant comfort through ventilation systems and addition of space cooling requires additional energy, reducing the energy savings observed between the existing building and the Retrofit options.
- Further, the carbon intensity of Nova Scotia's 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. When the electrical grid is sourced with renewable energy the electrification measures will reduce the carbon emissions.
- This analysis does not include reduced building enclosure maintenance costs, potential rent increases, or enhanced resale value due to these improvements or other factors of having a high-performing and resilient building.

Typical Elements of a Panelized Retrofit

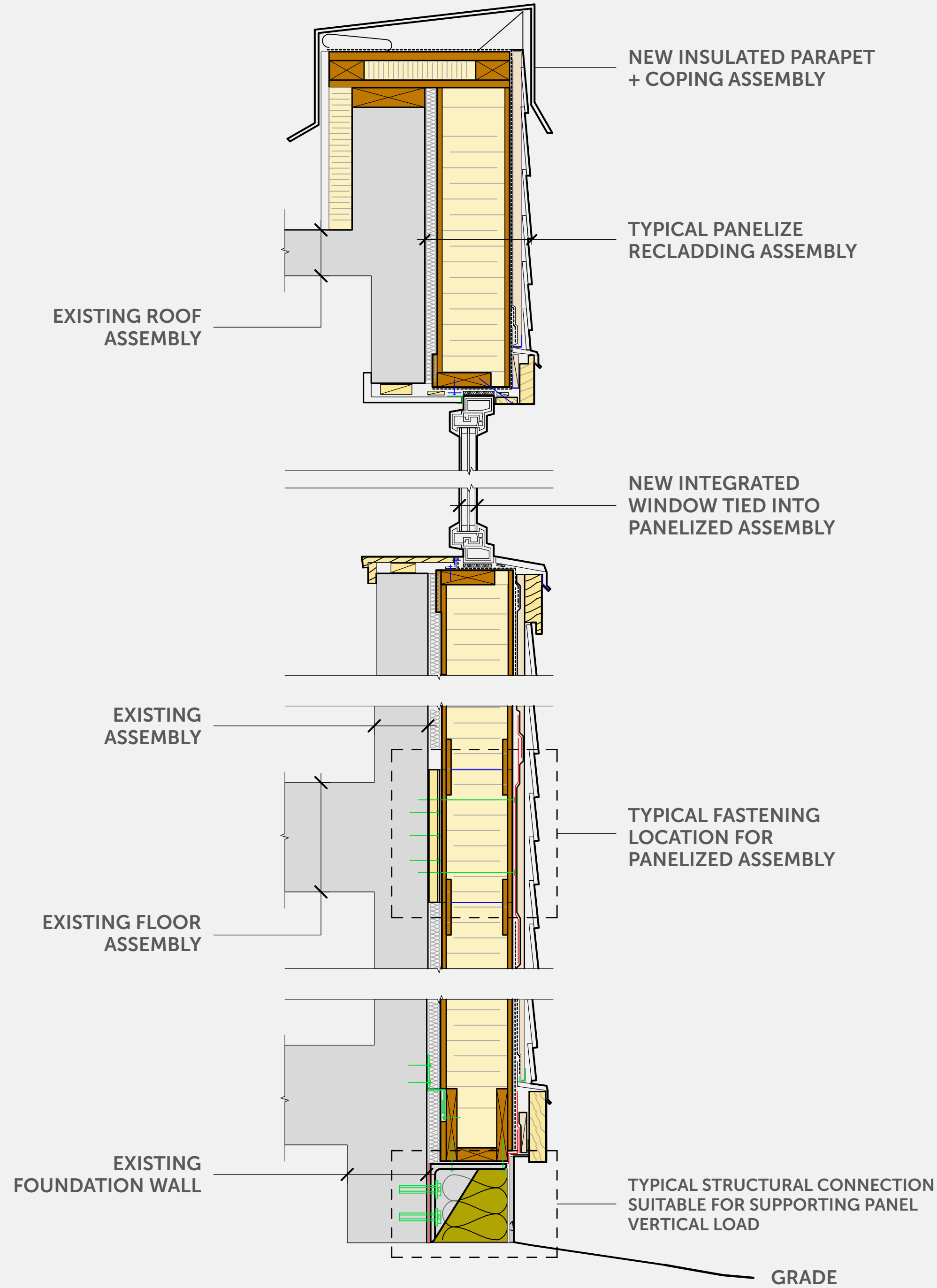


Illustration by zzap Architecture And Planning

Product Comparison

CONCRETE SANDWICH PANELS

Low-carbon concrete sandwich panel with 2 stage sealant joints.

Implementation requires extended foundation or ledger beam at grade. Likely requires targeted removal of bricks at rim joists for lateral load connetion to structure. Need to consider removal of moisture from existing bricks.

INSULATED METAL PANEL (IMP)

Insulated metal panels with thermal break and integrated windows.

Can likely be fastened to brick cladding with sub- framing (Z-girts). Considerations to be made for removal of moisture from existing bricks.

STEEL FRAMED PANELS

Metal framed panels gasket system (similar to curtain wall assembly). Can also be fabricated locally as a wood with exterior insulation.

Manufacturers indicate system cannot be installed as dead load bearing. Similar steel framed panels would require extended foundation or ledger beam at grade.

ALT OPTION - EXTERIOR INSULATION AND FINISH SYSTEM (EIFS) PANEL

EIFS panel with Water Resistant Barrier (WRB) applied to existing cladding.

Can be fastened through brick cladding with sub-framing (Z-girts). Possible to have integrated windows installed however this would require a steel frame and at-grade ledger.

	Concrete Sandwich Panels	Insulated Metal Panel (IMP)	Steel Framed Panels	Alt Option - EIFS Panel
MIN THICKNESS	3"	2"	2"	2"
WEIGHT	Heaviest option	light weight, may be able to attach to existing cladding	medium weight	light weight, can be attached to existing cladding
INSULATION TYPE	Expanded polystyrene (EPS)	Mineral Wool	Mineral Wool	Expanded polystyrene (EPS)
MEETS R VALUE TARGET?	Yes	Yes	Yes	Yes
AIR BARRIER LOCATION	Interior face of panel	Interior metal panel	Treated gypsum sheathing - gasket system with stack joints	Exterior finish is detailed as air control layer
AIR BARRIER MATERIALS	Interior skin, compressible foam sealant at joints			
CONCERNS	Continuity of air barrier at foam joints. No provision for sealing between existing wall assembly and new panels to limit odor, fire, smoke, sound, etc.			Exterior finish as air control layer
WATER CONTROL STRATEGY	site installed sealand joints	gaskets and site installed sealant at panel joints	site installed weather barrier and cladding at leave-outs or proprietary system with gaskets	site installed weather barrier
VAPOR CONTROL STRATEGY	Vapour closed	Vapour closed	Depending on system build-up	Vapour open weather barrier
MATERIALS	Proprietary 1/2" cementicious interior and exterior skin	Metal panels	Metal/ wood frame	EIFS Proprietary system
REQUIRE FOOTING/ LEDGER?	Yes	No	Yes	No
FLOOR LINE DETAILING	Fasten to rim joists	No	Fasten to rim joists	No
COMPATIBLE WITH WOOD FRAMING	Not currently - Manufacturers are working on an EIFS-like panel		No	
WINDOWS PREINSTALLED?	Yes	Yes	Yes	
WINDOW ANCHORAGE	Strap	Independantly supported to structure	Strap	Mechanical Fastener
SITE WORK REQUIRED (BASE SYSTEM)	Interior drywall trim at windows, Ledger at base of wall, Hanger clip at floor line, 2 stage sealant joints at panel to panel interfaces, Compressible foam sealant at joints.	Interior drywall trim at windows, Air-and water-tight treatment to (E) cement plaster	Ledger at base of wall	Air- and water-tight treatment to exterior finish, Window rough opening membrane Windows, Window interior sealant joints, Exterior water shedding seals
EMBODIED CARBON	High embodied carbon in tube steel	This system would use the least amount of support materials reducing embodied carbon		
GWP	Expanded polystyrene (EPS) foam middle of the road	Mineral wool ~high embodied Carbon but renewable	Metal frame and mineral wool ~ mid range embodied carbon	Expanded polystyrene (EPS) foam middle of the road
MANUFACTURER SUPPLIES ROOF PANELS?	Yes	No. Integrate panels with parapet. Separate roof upgrade required.	Yes	No. Integrate panels with parapet. Separate roof upgrade required.

Considerations

Moisture management is critical for the long-term durability of the panel system and building structure. Best-practice moisture management strategies for panel-to-panel joints should include a two-stage "rainscreen"-type joint design with an exterior, water-shedding seal and an interior primary air and water seal. When working with existing buildings, the residual moisture in the existing building materials (such as exterior cladding) must also be considered. It is often desired to retain existing cladding to reduce the amount of site-work required. For the 54 Jackson Road project and similar buildings with cladding materials that can hold significant amounts of water (e.g. bricks), the existing moisture must be taken into account in the design. Residual moisture can be reduced through construction practices such as temporary rain protection, or active drying through openings or forced air. Residual moisture can also be managed through the lifespan of the building by using vapour-permeable panel systems that permit drying to the exterior.

The structural support and attachment of the panels will need to be designed for specific loads that may vary based on the weight of the panel system. If the panelized wall system adds less than 5% of the load (weight) to the existing structure, it is likely that the panels can be simply fastened to the existing wall system. Pull-out tests of the new fasteners to the existing structure should be conducted to confirm existing strength/capacity. With a panel system heavier than 5% of the existing wall weight, the panels will likely need to be supported by a new, extended foundation or ledger beam at grade. The panels can then be laterally supported by (anchored to) the building at each floor line. Refer to the attached detail for visual depiction of the panel support.

With all panelized systems, dimensional tolerance of panels at joints, interfaces between panels, and interfaces with existing assemblies can lead to construction issues. When working with existing buildings, the exact dimensions are often unknown and may not be consistent throughout the building due to site tolerances, shrinkage, or movement that has occurred throughout the life of the building. Systems that use gaskets at joints for panel-to-panel air and watertightness often have a smaller allowance for dimensional tolerance in the panel joint dimensions. If this tolerance is exceeded, gaps in the gaskets can allow air and water infiltration into the building. Site-installed panel joints (such as sealant joints or site installed portions of panels) can more easily accommodate dimensional tolerance but add to labour and material cost of panel installation.

Since the retrofit design will depend on local codes and existing building conditions, we recommend engaging building enclosure and structural engineering consultants to evaluate the existing cladding and structure to review design options for building-specific retrofits with these considerations in mind.

Cost Analysis

Our Class D cost estimates for enclosure and mechanical retrofits are summarized here. 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 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.

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 to the right, 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.

Total Future Energy + Carbon Cost

We estimated the federal carbon price based on the following: Price is set per tonne of carbon emission, and the current (2023) 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.

The graph above shows the effects of the increasing carbon price on the buildings' utility costs. See Section 12 of attached document "Deep Retrofit Study of 54 Jackson Road" by RDH for further information.

Glossary of Terms

ANTHROPOGENIC GREENHOUSE GAS EMISSIONS (GHG):
Emission of greenhouse gases (e.g CO_2, Methane, NOx, HCFCs, HFCs, Ozone) resulting from human related activities (e.g. combustion of fossil fuels for energy or transportation, agricultural practices, land-use change, various industrial practices, etc.).

ASSET LIFE CYCLE:
The view of an asset (e.g. gas-fired furnace, air source heat pump) over the course of it's entire life. As it relates to this project, where an asset is in its life cycle should be considered when analyzing retrofit options to minimize sunk costs and take advantage of opportunities for system upgrades.

BUILDING ENVELOPE:
The physical separator or systems of separators between the conditioned and unconditioned environment of a building (e.g. exterior walls, windows, roofs).

BUILDING ENERGY MODEL:
An energy consumption/production analysis over a given time period for a given type of building (e.g. single family home, multi-family complex, office building, warehouse).

CARBON FOOTPRINT:
The total amount of carbon dioxide (or carbon dioxide equivalent) generated by a system over a given time period.

DECARBONIZATION:
The process of reducing a system's carbon dioxide emissions through efficient and low carbon emitting design principles or technologies.

DEEP ENERGY RETROFIT:
Whole building analysis and construction process that achieve emission reductions and large energy cost savings.

ENERGY CONSUMPTION:
The amount of energy a system uses to fulfill its function.

ENERGY RECOVERY VENTILATOR (ERV):
A type of mechanical equipment that features a heat exchanger combined with a ventilation system. Heat is transferred from the outgoing building air to the fresh incoming air to reduce the energy required for space conditioning.

ENERGY USE INTENSITY (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.

EXTERNALIZED COST:
Costs generated by producers but carried by society as a whole. For example, a building owner buys the fuel for the gas-fired furnace but does not pay for the costs associated with the CO_2 emissions.

GREENHOUSE GAS INTENSITY (GHGI):
The total greenhouse gas emissions associated with the use of all energy utilities on site divided by the conditioned floor area.

HEATING, VENTILATION, AIR CONDITIONING (HVAC):
The systems of mechanical equipment that condition interior space for human occupancy/comfort.

HYDRONIC HEATING/COOLING:
A type of mechanical equipment that uses water to transfer heating or cooling to interior spaces.

INFILTRATION/EXFILTRATION/AIR LEAKAGE:
Infiltration refers to the unintentional introduction of outside (unconditioned) air into a building, typically through cracks in the building envelope and through use of doors for passage. Exfiltration refers to the opposite, where inside (conditioned air) escapes through cracks in the building envelope and through the use of doors for passage. Air leakage refers to the transfer of unconditioned/conditioned air through the building envelope, resulting in energy loss.

INTERNAL SHADOW CARBON PRICE:
The hypothetical cost of carbon emissions. Shadow carbon pricing can help organizations better understand the impacts of future regulations and technological shifts.

NET PRESENT VALUE (NPV):
The difference between the value of cash now and the value of cash at a future date. NPV in project management is used to determine whether the anticipated financial gains of a project will outweigh the present-day investment — meaning the project is a worthwhile undertaking.

REHABILITATION PROGRAM:
The methods, design principles, and technologies used to achieve the desired energy retrofit goals.

THERMAL BRIDGING:
Areas or points in the building envelope which allow heat to pass through more easily. These areas or points break thermal barrier continuity by providing pathways for heat to easily travel from the building's interior to the exterior. Common examples include through-wall concrete balconies, outer wall edges, un-insulated concrete parapets, and penetrations through the wall assembly made from materials that conduct heat easily.

THERMAL ENERGY DEMAND (TEDI):
The annual heating delivered to the building for space conditioning and conditioning of ventilation air divided by the conditioned floor area.

THERMALLY BROKEN:
Areas or points in the building envelope that maintain the continuity of the thermal barrier. Typically refers to penetrations through the wall assembly (that otherwise would be thermal bridges) that do not allow heat to easily travel from the building interior to the exterior made from materials that do not easily conduct heat.

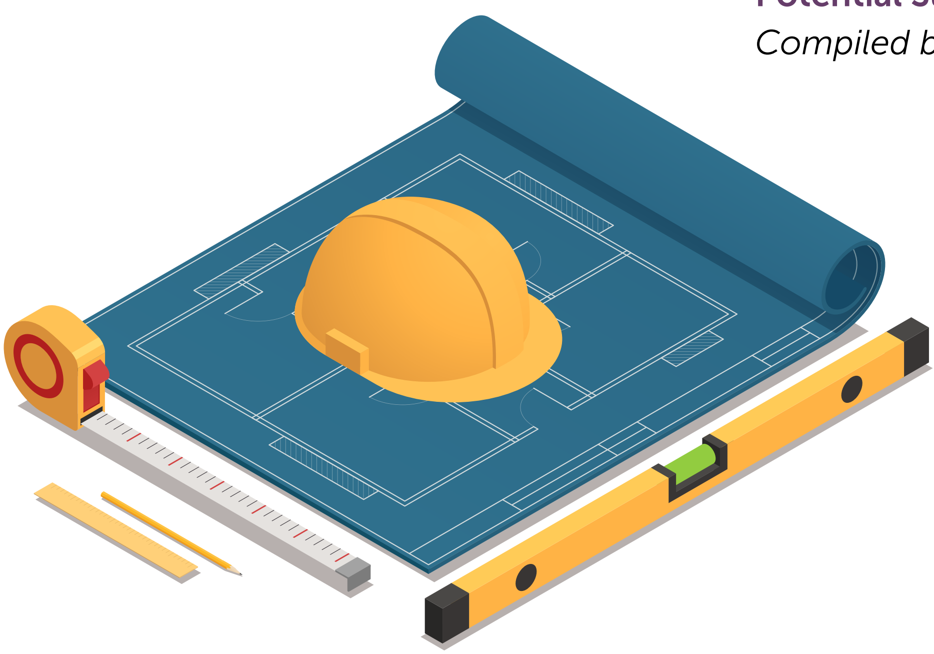
Further Resources

Deep Retrofit Study of 54 Jackson Road
by RDH Building Science, 2023

RDH Building Science Energy Modelling Inputs for a Deep Retrofit Study of 54 Jackson Road, *2023*

RDH Building Science Energy Modelling Results for a Deep Retrofit Study of 54 Jackson Road, 2023

Potential Suppliers for Prefabricated Exterior Work
Compiled by Zzap Architecture and Planning, 2023



PANELIZED RETROFIT TOOLKIT | JANUARY 2024

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