

PANELIZED DEEP RETROFITS OF MUNICIPAL BUILDINGS

Harrietsfield Williamswood Community Centre

Case Study Report

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HALIFAX

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ReCover

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This research project was led by The ReCover Initiative, a Nova Scotia based non-profit organization working to accelerate deep retrofits in Canada.

Harrietsfield Williamswood Community Centre

Executive Summary

Who is ReCover

ReCover is a Nova Scotia-based non-profit focused on revolutionizing Canada's buildings to combat climate change. Through innovative research, technology, and partnerships, they lead in scalable deep retrofit solutions. Their efforts in Canada lower energy costs and enhance well-being by collaborating with communities, building owners, and financial institutions.

What is the Project

This project examines six cases of municipally owned buildings, inspired by the successful Energiesprong approach from the Netherlands, which streamlines retrofits. Despite challenges adapting to Canada's diverse buildings and climates, some projects have successfully implemented some Energiesprong-inspired retrofits. The ReCover Initiative found cost-effective benefits in panelized retrofits for multi-unit dwellings, aiming for Net Zero Energy. The study seeks to apply effective residential retrofit strategies to support municipal decarbonization.

Project Objectives

The project objectives are to make deep retrofits in Canada more feasible, showcase a panelized retrofit approach, and enhance confidence in retrofits. It aims for a 50% reduction in EUI, a NZER scenario with potential for NZE through solar PV, minimal disruption to occupants, low embodied carbon solutions, cost-effectiveness, and a payback period of 20 years or less.

Methods Used

The project progressed through several phases : building selection based on criteria and evaluation, data collection including utility info and drawings, baseline energy modeling, designing retrofit scenarios with energy conservation measures, and cost analysis involving Class D cost estimation and TCBO modeling.



Building Performance Improvements

EUI

100% improvement

Existing : 146 kWh/m^2

Recommend : 0 kWh/m^2

GHG

100% improvement

Existing : 30,901 kg/yr

Recommend : 0 kg/yr

Operating Costs

51% improvement

Existing : $849,000/yr

Recommend : 0 kg/yr

Lifetime Savings

$1.8 Million

Existing : $4.9 M

Recommend : $3.1M

Retrofit Measures

2x4 ReCover wall panels

Attic insulation

High performance windows and doors

New ventilation system

69 kW Solar PV system

Acronyms and Definitions

ACH	**A**ir **C**hanges per **H**our, measured with a blower door test
CO_2e	**C**arbon di**O**xide **E**quivalent
Deep Retrofit	A project involving multiple energy efficiency and/or renewable energy measures in an existing building, designed to achieve major reductions in energy use. A deep retrofit usually includes reducing energy demand and switching from fossil fuels to electricity for space and water heating – to achieve 70% energy savings and 80% to 100% GHG emissions reductions.
Energiesprong	A retrofit methodology developed in the Netherlands to implement Net-Zero retrofits using prefabricated envelope panels and compact exterior mechanical pods. Energiesprong retrofits are financed by the cost savings from future energy consumption and required maintenance. Translation: Energy Leap.
EUI	**E**nergy **U**se **I**ntensity
FCA	**F**acility **C**ondition **A**ssessment: a comprehensive evaluation of a building's physical condition.
GHG	**G**reen**H**ouse **G**as
GWP	**G**lobal **W**arming **P**otential: a measure of how much energy the emissions of 1 ton of gas will absorb over a given time, relative to the emissions of 1 ton of carbon dioxide.
NZE	**N**et-**Z**ero **E**nergy building: a building in which on-site renewable energy generated equals the annual energy consumption of the building
NZER	**N**et-**Z**ero **E**nergy **R**eady building: a building whose annual energy consumption is low enough that it could be Net-Zero Energy with the addition of a source of renewable energy
PV	Solar **P**hoto**V**oltaic array
TCBO	**T**otal **C**ost of **B**uilding **O**wnership: building life cycle cost analysis that includes all major operating costs over the useful life of the building.
WRB	**W**ater-**R**esistive **B**arrier: a synthetic membrane installed outside of the building's sheathing to protect it from the impacts of bulk water.
ZCB	**Z**ero **C**arbon **B**uilding:

Introduction

Over one-third of Canada's planned greenhouse gas (GHG) emissions reductions will come from energy efficiency measures.[1] Increasing the pace and scale of deep retrofits is imperative to achieving net-zero emissions, as most buildings standing today will still exist in 2050.

Municipalities across Canada are working to implement climate action plans to reduce their GHGs and to protect people and infrastructure from the impacts of climate change. Deep retrofits support both efforts.

The Panelized Deep Retrofits of Municipal Buildings project includes six deep retrofit case studies of municipally owned buildings in Canada. The buildings studied are representative of buildings in municipalities throughout the country. Their uses include community centres, administration, transit, and maintenance facilities in three Canadian climate zones.

Conventional retrofit practices are not scalable. They require large budgets, custom design, and invasive construction. The only retrofit initiative to be successfully scaled to date is the Dutch approach, Energiesprong, which involves prefabricated panelized envelope over-cladding and systematic mechanical upgrades. This approach reduces time on site and project complexity compared with common retrofit practices and permits buildings to continue to be used during the work.

Energiesprong has succeeded in part because of the Netherlands' homogenous building stock. The diversity of buildings and range of climate conditions in Canada pose challenges in adapting the approach to this country, yet several Energiesprong-inspired projects have been completed or are under way. These include Ottawa Community Housing's four-unit townhouse retrofit completed in 2021, Sundance Housing Cooperative in Edmonton, which is mid-way through retrofits on their 59 townhouses, and three single family homes in Alberta.

Measures that focus on simple payback and short-term return on investment can be counterproductive with assets as long lasting as buildings. Economic evaluation through Total Cost of Building Ownership (TCBO) analysis is more appropriate for complex retrofit projects that make changes to multiple interrelated building systems.

The ReCover Initiative has studied the potential for prefabricated panelized deep retrofits in lo-rise multi-unit dwellings in two previous case studies[2]. These studies found the lowest TCBO over the anticipated life of the building was achieved through Net Zero Energy retrofits where

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[1] IEA (2022), *Canada 2022*, IEA, Paris https://www.iea.org/reports/canada-2022 , License: CC BY 4.0

[2] ReCover Initiative (2020) *ReCover Phase One Case Study Report* and ReCover Initiative (2022) *Scarlettwood Court Deep Retrofit Case Study Repor*t, https://www.recoverinitiative.ca/about-us/our-results/report-request

the targets were met with an Energy Use Intensity (EUI) reduction of at least 75% before adding solar PV.

This study of Panelized Deep Retrofits of Municipal Buildings was undertaken to develop deep retrofit strategies to support municipal decarbonization efforts.

Project Objectives

The objectives of this study were to de-risk investment in deep retrofits in Canada, to provide evidence on the effectiveness and scalability of a panelized deep retrofit approach and to build confidence and experience in deep retrofits among Canadian municipalities and industry stakeholders.

The goals for the Deep Retrofits explored included:

1. Develop a scenario that achieves an Energy Use Intensity (EUI) reduction of 50%.
2. Develop a Net Zero Energy Ready (NZER) scenario that can achieve Net Zero Energy (NZE) with the addition of solar PV.
3. All solutions minimize occupant disruption during construction.
4. All solutions target minimal embodied carbon.
5. Identify the retrofit pathway to the lowest Total Cost of Building Ownership.
6. Demonstrate a calculated payback of 20 years or better.

Methodology

The project was completed in the following phases:

1) Building selection.
   a) Definition of selection criteria.
   b) Building evaluation and selection.
2) Data and document collection, including:
   a) Utility data
   b) Building drawings
   c) Facility Condition Assessment, ideally no more than five years old
   d) Field Review
3) Baseline energy modeling (hourly analysis).
   a) Determination of model inputs
   b) Energy Model Calibration
   c) Baseline energy model results

4) Design Energy Conservation Measures (ECMs) for retrofit scenarios, including:
    a) u-values, window, and door performance specifications
    b) mechanical and electrical systems upgrades
    c) panel design, including:
        i) structural design and fastening details.
        ii) panel dimensions and layouts.
        iii) hygrothermal modeling with WUFI Pro to assess moisture risk.
        iv) embodied carbon accounting.
        v) aesthetic upgrades.
5) Cost Analysis.
    a) Class D cost estimate.
    b) TCBO modeling.

Building Selection

A short-list of community recreational facilities was proposed for study by HRM. Retrofits to recreation facilities was strategic because safe, comfortable shelters will be needed in Halifax's communities in future extreme weather events and recreation facilities are well suited to adaptation for this use.

Criteria for consideration included the following:

- high EUI
- potential to eliminate fossil fuel-based building systems.
- high maintenance deficit
- simple form
- ample space to stage a panelized construction project.
- solar potential

The Harrietsfield Williamswood Community Centre was selected by the ReCover team and HRM based on these criteria.

Data and Document Collection

HRM provided the following data and supporting documents pertaining to the Harrietsfield Williamswood Community Centre:

- Floor plans (Appendix A)
- Capital Plan, Building Condition and Energy Assessments, 2013 (Appendix B)
- Fuel oil consumption records January 2018 - December 2021 (Appendix F)
- Electrical consumption records April 2017 - October 2021 (Appendix F)

Typically, a minimum of two years of consumption records for all utilities serving a building is required. As the time frame for this project included reduced building occupancy during the pandemic, at least one year preceding the beginning of the pandemic was included in analysis.

Comprehensive building drawings were no available. Smarter Spaces was engaged to complete **LiDAR** (Light Detection and Ranging) imaging to capture the external building geometry. The 3D point cloud generated from the scan was interpreted to produce CAD and BIM drawing files for use by the design team (Appendix A).

A site visit was conducted by design team members to verify structural, mechanical, and electrical details from the resources provided and to understand building conditions. The team also engaged with HRM staff to understand building usage patterns, baseline operational settings for mechanical systems and for information on occupant comfort and building deficiencies.

A new **Facility Condition Assessment** (FCA) was obtained from Capital Management Engineering Limited (Appendix B) as the existing Building Condition Assessment was nearly 10 years old and did not fully reflect the existing conditions.

Building Description

The Harrietsfield Williamswood Community Centre is a two-storey building with a gross floor area of 581m^2 (6,256sq. ft)[3].



Figure 1 Harrietsfield Williamswood Community Centre



Figure 2 Site Plan: Harrietsfield Williamswood Community Centre

[3] Energy modeling is based on the internal area of 541m^2 (5833 sq. ft.).

The upper level of the building contains a day care centre which operates an after-school program and full day programs during summer and March Break. The facility includes a multipurpose room which is used for community recreation services including fitness classes, meetings, art classes and workshops and for private event rentals. Daily hours of operation are 10am – 9pm during the school year and 7:30am – 6:00pm in summer. The typical occupancy of the daycare is 50 people and occupancy of the multipurpose room varies, with an average of 150 people for events.

The building was originally a fire station estimated to have been constructed in 1970. It was converted to its current use in a major renovation in 1994. HRM has implemented several efficiency measures to the building including adding heat pumps (2015), LED lighting upgrades (since 2013) and a wall mounted solar air heater (2011).

The facility has been operated in partnership with the Harrietsfield Williamswood Community Centre Association (HWCCA) since 2010. Capital work on the building, including major repairs and maintenance of mechanical and electrical systems are the responsibility of HRM while utility costs are paid by the HWCCA.

Context

The Harrietsfield Williamswood Community Centre is located at 1138 Old Sambro Road, Halifax, Nova Scotia. Old Sambro Road is a busy street that connects rural and suburban parts of HRM and the Halifax Peninsula. The building is adjacent to an elementary school and backs onto a wooded area and a small lake. The surrounding area is primarily rural and residential.

Halifax is in Canadian building code climate zone 6. It has a temperate maritime climate, with short, warm summers and cold winters. The weather is humid and changeable in all seasons, with year-round potential for significant precipitation. Average temperatures in Nova Scotia are increasing and are predicted to continue to rise, with the incidence and severity of storms also accelerating.[4] High winds and driving rain are key building science concerns in Halifax.

Halifax was the second city in Canada to declare a climate emergency, shortly after Vancouver did so in January of 2019. In 2020, Halifax adopted one of Canada's most ambitious climate action plans, **HalifACT: Acting on Climate Together**. Decarbonizing buildings is the single most impactful GHG reduction strategy in the plan. In HRM, buildings are responsible for approximately 70% of energy use and 77% of GHG emissions (HalifACT: Acting on Climate Together, 2020, p.28). All existing buildings in the municipality to undergo deep energy and climate resilience retrofits by 2040 (HalifACT: Acting on Climate Together, 2020, p.36).

[4] Nova Scotia Department of Environment and Climate Change (2022) *Weathering What's Ahead: Climate Change Risk and Nova Scotia's Well-being*, https://climatechange.novascotia.ca/sites/default/files/uploads/climate-change-risk-report.pdf

Building Code Considerations

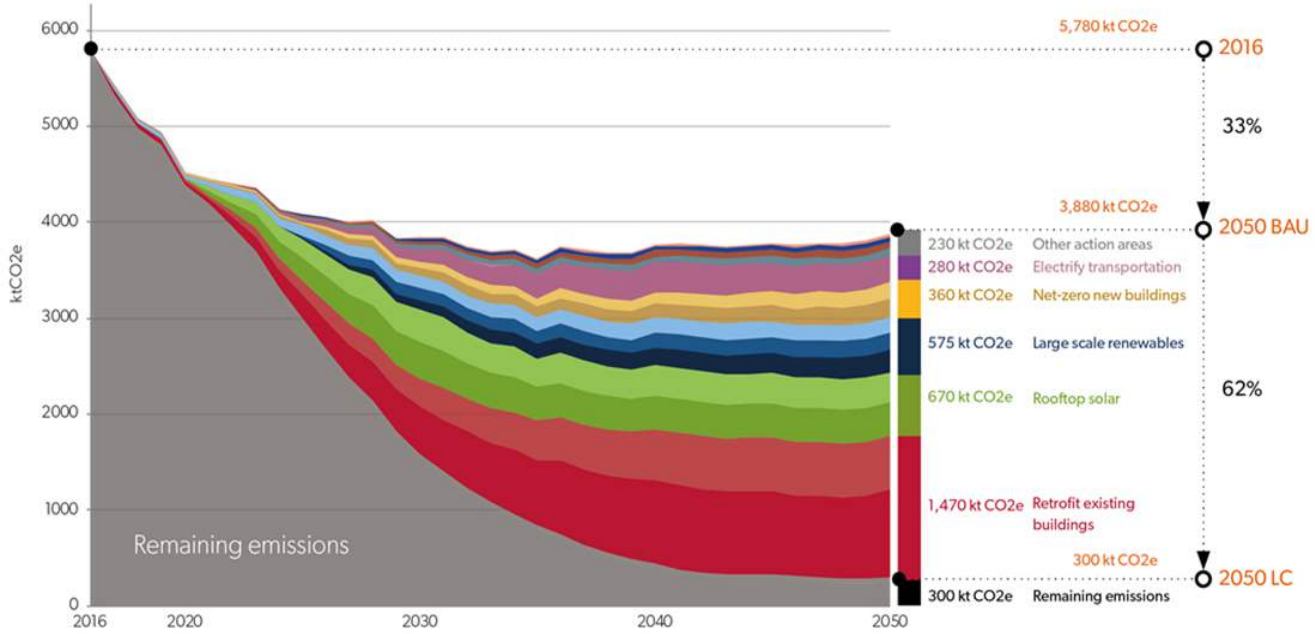


Figure 3 Pathway to reduce GHG emissions aligned with 1.5°

(HalifACT: Acting on Climate Together, 2020, p. 26-27.)

A preliminary National Building Code of Canada (NBCC) review was completed to determine building code implications of a panelized retrofit to the Harrietsfield Williamswood Community Centre (Appendix L). The primary focus of the review was to determine if panels made with combustible materials can be installed on the existing structure.

As the building's primary use is a daycare and community centre, the structure is categorized as a **High Importance Building** as per Sentence 4.1.2.1.(3) in the 2015 edition of the National Building Code of Canada (NBCC). High Importance structures are subject to higher environmental loading, including snow, wind, and seismic loads, than a normal importance building.

The construction type, cladding and fire rating requirements for each exterior wall of a building are based on the area of the wall, its proximity to the property boundaries, and the building's occupancy classification. Based on the building's use as a community centre and childcare facility, it is classified as **NBCC Group A2 - Assembly Occupancy**.

The site is an irregular shape. The closest part of the building to the property line is on the north side, with the north line 6.5m from the building and roughly parallel to the north wall. Based on the setback distances, the structure and the cladding are permitted to be of either combustible or noncombustible construction. Therefore, combustible panels are permitted to be installed on the building.

Building Enclosures

The main walls of the building are concrete block with interior 2x6 stud cavity walls offset from the concrete 100mm (4”) and insulated with fiberglass batt. The lower-level bump out walls are 2x6 framing with fiberglass batt. Openings from three former overhead doors on the west wall have been infilled with wood framing and fiberglass batt. The building is clad with fiber cement siding, with a small area of brick framing the former door openings. The windows are double glazed with vinyl frames.

The roof is framed with wood trusses and insulated with approximately 200mm (8”) of loose cellulose at the ceiling plane. There appears to be a polyethylene vapour barrier installed in the walls and roof. Given the building’s age, this is unlikely to be continuous.

The concrete slab-on-grade floors are believed to be uninsulated.

TABLE 1 Existing Thermal Enclosure Performance

	Effective USI $W/m^2 \cdot K$ ($Btu/h \cdot ft^2 \cdot °F$)	Effective RSI $m^2 \cdot K/W$ ($ft^2 \cdot °F \cdot h/BTU$)
weighted average walls	USI-0.47 (U-0.08)	RSI-2.11 (R-12)
weighted average roofs	USI-0.24 (U-0.04)	RSI-4.23 (R-24)
weighted average slab	USI-4.1 (U-0.7)	RSI-0.24 (R-1.36)
windows	USI-2.27 (U-0.4)	RSI-0.44 (R-2.5)

Existing Structure

The **foundation** consists of concrete foundation walls and strip footings. No structural deficiencies are apparent in visible portions of the foundation and there is no evidence to suggest deficiencies in the buried portions.

The **above-grade walls** are 150mm (6”) concrete masonry unit (CMU) block. These are the main load-bearing elements and the primary lateral load resisting system. The team was unable to confirm the presence of grout or steel reinforcing in the CMU voids. There is no evidence to suggest structural deficiencies in the wall system.



Figure 4 Roof structure

The **roof structure** is pre-engineered timber trusses with tongue and groove plank decking. The connection detail between the trusses and walls could not be verified during the site visit. It is assumed that the trusses bear on either a double top plate or a nailer on the CMU block walls.

The roof trusses are leaning, with the truss ridge approximately 25mm (1") east relative to the bottom chord of the truss. This issue wasn't identified in the 2013 Building Condition Assessment (Appendix B). A roof leak was also identified, by an employee of the daycare. This has anecdotally been present since Hurricane Dorian in September 2019.

The existing roof structure was determined to be inadequate to support existing loads. Alterations must be independent of the existing roof trusses.

Details of the existing structure and Structural Outline Specifications are in Appendix C.

Existing Mechanical Systems

Space heating is provided by a non-condensing oil-fired boiler with hydronic baseboard heaters. In 2011 a solar air heater was installed to provide supplemental heat. This is not believed to be contributing a significant amount of heat and was not included in energy modeling.

The building does not have a central **cooling** system. Two 2-ton heat pumps were installed to provide cooling in the multipurpose room and day care area around 2015 following occupant complaints during the summer. The heat pumps also provide supplemental space heating.

Building staff have reported that summertime comfort has improved since installing the heat pumps, but thermal comfort continues to be an ongoing issue in both summer and winter.

The building **ventilation** does not meet code. There is no mechanical ventilation system and fresh air is supplied through natural infiltration, via operable windows and two louvers located in the multipurpose room which building staff have indicated are usually closed.

Rooftop exhaust fans are installed in the building's four washrooms and the kitchen includes a range hood exhaust. All exhaust fans are controlled with wall mounted switches.

Hot water is supplied by five 40-gallon electric water heaters, located near the points of use.

Controls for the baseboard rads are standalone wall mounted thermostats and heat pumps are controlled manually. Baseboard heaters operate during the winter and shoulder seasons. The heat pumps do not have a consistent operating schedule and run year-round. Only baseboard heaters were operating during periods of unoccupancy due to the pandemic.

Appendix D provides details of the existing mechanical system and Mechanical Outline Specification.

Existing Electrical Systems

It is important to consider electrical **site services** in the context of a panelized retrofit as wall and roof mounted elements and overhead wires add complexity in installing panels. The building has two existing service entrances which share a set of overhead secondary wires. There are two separate meters, one for each service entrance, on the exterior of the building.

The **interior lighting** throughout the building is fluorescent fixtures that have been retrofitted with LED lamps and ballasts. Emergency lighting, exit signage and the building fire alarm panel are battery operated.

The building lacks an automatic **lighting control system** and relies on manual control. The staff are diligent in lighting only occupied spaces, but this could lead to energy waste if lights are left on in unoccupied areas of the building for extended periods of time.

Appendix E provides details of the existing electrical system and Electrical Outline Specification.

Energy Consumption

Energy analysis was based on electrical records spanning April 2017 to October 2021 and fuel oil records from January 2018 to December 2021 (Appendix F). During the documented time span the building used an average of 4,810 L of fuel oil (51,722 ekWh) and 26,282 kWh of electricity annually. From March of 2020 and throughout 2021, energy use decreased due to reduced operations during the COVID-19 pandemic.

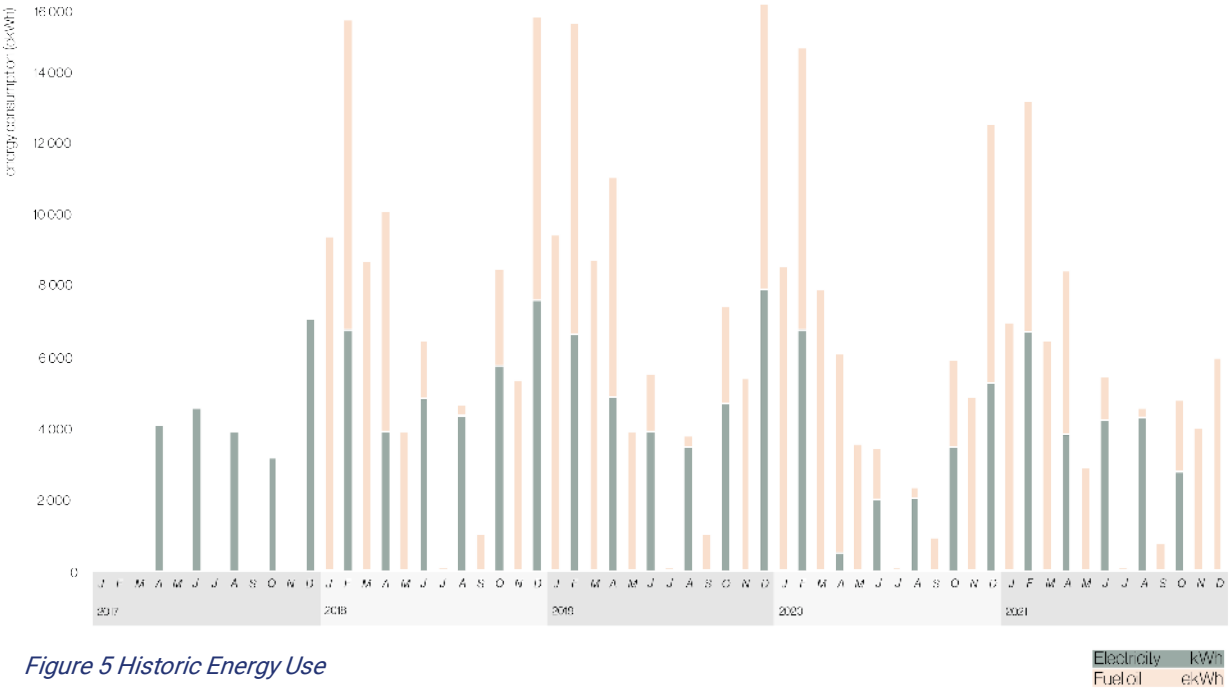


Figure 5 Historic Energy Use

Baseline Energy Model and Calibration

Whole building energy modeling was conducted with eQUEST to understand existing performance and to inform the development of retrofit scenarios. Energy model inputs (Appendix G) were based on data and documentation described earlier in this report and in consultation with HRM staff on occupancy patterns and operational set points of the mechanical and electrical equipment.

The heating system is complex with three heat sources operating on different schedules. The boiler is the primary heat source and is set to 15°C year-round. This is occasionally adjusted to 18-20°C in extremely cold weather. The two heat pumps operate at 20-21°C in the heating season and 18-19°C in summer. These are in use only when the building is occupied. The solar air heater is operational; however, its contribution is not believed to be significant, and it was excluded from the energy model.

The energy model was calibrated with historical utility data to closely reflect the current building performance. The modeled electrical consumption deviates from the existing usage by 3.4% and modeled fuel oil deviates by 0.8%.

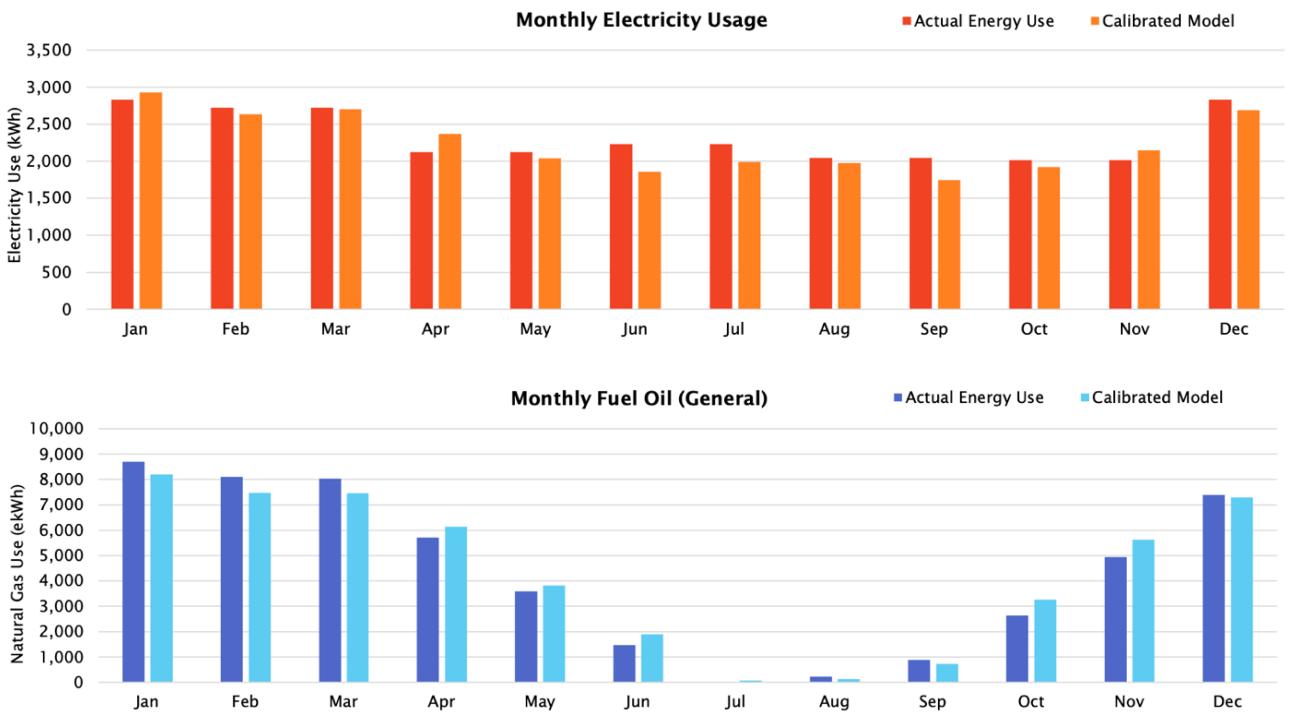


Figure 6 Calibrated Energy Use

Results

The design team worked collaboratively to develop retrofit scenarios targeting the project objectives. The analysis assumes a 'like for like' retrofit where space usage, occupancy schedules, internal geometry, volume of conditioned space, and window and door dimensions and locations are consistent with existing conditions.

The strategy for building enclosure upgrades is to retrofit the walls with prefabricated ReCover panels and to increase the depth of cellulose insulation in the roof. The existing roof can hold a few more inches of cellulose insulation, however for net-zero performance a new roof with a raised heel truss is necessary since a panelized approach is not possible.

Energy Conservation Measures

Energy conservation measures (ECMs) for the following four scenarios were developed:

1. Minimum Upgrade Scenario targeting a 50% reduction in TEUI from the baseline.
2. NZER – ASHP targeting a 75% reduction in TEUI from the baseline.
3. NZER - GSHP targeting a 75% reduction in TEUI from the baseline.
4. Net Zero Energy.

Building enclosure upgrades were developed for each scenario with post-retrofit airtightness targeting 0.5 L/s·m^2, a 75-80% reduction from the existing air infiltration. All scenarios propose upgrading to high performance windows.

Mechanical and electrical retrofits were developed based on ease of integration with existing systems and installation cost. All scenarios involve the full electrification of the building's mechanicals. As the building has a high occupant density, the heating and cooling systems were designed around the cooling loads. Each scenario includes the addition of high-performance ventilation.

For the Net Zero Energy Ready (NZER) scenarios, both air source heat pumps (ASHP) and ground source heat pumps (GSHP) were considered in the design analysis. A GSHP is more energy efficient than an ASHP, however the capital costs of installing a GSHP system are typically much higher. Depending on the specific building details it is not immediately apparent which option is the better investment. The Net Zero Energy scenario is based on the GSHP option which resulted in the lowest TCBO.

Details of the retrofit scenarios are summarized in Table 3.

Table 2 Harrietsfield Williamswood Community Centre Retrofit Scenarios Summary				
	Existing Building	**Minimum Upgrade**	**ASHP Net Zero Energy[1]**	**GSHP Net Zero Energy [1]**
Effective Wall R-value	RSI-2.11 (R-12)	2x4 ReCover panel. RSI-4.23 (R-24)	2x10 ReCover panel. RSI-7.04 (R-40)	2x10 ReCover panel. RSI-7.04 (R-40)
Effective Roof R-value	RSI-4.23 (R-24)	Top up existing insulation with loose cellulose, RSI-6.16 (R-35)	New truss roof, increase loose cellulose to RSI-10.5 (R-60)	New truss roof, increase loose cellulose to RSI -10.5 (R-60)
windows	Vinyl, double glazed RSI-0.44 (R-2.5)	triple pane RSI-1.02 (R-5.56)	triple pane RSI-1.02 (R-5.56)	triple pane RSI-1.02 (R-5.56)
Air Tightness ($L/s{\cdot}m^2$ at 75Pa)	2.3 L/s·m2	0.5 L/s·m2	0.5 L/s·m2	0.5 L/s·m2
Central Heating Equipment	Oil-fired boiler with single stage burner	Electric boiler (primary heat source)	Electric boiler	Ground source VRF (primary heat source), electric boiler
Heating System	Hydronic baseboards, 2 mini split units, and solar wall air heater	Hydronic baseboards[2] Existing + 2 new mini split units	Hydronic baseboards[2] Existing + 2 new mini split units (primary heat source)[3]	Hydronic baseboards[2], VRF indoor units
Air Conditioning	2 mini split units	existing + 2 new mini split units	existing + 2 new mini split units	VRF indoor units
DHW Equipment	Winter: tankless coil in boiler Summer: Electric water heater	Existing Electric Water Heater	Heat pump Water Heater	Heat pump Water Heater
Ventilation Equipment	none	90% SRE ERVs [4]	90% SRE ERVs [4]	90% SRE ERVs [4]
Electrical Service		Combine services in a new 400A main panel	Combine services in a new 400A main panel	Combine services in a new 400A main panel
Solar PV	none	none	51kW (DC)	51kW (DC)

[1] Net Zero Energy Ready systems are identical with exclusion of renewables.
[2] Includes extending the hydronic baseboard heaters into the daycare office.
[3] sized for 60% of the heating load.
[4] 90% heat recovery efficiency Tempeff Dualcore or similar.

The average Canadian daycare has an EUI of 230 kWh/m^2 and the average Canadian recreation facility has an EUI of 308 kWh/m^2 (this excludes high EUI occupancies such as ice rinks, swimming pools etc.).[5] Harrietsfield Williamswood Community Centre has an EUI of 145.9 ekWh/m^2/yr. It is 35% more efficient than the average daycare and 50% more efficient than the average rec centre.

This below average EUI can be partly attributed to the impact of the heat pumps and LED lighting in the building, but it is also due to the lack of ventilation. The Thermal Energy Intensity Demand (TEDI) gives a breakdown of heat losses by building component in the existing building. Ventilation heat losses account for only 2% of overall heat loss (Figure 8).

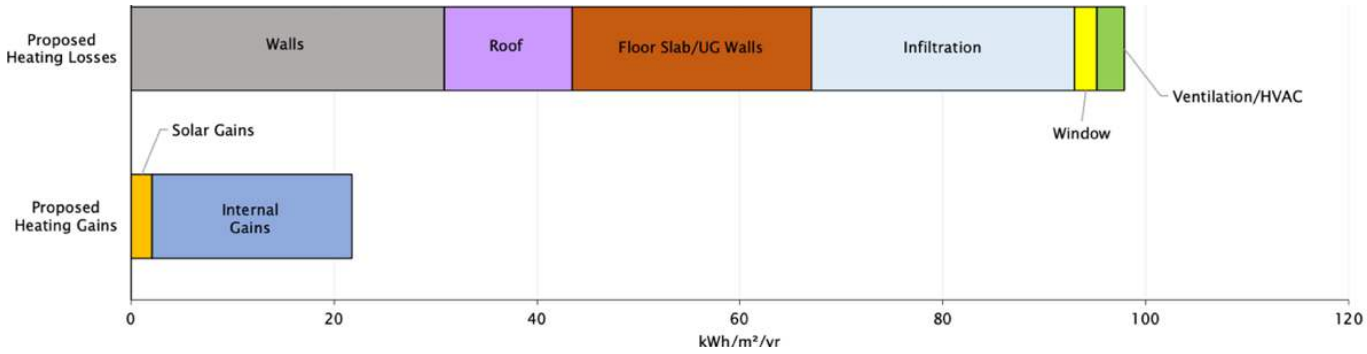


Figure 7 Thermal Energy Demand Intensity (TEDI) kWh/m^2/yr

[5] Energy Star (2021) Technical Reference. Canadian Energy Use Intensity by Property Type, https://portfoliomanager.energystar.gov/pdf/reference/Canadian%20National%20Median%20Table.pdf

Table 3 Retrofit Scenarios EUI Reductions			
	Target TEUI	**TEUI kWh/m^2**	**TEUI reduction**
Existing	-	145.9	-
Minimum Upgrade	50% savings	80.9	45%
NZER ASHP	75% savings	59.8	60%
NZER GSHP	75% savings	59.7	60%
NZE	100% savings	0	100%

The modeled performance of the Minimum Upgrade and NZER scenarios does not meet the EUI reduction targets. This is primarily due to the impact of adding code compliant mechanical ventilation in the retrofits, which offsets some of the savings from the energy conservation measures. The graph in Figure 9 shows the TEUI comparison between the scenarios. Scenario 1 is the minimum upgrade and scenario 1b is the minimum upgrade with ventilation excluded. Without ventilation the minimum upgrade TEUI is 59.6 kWh/m^2, a 60% reduction over the existing.

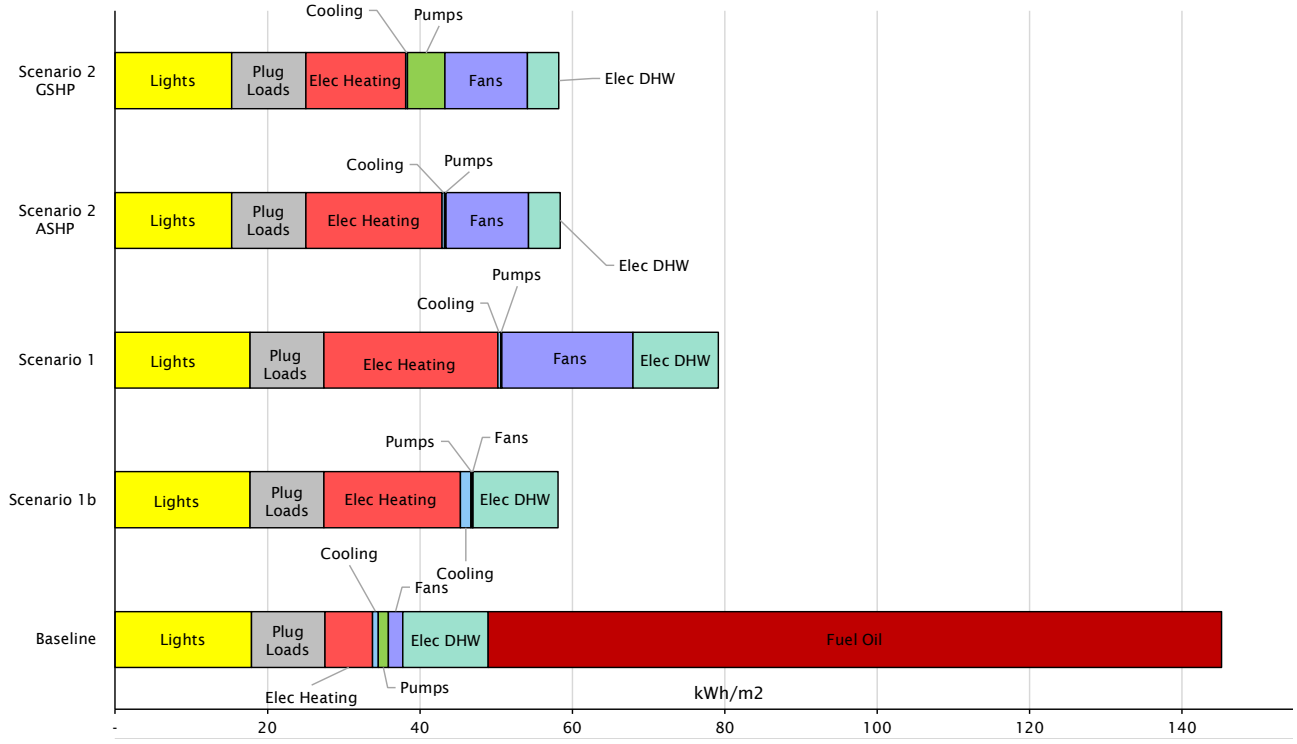


Figure 8 ECM Scenarios TEUI comparison

The decision was made to proceed with the proposed ECMs despite falling short of the targets as net-zero performance was achievable with only 60% EUI savings and further upgrades would not be cost-effective.

Design



Figure 9 Design South View

Aesthetic alterations may benefit the energy performance of the Harrietsfield Williamswood Community Centre. As noted earlier in this report, the building has a low window to wall ratio and its windows are obscured with security grilles. While glazing is thermally inferior to insulated walls, natural light and passive ventilation could meaningfully reduce energy use as lighting loads make up 25% of total energy used in the NZER scenarios.

To accurately evaluate the design options, the pre- and post-retrofit scenarios were modeled in a “like for like” manner. For this reason, increasing the glazing ratio was not explored in the study, however it is recommended that future design phases study the benefits of increasing window area on occupant comfort and lighting loads.

Replacing metal window grilles with alternative security measures such as improved exterior lighting and cameras would reduce obstruction to light and air flow through the windows. These measures may further reduce the EUI and provide less quantifiable benefits in increased comfort and enjoyment of the building by the users.

Currently the street elevation of the building is opaque and unfriendly. The concept design adds windows in the original overhead door openings and a timber shading device to filter light. This will screen sightlines of the daycare space from the street and mitigate overheating from late day sun. The doors at the public entrances are glazed to welcome in community members and daycare clientele.

The retrofitted walls and roof are clad with corrugated metal with wood accents at the entrances for a sense of warmth. Metal siding is an economical and environmentally

responsible cladding option. It is highly durable and long-lasting, with a low lifetime maintenance burden, and at its end of life, it can be recycled or repurposed.

The new roof pitch is increased to 8:12 and the roofline simplified, eliminating several junctions that are present in the current roof. This provides more area for solar panels and reduces the potential for air and water leaks.



Figure 10 Concept Design Partial West Elevation-Section

HRM has reported that vandalism has been experienced at the site. Attractive buildings can foster positive interactions between community members, and a heightened sense of community can positively influence issues such as littering, vandalism and crime.[6]

Architectural Elevation drawings are provided in Appendix L.

[6] Ramey, D., & Shrider, E. (2014). New Parochialism, Sources of Community Investment, and the Control of Street Crime. *Criminology and public policy*, 13, 193-216. https://doi.org/10.1111/1745-9133.12074.

Panelized Wall Details

The prototype ReCover panel is a wood framed box which holds carbon storing cellulose insulation. The depth of the frame is flexible depending on the needed performance.

The panel components were specified to reduce moisture risks from both internal and external sources. Strapping on the back side of the panel allows for fitting adjustments and makes an internal air cavity and moisture buffer, allowing any vapour diffusion from the inside to move out through the panels. The rear panel layer is a “smart” vapour control membrane which varies in permeability, also to let vapour pass. Cellulose and wood are hygroscopic, transporting moisture to support drying activity. A vapour-open water-resistive barrier (WRB) protects the panel’s outer plywood sheathing. This acts as a drainage plane behind the rainscreen cavity and metal siding. Metal siding is recommended for longevity and durability.

Proposed NZER Scenario Panel RSI-4.8 (R-27)

1. metal cladding [7]
2. 19mm strapping/rainscreen cavity.
3. WRB membrane
4. plywood sheathing
5. dense-pack cellulose
6. framing: 2x10 frame with staggered studs[8]
7. variable permeability vapour control membrane
8. interior strapping

Panel schematics and connection details for each scenario are in Appendix H.

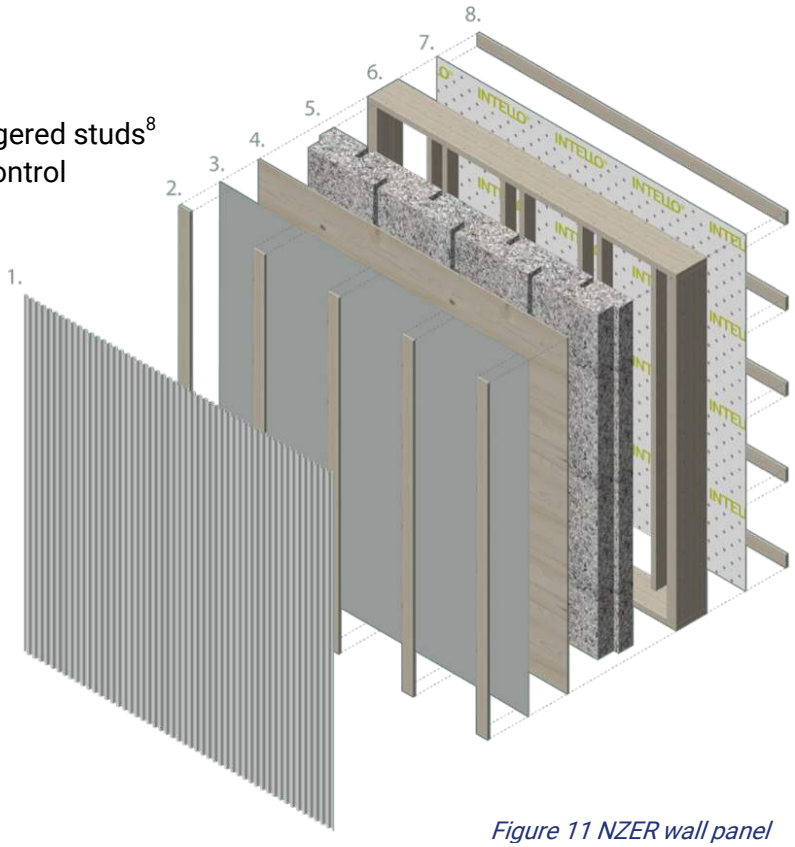


Figure 11 NZER wall panel

[7] Panels will be assembled remotely; however, the cladding will be installed on site.
[8] Minimum Upgrade scenario panel is RSI-1.94 (R-11) with 2x4 stud framing at 24”o.c.

Structural Design

- Panels are fastened at the top and bottom only, with no mid-span connections.
- Panel heights in the proposed layout vary, and where panels exceed 3658mm (12') tall, must be framed with 2x6s. The proposed panel layout is provided in Appendix I.
- Panels are supported at the base by a steel bent plate lintel fastened to the concrete foundation wall and secured to the top of the CMU with Simpson Strong-Tie tie plates (Figure 13).
- New roof trusses bear on a new knee wall and continuous double top plate which runs between the existing trusses (Figure 13).

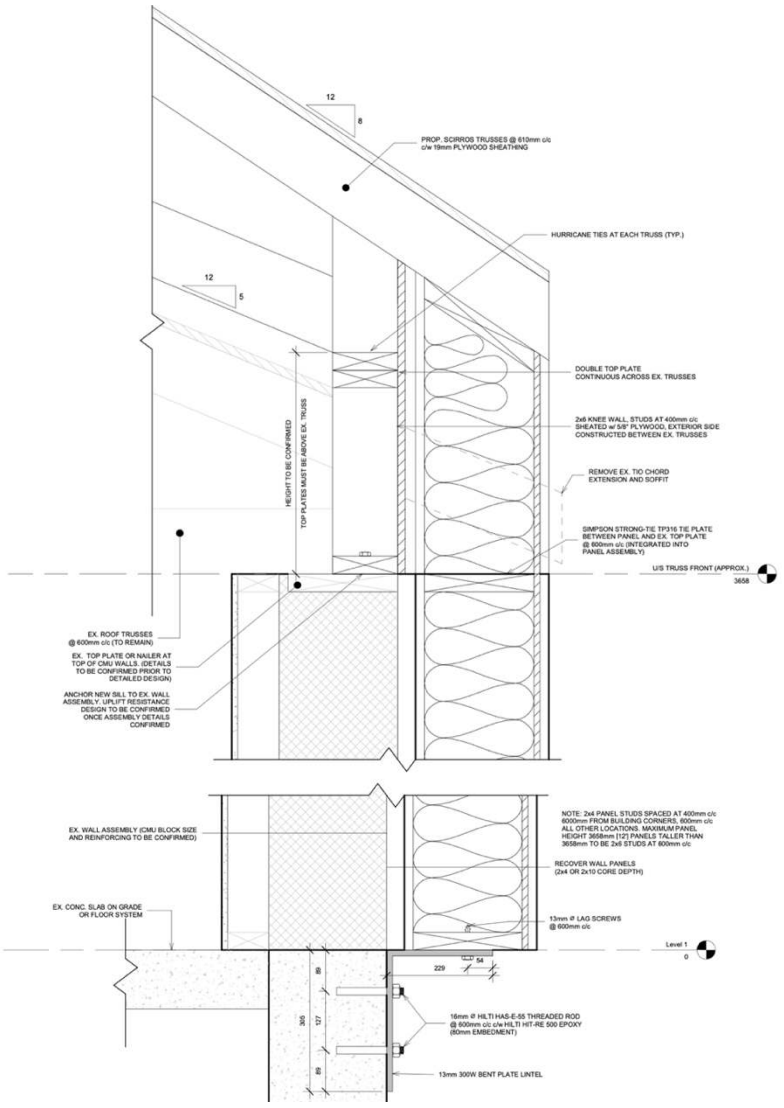


Figure 12 Panel connections at foundation and roof.

The panel widths vary based on optimized spacing around the building with a standard width of 2.4m (8') with modifications to suit the building geometry and window and door positions. The design includes prefabricated corner panels, to simplify installation in the field. These are 0.6m (2') wide in each direction.

The proposed panel layout is provided in Appendix I.

Foundation Insulation

The angled steel panel support at the foundation is a linear thermal bridge and should be fully covered by 100mm (4") of expanded polystyrene or mineral wool insulation to reduce heat losses and prevent localized condensation on the steel.

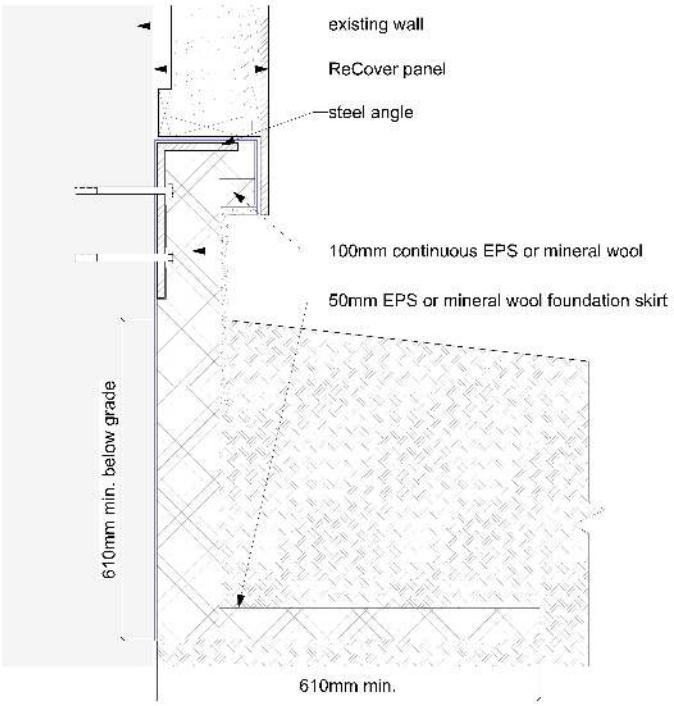


Figure 13 foundation insulation

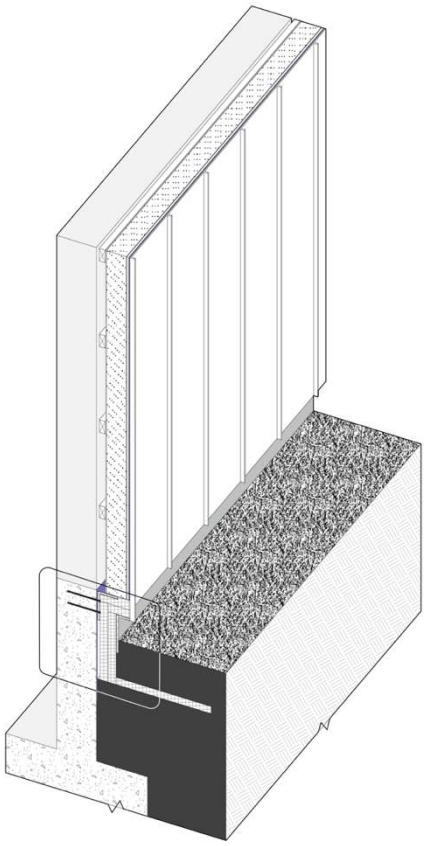


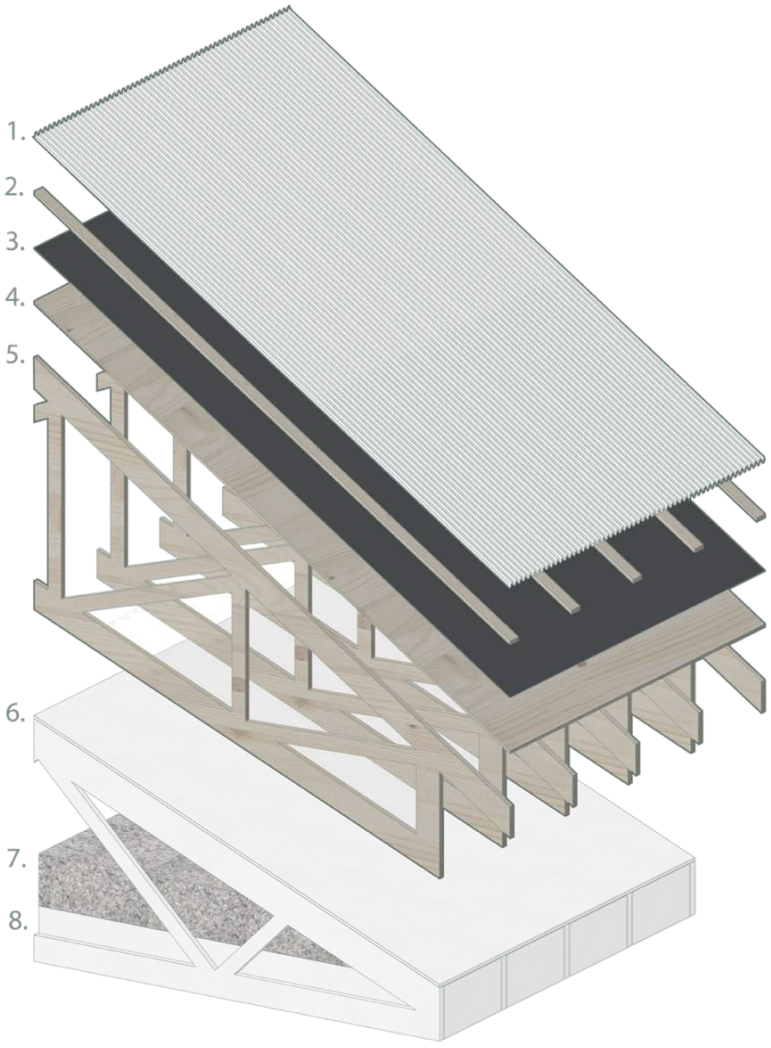
Figure 14 panel axonometric drawing

Roof Details

A panelized roof retrofit is not a viable solution for the Harrietsfield Williamswood Community Centre as the existing roof cannot support added loading.

In the Minimum Upgrade scenario, the existing roof structure will remain and the depth of the loose cellulose insulation will increase to bring thermal performance from RSI-4.23 to RSI-6.16.

In the NZER scenarios, pre-engineered scissor trusses will be installed above the existing roof, with loose cellulose insulation added to the existing cellulose to bring performance from RSI-4.23 to RSI-10.5. Generous openings will be made in the existing roof sheathing to provide a highly ventilated attic volume.



NZER Scenario Roof
effective RSI-10.6 (R-60)

1. metal roofing
2. strapping
3. WRB membrane
4. plywood sheathing
5. pre-engineered roof trusses
6. new cellulose insulation
7. existing cellulose insulation
8. existing roof trusses

Figure 15 NZER Roof

Hygrothermal Modeling

The analysis of moisture and temperature over time is called hygrothermal analysis. Adding new materials to the exterior of a building can slow or block moisture from passing through, and prolonged exposure to moisture in the building assemblies can lead to durability issues including mold growth and decay.

Hygrothermal simulations were conducted on the Harrietsfield Williamswood Community Centre NZER wall and roof assemblies using WUFI® Pro (Appendix J). The analysis focused on the plywood sheathing and cellulose insulation in the assemblies, as biogenic materials are most susceptible to moisture damage. When moisture content of wood exceeds 20% for prolonged periods it can decay.

Hygrothermal performance is dependent on the material characteristics of each component of a building assembly. Assumptions were made regarding the materials in the existing walls and roof. Confirmation of the assumptions is required prior to finalizing the retrofit designs.

Simulations were run for each orientation of each assembly for a 10-year period post-retrofit. All assemblies displayed cyclical seasonal moisture fluctuations consistent with expectations for buildings in the Nova Scotia climate. Specifically, moisture content peaks in winter, with the greatest peak occurring in the first year post-retrofit, and spikes decrease in subsequent years. A moisture spike that exceeds 20% in one winter does not typically damage the building as long as drying occurs in the summer. Spikes above 20% that persist for several years indicate a potential for mould and eventual decay.

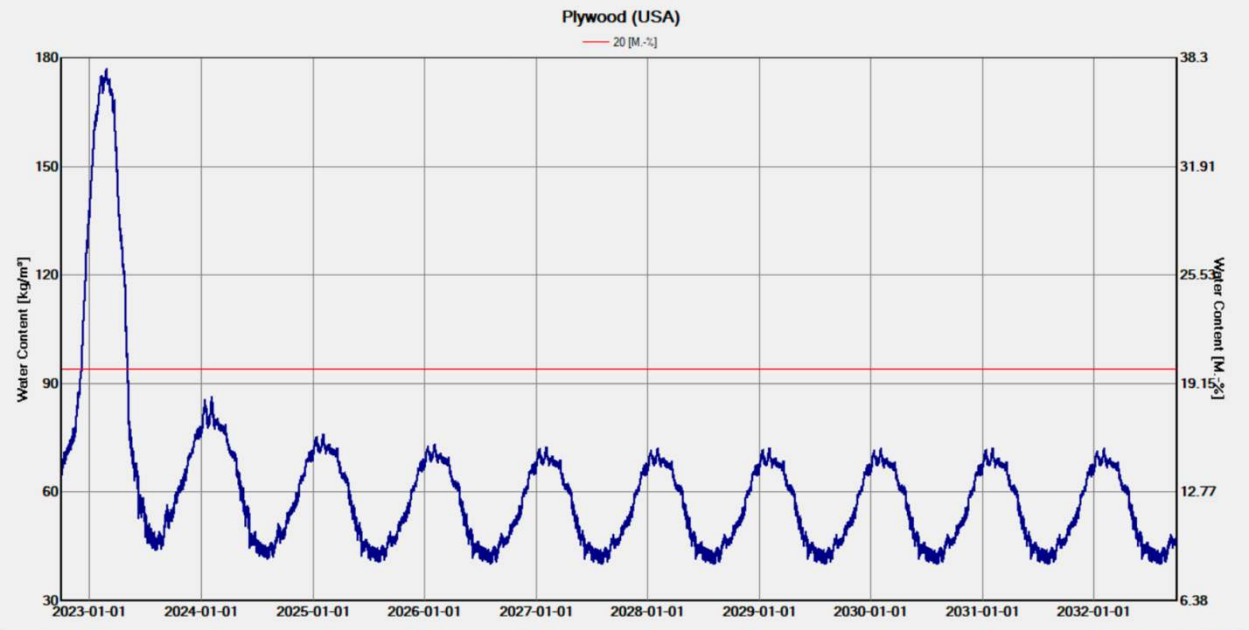


Figure 16 Wufi Pro output - north-west bump-out wall panel (inner plywood layer)

Most of the materials analyzed demonstrate a pattern like the one in Figure 17.

The east walls show annual spikes exceeding 20% moisture content in the outer layer of plywood in all 10 years of the analysis. This is indicative of risk but requires additional modeling after determining the actual materials in the existing assemblies. An alternate sheathing, such as gypsum based sheathing board, can be used for these walls if future modeling has the same results. Installing hygrothermal monitoring sensors in some assemblies may be valuable during the retrofit to compare modeled results with real data to inform future retrofits.

The building will have two attic spaces after the retrofit, a sealed inner attic and a ventilated outer one. Analysis of the roof assembly indicates that it should be designed with careful attention to venting. The attics will perform best with attic air exchange between 5-10 air changes per hour (ACH) however the best design from an airtightness perspective is for the existing attic to be airtight. Investigation of the existing roof to confirm the presence of a vapour barrier and other material specifications is needed to make a definitive determination on roof venting.

The analysis identified the potential for mold growth in the fiberglass batt insulation in the existing main wall assemblies. Masonry can absorb and release a high volume of water. The current moisture load likely dries to the exterior, but adding layers to the wall may inhibit drying. Additionally, this wall is believed to have a polyethylene vapour barrier, which would block moisture from drying to the interior.

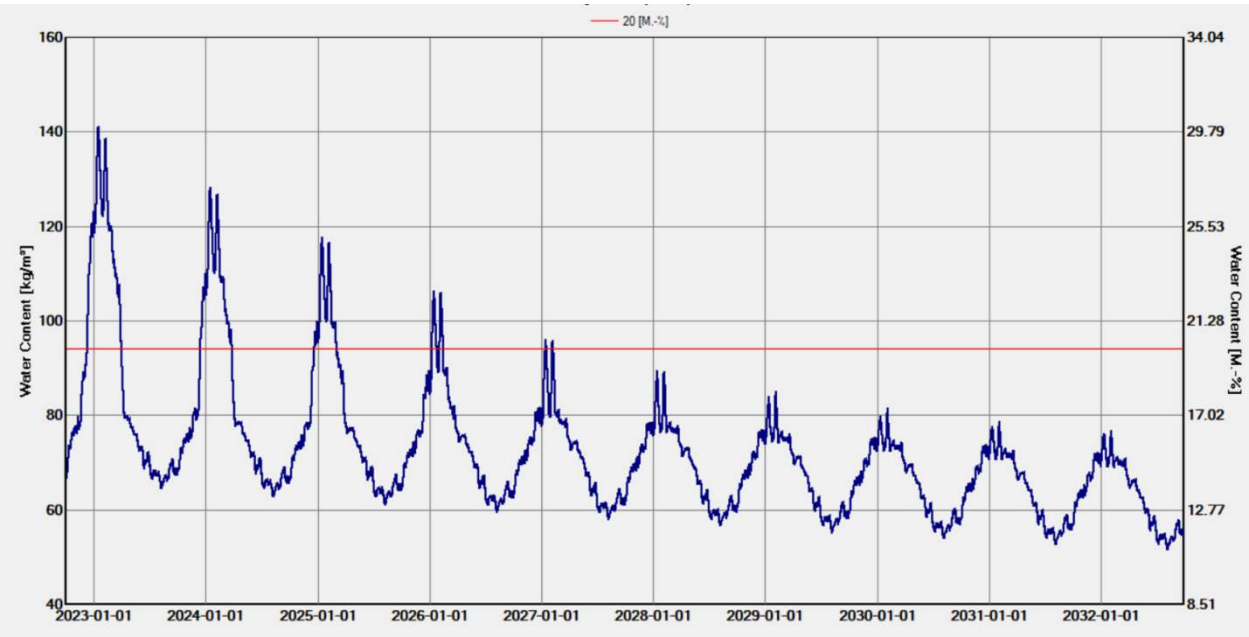


Figure 17 WUFI output - north-east roof assembly (inner plywood layer)

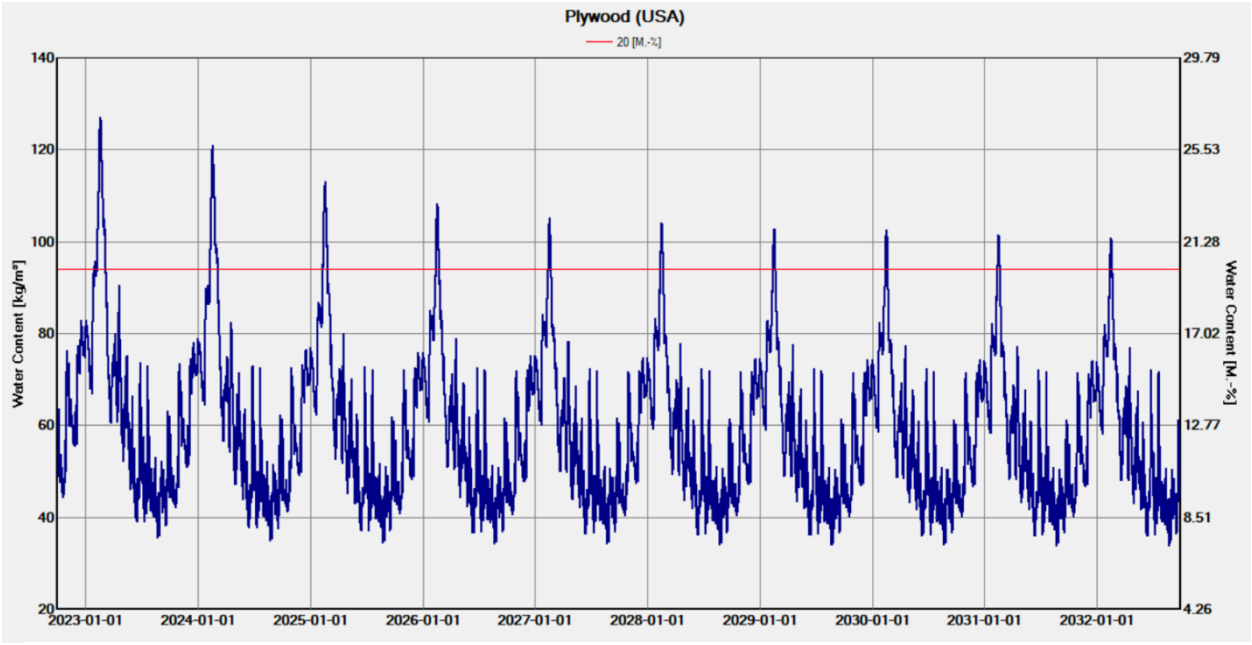


Figure 18 WUFI output- south-east wall panel (outer plywood layer)

Embodied Carbon

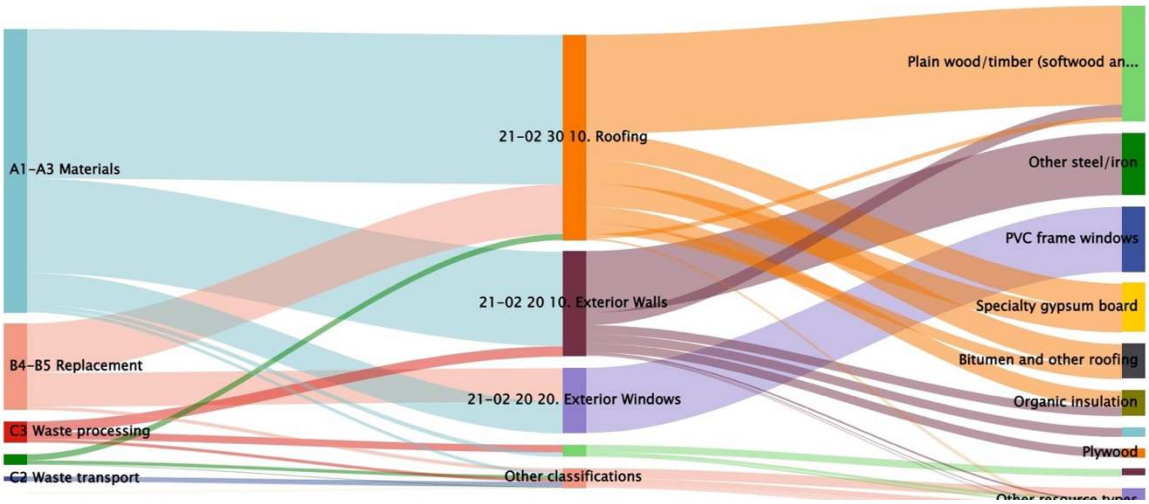


Figure 19 Life Cycle Impacts by Stage (%)

With the short time remaining to limit the impacts of climate change, it is not responsible to complete retrofits that reduce long-term operational emissions while emitting high up-front embodied carbon. Materials used in retrofits must emit the lowest possible carbon or the construction emissions may offset the intended GHGs saved through the retrofit.

Carbon accounting is complex and imperfect. This is frequently used as justification for not factoring embodied carbon into decision making. The objective of including it in this study is not to deliver a definitive value for embodied carbon in the building, rather it is to contribute to the necessary discourse in the building industry, so that the impacts of embodied carbon on GHG emissions are more widely understood.

Embodied Carbon was modeled for this project in One Click LCA (Appendix K). Materials modeled were based on the most representative materials available to the Canadian market with Environmental Product Declarations (EPDs) available in the One Click LCA database. The analysis was limited to embodied carbon of assembly materials being added to the existing building including panel additions to above-grade walls, roofs, below-grade components, and windows and doors. HVAC and electrical components were excluded from the analysis.

The results include a whole life cycle assessment of the building in six impact categories: Global Warming, Ozone Depletion, Acidification, Eutrophication, Formation of tropospheric ozone, Depletion of nonrenewable energy, and Biogenic carbon storage.

The major contributors to the GWP in this design are the wood trusses and steel cladding. The A1-A3 Materials stage contributed 70% of the total carbon emissions associated with this building as illustrated in Figure 20 & 21.

The biogenic carbon storage surpasses that of the A1-C4 emissions by 43%, making a surplus in carbon storage capacity (Table 4). This storage is attributed to the wood products (87%) and cellulose insulation (13%) used in the assemblies.

Table 4 Harrietsfield Williamswood Retrofit – Total Global Warming Potential			
gross floor area m^2	A1-A3 $KgCO2e/m^2$	A1-C4 KgCO2e/m2	Biogenic carbon KgCO2e/m2
456	**60.56**	**86.86**	**151.1**

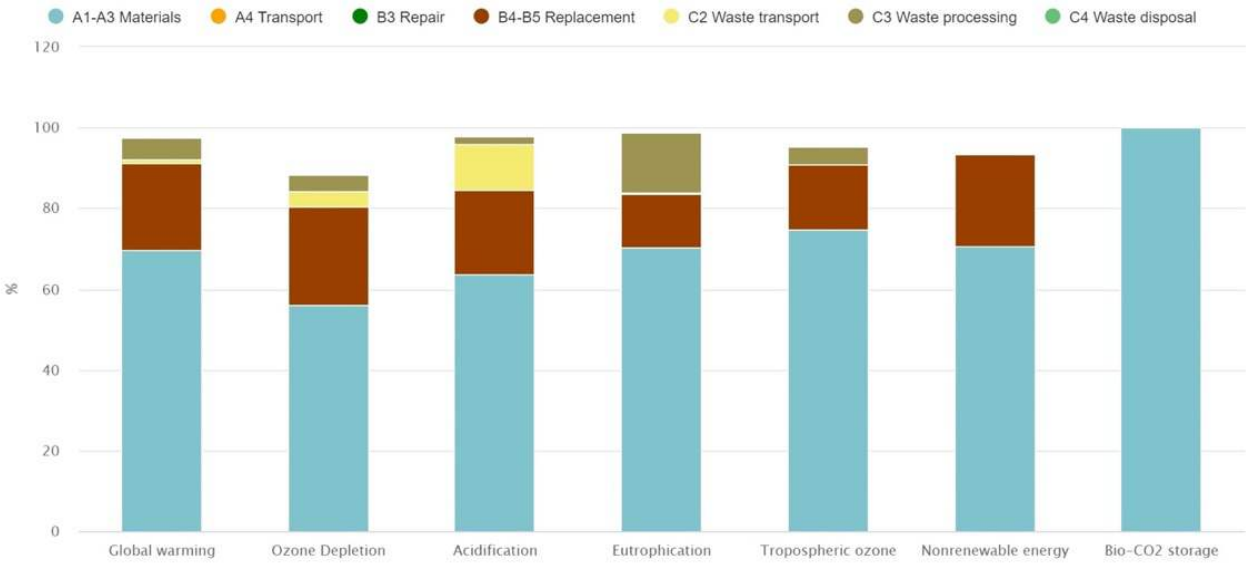


Figure 20 Global Warming by Stage and Material

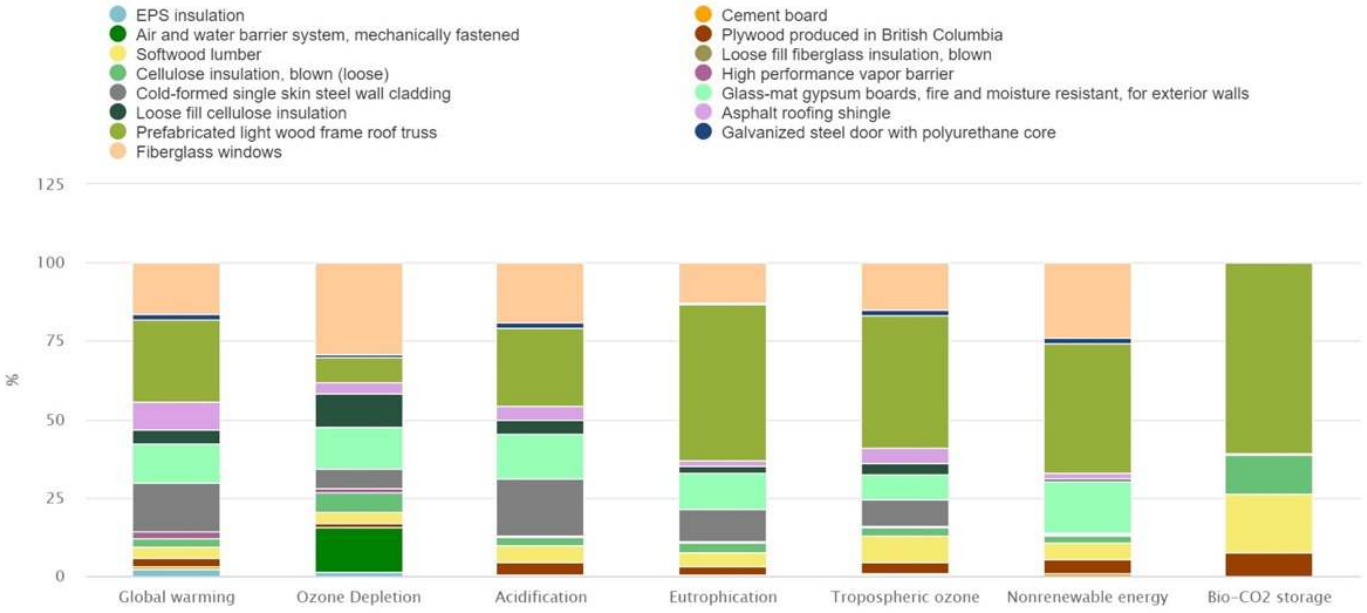


Figure 21 Life Cycle Impacts by Material (%)

Proposed Mechanical Systems

All scenarios:

- All scenarios are fully electrified.
- Plumbing vents that penetrate the roof are to be insulated from ceiling to floor with 3” pipe insulation to prevent thermal bridging.
- Hydronic baseboard heaters will be extended into the daycare office area.
- Existing building controls will remain with the addition of time clocks to ERVs.
- An auxiliary heat relay system will control both the mini split units and hydronic baseboards to ensure simultaneous heating and cooling does not occur.
- Two energy recovery ventilators (ERVs) will be added in the daycare and multipurpose areas. They will be dual core type with approximately 90% heat recovery efficiency.

1. Minimum Upgrade Scenario:

- Heating will continue to be provided by a combination of existing mini split units and hydronic baseboard heaters which will be served by a new 25 kW electric boiler.
- Cooling will be provided by a combination of new and existing mini split units. A 0.5-ton and a 1-ton unit will be installed for a total of 4 units in the building.
- Domestic hot water will be supplied by the existing electric water heater.
- Two energy recovery ventilators (ERVs) will be added in the daycare and multipurpose areas. They will be dual core type with approximately 90% heat recovery efficiency.

2. Net Zero Energy Ready Scenario - ASHP:

- Heating and cooling will be served by a combination of existing mini split heat pumps and two new single zone mini split units (0.5-ton and 0.75-ton) with indoor units located in the daycare and multipurpose rooms. Heat pump units are sized to meet 60% of the peak heating load.
- 10 kW electric boiler sized for the remaining 40% of the load. Heating from the boiler will be distributed through the existing hydronic baseboards.
- Domestic water provided by a new 50-gallon heat pump water heater (HPWH).
- As ventilation loads are occupant dependent, the ERVs will have variable speed fans and be controlled based on CO_2 sensors—one in the multipurpose room and one in the daycare.

3. Net Zero Energy Ready Scenario - GSHP:

- Heating and cooling will be provided by a 5-ton VRF ground source heat pump with ductless indoor units. It will be sized for 100% cooling capacity. Proposed borehole locations are shown in Figure 23.
- 5 kW electric boiler will serve as supplemental heat.

- The GSPH will use the existing hydronic baseboards, served from the new boiler.
- Domestic water provided by a new 50-gallon heat pump water heater (HPWH).
- As ventilation loads are occupant dependent, the ERVs will have variable speed fans and be controlled based on CO_2 sensors—one in the multipurpose room and one in the daycare.
- The GSHP and boiler plant will have direct digital control systems to operate equipment.

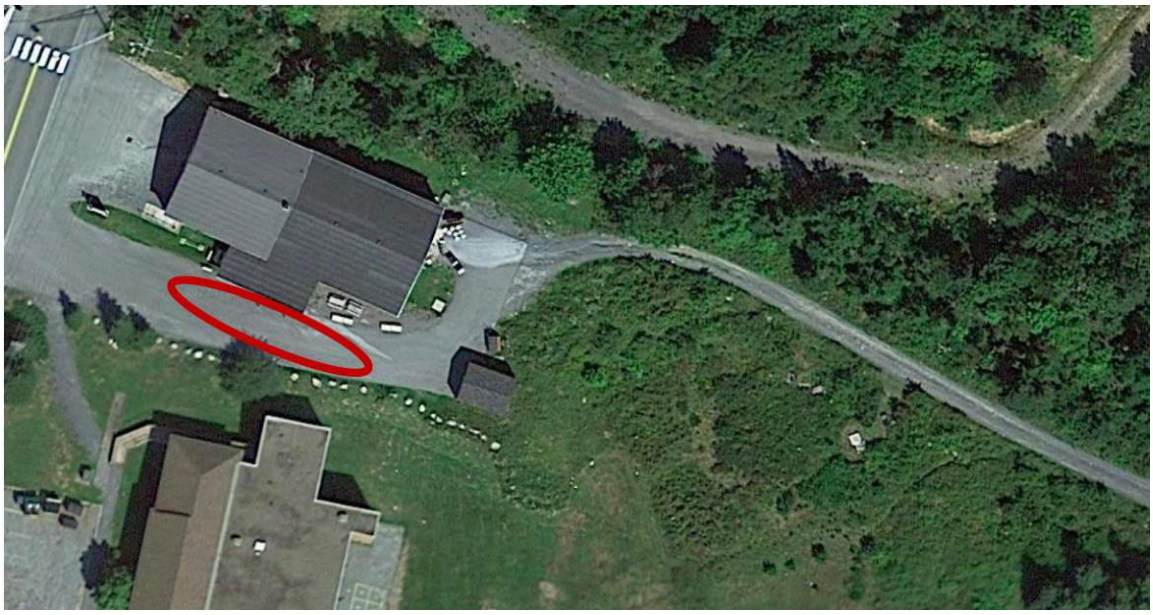


Figure 22 Proposed Borehole Location

Proposed Electrical Systems

All Scenarios:

- Service upgrade to combine the two existing services into one single 400A service.
- Upgrade 2 light fixtures to LED (these were missed in earlier lighting upgrades).

1. Minimum Upgrade Scenario:
    - Existing lighting controls will remain.
2. Net Zero Energy Ready Scenarios
    - The lighting control system will be updated to include automatic lighting control throughout the building.
3. Net Zero Energy
    - 51kW (DC) solar pv array

Nova Scotia Power Net Metering Program

The current NS Power net metering agreement has expired. An update to the program is currently under review by the Nova Scotia Utility Review Board and Nova Scotia Power. Under the new net metering agreement, it is proposed to allow up to 1MW of solar to be installed on any building that incurs a demand charge. There will be two new classifications of net metered systems in the new program, a class 1 system which is under 100kW and a class 2 system which is under 1MW.

In the net metering program, 100% of the excess energy generated from the solar array goes back onto the NSPI grid, and the customer is credited for the energy generated. Under the new proposal, the credit will be a percentage of the customers electricity rate for class 2 systems and will be equal to the customers electricity rate for class 1 systems. The credits automatically come off the power bill, further reducing the cost, the more solar that is installed. Being involved in a net-metering program is an essential part of achieving net-zero as it allows any excess energy generated to flow back onto the grid. This building would be considered a class 1 building due to the size of the proposed PV array.

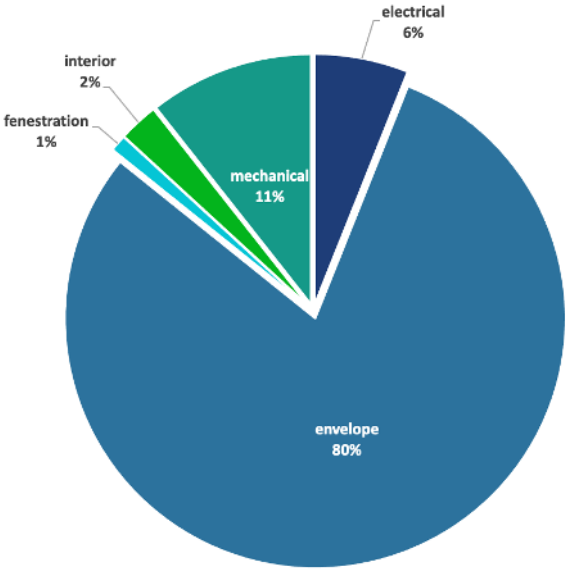
It is possible to install photovoltaics and not enroll in the net metering program. In this scenario, the building would draw power from the solar array as it is needed (up to the arrays maximum capacity). Any excess energy that is generated by the array is clipped (wasted) and no credit is given by the utility for that power. This scenario is only feasible if the customer routinely uses the approximate amount of power the array would generate. To optimize this, a short load study would be performed on the building to determine approximately how much energy is used at any given time of the day/ year, and an array of the average size could be constructed to offset that consumption. This scenario isn't truly considered net-zero since to use 100% of the energy generated, the solar array must overproduce.

The net-metered option is recommended to ensure that a net-zero system can be achieved. As the current conditions for the net-metering program are changing day to day, further consultation with Nova Scotia Power will be needed to ensure all requirements are met prior to construction.

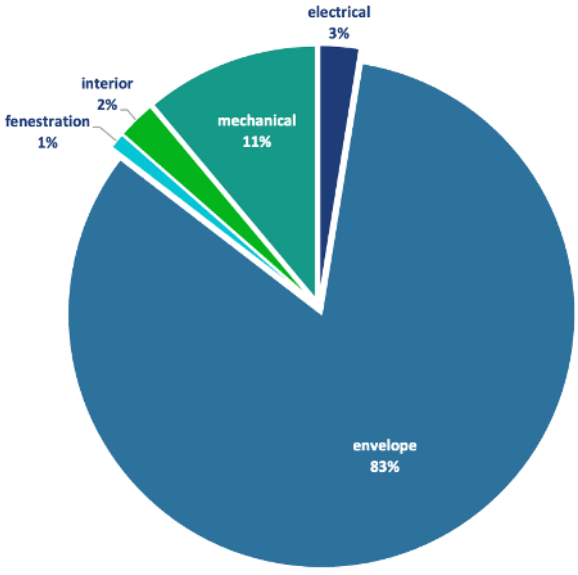
Construction Costs

Class D – Feasibility Cost Estimates (Appendix M) were obtained for the Minimum Upgrade, the two Net Zero Energy Ready scenarios and Net Zero Energy retrofit scenarios. A cost estimate for the Minimum Upgrade + Solar scenario was extrapolated from data in the Class D estimates.

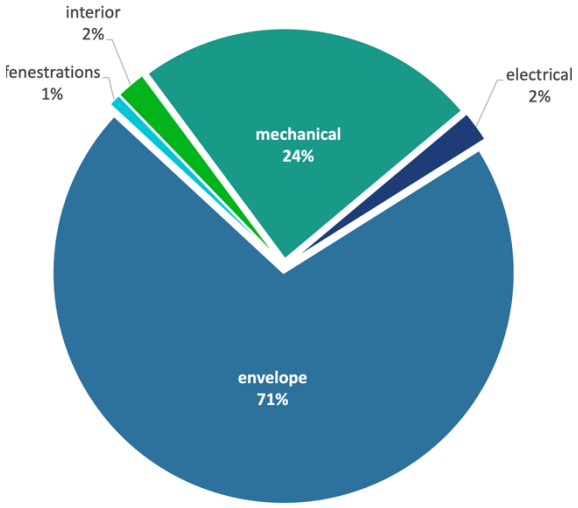
Minimum Upgrade	
Envelope	$921,031
Fenestration	$12,286
Interiors	$29,369
Mechanical	$122,524
Electrical	$69,790
total	**$1,155,000**



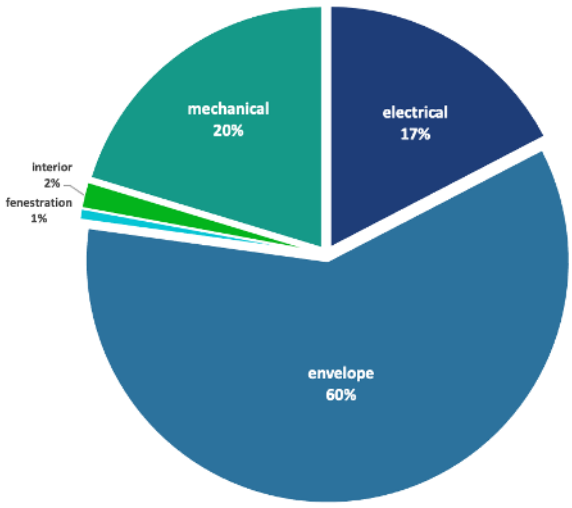
Net Zero Energy Ready ASHP	
Envelope	$994,999
Fenestration	$12,283
Interiors	$29,363
Mechanical	$133,216
Electrical	$30,624
total	**$1,200,486**



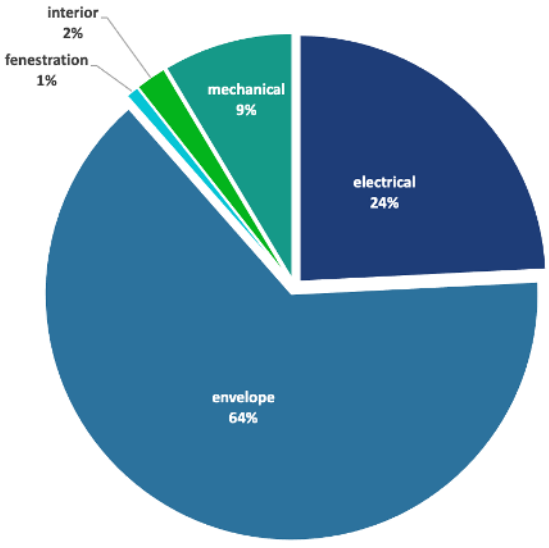
Net Zero Energy Ready GSHP	
Envelope	$994,717
Fenestration	$12,280
Interiors	$29,354
Mechanical	$337,538
Electrical	$29,3544
total	**$1,404,505**



Net Zero Energy - GSHP + PV	
Envelope	$994,717
Fenestration	$12,280
Interiors	$29,354
Mechanical	$337,538
Electrical	$288,958
total	**$1,662,998**



Net Zero Energy – Minimum Upgrade + PV	
Envelope	$921,031
Fenestration	$12,286
Interiors	$29,369
Mechanical	$122,524
Electrical	$346,582
total	**$1,431,792**



Total Cost of Building Ownership

Total Cost of Building Ownership (TCBO) analysis was conducted using the SEEFAR-Valuation© program. Calculations include costs for utilities, carbon tax, maintenance, maintenance capital (replacing major components as they age out), interest, and escalation of these costs over time. TCBO analysis typically includes property tax and insurance, however the building is not subject to property tax and insurance costs were not quantifiable as the building is covered through a blanket policy where costs for one specific building can't be isolated. The input parameters for the SEEFAR-Valuation© are given in Appendix N.

A base case TCBO was evaluated based on the current condition of the building and the maintenance and renewal that would be required for the next 60 years for all components of the building, including interior elements. The TCBO for each retrofit scenario was modeled based on the design details, modeled energy performance and construction cost estimates for the retrofit scenarios outlined in this report.

A sixth scenario was modeled as part of the TCBO that was not considered in the other five buildings in this study, the Minimum Upgrade scenario plus solar. This scenario is possible because the building is fully electrified in the Minimum Upgrade scenario. This scenario resulted in the best TCBO for the building.

Table 5 Total Cost of Building Ownership (TCBO)

	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZR - GSHP + Solar	Min + Solar
GHG emissions (kg) (60 Years)	1,854,060	1,762,328	1,302,802	1,298,862	0	0
EUI (kWh/m2/year)	146.0	80.9	59.8	59.6	0.0	0.0
TCBO at 60 years	**$4,917,000**	**$5,140,000**	**$4,517,000**	**$4,839,000**	**$3,442,000**	**$3,102,000**
TCBO Savings at 60 years	$0	-$223,000	$400,000	$78,000	$1,475,000	$1,815,000
60 Year TCBO savings compared to Base Case		**-5%**	**8%**	**2%**	**30%**	**37%**

Key TCBO Results:

- The base case TCBO is $4.9M, about three times the estimated Cost Replacement Value (CRV) of $1.75M.
- The minimum upgrade scenario uses 45% less energy than the base case but costs 5% more in lifetime operating costs.
- The Net Zero Energy Ready options use 60% less energy but offer less than 10% savings in lifetime operating costs.
- The Net Zero Energy retrofit provides 100% energy savings, and a $1.47M reduction in lifetime operating costs over a Net Zero Energy Ready retrofit.
- The lowest TCBO is the Minimum Upgrade plus which delivers a 37% reduction in lifetime operating costs, for a savings of $1.8M.

Table 6 Operating Cost Summary

Utilities (including carbon tax)	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar	Min + Solar
Cost	$ 2,972,000	$ 2,585,000	$ 1,922,000	$ 1,916,000	$ 42,000	$ 42,000
Difference in Cost from A		$ (387,000)	$ (1,050,000)	$ (1,056,000)	$ (2,930,000)	$ (2,930,000)
Percentage Change Over Base Cost		-13%	-35%	-36%	-99%	-99%
Energy Cost ($/ft2)	$ 509.51	$ 443.17	$ 329.50	$ 328.48	$ 7.20	$ 7.20

Maintenance	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar	Min + Solar
Cost	$ 849,000	$ 186,000	$ 140,000	$ 140,000	$ 308,000	$ 414,000
Difference in Cost from A		$ (663,000)	$ (709,000)	$ (709,000)	$ (541,000)	$ (435,000)
Percentage Change Over Base Cost		-78%	-84%	-84%	-64%	-51%
Maintenance Cost ($/ft2)	$ 145.55	$ 31.89	$ 24.00	$ 24.00	$ 52.80	$ 70.98

First Year Annual Maintenance	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar	Min + Solar
Cost	$ 4,800	$ 1,600	$ 1,300	$ 1,200	$ 2,644	$ 3,559
Difference in Cost from A		$ (3,200)	$ (3,500)	$ (3,600)	$ (2,156)	$ (1,241)
Percentage Change Over Base Cost		-67%	-73%	-75%	-45%	-26%
First Year Maintenance Cost ($/ft2)	$ 0.82	$ 0.27	$ 0.22	$ 0.21	$ 0.45	$ 0.61

- The 60-year utility costs for the Base Case are 1.5 times the CRV of the building.
- The NZR options reduce the 60-year utility costs by 35%.
- A Net Zero Energy retrofit reduces the energy cost by 99% to $42,000, which is the meter charge or minimum charge for the electrical service.
- In all retrofit scenarios maintenance costs are significantly reduced with maintenance for a Net Zero Energy retrofit costing 51% less than the existing building.
- Insurance and property taxes would typically be in the TCBO but are not included here.

Parameters:

- The analysis start year is 2024. Utility, construction, and maintenance costs have been escalated to 2024. Construction costs have been escalated by 20% for 2022-23, and by 10% from 2023-24, or 32% over the two years.
- NS Power rates will increase by 7.1% in 2023 and 7.0% in 2024.
- Carbon tax for fuel oil came into effect in NS in 2023, it is calculated separately in the SEEFAR model and is not included in the fuel oil price.
- Carbon tax has been applied to electricity as it is expected to be passed on to the customer by NS Power.
- Solar panel maintenance is based on $28/kWdc/year.

Table 7 Capital Cost Summary

Initial Retrofit / HPB CostYear 1	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar	Min + Solar
Initial Cost	$ 13,000	$ 1,369,000	$ 1,491,000	$ 1,708,000	$ 2,018,000	$ 1,646,000
Difference in Cost from A		$ 1,356,000	$ 1,478,000	$ 1,695,000	$ 2,005,000	$ 1,633,000
Percentage Change Over Base Cost		10431%	11369%	13038%	15423%	12562%
Cost ($/ft2)	$ 2.23	$ 234.70	$ 255.61	$ 292.82	$ 345.96	$ 282.19

Maintenance Capital Costs 60 Years	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar	Min + Solar
Cost	$ 1,083,000	$ 1,001,000	$ 965,000	$ 1,075,000	$ 1,075,000	$ 1,001,000
Difference in Cost from A		$ (82,000)	$ (118,000)	$ (8,000)	$ (8,000)	$ (82,000)
Percentage Change Over Base Cost		-7.57%	-10.90%	-0.74%	-0.74%	-7.57%
Cost ($/ft2)	$ 185.67	$ 171.61	$ 165.44	$ 184.30	$ 184.30	$ 171.61

Retrofit / HPB + Maintenance Capital Costs 60 Years	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar	Min + Solar
Total Costs	$ 1,096,000	$ 2,370,000	$ 2,456,000	$ 2,783,000	$ 3,093,000	$ 2,647,000
Difference in Cost from A		$ 1,274,000	$ 1,360,000	$ 1,687,000	$ 1,997,000	$ 1,551,000
Percentage Change over Base Cost		116.24%	124.09%	153.92%	182.21%	141.51%

The Capital Cost Summary compares the first-year capital investment in maintaining the existing building with the construction costs for the retrofit scenarios. The capital costs for the retrofits have been escalated to 2024 values from the construction cost estimate. The retrofit costs are high because of the extensive work on the building enclosure and new mechanical systems and solar panels. The capital cost of the NZE scenario is more than the CRV of the building.

Maintenance capital is the cost of replacing major building components as they wear or age out. For example, the boiler needs to be replaced every 25 years. The costs to maintain the building in all scenarios is similar, at around $1M.

This analysis assumes that solar panels will not be replaced in the 60-year time frame of the analysis, but that they will undergo regular renewal through annual maintenance.

Table 8 Annual Energy Consumption and GHGs

	Units	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar	Min + Solar
Annual Water Consumption	m3	0.0	0.0	0.0	0.0	0.0	0.0
Annual Sewer Discharge	m3	0.0	0.0	0.0	0.0	0.0	0.0
Annual Electric Consumption	kWh	26995.0	43839.0	32408.0	32310.0	32310.0	43839.0
Annual Heating Oil Consumption	Litres	4812.0	0.0	0.0	0.0	0.0	0.0
GHG emissions	kg CO2 eq	30901.0	29372.1	21713.4	21647.7	0.0	0.0
Annual Solar PV generated	kWh	0.0	0.0	0.0	0.0	32310.0	43839.0
Total Annual Energy Consumption	ekWh	79125.0	43839.0	32408.0	32310.0	0.0	0.0
Total Annual Energy Consumption	GJ	284.9	157.8	116.7	116.3	0.0	0.0
EUI	kWh/m2/yr	**146.0**	**80.9**	**59.8**	**59.6**	**0.0**	**0.0**

Key Results:

- Electricity consumption increases all retrofit scenarios due to electrification of the building's mechanical systems. Total annual energy consumption decreases all of the retrofit scenarios, and the Net Zero Energy scenarios have zero consumption.
- GHG emissions and EUI are reduced across all retrofit scenarios.
- The minimum upgrade reduces GHGs and EUI by 45%.
- The NZR options reduce GHGs and EUI by 60% and the Net Zero Energy retrofits reduce GHGs by 100%.
- A new NS Power net metering policy is proposed to be adopted later in 2023. The building could be net-positive if policy permits.

Notes:

- Water consumption and sewer discharge were not measured. The cost of annual septic tank pumping is $4900/year, but as the system is shared with the elementary school on the adjacent site and as the cost is consistent in all scenarios, it was excluded from the analysis. There may be an opportunity for savings by replacing plumbing fixtures, but that was not undertaken in this study.
- The electrical rate for the Base Case is the domestic rate for two meters.
- The electrical rate in the retrofit scenarios assumes conversion to commercial billing.
- The minimum upgrade has a slightly higher electric rate because the anticipated demand for the electric boiler will be higher.
- The Net Zero options have a slightly lower demand charge and, thus, a lower average electricity rate.

Cumulative TCBO

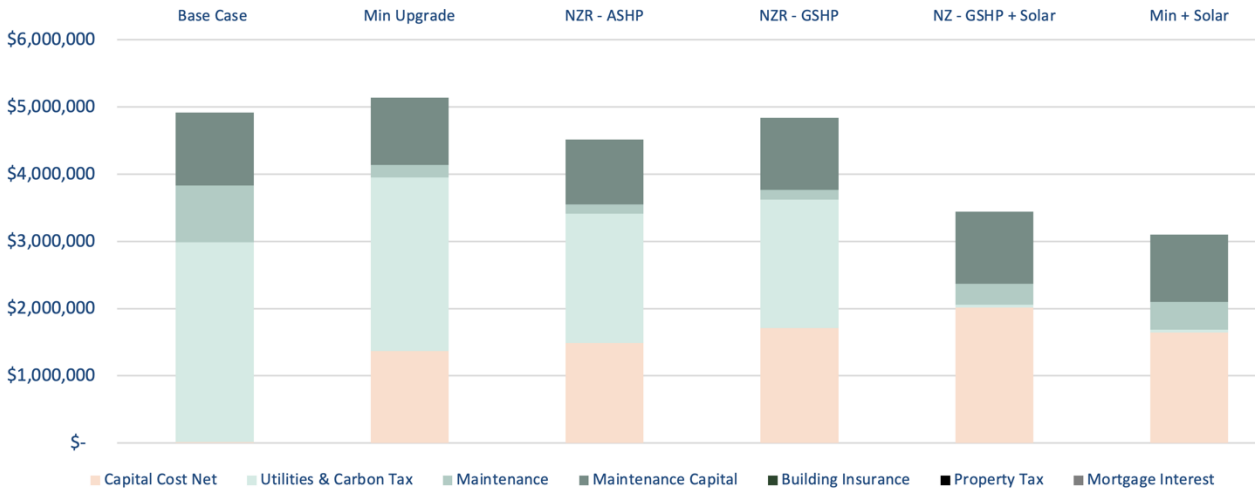


Figure 24 TCBO Comparison

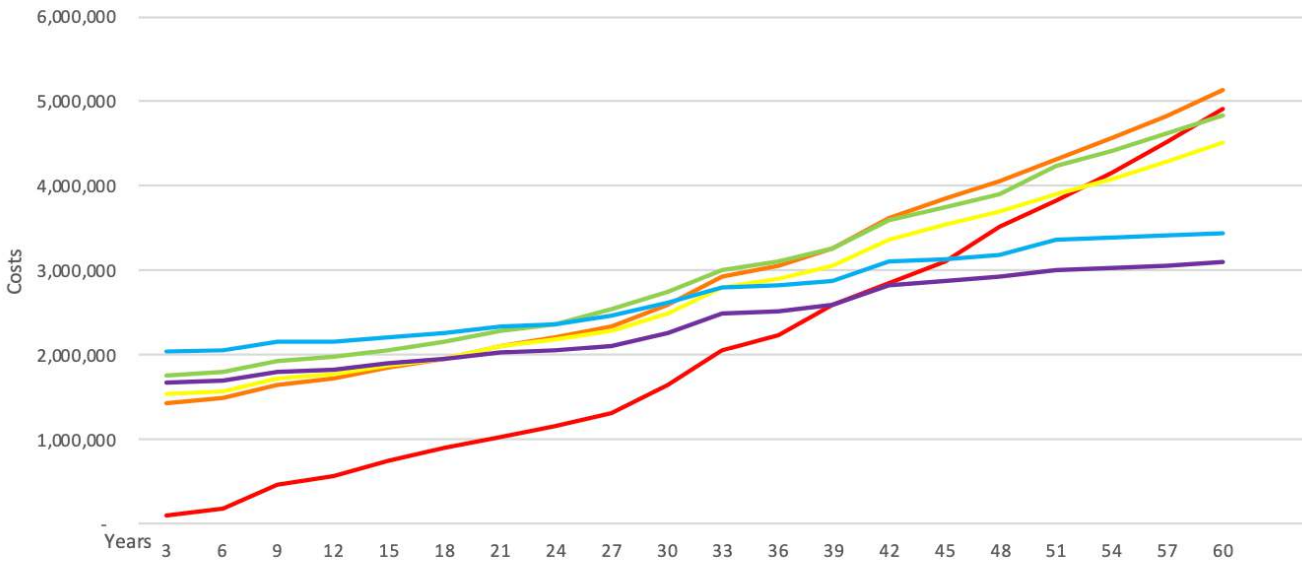


Figure 23 Cumulative TCBO

The existing building has the lowest TCBO for the first 39 years, but the Minimum Upgrade + Solar scenario has lower costs for the remaining life of the building.

The Minimum Upgrade retrofit scenario with the addition of Solar PV is the best investment for this building, resulting in 100% GHG reductions and 37% operational savings compared with the base case.

Discussion

The Harrietsfield Williamswood Community Centre is one of over fifty community recreation facilities owned by the city of Halifax. Many of these are in similar condition to Harrietsfield Williamswood, with wasted energy and maintenance backlogs. Each of these buildings also needs a deep retrofit to reduce energy consumption and for resilience, and to meet HRM's climate targets.

We can't underestimate the need for focus on resilience. In the past 12 months Nova Scotia has experienced unprecedented damage to property, infrastructure, and the natural world from the impacts of climate change from hurricane, wildfire and severe flooding. Every building we touch needs to be not only energy efficient but also robust enough to withstand the increased intensity of a more volatile climate, to protect its occupants and to protect the investment.

The cost of the recommended retrofit is higher than anticipated, but at $\$280/ft^2$ it is more economical to retrofit the building than to rebuilt it. The embodied carbon emissions from the retrofit are 86.86 $kgCO_2e$. Embodied carbon data is not readily available for community centres, however this building is small enough that it could be evaluated at the scale of a large house. If the Harrietsfield Williamswood Community Centre were to be replaced by a new build with moderate carbon materials, its embodied carbon would be 68,400 $kgCO_2e$ based on a value of 150 $kgCO_2e$ per m^2. [9] This number doesn't include the embodied carbon content of the existing structure which would be sent to landfill, which contains significant amounts of concrete. If our goal is to stop emissions today, evaluating every retrofit through the lens of embodied carbon is valuable.

The economic modeling shows that it will be nearly 40 years before the cost of the retrofit catches up with the business-as-usual scenario. This is far longer than the desired 20 year pay-back, however it is a building that needs a retrofit, among countless buildings that also need retrofits. The resulting building will be all electric, energy efficient and secure. While it will take a long time for the cash flow benefit to be seen, it is worth doing.

The learnings from retrofitting the Harrietsfield Williamswood Community Centre can then be applied to Halifax's other small recreation centres.

[9] Passive Buildings Canada and Builders for Climate Action (2022) Emissions of Materials Benchmark Assessment for Residential Cosntruction Report. https://www.buildersforclimateaction.org/report---embarc-report.html

Conclusions

This study of Panelized Deep Retrofits of Municipal Buildings was undertaken to develop deep retrofit strategies to support municipal decarbonization efforts by adapting the Energiesprong approach to the Canadian context.

The project goals were to develop deep retrofit scenarios that achieve 50% or more EUI savings and a scenario that can achieve Net Zero Energy (NZE) with the addition of solar PV. The solutions needed to minimize occupant disruption and embodied carbon. The recommended retrofit pathway would be the option with the lowest Total Cost of Building Ownership. Finally, the recommended solution should demonstrate a calculated payback of 20 years or better.

The ReCover team has studied the potential for prefabricated panelized deep retrofits in low-rise multi-unit dwellings in two previous case studies[10]. These studies found the lowest TCBO over the anticipated life of the building was achieved a Net Zero Energy retrofit with an approximate 75% reduction in EUI plus solar PV. The hypothesis of this project was that similar results would be found for municipal buildings. The results did not support the hypothesis.

While the results of this project were not expected, they do serve the objectives to de-risk investment in deep retrofits in Canada, to provide evidence on the effectiveness and scalability of a panelized deep retrofit approach and to build confidence and experience in deep retrofits among Canadian municipalities and industry stakeholders.

This study shows that the technical challenges are secondary to the overwhelming barrier of cost. It also showed that if investment in deep retrofits doesn't happen, municipalities will pay exponentially more down the road.

The work demonstrated that there is a myriad of technical options for most buildings, but the challenge is in developing solutions that are cost effective. Deep retrofits can save money, but it takes a very long time before the savings show up on a balance sheet.

Retrofitting the Harrietsfield Williamswood Community Centre will prevent over 30,000 $kgCO_2e$ annually and save 37% in lifetime operating costs over next 60 years.

[10] ReCover Initiative (2020) *ReCover Phase One Case Study Report* and ReCover Initiative (2022) *Scarlettwood Court Deep Retrofit Case Study Repor*t, https://www.recoverinitiative.ca/about-us/our-results/report-request