

PANELIZED DEEP RETROFITS OF MUNICIPAL BUILDINGS

New Glasgow Municipal Operations Building

Case Study Report

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New Glasgow flourish

Natural Resources Canada | Ressources naturelles Canada

ReCover

Table of Contents

Appendices 2
Acknowledgements 3
Executive Summary ..... Error! Bookmark not defined.
Acronyms and Definitions 6
Introduction 7
Project Objectives 8
Methodology 8
Building Selection 9
Data and Document Collection 9
Building Description 11
Context 12
Building Code Considerations 13
Building Enclosures 14
Existing Structure 14
Existing Mechanical Systems 15
Existing Electrical Systems 16
Energy Consumption 17
Baseline Energy Model and Calibration 17
Results 20
Energy Conservation Measures 20
Design 24
Panelized Wall Details 25
Panelized Roof Details 26
Structural Design 28
Hygrothermal Modeling 32
Embodied Carbon 34
Proposed Mechanical Systems 37
Proposed Electrical Systems 38
Nova Scotia Power Net Metering Program 38
Construction Costs 39
Total Cost of Building Ownership 41
Cumulative TCBO 45
Discussion 46
Conclusions 47

Appendices

Appendix A Pre-retrofit Drawings
Appendix B Facility Condition Assessment
Appendix C Structural Outline Specification
Appendix D Mechanical Outline Specification
Appendix E Electrical Outline Specification
Appendix F Pre-retrofit Utility Records
Appendix G Energy Model Reports
Appendix H Panel Schematics
Appendix I Panel Layouts
Appendix J Hygrothermal Report
Appendix K Embodied Carbon
Appendix L Architectural Elevation Drawings
Appendix M Cost Estimate
Appendix N Total Cost of Building Ownership

List of Figures

Figure 1 Municipal Operations Building 11
Figure 2 Site Plat : Municipal Operations Building. 11
Figure 5 New Glasgow Municipal Operations Building natural ventilation 16
Figure 6 Historical Energy Use: 17
Figure 7 Calibrated Energy Use. 18
Figure 8 Total Energy Use Intensity (kWh/m^2/yr) 19
Figure 9 Thermal Energy Demand Intensity (kWh/m^2/yr) 19
Figure 10 Partial section-elevation 20
Figure 11 TEUI of Scenarios 22
Figure 12 Concept Sketch 24
Figure 13 NZER wall panel 25
Figure 14 roof panel schematic 27
Figure 15 Partial Structural Section 28
Figure 16 panel to truss connection 29
Figure 17 mid-height wall panel connection 30
Figure 18 foundation lintel 30
Figure 19 foundation insulation 31
Figure 20 WUFI output: south wall (outer plywood layer) 32
Figure 21 WUFI output – roof assembly (cellulose layer) 33
Figure 24 Retrofit Global Warming by Stage and Material 34
Figure 22 Life Cycle Impacts by Stage (%) 35
Figure 23 Life Cycle Impacts by Material (%) 36
Figure 26 Cumulative TCBO 45
Figure 25 TCBO Comparison 45

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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.

New Glasgow Municipal Operations Building

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

77% improvement

Existing : 249 kWh/m^2

Recommend : 56 kWh/m^2

GHG

69% improvement

Existing : 554,390 kg/yr

Recommend : 171,930 kg/yr

Lifetime Utility Costs

75% improvement

Existing : $58.3 M

Recommend : $14.8 M

Lifetime Savings

$13.3 Million

Existing : $83.3 M

Recommend : $70.0 M

Retrofit Measures

2x4 ReCover wall panels

2x4 ReCover inverted roof panels

High performance windows and doors

Updated Boiler

New high performance ventilation 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 buildings was proposed for study by the Town of New Glasgow. 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

Several factors led to the selection of the Municipal Operations Building for this study by the Town of New Glasgow and the ReCover team. As one of New Glasgow's most energy intensive buildings, with annual energy costs above $100,000, it is a priority to retrofit, however operations must continue throughout any work to the building. A panelized retrofit may be the best solution to limit disruptions for the town.

It's geometry and generous space on the site make it a good candidate for a panelized retrofit, and it has a large and unshaded roof with strong solar potential.

Data and Document Collection

The Town of New Glasgow provided the following data and supporting documents pertaining to the Municipal Operations Building:

- 1987 floor plan of the space (Appendix A)
- Fuel oil consumption records April 2019 – April 2022 (Appendix F)
- Electrical consumption records January 2018 – April 2022 (Appendix F)
- 2017 SNC Lavalin condition assessment report.

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 the analysis.

Comprehensive building drawings were not 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 Town of New Glasgow 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).

Building Description

The New Glasgow Municipal Operations Building is a one-storey steel structure with a gross floor area of 7,430m^2 (80,000 sq. ft). The space is divided into two areas, a 5,670 m^2 retail space at the front of the building, which is presently unoccupied, and a 1,760m^2 space at the back used by the New Glasgow Public Works and Engineering Department.



Figure 1 Municipal Operations Building



Figure 2 Site Plan

The facility is used as a maintenance shop for storage and servicing of New Glasgow's fleet of trucks, snowplows, and other heavy machinery. It also contains office space, storage rooms, washrooms, and service spaces. The north wall of the building is partially shared with an adjacent movie theatre.

Prior to the start of this study the town of New Glasgow had initiated a preliminary plan to retrofit the building to address necessary upgrades and to convert a portion of the unused space to administrative use.

Context

The Municipal Operations Building is located at 624 E River Road, New Glasgow, in Pictou County, Nova Scotia. The building was originally built as a K-Mart box store in 1976. It is in a commercial area of New Glasgow with nearby forested areas. The building has been used by the Department of Engineering and Public works since 2012. The retail area of the building was used as a weekend Flea Market prior to the COVID-19 pandemic.

New Glasgow is in Canadian building code climate zone 6. 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.[3] High winds and driving rain are key building science concerns in New Glasgow.

In 2022 the Town of New Glasgow implemented their community climate action plan[4] which targets 50% reduction in community GHG emissions and 30% reduction in Municipal GHG emissions below 2018 levels by 2030. Acting on emissions from buildings is one of five focus areas in the plan.

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[3] 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

[4] McIntosh, E. and Mitchell, R. (2022) *Community Climate Action Plan & Greenhouse Gas Emissions Reduction Target 2022-2030,* Town of New Glasgow https://www.newglasgow.ca/departments/climate-change/482-new-glasgow-community-climate-action-plan-2022/file.html

Building Code Considerations

A preliminary building code review has been completed to determine building code implications of a panelized retrofit to the Municipal Operations Building, based on its present occupancy.[5] The primary focus of the review was to determine if panels made with combustible materials can be installed on the existing structure.

The construction type, cladding and fire rating requirements for each exterior wall of a building are based on the area of the wall and its proximity to the property boundaries. Due to the repair garage activities the building is classified as **NBCC Group F2 - Medium Hazard Industrial Occupancy.** At 7,430 m^2, the one storey, sprinklered, structure can be of either combustible or noncombustible construction. All structural elements are required to have a 45-minute fire resistance rating (FRR). The steel structure is not currently fire rated, so this work must be completed as part of a retrofit.

The south and east walls of the building are far from property lines and can be of either combustible or non-combustible construction. The west wall is 4m from the west property line and therefore requires a 2-hour FRR and noncombustible cladding. This means noncombustible panels can be installed on the south, east and west elevations.

Approximately half of the north wall of the building is a party wall shared with the adjacent building and the remainder sits on the north property line. As such, the entire north wall is required to be of noncombustible construction. The existing concrete block walls meet this requirement; however, the masonry is in poor condition and needs repairs to ensure continuity. The party wall section of the north wall must have a 4-hour FRR. This is requirement is not currently met and will need to be implemented as part of a retrofit.

Combustible panels are not permitted on the north wall. This wall is required to have a 2-hour FRR and must be of non-combustible construction. An alternate retrofit solution for the north wall is required to integrate with a panelized retrofit to provide continuous airtightness and thermal performance.

[5] The code requirements of proposed future occupancies are outside the scope of this study and have not been considered.

Building Enclosures

The walls of the Municipal Operations Building consist of 200mm (8”) concrete block. On the south, west elevations and exposed portion of the north wall, the wall has 25mm (1”) rigid insulation and brick cladding. There is interior drywall finish in some areas and exposed concrete block elsewhere. The east (rear) wall has no finishes or insulation.

The roof is an uninsulated corrugated metal roof deck with a modified bitumen roof system. The concrete slab-on-grade floor and cast in place concrete foundations are also uninsulated. Windows are single glazed aluminum storefront units and are concentrated on the west wall.

TABLE 1 Existing Building 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-1.49 (U-0.26)	RSI-0.67 (R-3.8)
weighted average roofs	USI-8.1 (U-1.42)	RSI-0.12 (R-0.7)
weighted average slab	USI-4.1 (U-0.7)	RSI-0.24 (R-1.36)
overhead doors	USI-2.8 (U-0.5)	RSI-0.35 (R-2)
windows	USI-3.8 (U-0.67)	RSI-0.26 (R-1.5)

Existing Structure

The building consists of **structural steel** columns and beams that support an open web steel joist (OWSJ) and corrugated steel deck roof system. Details on the steel strength and weld connections is unavailable, and analysis was based historic steel strengths and the construction date.

Modeling indicates that most of the primary steel structure can support the post-retrofit loads but reinforcement of some columns and beams may be necessary. The OWSJs can’t support added loading. Verification of the steel strength and connection details must be done prior to construction.

The **exterior walls** of the building are 200 mm (8”) thick concrete block. These serve as part of the lateral load resisting system (LLRS) and do not support the roof. Various penetrations have been made in the masonry over the years and there are cracks in the walls and at openings. There is no visible grout or reinforcing in the blocks.

Further details on existing structure are given in Appendix C.

Existing Mechanical Systems

The building has a flat roof, sloped to internal **rainwater drains** and numerous mechanical penetrations which must be carefully detailed in a panelized retrofit.

The building is sprinklered.

Hot water is supplied by five electric water heaters are located near the points of use. Each tank has a nominal capacity of 40 gallons.

Space heating is provided by a single oil-fired hot water boiler with a two-stage burner. Heat is distributed from the boiler by two main heating loops. The first loop is connected to a built-up air handling unit with a hydronic heating coil which supplies air to the retail space at the front of the building. Its setpoint is 7°C but the space generally remains at 9°C or higher throughout the winter, so it remains off. The air handling unit also has a DX **cooling** coil served by four 34-ton rooftop condensing units. The unit has not operated since the summer of 2020.

The second heating loop feeds multiple unit heaters distributed throughout the maintenance shop area at the back of the building, storage rooms at the side of the building and a unit heater in the retail entrance. The unit heaters receive water directly from the boiler. The shop area is maintained at around 18°C. A mini split and electric baseboards have been installed in the office area and a mini split has also been installed in the back storage room.

Ventilation is provided to the retail space when the air handling unit is running. The maintenance shop does not have a continually operating ventilation system. Two inline exhaust fans are connected to flexible hoses in the space and can be operated in certain shop areas when there is an increased risk of pollutants due to welding and automotive fumes. Makeup air is provided by motorized dampers and a louver that are triggered by a CO sensor or manual operation along with two wall mounted exhaust fans. Destratification fans have also been installed in the back storage area for improved air movement.

The HVAC systems were not designed for the current building use. Consequently, ventilation is inadequate in occupied areas, particularly in the winter when the garage doors are not open. Areas of high heat loads (i.e., server room) were noted by the staff to frequently get very hot.

Appendix D provides further details of the existing mechanical system.



Figure 3 Natural ventilation

Existing Electrical Systems

The incoming power service consists of two, 4” conduits servicing a pad mount transformer on the east side of the building. The secondary service entrance enters in the main electrical room.

All **main distribution equipment** is original to the building and has surpassed its reasonable life expectancy, with some equipment showing signs of rust.

Most of the **interior lighting** is provided by fluorescent fixtures, however approximately 15 fixtures have been replaced with LED lamps. Lighting throughout the building is past its reasonable life expectancy and many fixtures require service. 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. This could lead to energy waste if lights are left on in unoccupied areas of the building for extended periods of time (overnight).

Appendix E gives further details of the existing electrical system.

Energy Consumption

Energy analysis was based on electrical records spanning January 2018 to April 2022 and fuel oil records from April 2019 to March 2022 (Appendix F). During this time span the Municipal Operations Building used an average of 63,347 L of fuel oil (680,342 ekWh) and 258,000 kWh of electricity annually. Energy use decreased slighting after June of 2021 when the Flea Market stopped operating out of the space.

Annual energy costs for the building exceed $100,000. The combined annual emissions measure nearly 400tCO2e, representing 13% of New Glasgow's total GHG emissions.

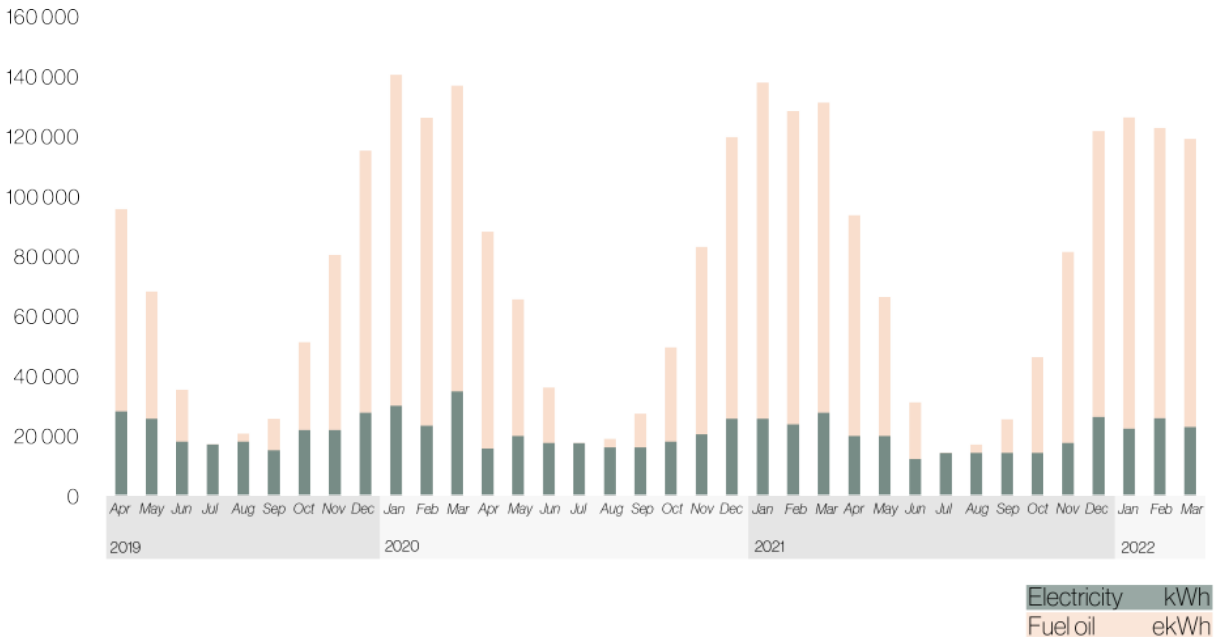


Figure 4 Historical Energy Use:

Baseline Energy Model and Calibration

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

The energy model was calibrated with historical utility data to closely reflect the current building performance. Initial model calibration results deviated substantially from the documented performance. It is possible that the building is gaining heat from the adjacent movie theatre through its party wall. Additionally, under certain winter conditions, heat losses through a highly

conductive building envelope can be reduced due to heat recovery through infiltration. As the Municipal Operations Building is an uninsulated steel building, it is believed to be experiencing this condition.

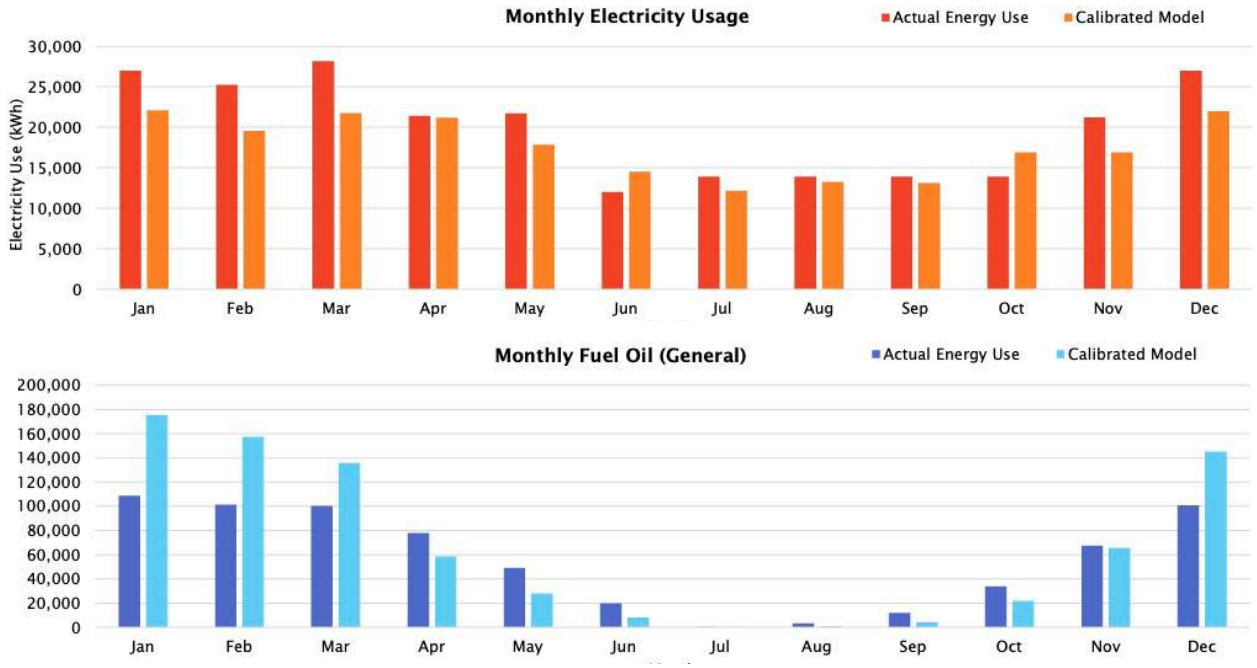


Figure 5 Calibrated Energy Use.

Correction factors were applied in the energy model to calibrate the model more accurately. The air infiltration rate was reduced from 2.3 l/s/m^2 to 1.5 l/s/m^2 and the roof assembly was increased from R-0.7 to R-4 in the baseline energy model.

The final modeled electrical consumption deviates from the existing usage by 11.8% and modeled fuel oil deviates from existing use by 18.7%.

The retail area of the Municipal Operations Building, which makes up 75% of the floor area of the building, is maintained at 7°C. It is implausible that it will continue to be operated at that temperature post retrofit. Performance comparisons between a 7°C baseline and a 20°C post retrofit will not be fair, so the model was calibrated for both the actual 7°C baseline and for a theoretical 20°C baseline.

The Total Energy Use Intensity (TEUI) for the building at current operating conditions is 136 kWh/m^{2}a, and in the theoretical scenario where it is maintained at 20°C it is 248.5 kWh/m^{2}a (see Figure 8). Over 80% of the heat losses are through the uninsulated steel roof (Figure 9).

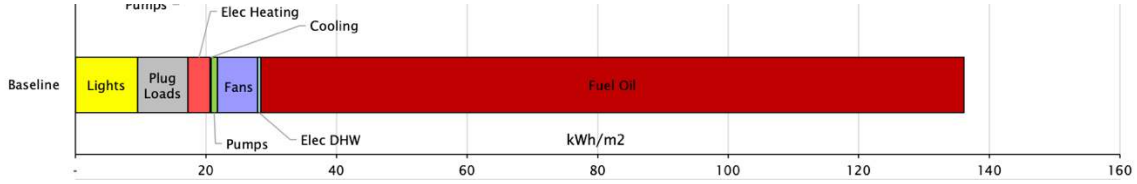


Figure 6 Total Energy Use Intensity (kWh/m^2/yr)

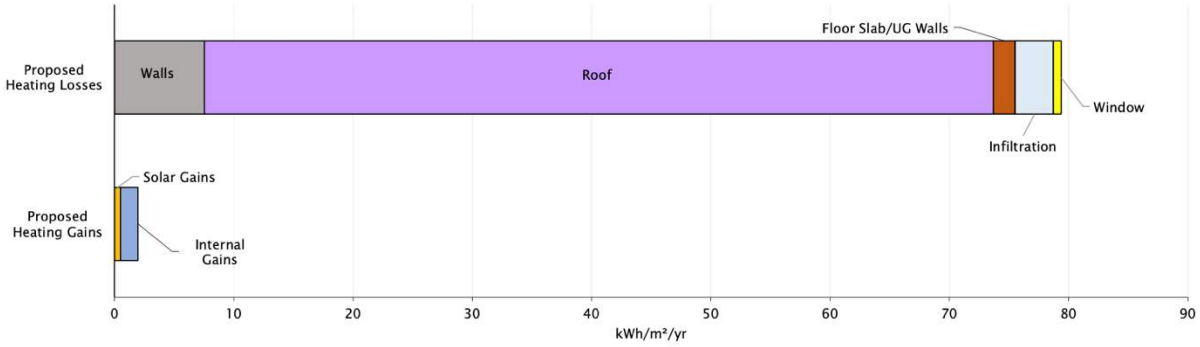


Figure 7 Thermal Energy Demand Intensity (kWh/m^2/yr)

Results

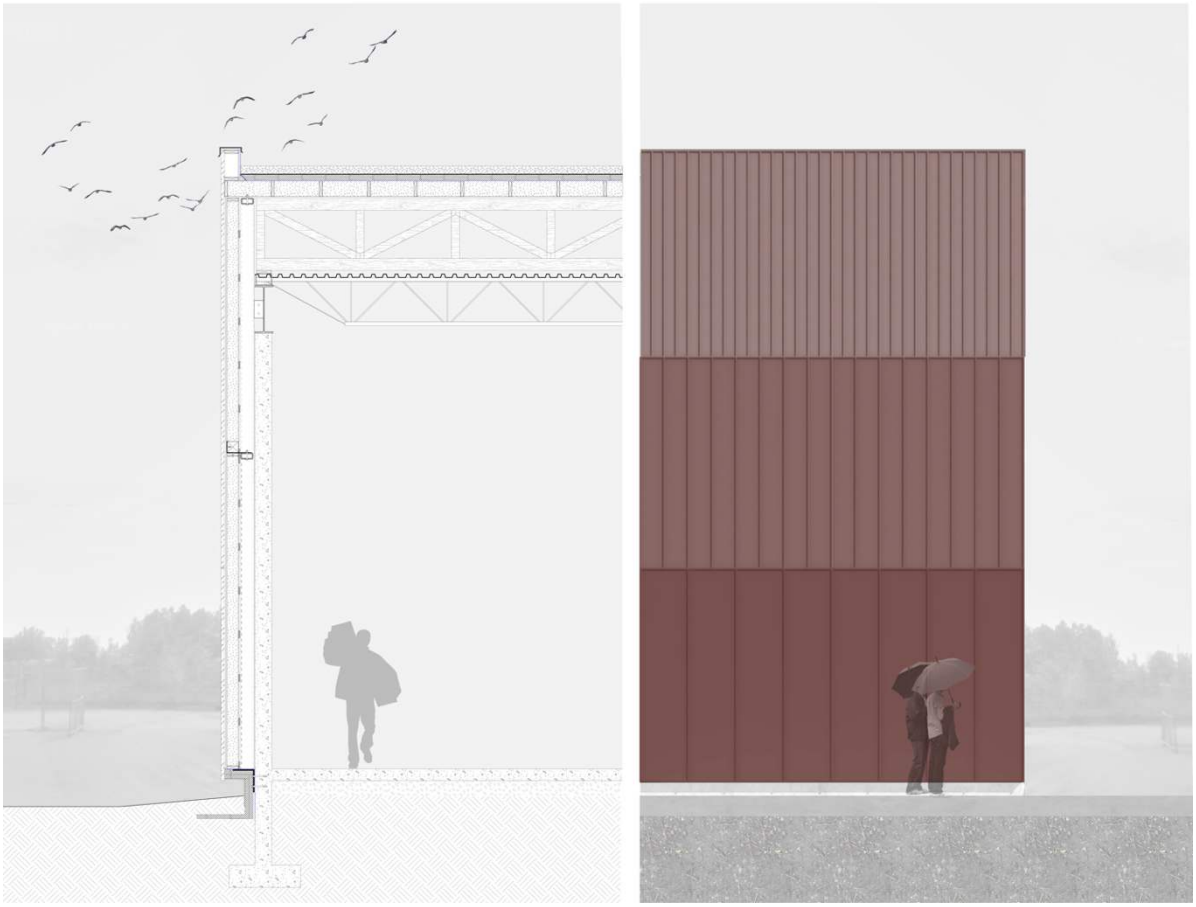


Figure 8 Partial section-elevation

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 includes prefabricated ReCover panels installed on both the walls and roof.

Energy Conservation Measures

Energy conservation measures 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, an estimated 83% 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. Building systems upgrades for the Minimum Upgrade scenario will continue to use fuel-oil as achieving 50% EUI savings with full electrification of the building is cost prohibitive given its age and condition. The NZER scenarios involve full electrification of the HVAC and domestic hot water (DHW) systems.

Both air source heat pumps (ASHP) and ground source heat pumps (GSHP) were considered in the design analysis to learn which option has the lowest TCBO. A GSHP is more energy efficient than an ASHP, however the capital costs of installing a GSHP system are typically significantly higher, so the best investment depends on specific building conditions. 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 Retrofit Scenario Results				
	Target TEUI	**TEUI kWh/m^2**	**TEUI reduction from 7C**	**TEUI reduction from 20°C**
Existing 7°C	-	136.1	-	-
Existing 20°C	-	248.5	-	-
Min. Upgrade	50% savings	85.1	38%	66%
NZER ASHP	75% savings	36.4	75%	86%
NZER GSHP	75% savings	32.6	75%	86%
NZE	100% savings	0	100%	100%

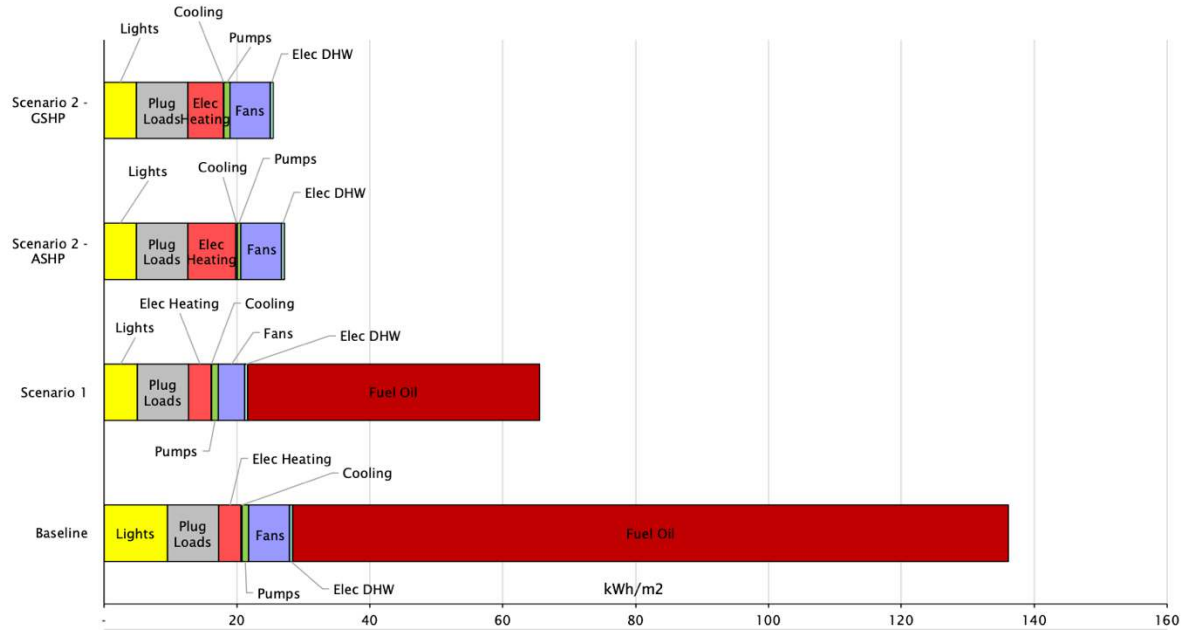


Figure 9 TEUI of Scenarios

Table 3 New Glasgow Municipal Operations Building Retrofit Scenarios Summary				
	Existing Building	**Minimum Upgrade**	**ASHP Net Zero Energy[1]**	**GSHP Net Zero Energy [1]**
Effective Wall R-value	RSI-0.7 (R-3.8)	2x4 ReCover panel RSI-2.46 (R-14)	2x6 ReCover panel RSI-3.52 (R-20)	2x6 ReCover panel RSI-3.52 (R-20)
Effective Roof R-value	RSI-0.12 (R-0.7)	2x6 ReCover panel And rigid XPS RSI-3.17 (R-18)	2x8 ReCover panel And rigid XPS RSI-3.17 (R-18)	2x8 ReCover panel And rigid XPS RSI-3.17 (R-18)
windows	Vinyl, single 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 at 75Pa	3.0 L/s·m2	0.5 L/s·m2	0.5 L/s·m2	0.5 L/s·m2
Central Heating Eq.	Oil-fired boiler with two stage burner	Oil-fired boiler with modulating burner	ASHP	GSHP
Heating System	Maintenance: Unit heaters Retail: Air handling unit [2] Office: Electric baseboards	Maintenance: Unit heaters Retail: Air handling unit [2] Office: Electric baseboards	Maintenance: Unit heaters Retail: Four pipe fan coils Office: Four pipe fan coils	Maintenance: Unit heaters Retail: Four pipe fan coils Office: Four pipe fan coils
Air Conditioning	Maintenance: Mini split [3] Retail: Air handling unit [2] Office: Mini split [4]	Maintenance: Mini split [3] Retail: Air handling unit [2] Office: Mini split [4]	Maintenance: Mini split [3] Retail: Four pipe fan coils Office: Four pipe fan coils	Maintenance: Mini split [3] Retail: Four pipe fan coils Office: Four pipe fan coils
DHW Equip.	Electric Water Heater	Electric Water Heater	Heat pump Water Heater	Heat pump Water Heater
Ventilation Equipment	Maintenance: Exhaust fan Retail: Air handling unit Office: None	Maintenance: 90% SRE ERV Retail: Air handling unit Office: 90% SRE ERV	Maintenance: 90% SRE ERV Retail: 90% SRE ERV Office: 90% SRE ERV	Maintenance: 90% SRE ERV Retail: 90% SRE ERV Office: 90% SRE ERV
Lighting		LED retrofit kit	All new LED	All new LED
Solar PV	none	none	230 kW (DC)	230 kW (DC)

1 Net Zero Energy Ready systems are identical with exclusion of renewables.
2 Installed with heat coil and DX cooling coil served by rooftop condensers.
3 Located in storage room.
4 Located in server room.
5 Controlled through CO sensors.

Design

The New Glasgow Municipal Operations Building is a former big box store, a building type that is ubiquitous and forgettable. There are thousands of pre-engineered steel buildings across Canada that must be retrofit to achieve a net-zero emissions future. These retrofits presents an opportunity for placemaking and to instill character in a building archetype that is a blank slate.

The design concept for the New Glasgow Municipal Operations Building is a nod to the mining heritage of the community. Three courses of rust toned metal with varied vertical rib spacings represent stratified layers of earth. The colour will stand out against its backdrop of trees in all seasons. Metal is cladding is recommended as the cladding as while it has high up-front carbon emissions, it is a good investment for its durability and longevity, and it can be later recycled or repurposed at its end of life.

The proposed cladding update to the Municipal Operations Building is distinctive and elevates the building's presence on the site.

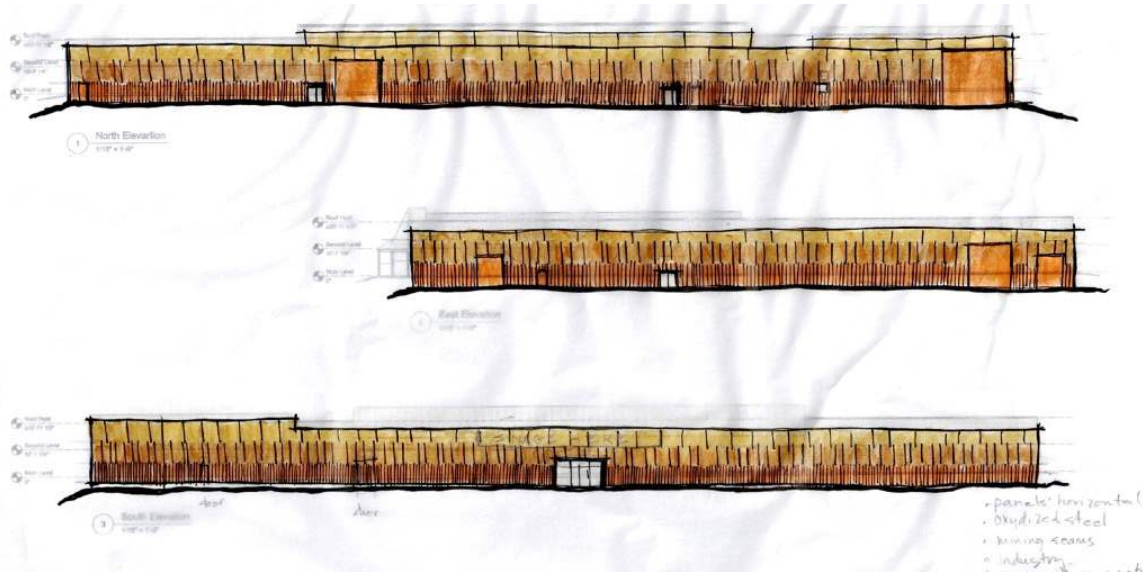


Figure 10 Concept Sketch

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 outer plywood sheathing and is a drainage plane behind the rainscreen cavity and siding.

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

NZER Scenario Wall Panel effective RSI-2.46 (R-14)

1. metal cladding[6]
2. 19mm strapping/rain screen cavity
3. WRB membrane
4. Plywood sheathing
5. Dense-packed cellulose insulation
6. Framing: 2x6 wood studs 24"o.c.[7]
7. variable permeability vapour control membrane
8. strapping

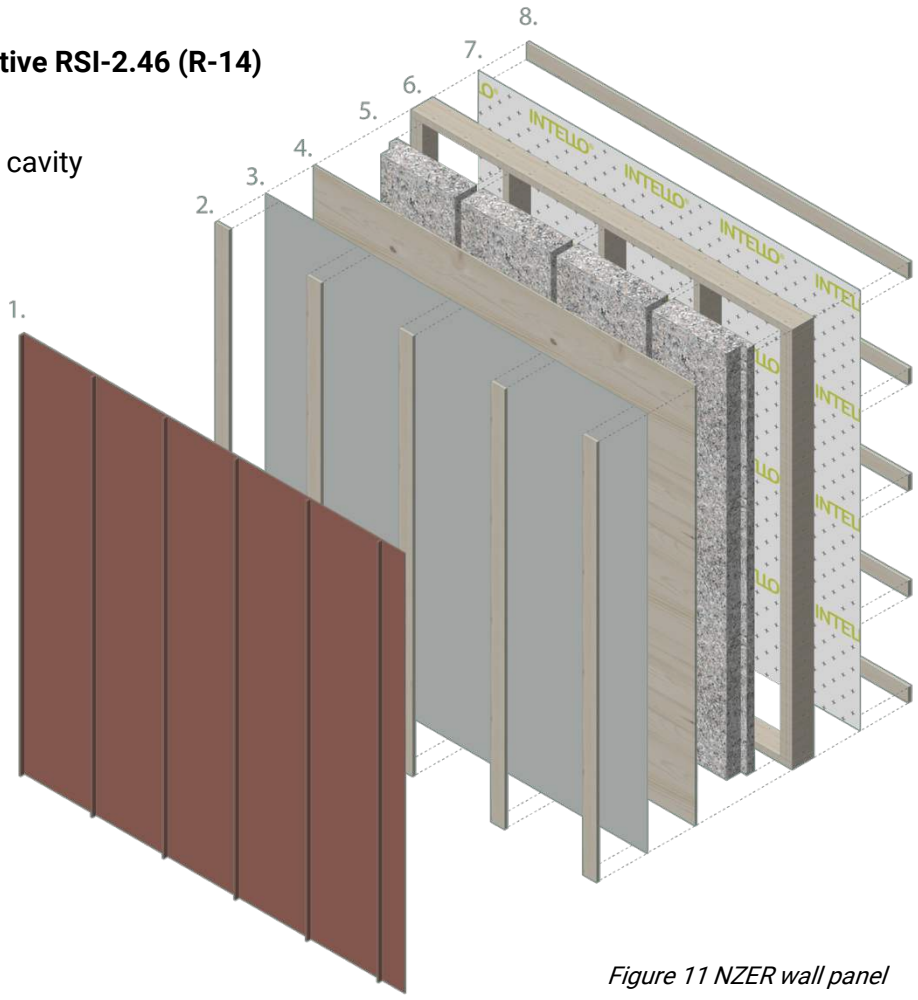


Figure 11 NZER wall panel

[6] Panels will be assembled remotely; however, the cladding will be installed on site.

[7] Wall panel framing is based on 2x4s in the Minimum Upgrade scenario.

The new wall assembly will be two panels high, each approximately 12’-6” in height, running from the foundation and beyond roof to make a new parapet. 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. Panel schematics and connection details for the Municipal Operations Building are provided in Appendix H and the proposed panel layout is provided in Appendix I.

Panelized Roof Details

A flat roof insulated with dense packed cellulose insulation is risky from a hygrothermal perspective. This risk can be mitigated by adding a sufficient depth of rigid foam insulation outboard of the sheathing to keep it warm and thereby prevent condensation. Hygrothermal analysis of the roof panel showed a high risk of moisture and condensation on the sheathing if the panels were installed as part of a conventional flat roof assembly; consequently, the proposed roof is an inverted or protected membrane roof (PMR).

A protected membrane roof has roofing membrane installed on the sheathing surface with insulation above it and ballast on top. The only suitable rigid foam for this application is extruded polystyrene (XPS), which has high embodied carbon. Sopra-XPS has been specified for this assembly, as it is made with 70% recycled XPS and has a much lower embodied carbon than similar XPS products. Gypsum based sheathing is used to prevent any risk from moisture on the sheathing layer. The roof panel is designed to dry to the interior through variable permeability vapour control membrane or ‘smart membrane’ installed at the warm side of the panel to release any moisture that migrates through the panel.

Proposed NZER Scenario Roof effective RSI-2.8 (R-16)

1. Ballast
2. Sopra XPS
3. Roof membrane
4. DensElement sheathing
5. Dense-packed cellulose
6. Framing: 2x8 joists 24”o.c.[8]
7. variable permeability vapour control membrane
8. strapping

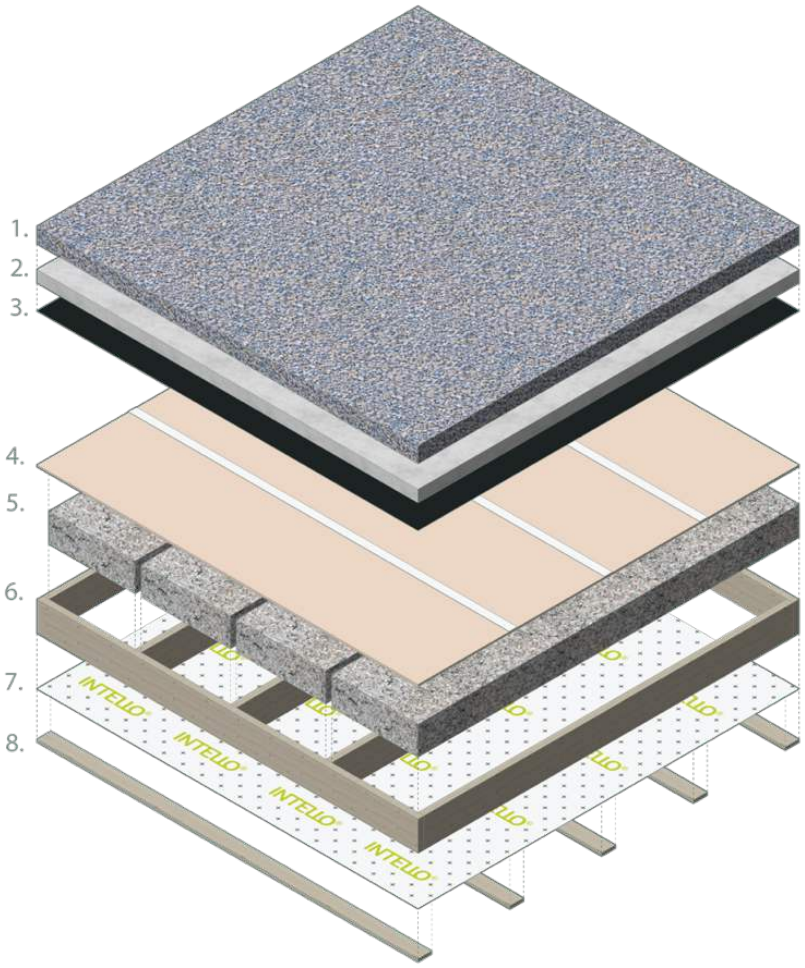


Figure 12 roof panel schematic

[8] Panel framing is based on 2x6 joists in the Minimum Upgrade scenario.

Structural Design

A new structural system is proposed to attach ReCover panels to the existing steel structure. To avoid loading the existing OWSJs, a system of new preengineered wood trusses will span between existing structural steel beams, an overall span of approximately 50’. These trusses will distribute the load of ReCover roof panels to the existing steel superstructure.

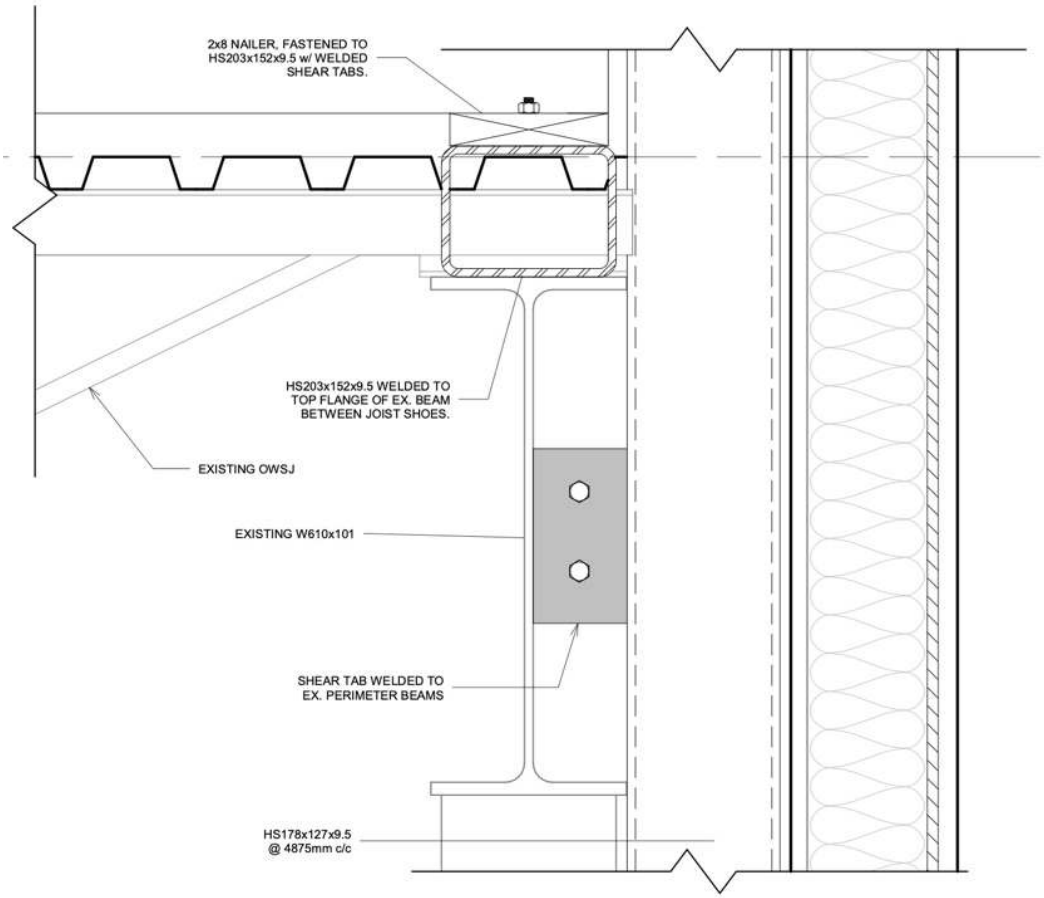


Figure 13 Partial Structural Section

The new roof trusses connect to the existing steel structure with steel HSS blocking installed between the existing OWSJ shoes, fastened with a 2x8 nailer at the top.

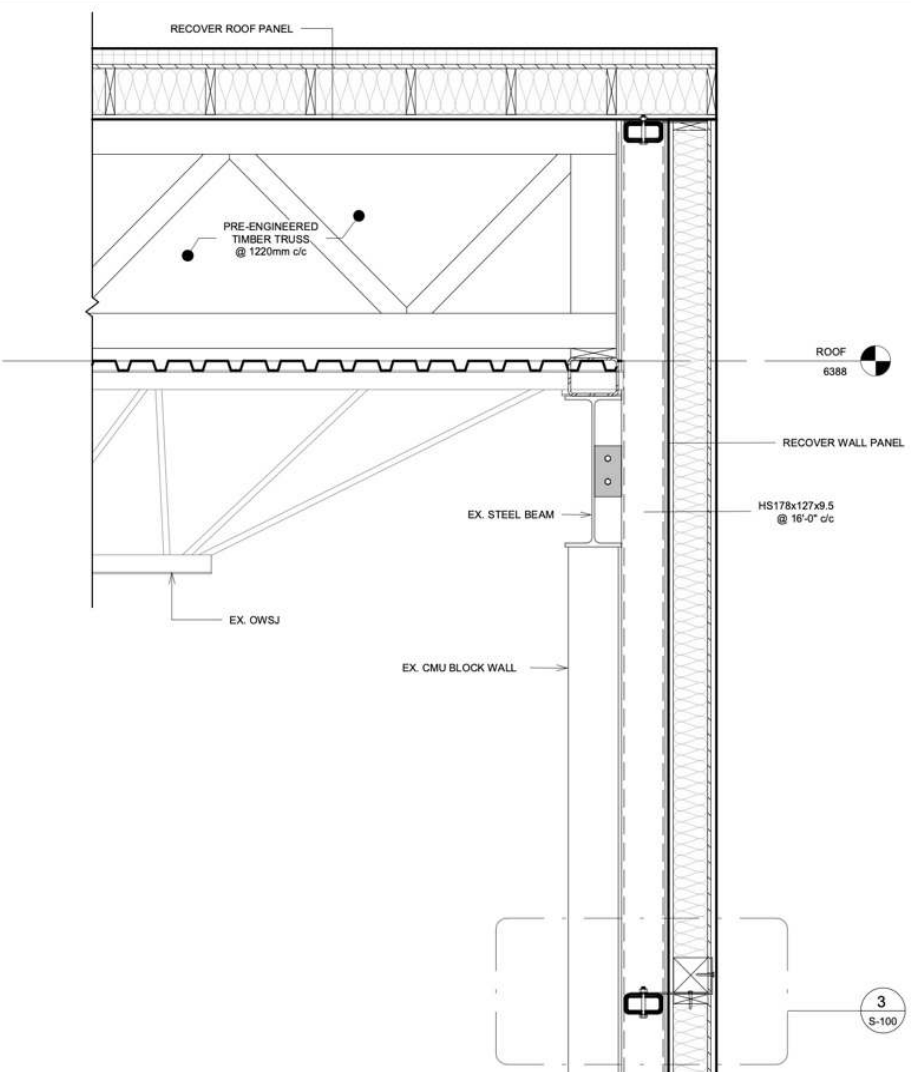


Figure 14 panel to truss

The new wall assembly is two panels high. A steel exoskeleton transfers mid-height wall panel loads to the existing roof diaphragm and foundation.

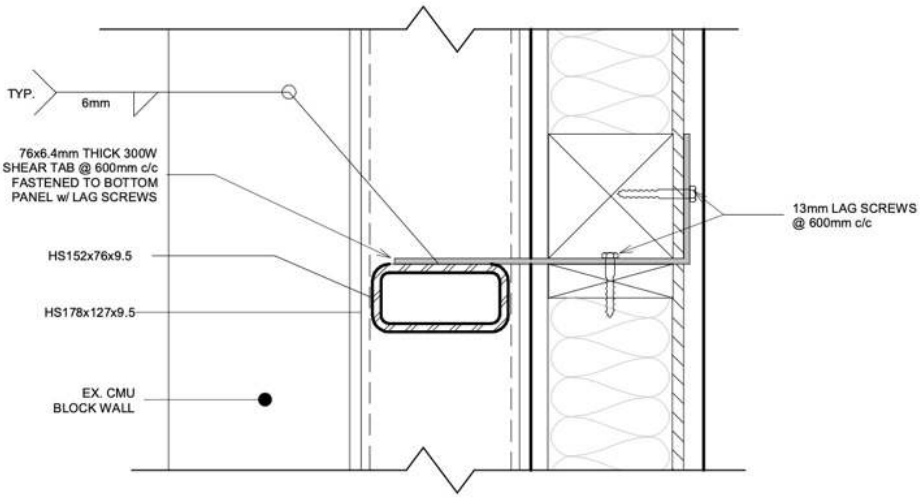


Figure 15 mid-height wall panel connection

A steel lintel supports the steel wall structure and wall panels at the base.
The lintel fastens to the existing concrete foundation walls using post-installed epoxy anchors.

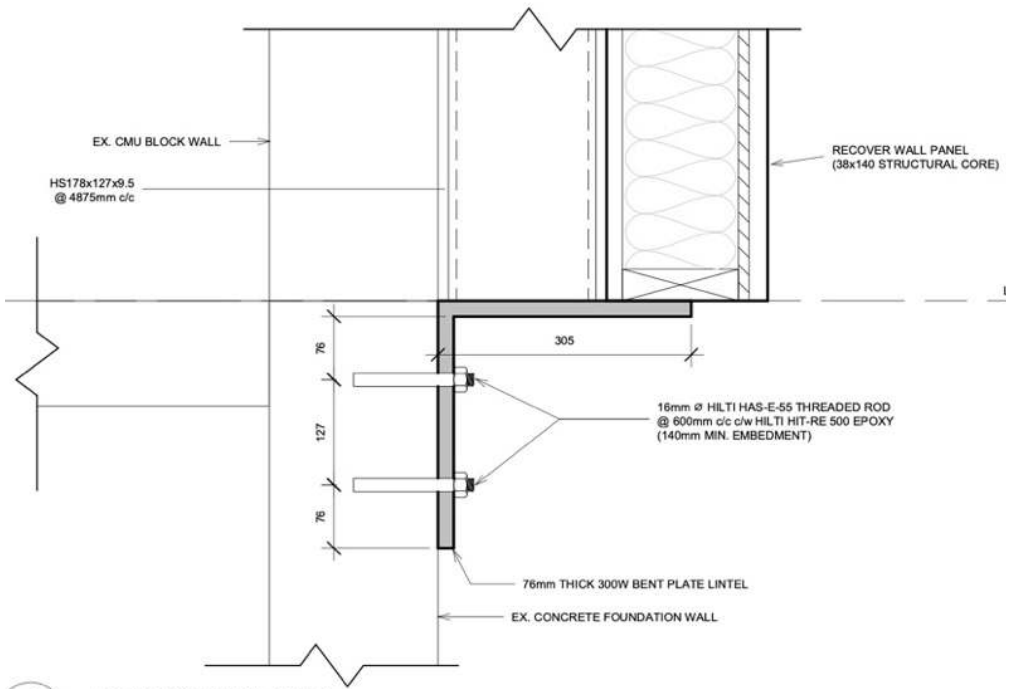


Figure 16 foundation lintel

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.

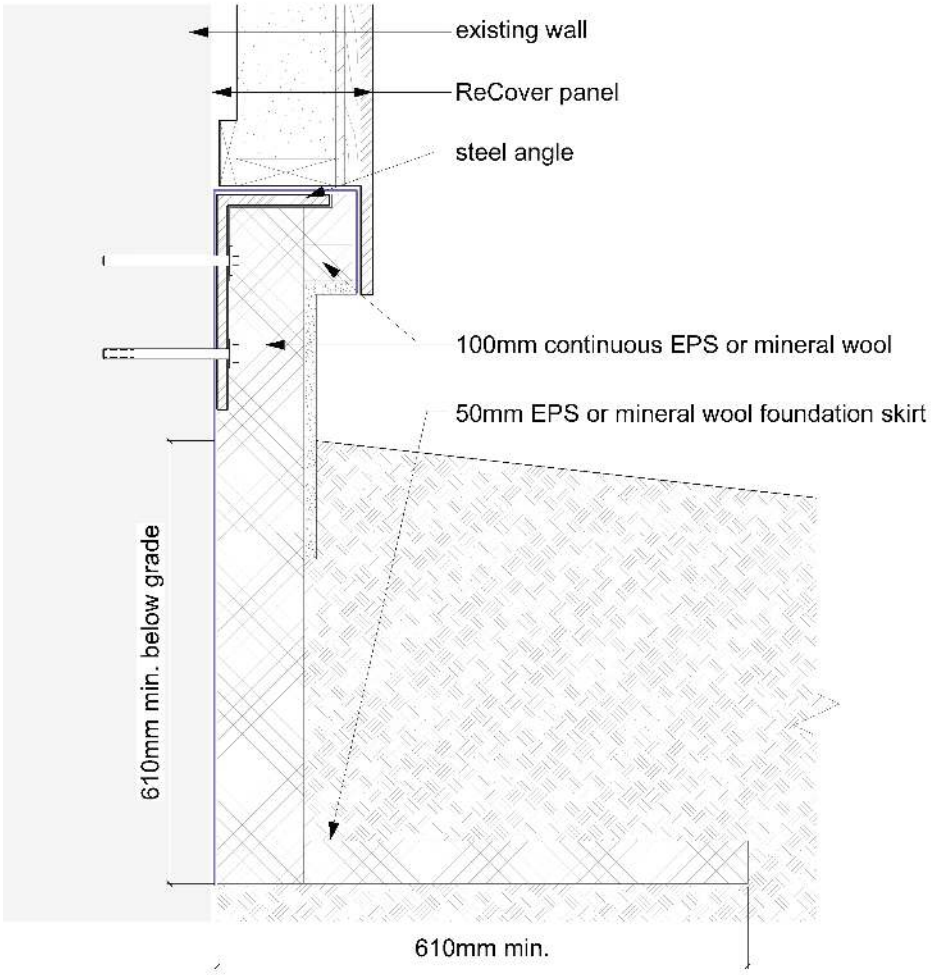


Figure 17 foundation insulation

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 New Glasgow Municipal Operations Building 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 simulations use the post-retrofit 20°C temperature as the 7°C scenario presented unacceptable moisture risk.

Most materials tested were shown to undergo cyclical seasonal moisture fluctuations consistent with expectations for buildings in the Nova Scotia climate. Specifically, the moisture content peaks in winter, with the greatest peak occurring in the first year post-retrofit, and with spikes that decrease over the subsequent years. A moisture spike that exceeds 20% in one winter does not typically damage the building so long as drying occurs in the warm season.

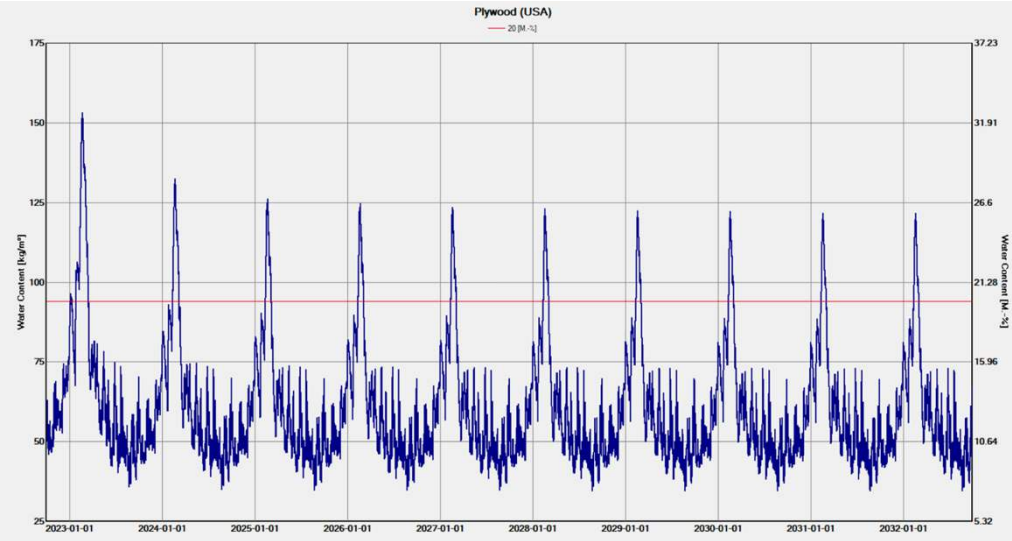


Figure 18 WUFI output: south wall (outer plywood layer)

Spikes above 20% that persist for several years indicate a potential for mould and eventual decay.

In the new wall assemblies, all orientations simulated show moisture content spikes above 20% occur in the plywood with varying magnitude and duration of these spikes depending on material and orientation. The modeling indicates potential moisture risks in walls in both the south and east walls (eg Figure 20). As multiple assumptions were made regarding specific material properties of the existing assemblies, additional modeling should be done after confirming the actual materials.

Modeling also indicated a risk of mould growth on the east wall panel sheathing. An alternate moisture and mould resistant sheathing, such as gypsum based sheathing board, is recommended if further analysis continues to indicate risk.

The post-retrofit roof also demonstrates a necessity for a sheathing substitution as the moisture content several of the plywood layers experience recurring annual spikes above 20% (Figure 21), as well as high mold growth indices. As the materials that make up the proposed roof are all known, the proposed roof assembly includes gypsum based sheathing board in place of plywood. The cellulose layer of the proposed roof did not indicate risk.

Hygrothermal monitoring of selected assemblies of the post retrofit building could offer valuable data on the real-world performance of assemblies that contain biogenic materials such as wood and cellulose.

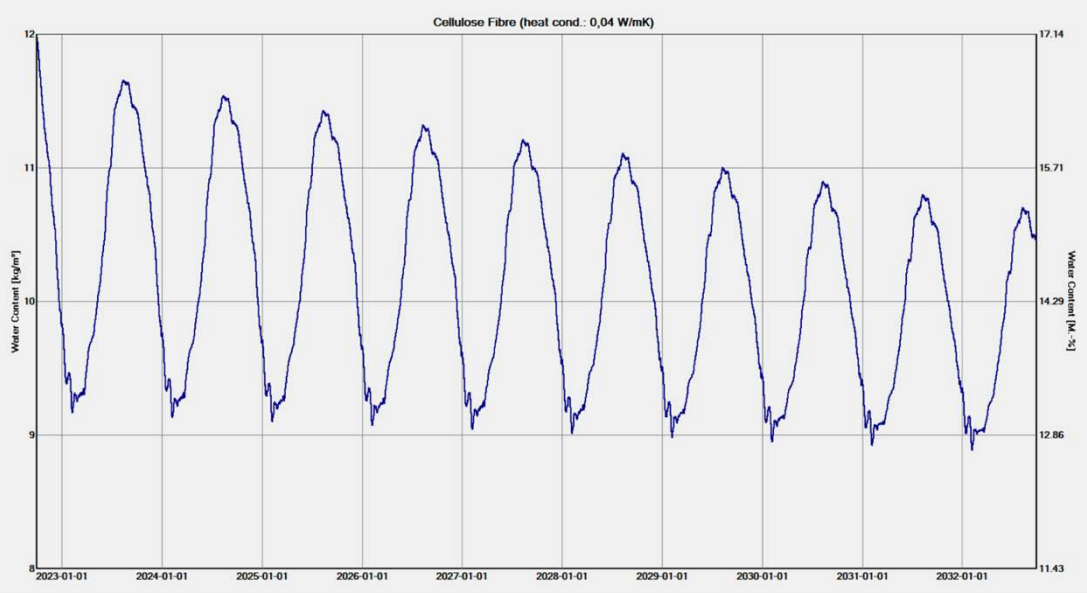


Figure 19 WUFI output – roof assembly (cellulose layer)

Embodied Carbon

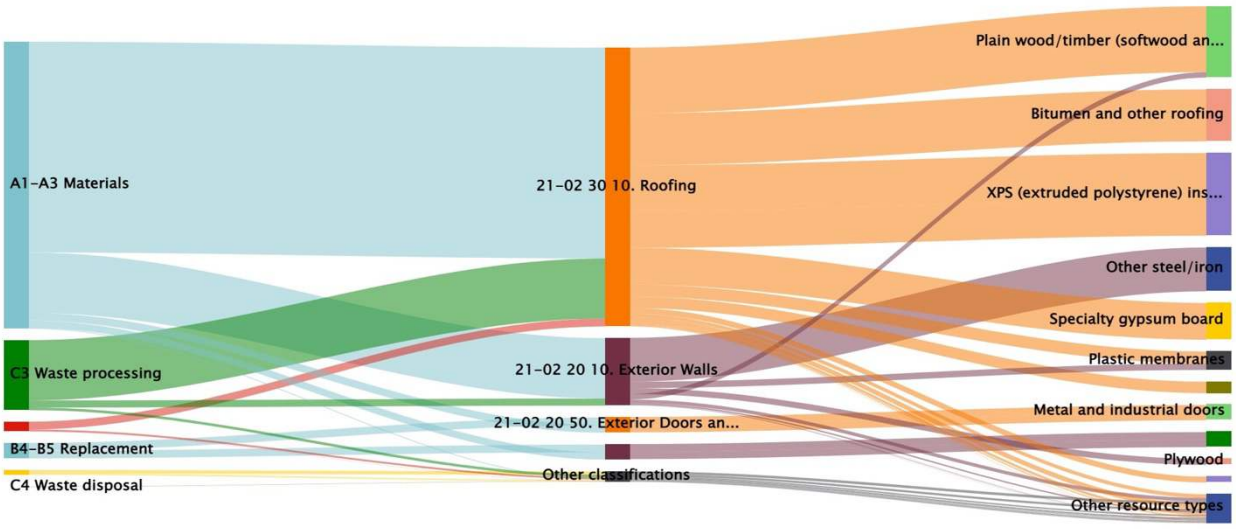


Figure 20 Retrofit Global Warming by Stage and Material

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 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.

Table 4 Municipal Operations Building – Total Global Warming Potential			
gross floor area m^2	A1-A3 $KgCO2e/m^2$	A1-C4 KgCO2e/m2	Biogenic carbon KgCO2e/m2
7,478	**37.91**	**51.13**	**79.4**

The major contributors to the GWP in this design are the wood trusses, the roof membranes, the XPS foam insulation in the roof, and the steel wall cladding. The A1-A3 Materials stage contributed 74% of the total carbon emissions associated with the building as illustrated in Figure 22 & 23.

The biogenic carbon storage of this building design surpasses that of the A1-C4 emissions by 36%, making a surplus in carbon storage capacity. This storage is attributed to the wood products (75%) and cellulose insulation (25%) used in the assemblies.

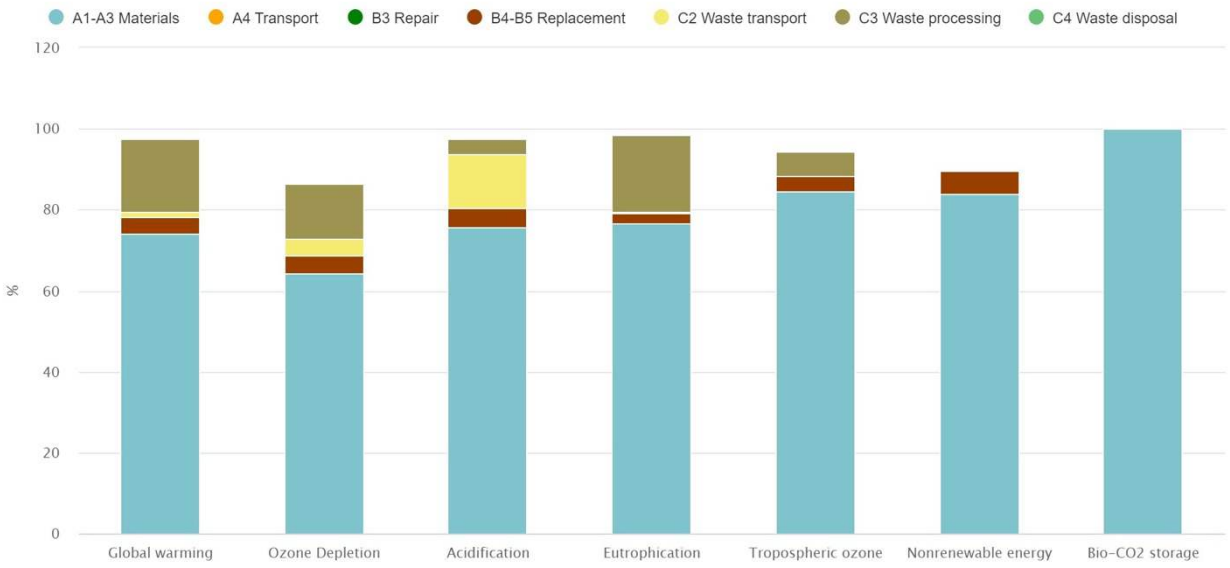


Figure 21 Life Cycle Impacts by Stage (%)

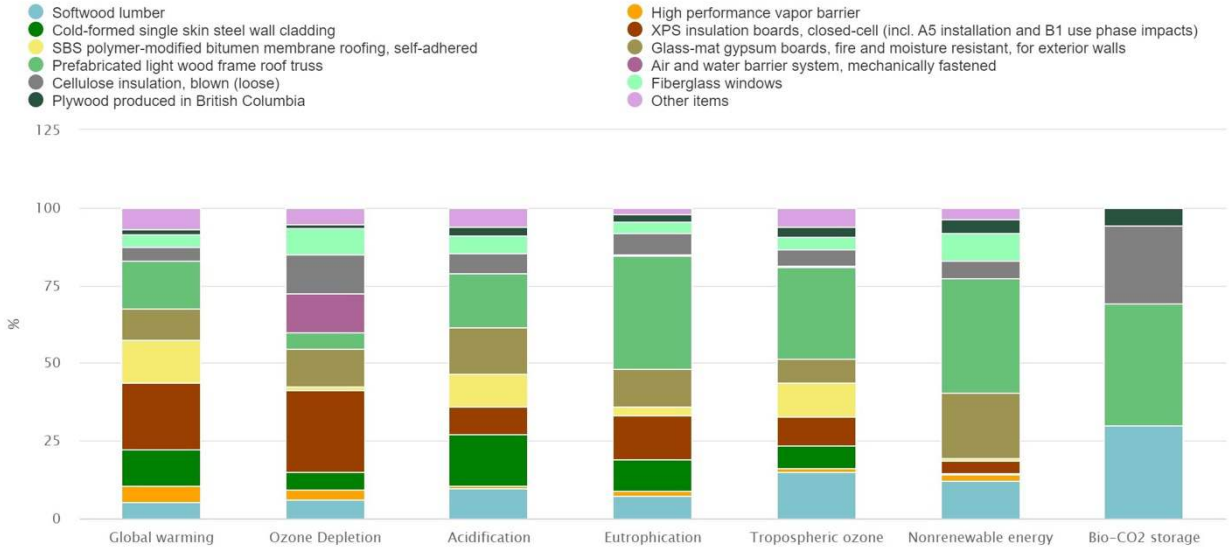


Figure 22 Life Cycle Impacts by Material (%)

Proposed Mechanical Systems

All scenarios:

- Rainwater drains and plumbing vents that penetrate the roof are to be insulated from ceiling to floor with 3” pipe insulation to prevent thermal bridging.
- Two energy recovery ventilators (ERVs) will be added in the offices in the maintenance office. They will be dual core type with approximately 90% heat recovery efficiency.
- All existing building controls will remain, with NOx and CO sensors to control the maintenance ventilation and a programmable time clock added for all other ERVs.
- Direct exhaust will remain in the engine and welding area.

1. Minimum Upgrade Scenario:
    - Heating will be provided by the existing unit heaters served by a new 480 kW cast iron oil-fired boiler, existing mini split heat pumps and baseboard heaters. Heating loads in the building remain high enough that a high temperature boiler is required to avoid replacement of the entire distribution system.
    - Cooling for the maintenance area will continue to be with existing mini split units.
    - Cooling in the retail area will continue to be with existing rooftop and air handling units.
    - Domestic hot water will continue to be served by the five existing electric water heaters.
    - Ventilation in the retail area will continue to be through the existing air handling unit.

2. Net Zero Energy Ready Scenario - ASHP:
    - Heating provided by three 24-ton cold climate air to water heat pumps. This includes upgrading the distribution system. The ASHP system is sized to meet 60% of the peak design heating load.
    - 120 kW electric boiler sized for 40% of the load.
    - Cooling in the maintenance office and retail areas provided by chilled water from the ASHP. The maintenance area will continue to be cooled with existing mini split units.
    - Heating and ventilation systems will be decoupled.
    - Domestic water provided by a new 80-gallon heat pump water heater (HPWH).
    - New ERV, dual core type with approximately 90% heat recovery efficiency, serving the retail area.
    - Direct digital control system to operate heat pumps and circulation pumps.

3. Net Zero Energy Ready Scenario - GSHP:
    - Heating and cooling provided by a 20-ton GSHP system. This includes upgrading the distribution system. The ASHP system is sized to meet 60% of the peak heating load.
    - 110 kW electric boiler sized for the remaining 40% of the load.
    - Domestic water provided by a new 80-gallon heat pump water heater (HPWH).
    - New ERV, dual core type with approximately 90% heat recovery efficiency, serving the retail area.
    - Direct digital control system to operate heat pumps and circulation pumps.
    - Direct exhaust system with makeup air unit serving the maintenance area.

Proposed Electrical Systems

All Scenarios : Existing service to remain.

1. Minimum Upgrade Scenario:
    - Lighting upgrade with LED lighting kits.
    - Existing lighting controls remain.

2. Net Zero Energy Ready Scenarios
    - Lighting upgraded to LED fixtures throughout.
    - The lighting control system will be updated to include automatic lighting control.
    - New 800A switchboard.

3. Net Zero Energy : 230kW (DC) solar pv array

Nova Scotia Power Net Metering Program

The current Nova Scotia Power net metering agreement has expired. An update to the program is under review by the Nova Scotia Utility Review Board and Nova Scotia Power. Under the old agreement only 100kW of solar could be installed on any building. 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 gets a credit 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.

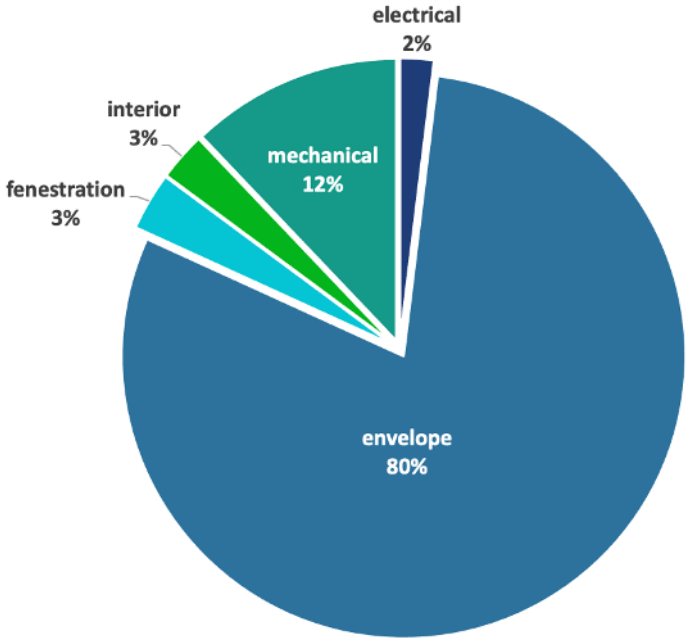
It is possible to install photovoltaics and not enroll in the net metering program. In this scenario, the building would draw power from the solar array as it is needed (up to the arrays maximum capacity). Any excess energy that is generated by the array is clipped (wasted) and no credit is given by 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 in order to use 100% of the energy generated, the solar array must overproduce.

Out of the two different methods of metering, 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.

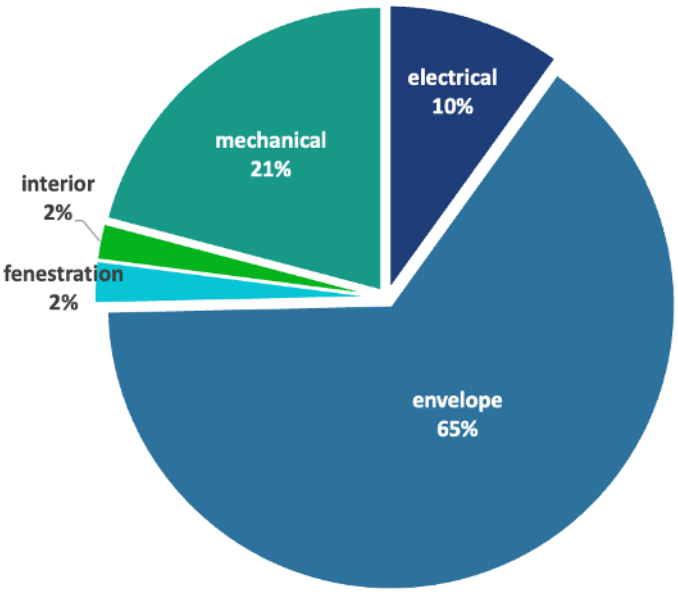
Construction Costs

Class D – Feasibility cost estimates (Appendix M) were obtained for the Minimum Upgrade, Net Zero Energy Ready and Net Zero Energy retrofit scenarios.

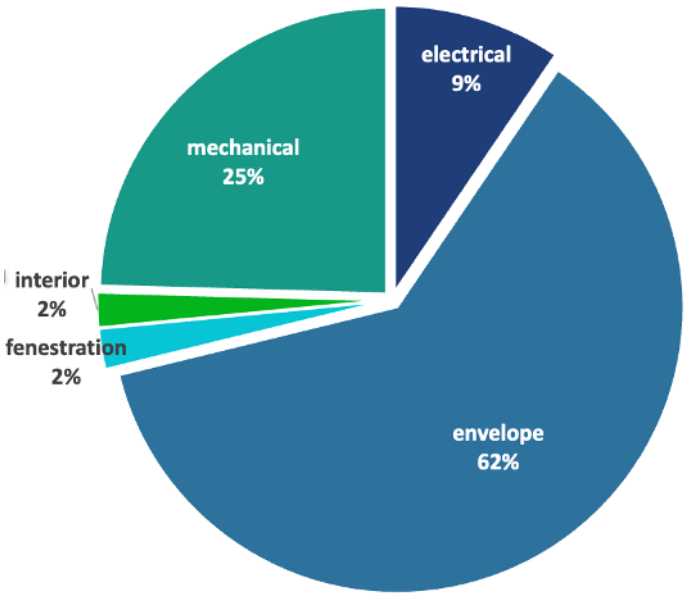
Minimum Upgrade	
Envelope	$10,865,224
Fenestration	$451,607
Interiors	$375,749
Mechanical	$1,647,125
Electrical	$262,293
total	**$13,601,998**



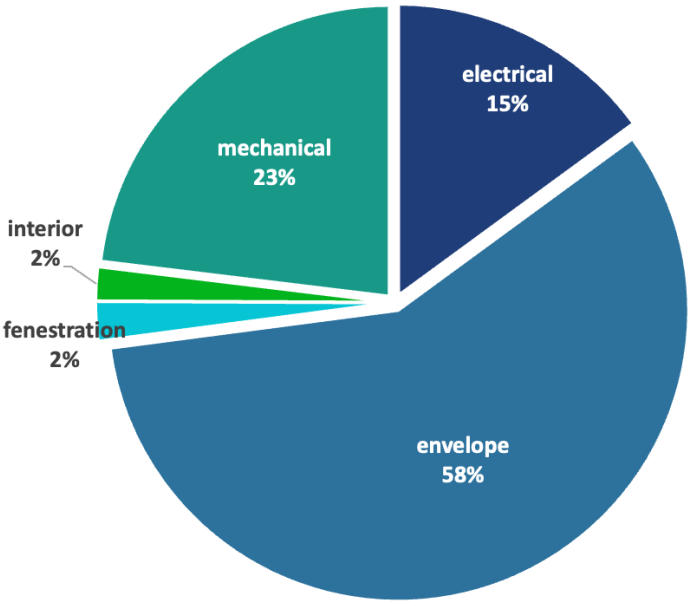
NZER ASHP	
Envelope	$12,165,733
Fenestration	$451,608
Interiors	$388,291
Mechanical	$3,928,074
Electrical	$1,869,293
total	**$18,803,000**



NZER GSHP	
Envelope	$12,165,506
Fenestration	$451,600
Interiors	$388,284
Mechanical	$4,842,353
Electrical	$1,869,258
total	**$19,717,000**



NZE GSHP	
Envelope	$12,165,859
Fenestration	$451,613
Interiors	$388,295
Mechanical	$4,842,493
Electrical	$3,136,740
total	**$20,985,000**



Total Cost of Building Ownership

Total Cost of Building Ownership (TCBO) analysis was conducted using the SEEFAR-Valuation© program. Calculations include costs for utilities, insurance, 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 taxes, however the building is not subject to property tax. 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.

Table 5 TCBO Summary

	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZR - GSHP + Solar
GHG emissions (kg) (60 Years)	33,263,379	10,315,774	10,890,984	9,750,148	0
EUI (kWh/m2/year)	248.6	56.0	36.4	32.6	0.0
TCBO at 60 years	**$83,302,000**	**$70,019,000**	**$88,623,000**	**$82,166,000**	**$73,947,000**
TCBO Savings at 60 years	$0	$13,283,000	-$5,321,000	$1,136,000	$9,355,000
60 Year TCBO savings compared to Base Case		**16%**	**-6%**	**1%**	**11%**

Key TCBO Results:

- The base case TCBO is $83M, about seven times the estimated Cost Replacement Value (CRV) of $12.3M.
- The minimum upgrade scenario uses 77% less energy than the base case and saves 16% in lifetime operating costs.
- The Net Zero Energy Ready ASHP option uses 85% less energy than the base case but costs 6% more than the base case.
- The Net Zero Energy Ready GSHP option uses 85% less energy than the base case but costs virtually the same over the remaining life of the building.
- A Net Zero Energy retrofit provides 100% energy savings, and a $9.3M reduction in lifetime operating costs over a Net Zero Energy Ready retrofit.
- The lowest TCBO is the Minimum Upgrade with a 16% reduction in TCBO and a savings of $13.3M. However, this analysis does not include the costs associated with eventual electrification of the Minimum Upgrade between now and 2050.

Table 6 Operating Cost Summary

Utilities (including carbon tax)	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar
Cost	$ 58,279,000	$ 14,812,000	$ 11,743,000	$ 10,565,000	$ 493,000
Difference in Cost from A		$ (43,467,000)	$ (46,536,000)	$ (47,714,000)	$ (57,786,000)
Percentage Change Over Base Cost		-75%	-80%	-82%	-99%
Energy Cost ($/ft2)	$ 728.49	$ 185.15	$ 146.79	$ 132.06	$ 6.16

Maintenance	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar
Cost	$ 279,000	$ 302,000	$ 407,000	$ 407,000	$ 1,165,000
Difference in Cost from A		$ 23,000	$ 128,000	$ 128,000	$ 886,000
Percentage Change Over Base Cost		8%	46%	46%	318%
Maintenance Cost ($/ft2)	$ 3.49	$ 3.78	$ 5.09	$ 5.09	$ 14.56

Insurance & Taxes	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar
Costs	$ 570,000	$ 570,000	$ 570,000	$ 570,000	$ 570,000
Difference in Cost from A		$ -	$ -	$ -	$ -
Percentage Increase over Base Cost		0%	0%	0%	0%

First Year Annual Maintenance	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar
Cost	$ 2,400	$ 2,600	$ 3,500	$ 3,500	$ 10,011
Difference in Cost from A		$ 200	$ 1,100	$ 1,100	$ 7,611
Percentage Change Over Base Cost		8%	46%	46%	317%
First Year Maintenance Cost ($/ft2)	$ 0.03	$ 0.03	$ 0.04	$ 0.04	$ 0.13

- The 60-year utility costs for the Base Case are 4.75 times the CRV of the building.
- The NZR options reduce the 60-year utility costs by 80%.
- A Net Zero Energy retrofit reduces the energy costs by 99% to $42,000, which is the meter charge or minimum charge for the electrical service.
- The maintenance costs for all scenarios have increased due to added mechanical and solar equipment.
- Insurance costs are the same for all options.

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
Initial Cost	$ 1,616,000	$ 15,947,000	$ 21,487,000	$ 22,461,000	$ 23,289,000
Difference in Cost from A		$ 14,331,000	$ 19,871,000	$ 20,845,000	$ 21,673,000
Percentage Change Over Base Cost		887%	1230%	1290%	1341%
Cost ($/ft2)	$ 20.20	$ 199.34	$ 268.59	$ 280.76	$ 291.11

Maintenance Capital Costs 60 Years	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar
Cost	$ 21,806,000	$ 30,976,000	$ 44,427,000	$ 37,722,000	$ 37,604,000
Difference in Cost from A		$ 9,170,000	$ 22,621,000	$ 15,916,000	$ 15,798,000
Percentage Change Over Base Cost		42.05%	103.74%	72.99%	72.45%
Cost ($/ft2)	$ 272.58	$ 387.20	$ 555.34	$ 471.53	$ 470.05

Retrofit / HPB + Maintenance Capital Costs 60 Years	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar
Total Costs	$ 23,422,000	$ 46,923,000	$ 65,914,000	$ 60,183,000	$ 60,893,000
Difference in Cost from A		$ 23,501,000	$ 42,492,000	$ 36,761,000	$ 37,471,000
Percentage Change over Base Cost		100.34%	181.42%	156.95%	159.98%

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 retrofits costs are high because of the extensive work on the building enclosure and due to new mechanical systems and solar panels in the NZER and NZE scenarios. The costs of all retrofit scenarios are 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.

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 Consumptions and GHGs

	Units	Base Case	Min Upgrade	NZR - ASHP	NZR - GSHP	NZ - GSHP + Solar
Annual Water Consumption	m3	902	902	902	902	902
Annual Sewer Discharge	m3	902	902	902	902	902
Annual Electric Consumption	kWh	235,673	164,078	270,920	242,541	242,541
Annual Gas Consumption	m3	-	-	-	-	-
Annual Heating Oil Consumption	Litres	148,888	23,281	-	-	-
GHG emissions	kg CO2 eq	554,390	171,930	181,516	162,502	-
Annual Solar PV generated	kWh	-	-	-	-	242,541
Total Annual Energy Consumption	ekWh	1,848,626	416,289	270,920	242,541	-
Total Annual Energy Consumption	GJ	6,655	1,499	975	873	-
EUI	kWh/m2/yr	249	56	36	33	-

Key Results:

- Total energy consumption is decreased in all retrofit scenarios the Net Zero Energy scenario has zero consumption.
- Annual electrical consumption increases in the NZER and NZ scenarios due to the electrification of mechanical equipment.
- GHG emissions and EUI are reduced across all retrofit scenarios.
- The minimum upgrade reduces GHGs and EUI by 77%.
- The NZR options reduce GHGs and EUI by 86% 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.
- Water consumption is the same in all options, as this water use was not a focus of the study. There may be an opportunity for savings through plumbing upgrades.

Cumulative TCBO

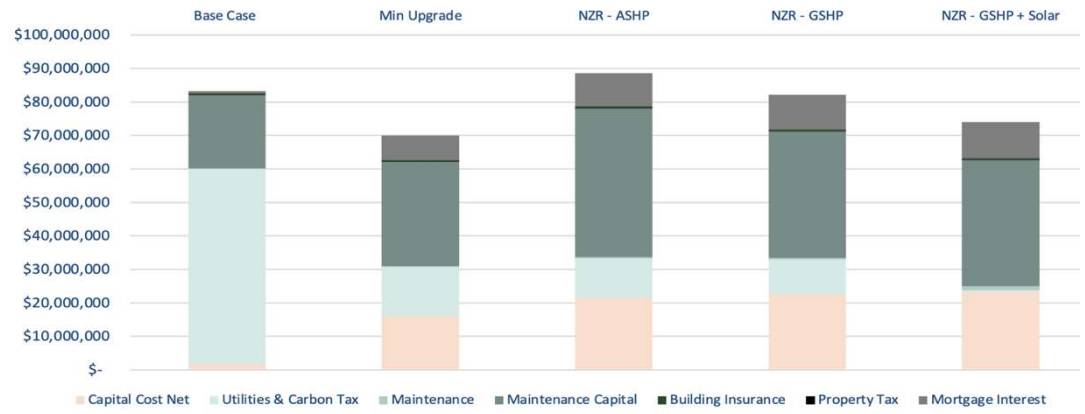


Figure 24 TCBO Comparison

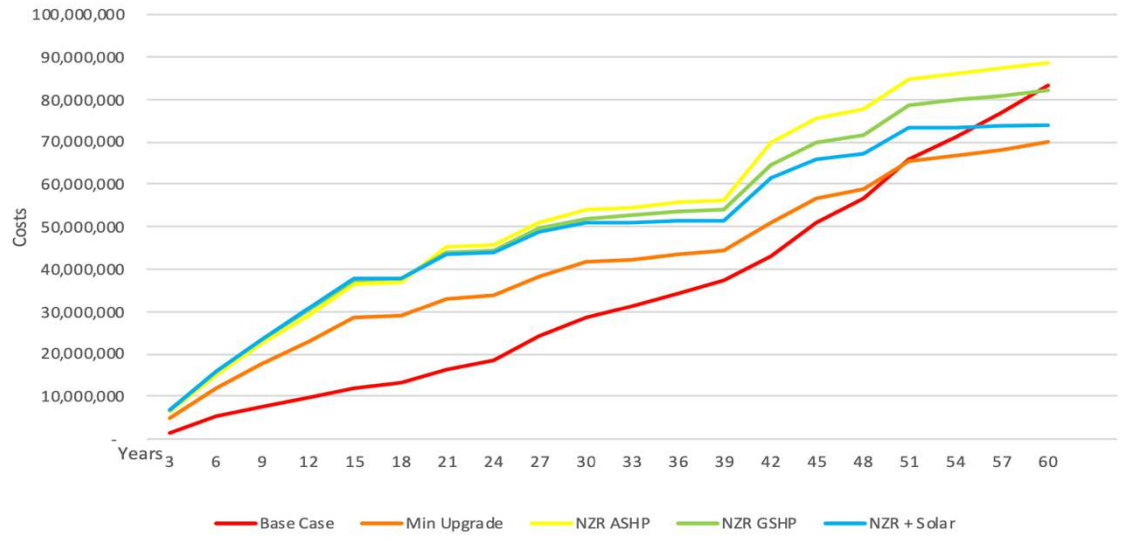


Figure 23 Cumulative TCBO

The existing building has the lowest TCBO for the first 51 years, but the Minimum Upgrade has lower costs for the remaining life of the building.

The Minimum Upgrade retrofit is the best investment for this building, resulting in a 77% reduction in GHG emissions and 16% operational savings compared with the existing base case.

This scenario maintains fuel oil-based heating, and the building must be electrified by 2050.

Discussion

The Town of New Glasgow has a population of approximately 10,000 people. Their operating budget for 2022-2023 is just over $22 million dollars. The least expensive retrofit considered, the Minimum Upgrade, costs more than their annual capital budget of $13.1M.

The high cost to retrofit this building will inevitably raise the question of demolishing and building new or pulling up stakes entirely and finding a new location for the Municipal Operations. A new building would have the advantage of being purpose built for the municipality's needs and could more easily attain high performance targets.

Yet, this building exists now. A deep retrofit today means it can last another 60 years or more. A panelized deep retrofit means that it can continue to be operational with only minimal disruption to essential town services. Demolishing it and building new means additional expense in relocation, a much longer wait to be in the finished building and preventable emissions in the form of embodied carbon will be released in construction.

The embodied carbon in the retrofit is 51.13 kgCO2e. One 15m steel beam in the existing building has an embodied carbon of 12,56 $kgCO_2e$[9]. We need to be very thoughtful about demolition.

Money is a barrier to retrofit acceleration. But it only one resource among many that we lack. We don't have enough time, we don't have enough people, we don't have enough raw material to rebuild every building in the country that is too inconvenient, too technically challenging, or too expensive to retrofit.

The $13M Minimum Upgrade scenario achieves a 66% reduction in EUI and saves 382,460 $kgCO^2e$ from being emitted annually and has the best TCBO at 16% lower than the base case. It is the best investment for the Town of New Glasgow, of the options presented. Yet it is challenging to recommend this scenario, because its oil-fired systems will be locked in for years to come. The TCBO analysis done did not capture the costs of the necessary electrification of the building at some point between now and 2050. Will that cost more than the difference between the Minimum and Net Zero options now?

Should New Glasgow spend their entire capital budget to retrofit one building? It is not their only building, and not their only building with a terrible EUI. This situation demonstrates the magnitude of the problem facing Canada's municipalities. Small and large they are under-resourced for the work ahead.

The Net Zero Energy option is an 11% TCBO savings and prevents 554,390 $kgCO^2e$ from being emitted per year and costs more than $20M. It is not the easy option, but it is the right one.

[9] Calculated using Building Emissions Accounting for Materials (BEAM) calculator, by Builders for Climate Action.

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 technical details of the retrofit scenarios were straightforward. The economic targets were challenging and in the case of the 20-year payback, not one of the six proposed retrofits can achieve it.

The ReCover Initiative has studied the potential for prefabricated panelized deep retrofits in lo-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 through Net Zero Energy retrofits where the targets were met with an Energy Use Intensity (EUI) reduction of at least 75% before adding solar PV. This was not the result in the Panelized Retrofits to Municipal Buildings study.

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 start now robust building upgrades now, municipalities will pay exponentially more down the road.

The New Glasgow Municipal Operations Building is one of the town's most energy intensive buildings, with annual GHGs measuring close to 400tCO2e. Investment in an innovative deep retrofit solution for this building will result in $9.3M in savings for the Town of New Glasgow, enable densification of an underused resource and increase the lifespan of the asset.

Investment in the project is an opportunity to begin to create a deep retrofit recipe for a building type that is incredibly energy inefficient and ubiquitous.

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[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