Unlocking the Value of Existing Buildings

a new approach to codes for carbon, culture, and cost

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This report is issued by the Canadian Association of Heritage Professionals (CAHP) and funded by Natural Resources Canada's Energy Efficiency Program through the Codes Acceleration Fund.

Prepared by Giaimo + Associates Architects Inc., Ha/f Climate Design, WSP, and A. W. Hooker Associates Ltd.

Table of Contents

Table of Contents

Abbreviations

BCBC	British Columbia Building Code
CAHP	Canadian Association of Heritage Professionals
CCBFC	Canadian Commission on Building and Fire Codes
EC	Embodied Carbon
ERV	Energy Recovery Ventilator
GFA	Gross Floor Area
GHG	Greenhouse Gas Emissions
GWP	Global Warming Potential
IGU	Insulated Glass Unit
LCA	Life Cycle Assessment
LCC	Life Cycle Cost
NBC	National Building Code
NECB	National Energy Code of Canada for Buildings
NSBC	Nova Scotia Building Code
OC	Operational Carbon
PTPACC	Provincial/Territorial Policy Advisory Committee on Codes
QCC	Quebec Construction Code
ROI	Return on Investment
TAF	The Atmospheric Fund
VBBL	Vancouver Building By-Law
VRF	Variable Refrigerant Flow
WLC	Whole Life Carbon
WWR	Window to Wall Ratio

Definitions

The following terminology associated with LCA and the measurement of embodied carbon is used throughout this document:

A1-A5 Upfront Carbon refers to the embodied carbon emissions associated with the extraction, manufacture and transport of building materials and construction phases before the building, landscape, or infrastructure begins to be used.

A-C Embodied Carbon refers to the material emissions associated with all stages of the carbon life cycle, from raw extraction, through the use stage including repair and replacement, and to the assumed end-of-life scenario.

Biogenic Carbon is the carbon that is sequestered and stored in biological materials, such as trees, other plants, or soil. Carbon accumulates in plants through the process of photosynthesis, and becomes sequestered when that plant is felled. Bio-based materials absorb carbon dioxide in their production phase and can help mitigate the challenge of climate change through sequestration.

Embodied Carbon Emissions (kgCO2e or tCO2e) measures the total A-C phase emissions of a particular building. The system boundary for the study is an expanded scope LCA that analyses the building's structure, envelope, and interiors.

Embodied Carbon Intensity Per Square Meter (kgCO2/m2) is the total embodied carbon emissions divided by the GFA of a building. Emissions per square metre of GFA allows for the comparison of buildings across various scales to give a relative metric that helps discern which buildings perform better due to variations in building form, structural systems, material selections, and facade articulation. Intensity per square metre of elevational area is also used to compare the carbon footprint of various facade assemblies.

Global Warming Potential (GWP) is one metric for quantifying a product or building's contribution to climate change, often referred to as its carbon footprint.

Life Cycle Assessment (LCA) involves breaking down a building's life into the stages and modules described above, and quantifying carbon emissions, along with other environmental impact categories, at each stage.

Operational Carbon refers to the greenhouse gas emissions produced during a building's daily operation, primarily from energy consumption for heating, cooling, lighting, and appliances.

Whole Life Carbon (WLC) refers to both the operational and embodied carbon emissions associated with a building throughout its entire life cycle. It quantifies the total carbon footprint, considering both direct emissions during use and indirect emissions from materials and construction processes. Recognizing trade-offs and synergies between operational and embodied carbon is crucial, aiming ultimately for a unified metric that integrates both aspects.

The following terminology associated with existing buildings is used throughout this document:

Adaptive Reuse: The process where existing buildings are reused in a different capacity to their original purpose. Buildings that undergo this process are usually at the end of their lifespan. Reusing them allows elements of their appearance, design, cultural heritage and historic significance to be maintained, while serving a new function and preventing them from being demolished in processes that consume a significant amount of energy (University of Built Environment).

Conservation: All actions or processes that are aimed at safeguarding the character defining elements of a cultural resource so as to retain its heritage value and extend its physical life. This may involve "Preservation," "Rehabilitation," "Restoration," or a combination of these actions or processes (Standards and Guidelines for the Conservation of Historic Places in Canada, 2010).

Existing Buildings: All standing buildings, whether heritage-designated or not.

Heritage Buildings: Buildings formally recognized (by federal, provincial, or municipal authorities) for their cultural, architectural, or historical significance. These are subject to conservation principles and policies.

Redevelopment: Throughout this report, redevelopment refers to demolition of a building and replacement of it with a new structure.

Retrofit: An upgrade or modification to an existing building's systems aimed at improving energy efficiency. A retrofit may involve enhancing or replacing lighting fixtures, ventilation systems, windows, doors, or insulation, and integrating energy efficiency measures into renovation and repair activities. A thorough retrofit can reduce operational costs, especially in older buildings, while also enhancing tenant appeal and market competitiveness (based on Natural Resources Canada definition of Retrofitting). Within this report, the Montreal and Halifax case studies' *Scenario A: Retrofit,* and *Scenario B: Retrofit and Addition,* is paired with adaptive reuse of the buildings.

Letter from the President

This report builds on the work CAHP began with its Green Paper in 2022 titled *Building on the Past to Sustain the Future*. As we issue this report in 2026, the world around us is different than it was when we released the Green Paper; climate action has seen less prioritization globally, cost escalation has continued to fuel a housing and affordability crisis, and Canada's sovereignty is facing unprecedented external pressures. We are living in a time of compounding crises, yet one thing remains the same: Heritage Professionals are uniquely positioned to bring solutions to the big problems our nation is facing.

We've known for a long time that sustainability is about more than operational carbon performance; there's purpose behind why we work hard to sustain our physical and cultural resources for generations to come. Heritage places embody the Canadian story, and when we lose places that matter to communities we lose irreplaceable parts of our identity. Canada's existing buildings stand at the heart of a more sustainable and affordable future; by bringing a conservation-centric approach to retrofits, we can unlock the value of existing buildings, be it the money and carbon already spent on them, or the heritage value they contribute to their community and their potential to steward growth and change.

It's been my privilege to watch this initiative evolve from a grant application written by moonlight into a cross-Canada effort to recognize the value in what we already have. I invite you to join us in this retrofit revolution, because a new approach to building and energy codes is urgently needed to help us rise to this moment and make reuse more viable than single-use buildings.

Adam Hatch Architect AIBC, CAHP

President, Board of Directors
Canadian Association of Heritage Professionals

Acknowledgments

Contributing Authors

Canadian Association of Heritage Professionals (CAHP)

Carly Connor, ON
Chair, Advocacy Committee

Adam Hatch, BC
President

Giaimo

Ria Al-Ameen, OAA, CAHP, PMP
Associate
Joey Giaimo, OAA, CAHP, MRAIC
Principal
Mitchell May, OAA, CAHP, CPHD
Associate
Sara Shemirani, BArchSc, CAHP
Architectural Designer

Graphic Design Support
Stenzo Martin
Emma Chudoba

Ha/f Climate Design

Kelly Alvarez Doran, OAA, MRAIC
Juliette Cook, M.Arch
Malin Ek, M.Eng., BEMP, CPHD
Miriam Palmer, B.Arch
Rashmi Sirkar, M.Arch

WSP

Russell Ashbourne, P.Eng., LEED AP
Manager, M&E
Peter Ekladious, P.Eng.
Project Manager, Electrical
Anita Cheng, B.Arch.Sc., M.Eng.
Project Manager, Building Sciences
William Kuffner, M.A.Sc., P.Eng.
National Fire Protection Engineering Principal
Ethan Paquette, B.A.Sc.
Structural Designer
Jason Paulos, M.B.Sc, LEED AP
Façade Project Manager, Building Sciences
Emily Pepper, B.A.Sc., M.Sc., DIC, P.Eng, CAHP
Structural Engineer, Heritage Structures Local Market Sector Lead
Andrea Yee, P.Eng.
Façade Specialist, Project Director, Building Sciences
John Wong, P.Eng., LEED AP, PMP
Senior Mechanical Engineer/Energy Analyst

A.W. Hooker Quantity Surveying & Cost Consulting

Weger Barwari, PQS
Associate
Glenn Hultzer, BSc.(QS), PQS, MRICS
Principal
Bineesh Susamma, PMP, PQS
Associate

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Julie Tyndorf, ON

CAHP Advocacy Committee

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Victoria Angel, ON
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Dima Cook, ON
Elizabeth Cushing, NS
Elisabeth Edwards, ON
Emad Ghattas, ON
Sonya Jensen, QC
Cynthia Klassen, AB
James Maddigan, ON
Rosa Milito, NS
Tom Morrison, NB
Austin Parsons, NS
Tejaswini Rai, ON
Geoff Scott, ON
Kate Robertson, BC
Elana Zysblat, BC

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Montreal: Groupe Montoni
Vancouver: MA + HG Architects
Case study designers: hcma architecture + design

Executive Summary

This project, by the Canadian Association of Heritage Professionals (CAHP) and funded through Natural Resources Canada's (NRCan) Codes Acceleration Fund (CAF), investigates how retrofitting existing buildings compares to new construction under the National Building Code (NBC) and National Energy Code for Buildings (NECB). Through research, capacity-building tools, and educational materials, the project aims to prepare Canadian markets for forthcoming retrofit codes while informing policies that promote the conservation of existing and heritage buildings. Three case studies representing different cities, building types, uses and scales, anchor the analysis, each evaluating Whole-Life Carbon (WLC) and cost across three scenarios: Retrofit, Retrofit + Addition, and Demolish + Replace.

Reusing existing buildings through retrofits emerges as one of the most effective strategies for reducing carbon emissions, development costs, and construction timelines. This approach minimizes embodied carbon and avoids the environmental and financial burdens of demolition, excavation, and new material production. The three case studies from Halifax, Montréal, and Vancouver show that regional energy grids significantly influence whole-life carbon outcomes. As grids across Canada decarbonize, embodied carbon will increasingly determine total lifecycle emissions, making retrofit and reuse strategies even more essential for meeting climate goals.

Retrofit and addition scenarios consistently demonstrate the best balance of cost, performance, and emissions reduction across all case studies. A conservation-centric approach to these scenarios, guided by heritage best practices and guidelines, further strengthens this approach by emphasizing retention, repair, and adaptive reuse, contributing not only to environmental outcomes but also to social resiliency and community identity. To fully realize these benefits, Canada requires modernized policies, financing tools, workforce training, and codes designed specifically for existing and heritage buildings.

The case studies also reveal that several municipal and provincial models already provide workable pathways for retrofits, offering practical precedents for national implementation. Overall, the findings point to the need for coordinated, retrofit-focused code development that reflects the realities of existing and heritage buildings and unlocks their full value as Canada advances its climate and housing goals.

01
Introduction

1.1 Project Description

This project by the Canadian Association of Heritage Professionals (CAHP), aims to conduct research, and share findings through educational materials to prepare Canadian markets for the release and adoption of forthcoming retrofit codes. It is funded by Natural Resources Canada's Energy Efficiency Program through the Codes Acceleration Fund (CAF).

The project explores how the retrofit of existing buildings compares to new construction under the National Building Code of Canada (NBC) and the National Energy Code of Canada for Buildings (NECB). It also examines the capacity of existing and heritage buildings to comply with current energy codes, with the goal of informing future retrofit codes and policies that encourage the conservation of existing buildings while supporting the decarbonization of Canada's cities and communities.

To ground this research, three case studies were selected and developed by CAHP. These represent a range of geographic contexts, building types, uses, and scales. Each case study includes a whole life carbon analysis and cost of three scenarios: Scenario A: Retrofit, Scenario B: Retrofit and Addition, and Scenario C: Demolish and Replace.

The objectives of this report are as follows:

- The project seeks to investigate the value of existing buildings through a whole life carbon lens and;
- To encourage the adoption of a Whole Life Carbon (WLC) metric that integrates both embodied emissions from materials, construction, and maintenance, and operational emissions from energy use over 60 year lifespan.
- To provide recommendations for Canada's National Building and Energy Codes to unlock the value of existing buildings and;
- To build capacity and support market preparedness for ambitious code adoption.

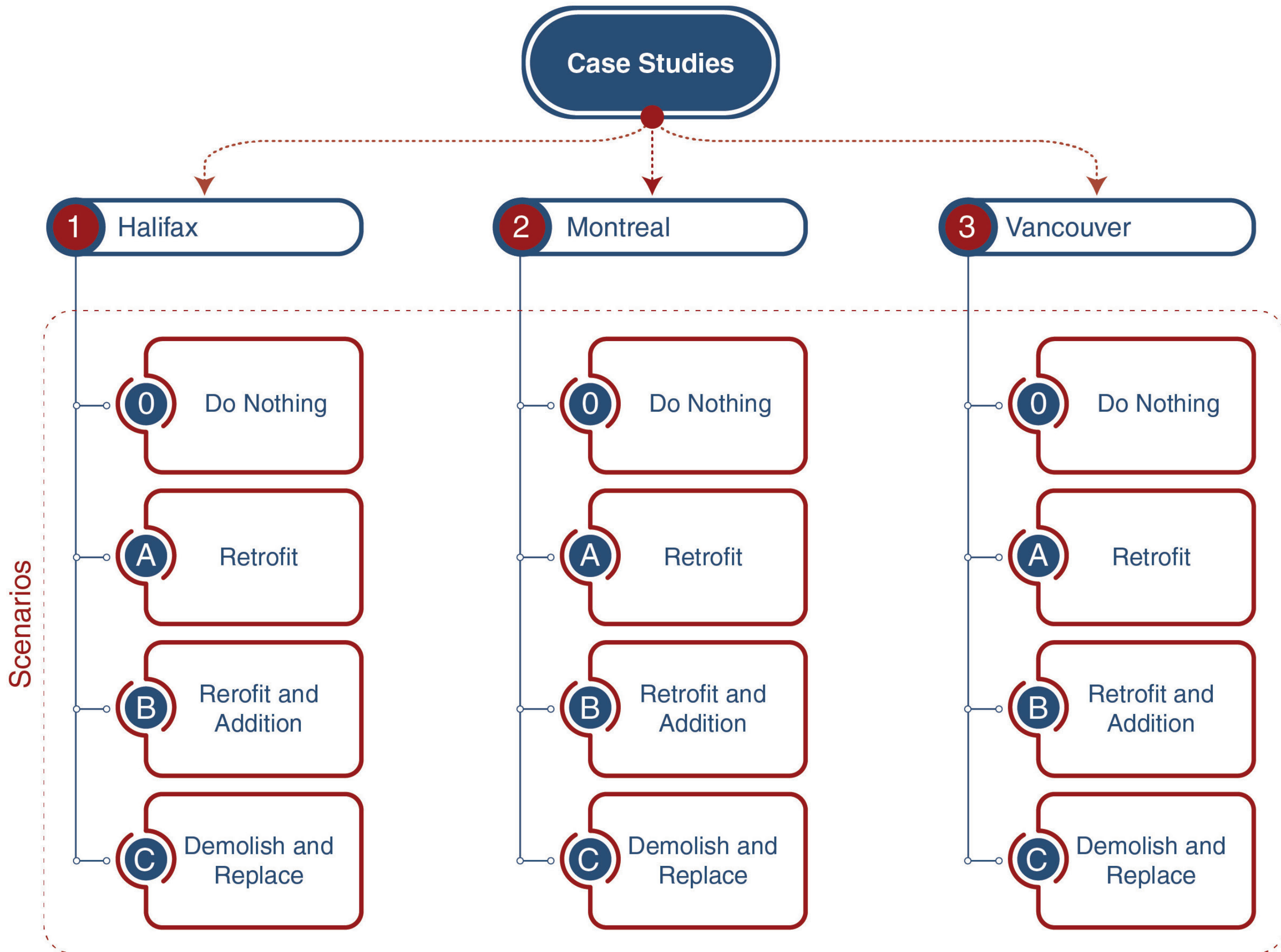


Figure 1.1. This report focuses on three case studies across the country located in Halifax, Montréal, and Vancouver. Each case study includes a whole life carbon analysis and cost of three scenarios: Scenario A: Retrofit, Scenario B: Retrofit and Addition, and Scenario C: Demolish and Replace. Additionally, a baseline "do nothing" condition was also modelled for comparison.

Case Study 1 | Halifax
Office to Residential Conversion

Figure 1.2. The Centennial Building transformed from office use to residential use in Halifax, Nova Scotia.

Credit: Sidewalk Real Estate Development, Agency Art Lofts (sidewalkred.ca)

Case Study 2 | Montréal
Industrial to Office Conversion

Figure 1.3. Textile factory adaptively reused for office space in Montréal, Quebec.

Credit: Groupe Montoni, 7250 Marconi (groupemontoni.com)

Case Study 3 | Vancouver
Residential Retrofit and Addition

Figure 1.4. Conserved historic house and infill in Vancouver, British Columbia.

Credit: Janis Nicolay, Canadian Architect.

1.2 About CAHP

The Canadian Association of Heritage Professionals (CAHP) is a national, member-based organization representing qualified heritage professionals across the public, private, and not-for-profit sectors. CAHP advances excellence in the conservation of Canada's built, cultural, and landscape heritage by:

- setting and upholding national standards of practice,
- fostering interdisciplinary expertise across conservation architecture, planning, engineering, history, archaeology, and landscape architecture,
- supporting the responsible stewardship of places of cultural, social, and environmental value, and
- promoting public and legislative support for heritage conservation.

CAHP members work at the intersection of policy, design, planning, and technical practice. Their work spans early-stage planning and feasibility, condition assessment, conservation strategies, adaptive reuse, and long-term stewardship. As part of its mandate, CAHP advocates for the engagement of qualified heritage professionals whenever places of heritage value are identified, assessed, rehabilitated, or transformed.

CAHP defines a heritage professional as an individual with specialized knowledge in the conservation and stewardship of cultural heritage—supported by formal training and/or professional experience—who adheres to accepted technical and ethical standards and works in accordance with the regulations and guidelines governing their area of practice.

Through national programming, professional accreditation, continuing education, and public advocacy, CAHP works to ensure that conservation is both a cultural responsibility and an essential climate strategy. Increasingly, CAHP is focused on advancing the role of existing buildings with value for re-use, whether heritage designated or not, as cornerstone assets in Canada's transition to a low-carbon, climate-resilient built environment.

About the Advocacy Committee

The CAHP Advocacy Committee leads the Association's national efforts to influence policy, guide best practices, and strengthen the role of heritage and existing buildings in Canada's climate and development agenda. Its mandate is to support heritage conservation; elevate public and professional regard for the heritage consulting profession; advocate for the application of best practices; and maintain strong working relationships with all levels of government, national agencies, and allied organizations.

In recent years, the Committee has focused its work on the existing buildings space, recognizing that Canada cannot meet its climate objectives without addressing the carbon and energy performance of the buildings already standing. This includes designated heritage places as well as the vast majority of older, un-designated buildings that form the backbone of Canadian cities.

The Committee's activities include:

- Policy leadership and federal engagement through the Federal Industry Real Property Advisory Council (FIRPAC), a forum for the public and private sectors in Canada to discuss issues relating to the planning and managing of Federal Properties. CAHP also participated in an inaugural Day on the Hill, where CAHP members met with parliamentarians and federal departments to advance discussions around retrofit codes, embodied carbon, and conservation as climate action.
- National capacity building through workshops, workrooms, and training sessions that convene industry, government, and academic partners to discuss practical barriers and opportunities in retrofitting existing buildings.
- Collaboration with federal programs such as the Codes Acceleration Fund, under which this report was developed, to embed heritage and existing-building expertise into Canada's emerging approach to retrofit codes, whole-life carbon, and energy performance.
- Advocacy for integrated approaches that unite heritage conservation, building science, engineering, planning, sustainability, and circular-economy practices to ensure existing buildings remain viable, adaptable, and low-carbon assets.

By contributing to this research initiative, the Advocacy Committee underscores CAHP's belief that retention, repair, and reuse—supported by clear pathways in codes and policy—are essential to Canada's climate goals. This project reflects the Committee's commitment to ensuring that the expertise of heritage professionals informs the development of national frameworks that govern the future of existing buildings.

1.3 Consultant Team

This report has been prepared by a multidisciplinary team of professionals assembled to examine compliance pathways for existing and heritage buildings with the requirements of the NBC and the NECB. The goal is to share findings that will help prepare Canadian markets for the upcoming adoption of retrofit codes.

The team was strategically brought together to leverage expertise in heritage and existing buildings from both heritage conservation and architectural perspectives, as well as from key technical disciplines.

Giaimo + Associates Architects (Giaimo) and Ha/f Climate Design (Ha/f) have partnered on this project as two firms committed to advocacy, education, and policy development in the areas of conservation and reuse, whole life carbon best practices, and climate solutions for the built environment. Giaimo serves as the prime consultant and project manager, coordinating the work of all consultants and advising on heritage conservation practices, as well as assembling the final report in collaboration with the team. Ha/f acts as co-lead, contributing expertise in sustainability, architecture, policy research, circularity, and energy modeling.

The two firms have previously collaborated on advocacy initiatives such as the award-winning Circular Living Lab in Toronto. Launched as part of the DesignTO Festival 2024, the Circular Living Lab was a temporary, multidisciplinary collaborative exhibit and installation that explored sustainable design practices through deconstruction, material salvage and reuse, as an alternative to demolition.

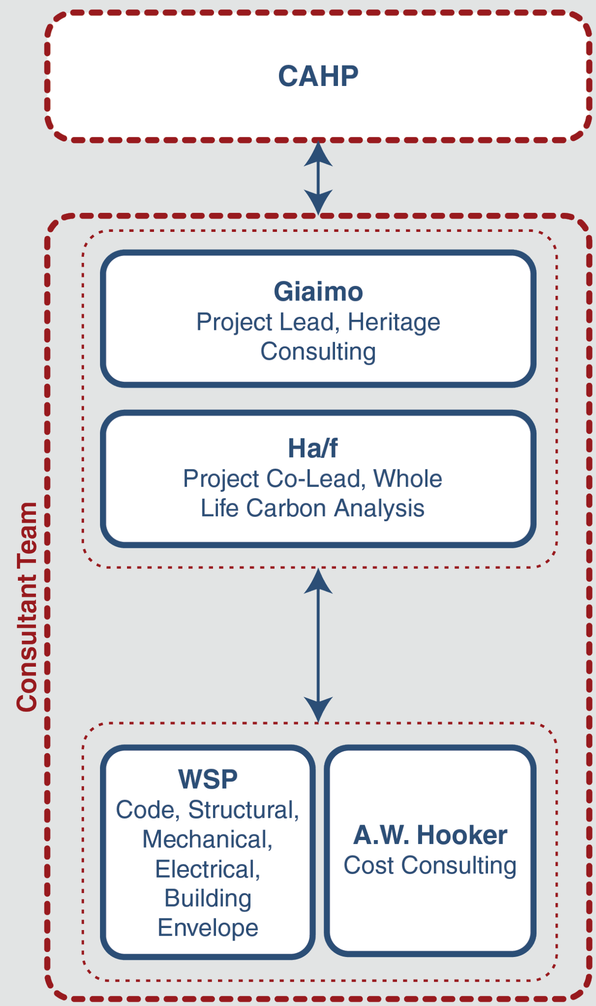


Figure 1.5. Diagram showing the project team structure, which includes the CAHP and a multidisciplinary consultant team. The consultant team comprises Giaimo as the project lead, Half as co-lead and WSP providing expertise in code, structural, mechanical, electrical, building envelope systems, and A.W. Hooker providing cost consulting.

Figure 1.6. The Hermant Building Transformation by Giaimo, recipient of the Heritage Toronto 2024 Adaptive Reuse Award.

Credit: Doublespace Photography

The project team also includes well-established firms engaged as sub-consultants to support technical and cost-related components. WSP, one of the world's leading professional services firms, provides code consulting, as well as mechanical, electrical, building envelope, and structural engineering services. With offices across Canada and a national team of over 12,000 technical experts, WSP brings extensive experience from both new construction and existing building projects, including expertise in low-carbon and high-performance design. A.W. Hooker provides cost consulting services, contributing national expertise in analyzing and identifying factors that impact project costs.

This strategic partnership brings together the creativity, innovation, and agility of smaller, forward-thinking practices with the technical depth and national reach of established firms. Key personnel are based in Ontario, British Columbia, and Quebec, with project experience spanning all provinces and territories.

Figure 1.7. Ha/f developed a reuse strategy for Waterhouse Square's granite facade, in collaboration with Local Works Studio, London. By prioritizing deconstruction, on-site reuse, and low-carbon fabrication, the project reduces waste and emissions while advancing the goals of London's Circular Economy Roadmap for sustainable building practices.

Credit: Ha/f

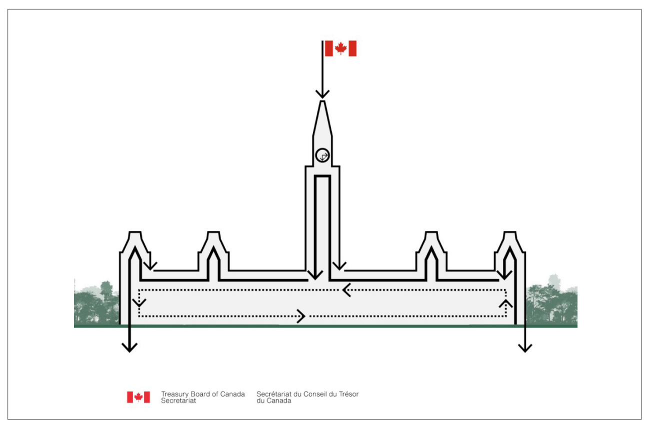


Figure 1.8. Ha/f authored the Project Planning & Design Primer for Low-Carbon Construction for the Government of Canada, to guide Canada's shift to net-zero buildings. The primer outlines whole-life carbon concepts, introduces mitigation frameworks, and applies strategies across project phases, to reduce embodied carbon emissions.

Credit: Ha/f

Figure 1.9. Circular Living Lab exhibition featuring salvaged historic brick art installation, the exhibition was a collaboration between TAS, Giaimo, Ha/f, Ouroborous Deconstruction and Haley Anderson Consulting. The exhibition was awarded the DesignTO 2024 Founders' Award.

Credit: Giaimo

02
Retrofit or Redevelopment

2.1 The NBC and the NECB

In Canada, the National Building Code (NBC) and the National Energy Code of Canada for Buildings (NECB) set the regulatory standards for designers, developers, engineers, and building consultants across all types of construction, from single-family homes to industrial warehouses. In regard to existing buildings, particularly when considering their rehabilitation through renovations, retrofits, and conversions, both codes focus entirely on operational energy performance. This focus is important, as energy efficiency, occupant comfort, and building durability are essential components of sustainable building practice. However, the codes offer little to no guidance on the myriad of other issues that inevitably arise in design scenarios for existing and heritage buildings. These include: the cultural, environmental and economic value of repair and maintenance, the ability to accommodate future changes of use, and conservation of heritage value. The opportunity for national codes to establish progressive standards that both safeguard existing and heritage buildings and address climate imperatives is immense yet remains underutilized.

Operational energy performance represents only one dimension of a building's climate impact. Embodied carbon, which is a measure of the greenhouse gas emissions released throughout the life cycle of materials, from extraction and production through installation, maintenance, and end-of-life, can account for 40% to 70% of a new building's whole life footprint, depending in part on the fuel selection and carbon intensity of the local electricity grid.

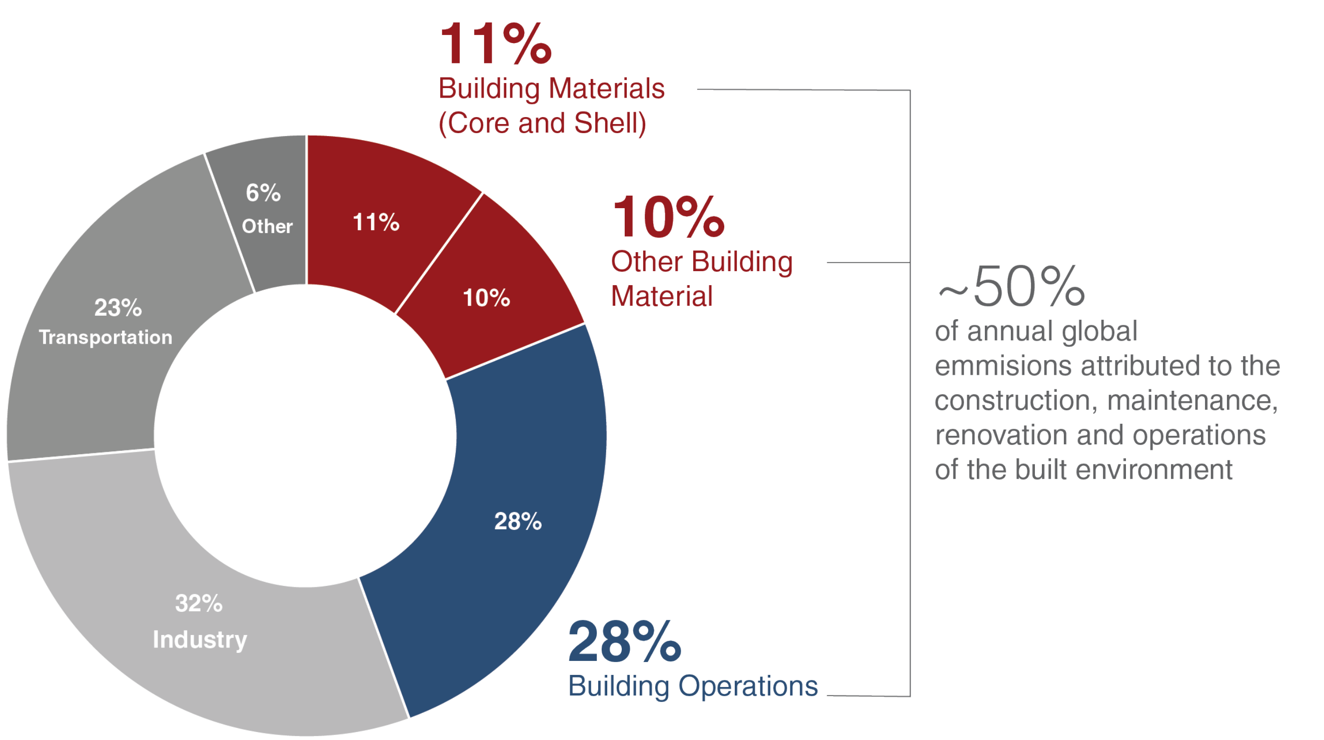


Figure 2.1. Overview of annual global emissions adapted from 2019 Global Status Report, Global Alliance for Building and Construction and Architecture 2023.

In the case of an existing building, that embodied carbon has already been expended and is essentially fixed in the building's materials. Demolition effectively wastes this stored energy and sends valuable materials to landfill. While deconstruction can salvage some materials for reuse, the new construction that follows still compounds additional emissions on top of those already released in the construction of the initial building.

From an atmospheric perspective, the warming trajectory we face today already includes the carbon emissions embodied in existing buildings. The damage from their original construction has already been done. For this reason, conservation itself functions as a form of climate mitigation: adapting and retrofitting existing structures to meet current performance standards can substantially reduce the construction industry's carbon footprint, which currently makes up roughly 40% of global greenhouse gas emissions.

In the context of this study, The NBC and NECB served as foundational benchmarks, guiding the evaluation of code compliance across various building scenarios. By analyzing as-built case studies from multiple cities—including retrofit existing, retrofit with addition, and demolish-and-replace options—the study applies the performance path outlined in the codes to assess energy consumption, cost, and carbon emissions. This approach ensured that each scenario was measured against nationally recognized standards, allowing for consistent comparison and meaningful insights into how different design strategies align with current regulatory expectations.

The current emphasis of the NBC and NECB on operational performance therefore represents only a partial response to the climate challenge. For existing buildings, national codes could do much more to balance operational targets with recognition of embodied carbon, conservation practices, and the circular economy. This approach is twofold: it enables Canada to both safeguard cultural heritage and advance its climate objectives by promoting standards that explicitly encourage repair, reuse, and retrofit as default strategies over demolish and replace.

A joint task group on alterations to existing buildings consisting of members of the former Canadian Commission on Building and Fire Codes (CCBFC) and Provincial, Territorial Policy Advisory Committee on Codes (PTPACC) recommended application provisions to existing buildings included in the NECB for energy conservation. The conservation of heritage buildings characteristics and renovations to existing buildings were recommended for inclusion in the NBC during the 2025 development cycle. An example of the changes to both NBC and NECB are the addition of defined terms "Existing Building" and "Heritage Building" are expected to be published in the 2025 version.

Several provincial building and fire codes have already included provisions to protect heritage characteristics of buildings and developed criteria for building renovations, extensions and changes of use. For example, Article 3.2.2.93 of the Nova Scotia Building Code (NSBC) provides for alternative compliance methods for existing buildings through Schedule D. A heritage building or a building in a heritage conservation district in Nova Scotia is permitted to undergo a change of use and make use on any of the provisions in Schedule D – Alternate Compliance Methods for Existing Buildings. For mechanical systems, provision 35 of Schedule D permits exemption from compliance with NBC Parts 6 and 7 where an unsafe condition is not presented and where acceptable to the authority having jurisdiction.

Another example is Parts 10 and 11 of the Quebec Construction Code (QCC) that make provisions for renovations and energy efficiency. Under Section 10.5 of the QCC, environmental separation requirements from Part 5 of the NBC are not required to be applied during a change of use not involving modifications unless equipment is installed that creates a different indoor environment within the building.

The British Columbia Building Code (BCBC) includes Table 1.1.1.1.(5) Alternate Compliance Methods for Heritage Buildings which may substitute requirements contained elsewhere in the code. BCBC defines a heritage building as "a building which is legally protected or officially recognized as a heritage property by the Provincial government or a local government". In Vancouver, the VBBL includes application statement to the alteration, rehabilitation and change of occupancy of heritage buildings [1.1.1.1(1)(o)] and in other clauses to other buildings [1.1.1.1(1)(c) –(e)]. A heritage building is defined as "a building which is legally protected or officially recognized as a heritage property by the Provincial government or the City, or a building that in the opinion of the City Building Inspector, has sufficient heritage value or heritage character to justify its conservation". Alternative compliance measures for heritage buildings are set out in Section 11.5.

An objective of NBC is to limit the probability that resources will be used that have an unacceptable effect on the environment. The two specific objectives deal with energy and water. QCC Table 11.3.1.1. provides attributions to these objectives.

2.2 Value of Existing Buildings

Figure 2.2. A typical rental residential unit at 1660 Hollis Street, Halifax (Case Study 1), a former mid-century office building transformed into hard lofts. Photo taken during the National Trust Conference Halifax workroom tour led by the developer.

In Canada, buildings have been considered worthy of conservation on the basis of their importance or significance, for example: an innovative construction technique, status as an early example of an architectural style, or association with a historical figure or event. These criteria establish clear-cut cases for conservation, but leave open a question: what is the value of existing buildings that do not meet these criteria?

The case studies featured in this report are not formally heritage designated but were all well-built historic buildings in good condition and considered valuable resources.

By quantifying both carbon and cost across different scenarios, the report highlights how conservation and retrofit can serve broader social, cultural, economic, and environmental goals. The timeline diagram illustrates the contrast between buildings that are demolished and rebuilt every 60 years, and those that are carefully maintained and retrofitted to serve for 120 years or more. In the shorter cycle, demolition, disposal, and reconstruction carry heavy carbon and cost burdens with each building cycle. In the longer cycle, materials are preserved, cultural identity is maintained, and costs are deferred across time. Extending lifespan depends on both selecting more durable materials at the outset and maintaining buildings through adaptable strategies.

In this light, the conservation of existing buildings offers extraordinary value. Additionally, heritage conservation practices offer important guidance for the reuse of existing buildings by emphasizing minimal intervention—repairing, maintaining, and upgrading rather than replacing—these practices support long-term durability while reducing carbon and cost impacts. Retention avoids the repeated embodied carbon emissions and financial costs of demolition and replacement, lowers long-term expenditures, and secures cultural continuity across generations. The case studies in Halifax, Montréal, and Vancouver demonstrate how retrofitting can extend building service lives far beyond the standard 60-year cycle, aligning heritage conservation practices with climate and affordability goals.

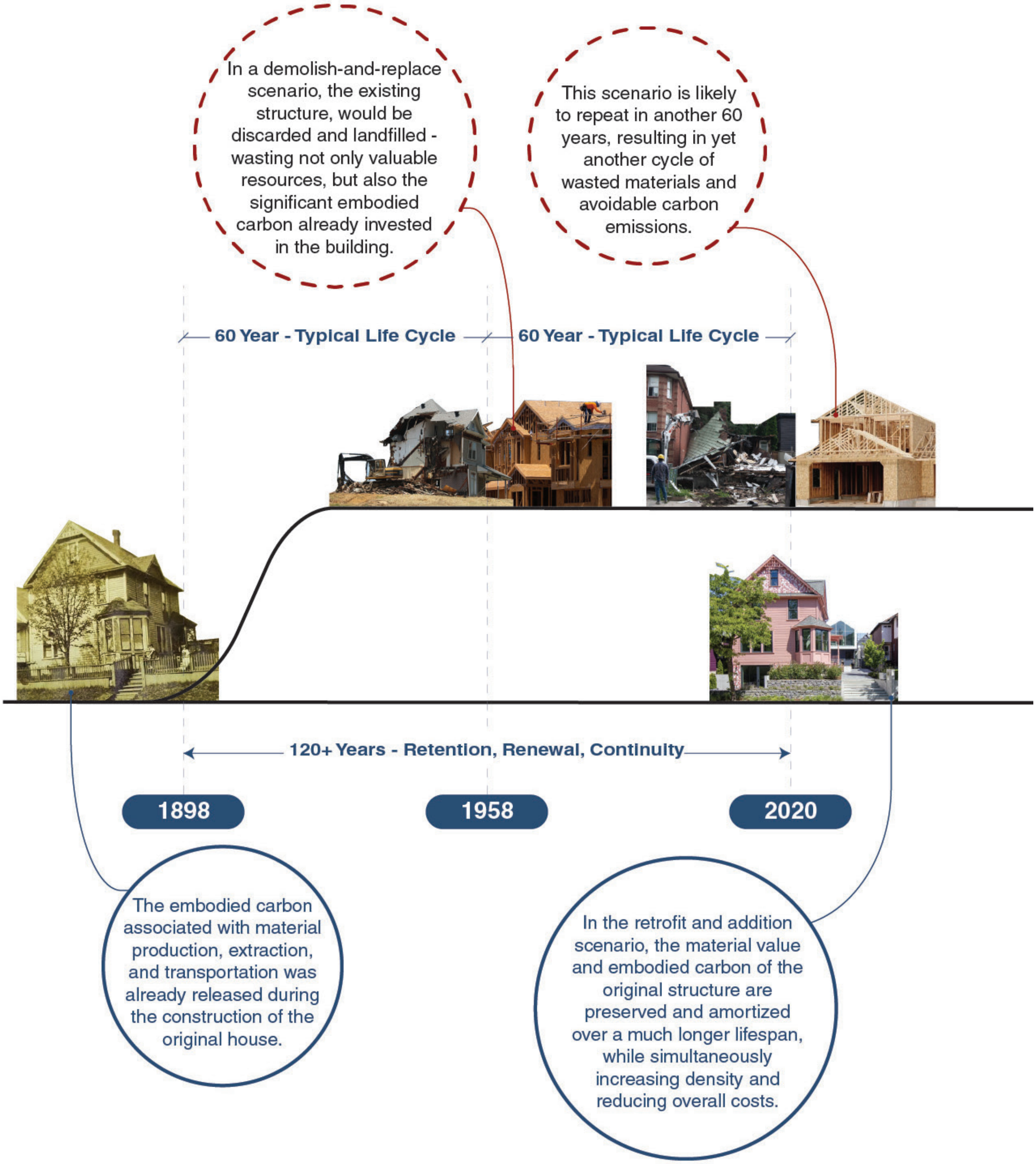


Figure 2.3. The timeline diagram above illustrates that retrofit interventions extend the service life of existing buildings, conserving heritage value and avoiding the carbon and cost impacts of demolition and new construction.

2.3 Pathways to Compliance

There are multiple viable approaches to retrofitting or new construction that can meet current building and energy codes. Whether a project involves retaining an existing structure, adding to it, or demolition and replacement, each pathway presents distinct opportunities and challenges in achieving compliance with the National Building Code (NBC) and the National Energy Code for Buildings (NECB).

The scenarios in this study simulate the decision-making process of a development team—public or private—selecting a design strategy for a site that includes an existing building. They all involved sites that did not have legal heritage designations, and development proposals that involved the retention of the existing building. With this starting point there are several potential pathways to achieving code compliance.

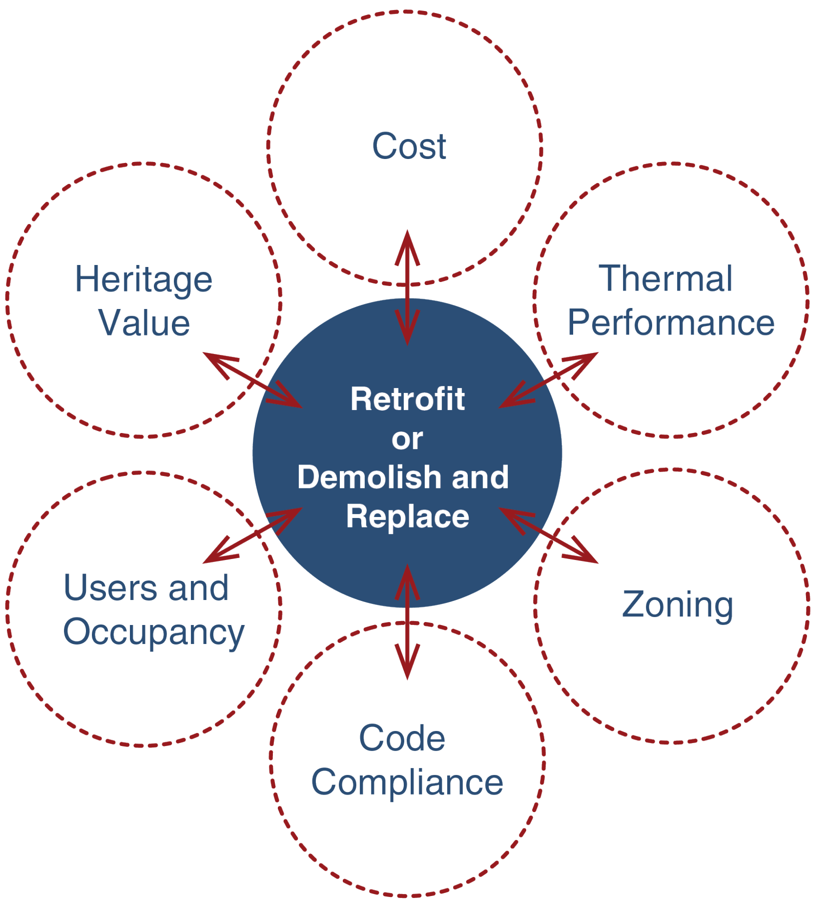


Figure 2.4. Key considerations influencing the decision-making process of a public or private development team.

Scenario A: Retrofit Existing

Retrofitting existing buildings is one of the most impactful strategies for achieving meaningful environmental, cultural, and urban sustainability. Each retained structure preserves embodied carbon, craftsmanship, and cultural identity, forming a foundation upon which new layers of use, technology, and culture can be built.

The process requires a critical understanding of existing conditions and forward thinking strategies for extending their life. By integrating new systems for energy efficiency, comfort, and accessibility, while maintaining the integrity and identity of the original fabric, this approach can meaningfully bridge past and future.

Retrofitting is most viable when the building is found to be in relatively good condition. While typically a lower intervention approach, the scope can vary depending on the found condition and the new use. At one end, this may mean light renovations such as replacing partitions, refinishing floors and ceilings, and repairing doors and windows. At the other, it may require full window replacement, increasing insulation, mechanical and electrical system replacement, foundation underpinning and other structural upgrades. The adaptability of the interior layout can significantly influence the level of intervention required. In most cases, the project must meet energy codes designed for new construction, with no recognition of the embodied carbon retained by avoiding demolition.

Ultimately, retrofit represents the practical and resourceful reuse of existing structures and materials. Extending the life of existing buildings results in carbon and cost savings and supports a sustainable future.

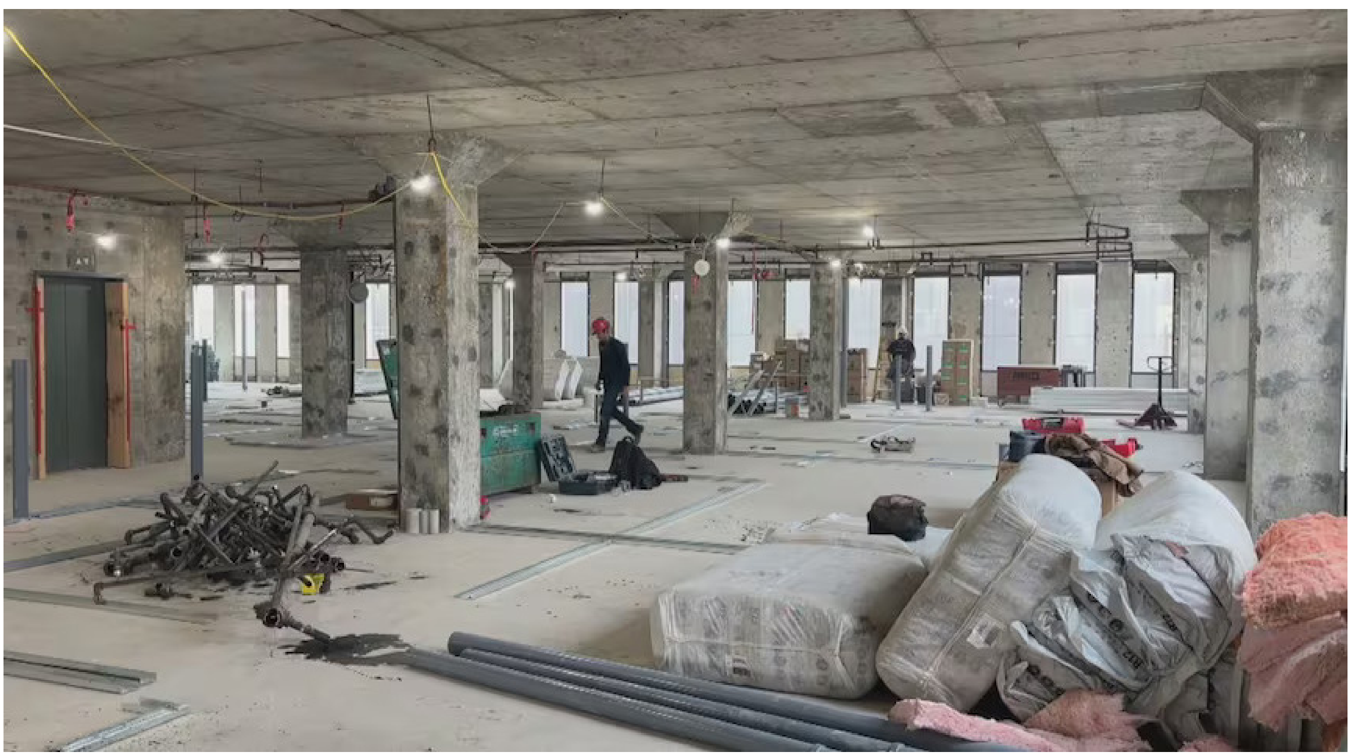


Figure 2.5. Interior demolition underway at 1660 Hollis Street (Case Study 1, Halifax), as the former office tower was being transformed to a multi-unit residential building in 2021.

Credit: Preston Mulligan, CBC

Scenario B: Retrofit and Addition

Adding to an existing building extends the life of what is already there while introducing new spaces and uses that reflect present needs and future considerations. This process promotes dialogue and a careful negotiation between the existing and the newly introduced.

An addition offers the opportunity to recalibrate a building's performance, function, and relevance. It allows for new spatial relationships to emerge, to improve energy efficiency, and enhance accessibility. When thoughtfully conceived, the addition strengthens the existing one by bringing it into active or a more relevant use.

The success of a retrofit with addition depends on balance. The new should be distinct enough to express its own time, yet sensitive enough to respect the scale, materiality, and rhythm of the existing. The junctions of where old meets new become areas of meaning, revealing the building's evolution over time. This approach recognizes that every existing building carries latent potential. Through addition, we can uncover and amplify this potential by intensifying use, expanding capacity, and ensuring longevity for the existing building.

This approach is most common in cases of change of use or where there is a need to rethink the building's occupancy and/or density. An addition can provide additional floor area needed for financial viability by allowing the flexibility to accommodate modern mechanical and electrical systems required to achieve energy code compliance. This option is most viable where the site has unbuilt capacity under zoning policy or (if adding vertically) the structure can support expansion.

Figure 2.6. Construction of an addition underway at 7250 Rue Marconi (Case Study 2, Montreal), as the former textile factory was being transformed to an office building in 2014.

Credit: Alexis Hamel, Images Montreal (imtl.org)

Scenario C: Demolish and Replace

The replacement of an existing building is only justified when its continued use, adaptation, or rehabilitation are demonstrably unfeasible structurally or functionally. Demolition should be the conclusion of careful study, critical assessment, and exhausted alternatives.

In some cases, buildings may have deteriorated beyond repair, contain hazardous materials that compromise safety, or lack the structural capacity to meet essential life-safety, accessibility, or performance standards. In these rare circumstances, replacement may be the only viable solution to address the requirements for a project.

Unfortunately, redevelopment becomes the default when deterioration is extensive, when urban density targets call for larger buildings, or when the desired use is incompatible with the existing structure. Post-war buildings with large, deep floor plates, longer exit distances, and limited daylight are especially difficult to adapt for new uses, particularly residential. In these cases, demolition and redevelopment often prevail, even though they carry the greatest embodied carbon and financial impacts.

Demolition should be approached as an act of stewardship, not erasure. Before replacement, all reasonable options for retention, adaptive reuse, or partial integration should be explored. Documentation, material salvage, and interpretation can ensure that the physical and cultural memory of the building endures beyond its lifespan.

Where demolition is necessary, deconstruction offers a more circular pathway. Instead of treating the existing building as waste, deconstruction selectively dismantles building elements, enabling material recovery for reuse or high-quality recycling. This approach reduces disposal emissions, recaptures value locked in existing materials and lowers demand for virgin resources in the replacement building. While regulatory policies are not yet in place in most places in Canada, integrating deconstruction into redevelopment pathways creates a bridge between climate objectives and urban growth pressures.

2.4 Socioeconomic Benefits of Retrofits and Adaptive Reuse

The purpose of this study is to underscore the environmental imperative for retrofit and reuse; however, it is equally important to recognize the social and economic co-benefits of these lower-impact forms of development. Retrofitting existing buildings and adapting them for new uses can generate multiple forms of value– jobs, health benefits, social equity, local investment, and heritage-driven economic activity– that conventional demolition-and-rebuild strategies often overlook.

Recent national and municipal studies, such as *Green Communities Canada's 2025 National Progress Report on Retrofitting Canada's Homes,* emphasize that retrofit and adaptive reuse can substantially mitigate lifecycle emissions by avoiding demolition and new material production, while also strengthening local economies, preserving cultural assets, and improving community well-being. The following section synthesizes key findings from recent studies and projects.

Figure 2.7. Evergreen Brick Works is the transformation of the Don Valley Brick Works in Toronto, which operated as a brickyard from 1889 to 1984, into a cultural and ecological hub that fosters environmental education, local employment, and inclusive public space. Additionally, the project maintains the character and industrial heritage of the space.

Credit: DTAH

Job Creation, Local Economic Stimulus, and Value Retention

High labour intensity and local multiplier effects	The Atmospheric Fund's *The Case for Deep Retrofits* estimates that deep retrofit projects in Canada generate about 29 job-years per CAD 1 million invested, reflecting the higher labour intensity of retrofit work relative to new construction (TAF, 2020).
Macroeconomic uplift and GDP gains	*The Green Retrofit Economy Study* (Delphi Group) models a "moderate" retrofit pathway in Canada and projects 777,000 direct job-years generated across the retrofit sector, highlighting the macroeconomic potential of scaling up retrofit activity (Delphi, 2022).
Avoided economic loss from demolition and waste	Reusing existing structures conserves embodied value, reduces landfill costs, and avoids the economic waste of demolition. Studies on adaptive reuse in Ontario (Vecchio et al., 2020) note that avoiding demolition not only reduces material waste but also preserves municipal infrastructure investment and local tax base continuity.
Value uplift, improved occupancy, and rent premiums	Energy-efficient retrofits lower operating costs and attract tenants, improving building performance and financial returns.
Catalyst effects on neighbourhood revitalization and property values	Adaptive reuse signals reinvestment, spurring local upgrades, raising property values, and strengthening community vitality.

Health, Comfort, and Quality-of-Life Gains

Indoor environmental quality and health savings	In Alberta, the Pembina Institute's *Valuing Deep Retrofits* links retrofit interventions (insulation, ventilation, envelope upgrades) with measurable reductions in health risks and suggests a return of ~$4 in energy + health savings per dollar invested (Pembina Institute, 2025).
Public health benefits of insulation and thermal comfort	Upgraded envelopes reduce cold exposure and dampness, protecting vulnerable populations from temperature extremes.
Thermal equity and alleviating energy poverty	Targeted retrofits reduce energy bills and improve comfort for low-income households, advancing social equity and resilience. Programs highlighted in Green Communities Canada's report show that community-led retrofit initiatives can directly reduce household energy burden while creating skilled local employment.

Heritage, Community Identity, and Long-term Social Value

Preserving cultural capital and sense of place	Reusing existing buildings sustains local identity, memory, and continuity within neighbourhoods. Research by Savoie et al. (Key Factors for Revitalising Heritage Buildings through Adaptive Reuse, 2025) emphasizes that heritage-sensitive retrofits help maintain social cohesion and foster shared stewardship of the built environment.
Stimulating cultural tourism and creative economy	Revitalized heritage sites attract visitors and creative industries, supporting local cultural and economic growth.
Lower long-term maintenance burden and lifecycle cost stability	Extending building life through upgrades spreads costs and reduces major capital replacements over time.

Challenges, Equity Considerations, and Enabling Factors

It is important to acknowledge that these benefits are not automatic: realizing them requires enabling policies, financial structuring, and equitable program design. Key considerations include:

Financing and upfront capital	Projects involving retention, retrofits and adaptive reuse often stall due to perceptions of high upfront costs and risk perceptions. The Atmospheric Fund (TAF) notes that conventional ROI models fail to fully account for non-energy benefits, making it harder to attract financing (TAF, *The Case for Deep Retrofits*, 2020). Policy frameworks proposed by Vecchio et al. (2020) highlight how municipal tools– such as tax increment grants or density bonuses– can incentivize adaptive reuse and offset early-stage costs.
Inclusion of non-energy benefits in appraisal and decision-making	Factoring in health, cultural, and social gains strengthens the full business case for retrofit investment. The City of Calgary's Heritage Value Analysis & Conservation Tool illustrates how municipalities can begin to quantify these broader community benefits, linking heritage conservation and adaptive reuse to economic and social value outcomes.
Ensuring equitable access	Retrofit programs need to address the complex issues of displacement and ensuring benefits reach lower-income and marginalized groups.
Capacity, skills, and supply chains	The expansion of specialized training and heritage craft skills is needed to deliver quality retrofit and reuse at scale. The Savoie et al. (2025) study identifies gaps in regional capacity for managing heritage projects, calling for broader coordination between trades, municipalities, and educational institutions.
Policy consistency and long-term incentives	Stable and explicit codes for existing buildings and incentivizing retention would build confidence for sustained investment in retrofit and reuse markets. Aligning planning and heritage policy objectives is key to making adaptive reuse a mainstream, repeatable development pathway across Canadian cities.

03
Research Approach

3.1 Methodology

This study compares the embodied carbon, operational carbon, and construction cost impacts of retrofit and new construction scenarios for three case study buildings, located in Halifax, Montréal, and Vancouver. Each site was assessed under three primary scenarios: retrofit, retrofit and addition, and demolish and replace. A baseline “do nothing” condition was also modelled for comparison. Using a common framework and coordinated consultant inputs, the analysis allows for meaningful comparison across both scenarios and geographies.

Embodied and Operational Carbon

Life cycle assessment (LCA) was led by Ha/f Climate Design, with support from Acorn Sustainability Consulting for energy modelling. The LCA followed established life cycle stages from product stage (A1–A5), use stage (B1–B5, with B6 for operational energy), through end of life (C1–C4). Embodied and operational carbon are presented side by side in whole life carbon results. Consistent, industry-standard systems and equipment were assumed across scenarios to enable comparability between case studies.

A 60-year service period was assumed for all new construction elements, systems, and materials. Shorter-lived components, such as windows, roof membranes, and interior finishes, were assumed to be

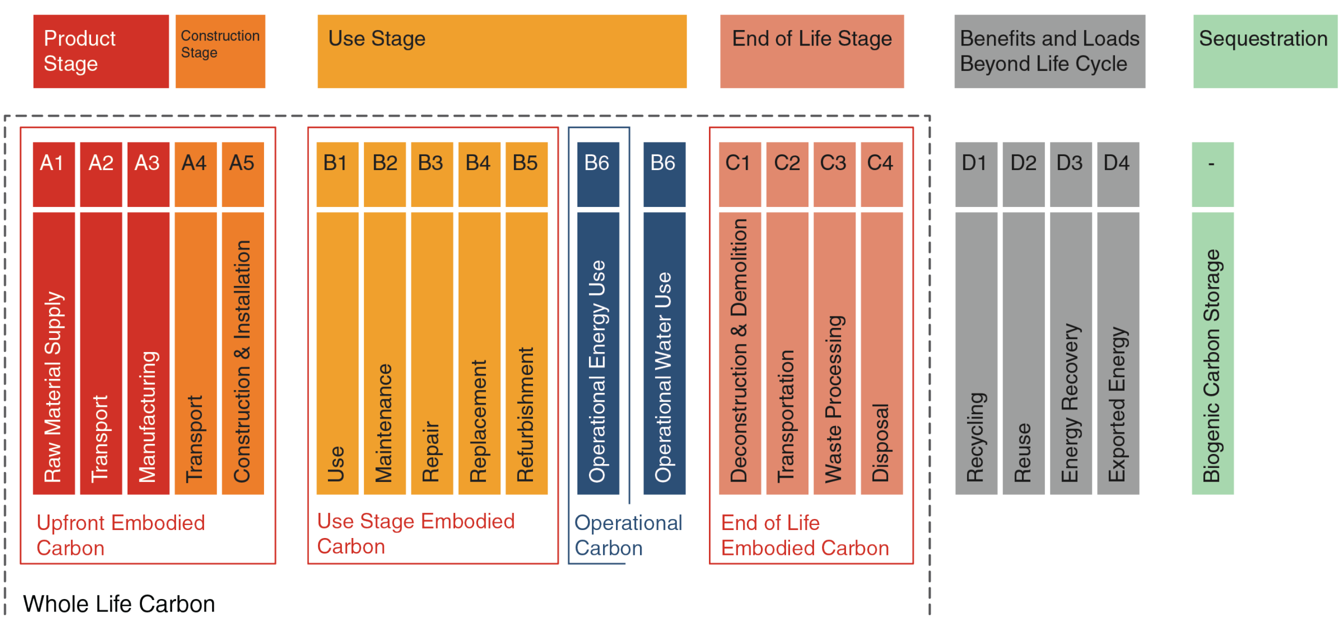


Figure 3.1. Life Cycle Assessment (LCA) systems boundaries as defined by EN 15978 and ISO 21930, including biogenic carbon storage.

replaced during this period, compounding their embodied carbon impact. For existing heritage structures, the team first quantified embodied carbon in the pre-retrofit condition to provide a baseline for demolition scenarios. Existing materials were not double-counted in retrofit cases, as their embodied impacts are not new.

Demolition was assessed separately for selective removals in retrofit scenarios and for whole-building demolition in redevelopment scenarios. In both cases, the process impacts (e.g. machinery, disposal) were combined with end-of-life (C-phase) impacts of the removed materials. No credits were assumed for material salvage or reuse, reflecting current Canadian industry practice.

Environmental Product Declarations (EPDs) from the One Click LCA (OCL) data library were used to calculate the embodied carbon content of the design scenarios. OCL has one of the largest global databases EPDs from material suppliers and manufacturers. If a specified material is not included in the database, the most similar material in terms of material composition is selected instead. Material types and quantities were obtained from available information on the case studies.

The energy models were developed following Part 8 of NECB and assumptions provided by WSP. All three case studies were assumed to be fully electric. The operational carbon emissions were calculated using the 2025 provincial grid electricity emission factors.

Code, Structural, Envelope, and Mechanical Assumptions

Based on the case studies provided by CAHP, WSP developed technical assumptions for structural, envelope, and mechanical systems across all scenarios. In some instances, assumptions were varied to fit more typical assemblies, where deemed appropriate.

The case studies confirmed that the as-built conditions met NBC and NECB requirements through the performance path, establishing a reference point for how codes are typically achieved in practice. These metrics served as a baseline to inform and refine the development of key assumptions.

In some instances, where unique assemblies or materials were used, assumptions were varied to fit more typical assemblies, where deemed appropriate.

Through this work, the case studies revealed critical factors that most significantly influence carbon emissions and cost, offering valuable insights to support policy recommendations related to the NBC and NECB.

Cost Estimating

Order-of-magnitude cost estimates were prepared by A.W. Hooker Associates Ltd. for all three sites and scenarios. Estimates represent fair market construction costs, aligned with the median of expected competitive bids rather than lowest bid outcomes. Quantities were measured from drawings where available, with historical cost data used where design information was incomplete.

The estimates include allowances for general requirements, contractor fees, and contingencies. A 20% design and pricing contingency was applied across disciplines (architectural, structural, mechanical, electrical, siteworks) to reflect the early design stage. Post-contract construction contingencies varied by scenario: 10% for retrofit, 7.5% for retrofit with addition, and 5% for new build. Escalation was excluded, with costs based on market conditions at tender. All estimates are expressed in Canadian dollars, exclude HST and soft costs, and are based on the local cost base for each city (Halifax, Montréal, Vancouver).

Building Conservation Considerations

At the core of heritage conservation is the principle of retention before replacement where the greatest value, both cultural and environmental, lies in what already exists. This principle forms the foundation for evaluating any intervention in a heritage building, particularly when considering embodied carbon and life-cycle impacts.

In the context of climate action, this understanding frames conservation as an active environmental strategy, and one that positions existing buildings as crucial, irreplaceable assets in the transition to a low-carbon future.

Retention preserves more than material: it sustains the craftsmanship, character, and cultural narratives embedded within a building's fabric. Each component represents past investment of labour, energy, and resources.

In carbon terms, retention aligns perfectly with the concept of avoided emissions. Every tonne of material preserved is a tonne that does not need to be extracted, processed, transported, and installed anew. The environmental value of conserving existing fabric is thus both quantifiable and qualitative, through the maintenance of collective memory and cultural identity.

From a conservation standpoint, this approach is consistent with established frameworks such as the *Standards and Guidelines for the Conservation of Historic Places in Canada* (2010), which prioritizes repair over replacement, and replacement only when deterioration is beyond repair.

Currently, the case studies are not designated and do not form part of each municipality's heritage registers. However, the approaches taken for the Scenario A: Retrofit and Scenario B: Retrofit and Addition are in alignment with the heritage conservation practices and guidelines.

3.2 Study Process

Managing a set of case studies with varying as-built conditions and code compliance strategies, while maintaining comparability, required a flexible and iterative process across the team. Ha/f began with a review of the as-built architectural, mechanical, and structural drawing sets and performed quantity take-offs. WSP then reviewed envelope assemblies, structural quantities, and mechanical systems to confirm compliance with NBC/NECB minimums, with adjustments made as required.

Ha/f performed energy modelling to confirm system and envelope performance. WSP adjusted assumptions as needed to meet NBC and NECB performance-based code requirements. Ha/f then synthesized the drawings, assemblies, and systems into quantities for each scenario and calculated embodied and operational carbon impacts, using industry-standard or regional average data wherever possible.

Finally, AW Hooker Associates prepared high-level cost estimates based on these quantities, using current local market data. Estimates were aligned with the same component categories as the LCA to allow direct comparison. The combined results on cost, embodied carbon, and operational carbon were reviewed by the project team and CAHP to inform recommendations for potential code reform.

3.3 Study Assumptions and Limitations

A number of study-wide assumptions were necessary to ensure comparability across the three case studies in Halifax, Montréal, and Vancouver. The case studies are actual building sites that have undergone retrofit or retrofit and addition approach. The as built scenario is noted in each case study.

For retrofit scenarios (Scenarios A & B), heritage conservation best practices were assumed, with structure and envelope elements retained wherever feasible. Where replacement was required, standard interventions such as window replacement or selective envelope repair were applied, reflecting the actual retrofit projects, with adjustments made as needed to ensure compliance with NBC and NECB. In the redevelopment scenario (Scenario C), assumptions were based on typical developer practices, using standard structural systems, envelope assemblies, and mechanical systems that reflect common new construction approaches in each market. These scenarios also assumed redevelopment to align with zoning allowance, reflect typical developer strategies for financial viability and illustrate a benchmark for a new building of comparable size for each Case Study. Together, these assumptions ensured that Scenario C represented a realistic baseline for how new projects are currently delivered in Canada.

The study also carries limitations. The sample size of three case study buildings does not capture the full diversity of the Canadian building stock, and the selected sites differ in age, typology, and planning context. This limits the ability to make direct comparisons between cities, although the consistent methodology allows results to be compared within each site. While the study quantifies embodied carbon, operational carbon, and cost across scenarios, it does not account for potential salvage or reuse of materials in redevelopment, nor does it capture future shifts in energy grids or material supply chains. These limitations mean that the findings should be understood as indicative rather than predictive, highlighting relative differences between scenarios rather than precise forecasts.

Despite these constraints, applying consistent assumptions across sites enables the analysis to provide useful insight into how different compliance pathways perform in terms of carbon and cost. The scenarios demonstrate the trade-offs between retrofit, retrofit with addition, and redevelopment, and highlight where heritage conservation practices can align with climate objectives.

04
Workshops

4.1 Introduction

Figure 4.1. Vancouver workshop participants discussing questions, VanDusen Botanical Garden, March 2025.

Throughout the development of the project, workshops were held in each of the three case study cities to consult with local experts and industry stakeholders. The workshops introduced the project to CAHP members, industry professionals, and local stakeholders, and sought feedback on the challenges and opportunities associated with existing and heritage buildings at both local and national levels.

A key objective was to gather input on the development of educational and capacity-building resources as the next step for the project. Feedback from these workshops helped inform the research approach and shape the outline of the final written report.

The workshops provided a platform for experts from diverse disciplines to discuss challenges faced by designers, owners, and policymakers when retrofitting existing buildings. Discussions highlighted the importance of complying with both national and local building codes, which are typically designed for new construction, creating unique challenges for retrofit projects.

Participants contributed valuable, location-specific insights on economic, regulatory, and technical barriers to retrofits, including perspectives on energy codes and their interaction with other local codes and regulations. These contributions were instrumental in shaping practical recommendations for the project.

4.2 Vancouver Workshop

March 2025, VanDusen Botanical Garden, Vancouver, British Columbia

At the start of the project, CAHP in collaboration with Giaimo and Ha/f, hosted a kick-off workshop in Vancouver, BC, to explore the intersections of sustainability, heritage, and building codes. The event brought together professionals from private, municipal, and public institutions to discuss sustainability, code compliance, and heritage conservation within the context of the study. Members of the British Columbia Association of Heritage Professionals (BCAHP) attended the workshop and contributed to the discussions with a focus on the local context.

The project team introduced the project to the attendees and posed several questions to facilitate discussion around current challenges and opportunities related to retrofitting existing buildings, from both local and national perspectives. This multidisciplinary discussion helped inform the project's direction and fostered collaboration across sectors. The discussions were highly engaging, and several follow-up initiatives have since been explored with BCAHP and individual participants.

Following the workshop, the project team reviewed and analyzed the key takeaways and incorporated these insights into the research approach and the development of the study outline.

Figure 4.2. Group photo at the Vancouver workshop, VanDusen Botanical Garden, March 2025.

4.3 Montréal Workshop

May 2025, Canadian Centre for Architecture, Montréal, Quebec

As the project progressed and entered the case study analysis phase, including a case study based in Montréal, an additional workshop was held in May at the Canadian Centre for Architecture (CCA). This workshop was strategically aligned with the CCA's exhibition *To Build Law* and its accompanying documentary, both of which advocate for a systemic shift in how we build and value the built environment. In particular, they promote renovation over demolition and new construction, an approach that strongly aligns with the objectives of this study.

The workshop brought together professionals and stakeholders from a range of backgrounds, including private-sector, municipal, and public institutions. Participants discussed issues related to sustainability, heritage conservation, and building code challenges, and provided feedback to inform the project's research and next steps. The project team presented the study's progress and sought input on the proposed outline of the final report as well as the presentation of findings.

Figure 4.3. Montréal workshop participants discussing questions, Canadian Centre for Architecture, May 2025.

4.4 Key Takeaways from Workshops

Based on the questions posed and the open discussion that followed at the Vancouver and Montréal workshops, participant feedback was synthesized into four key thematic areas: Knowledge and Capacity Building, Decision-Making Processes, Building and Energy Codes, and Policy. These categories shaped the following key takeaways.

Question 1

When retrofitting heritage and existing buildings, a number of challenges may come up, resulting in partial or full building demolition. From your experience, do you have examples of common issues you've encountered? How can these challenges be addressed? Please consider both BC and national levels, including challenges related to Building Code, Energy Compliance, Policy, Zoning, Financial, and other factors.

Question 2

For this project, the findings from the 3 case studies will be written into a report analyzing the results and offering best practices guides for common issues. This report aims to be a valuable reference document for projects under current codes, while also building a roadmap for future retrofit codes. What components of this report would you find useful/essential to meet this goal? Please list out what you would and would not like to see in this report, from various perspectives.

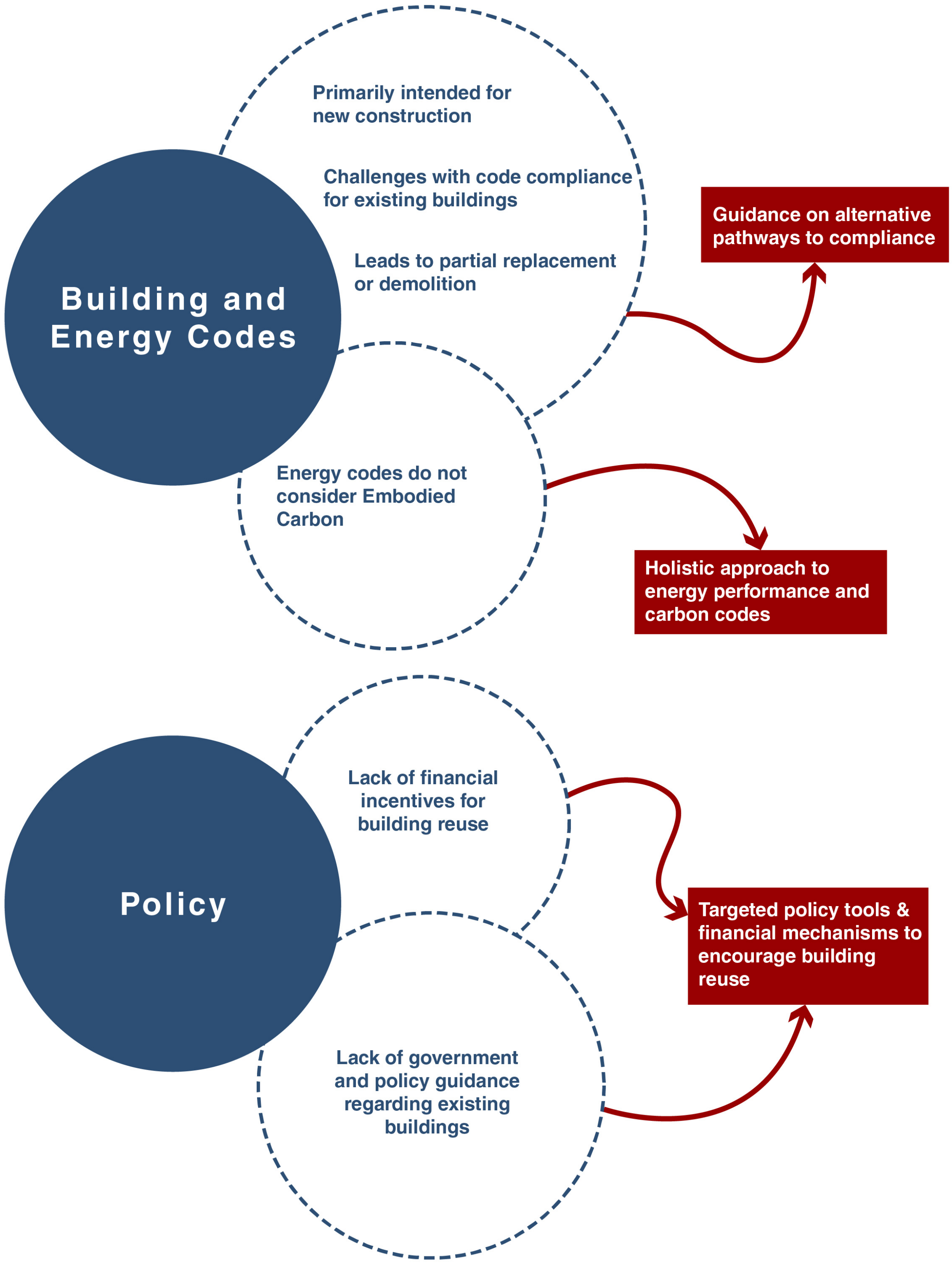


Figure 4.4. Takeaways from Vancouver and Montréal Workshops. Blue circles on the left shows the thematic areas; dashed circles indicate challenges, while red rectangles highlight opportunities.

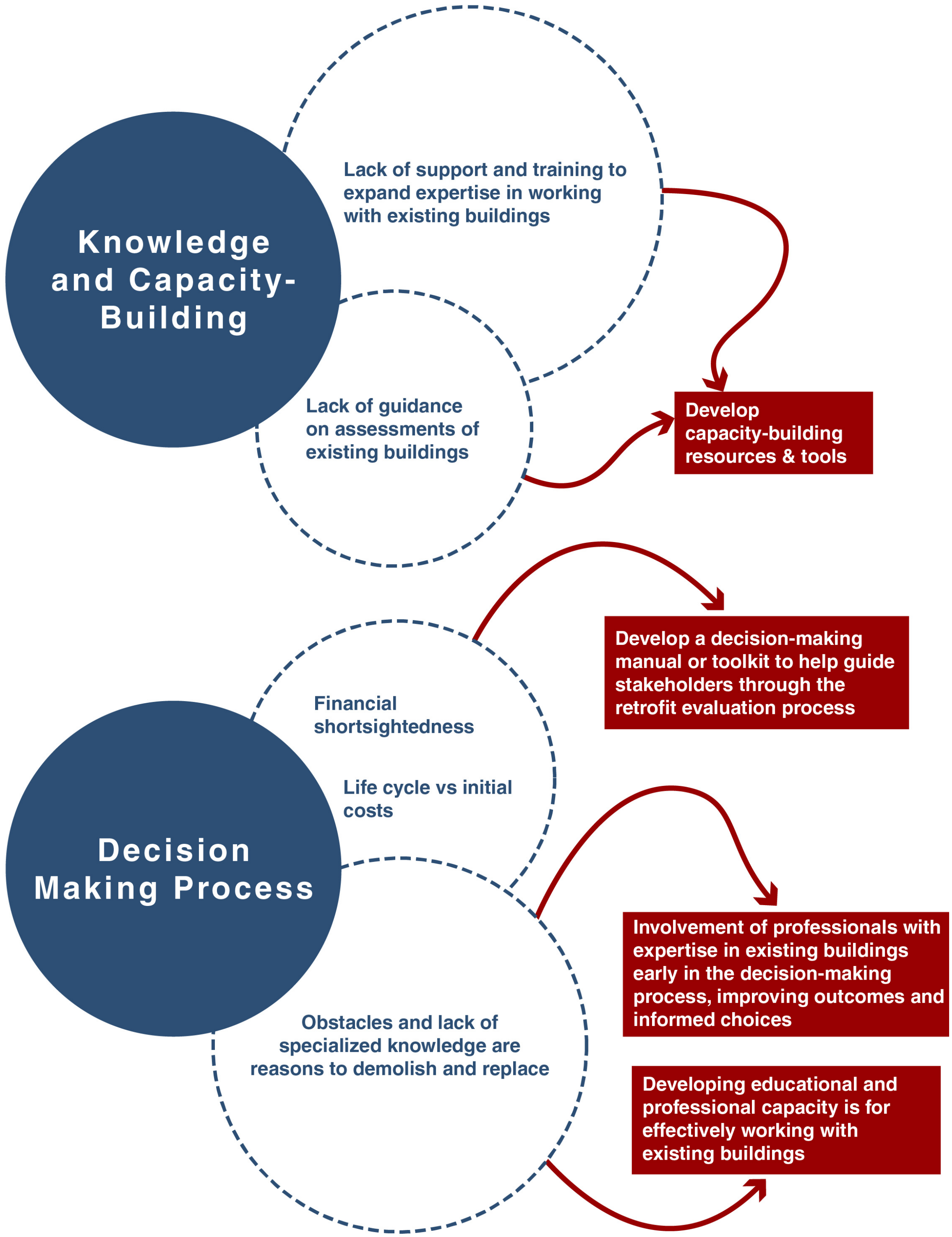


Figure 4.5. Takeaways from Vancouver and Montréal Workshops. Blue circles on the left shows the thematic areas; dashed circles indicate challenges, while red rectangles highlight opportunities.

4.5 Halifax Workshop

October 2025, Halifax Convention Centre, Halifax, Nova Scotia

In October 2025, as part of the annual National Trust Conference (with CAHP and the Indigenous Heritage Circle), CAHP hosted the final project workshop in Halifax, Nova Scotia, in collaboration with Giaimo and Ha/f.

The workshop began with a guided tour of 1660 Hollis Street (Centennial Building/ Agency Art Lofts), led by the project developer Sidewalk RED. As one of the project's three case studies, this former office tower has been transformed into residential suites with a commercial podium, demonstrating adaptive reuse and carbon-conscious design in practice.

Following the tour, the project team presented research updates and shared insights on using life cycle thinking to compare retrofit and new-build approaches. The discussion emphasized how carbon, cost, and building code considerations can align to make the reuse of existing buildings and heritage conservation practices effective climate strategies.

The workshop gathered professionals from across sectors, including heritage, policy research, engineering, and sustainability advocacy.

Figure 4.6. Halifax workshop attendees begin their tour of 1660 Hollis Street (Case Study 1), led by developer Sidewalk RED, starting in the building's lobby. A custom artwork, first of many featured throughout the building, is visible in the background.

A draft of the final report was shared, and the case study findings were highlighted to gather input on next steps. Participants then engaged in a conversation to provide feedback on the project's outcomes to date. To guide this discussion, the questions on the following page were posed during the workshop. Their responses are reflected in the Key Takeaways section of the study and will inform the development of educational materials to support broader knowledge sharing and practical application in the next phase of the project.

Question 1

What are your key takeaways from this study?
Are there any surprises for you in the results thus far?

Question 2

What further studies are required to take this research forward?
Reflect on questions and barriers that occur in your practice - and what kind of data you would like to be able to point to as evidence.

Question 3

In what formats and forums should we disseminate this data, for it to have the widest reach and impact in shifting the conversation?

Figure 4.7. Workshop attendees viewing a typical one-bedroom unit at 1660 Hollis Street (Case Study 1).

Figure 4.8. Workshop attendees at the final stop of the tour, the penthouse of 1660 Hollis Street (Case Study 1) where construction is still in progress.

Figure 4.9. Group photo at the Halifax workshop at the end of the session.

05
Case Studies

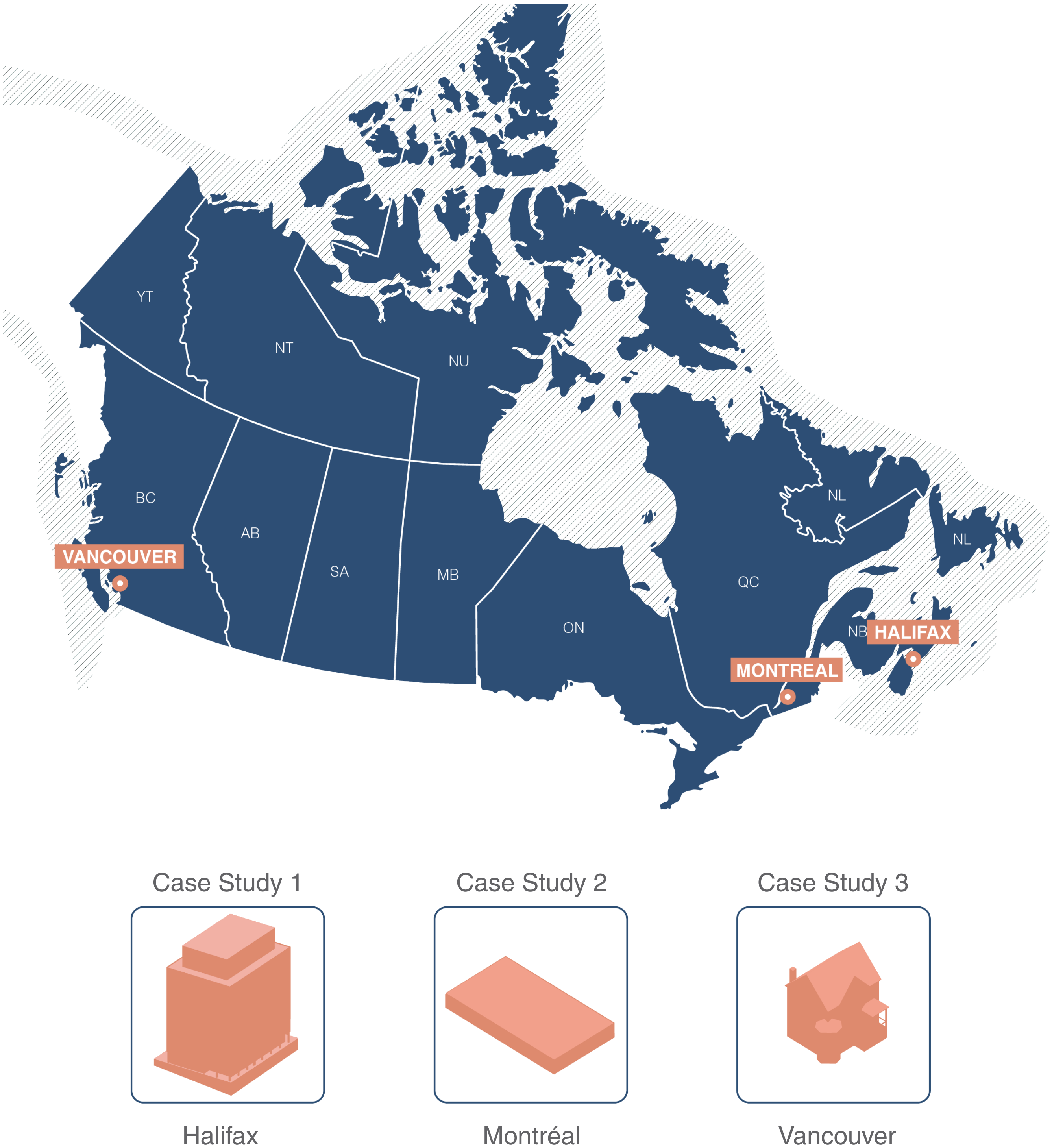


Figure 5.1. Map showing the location of all case studies.

This study approaches issues around codes, carbon, and existing buildings through a diverse, nationwide study set. Three locations across Canada were chosen, with three different typologies representing a broad range of project types: a high-rise office to residential conversion in Halifax, a light industrial to office conversion in Montréal, and a single-family home to multi-unit residential conversion in Vancouver.

Each existing building represents a different era in Canadian architecture, ranging from turn of the century wood-framed Queen Anne Revival to classic modernist precast concrete and curtain wall. By addressing a diversity of building ages, types, sizes, and construction systems, this study aims to demonstrate the viability of retrofit projects across a range of Canadian building stock and encourage consideration of a wide variety of building types in the code reform conversation.

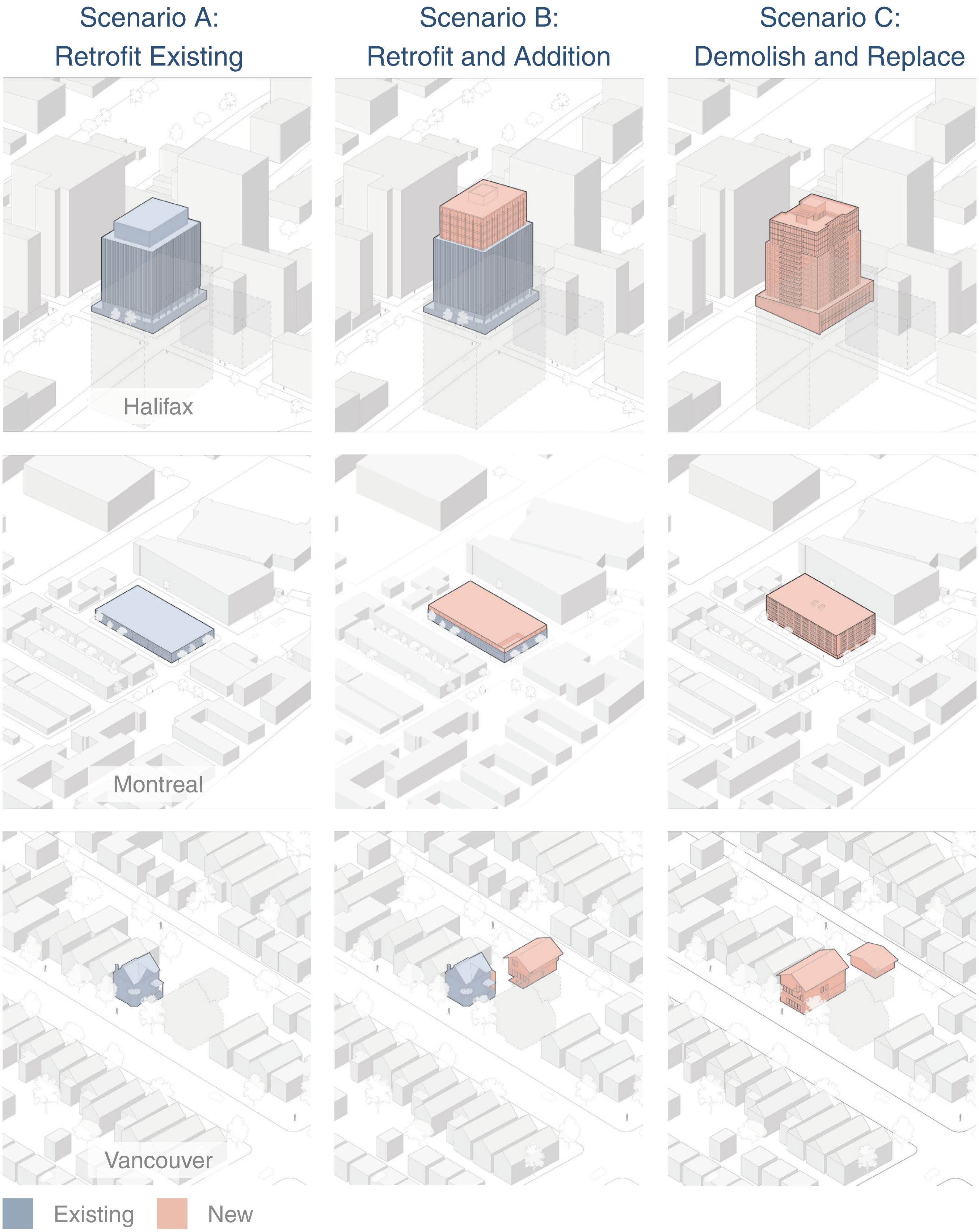


Figure 5.2. Diagrams of Scenarios A, B, and C in all three case studies showing existing and new portions of the building.

5.1 Case Study 1 | Halifax

Address	1660 Hollis Street, Halifax
Owner	Sidewalk RED
Date of Construction	1967-1974
Original Use	Office
Adaptive Reuse	Residential
Architect	Fathom Studio

Project Context

Construction of the Centennial Building at 1660 Hollis Street began in 1967 in phases and was fully completed in 1974. As one of Halifax's first high-rise buildings, it stood as a notable example of mid-century development. By 2021, it was nearly 40% vacant as commercial tenants had moved out. The building then was acquired by Sidewalk RED, who began transforming it into multi-unit rental housing called Agency Art Lofts. Fathom Studio was hired as the architects for the retrofit, and construction is expected to be completed in 2025.

Figure 5.3. Halifax office building transformed to multi-unit rental housing.

Credit: Sidewalk Real Estate Development, Agency Art Lofts (sidewalkred.ca)

Scenario A:

Retrofit

Scenario B:

Retrofit and Addition

Scenario C:

Demolish and Replace

As Built: Scenario A, Retrofit

In the residential conversion of the Agency Art Lofts, the former open-plan office floors were stripped of finishes and partitions, with new residential layouts organized around the existing elevator cores. All primary structural elements, elevators, and stair cores were retained, while the concrete floor slabs were left exposed to serve as both ceiling and floor finishes. The existing precast concrete cladding on the steel-stud exterior walls was preserved, with the insulated glazing units and spandrel panels replaced to meet enhanced performance standards. On the two penthouse levels, exterior walls were fully removed and rebuilt with new opaque assemblies and punched window openings. Roof assemblies across all levels were stripped to the structural slab and reinstalled with upgraded insulation. New mechanical, electrical, and plumbing systems were introduced to improve operational energy efficiency.

Overview of Results

The Halifax Case Study stands out as an outlier in this report due to the predominance of operational carbon emissions in the whole life carbon performance of the building–between 86% to 96% across all three scenarios. This percentage remains very high in spite of building electrification and installation of all new mechanical and electrical systems. This is because unlike Quebec and British Columbia which largely generate power from renewable sources, in Nova Scotia only about 43% of the grid is generated from clean sources like hydroelectric, wind and solar. The majority of the grid is still based on fossil fuels such as coal, natural gas and oil.

In the “Do Nothing” Scenario, the existing office building locks in very high operational carbon intensity at 6,641 $kgCO2e/m^2$ over 60 years, or more than 1,779 tCO2e in total. The assumption is that the building continues to run on gas heating, with no upgrade to mechanical systems or building envelope.

Scenario A, in which the building retrofit is modelled, shows that the operational carbon intensity over a period of 60 years reduces to 5,032 $kgCO2e/m^2$ due to upgrades in envelope, building electrification and installation of centrally ducted VRF systems for heating and cooling. The embodied carbon associated with upgrades in envelope and interiors account for only 4% of the whole life carbon intensity of 5,216 $kgCO2e/m^2$.

In Scenario B, 3,840 m^2 of GFA is added to the residential conversion by modelling the construction of a 4 storey addition atop the existing structure. This “Retrofit and Addition” Scenario has an embodied carbon intensity of 306 $kgCO2e/m^2$ and an improved operational carbon intensity of 4,342 $kgCO2e/m^2$. In terms of whole life carbon emissions per square meter of GFA this is the best performing scenario, with the lowest WLC intensity at 4,648 $kgCO2e/m^2$ as well as the highest residential density at 198 units.

Scenario C delivers the lowest operational emissions at 4,110 $kgCO2e/m^2$, but a much higher embodied carbon intensity at 704 $kgCO2e/m^2$. From a WLC per square meter perspective, Scenario C performs better than Scenario A due to its improved energy efficiency, but at 4,803 $kgCO2e/m^2$, it performs slightly worse than Scenario B.

In terms of total emissions over a period of 60 years, we see that Scenario C “Demolish and Replace” Scenario has the lowest WLC emissions, at 78,807 tCO2e because the retrofit plus addition Scenario actually results in a bigger building, with higher GFA, a greater number of units and consequently higher total WLC emissions. Additionally, the scenarios are modelled to current emission factors from Halifax’s power grid. As per Nova Scotia’s goal to decarbonize its grid to 80% renewable energy by 2030, we can also assume that the outsize impact of operational carbon over time will reduce, and make the balance between embodied and operational carbon more similar to the Montreal and Vancouver case studies.

Note: For more information on the assumptions and methodology behind the data in this chapter, see Appendix B - Costing Reports, Appendix C - Engineering Reports, and Appendix D - Energy Modeling Reports.

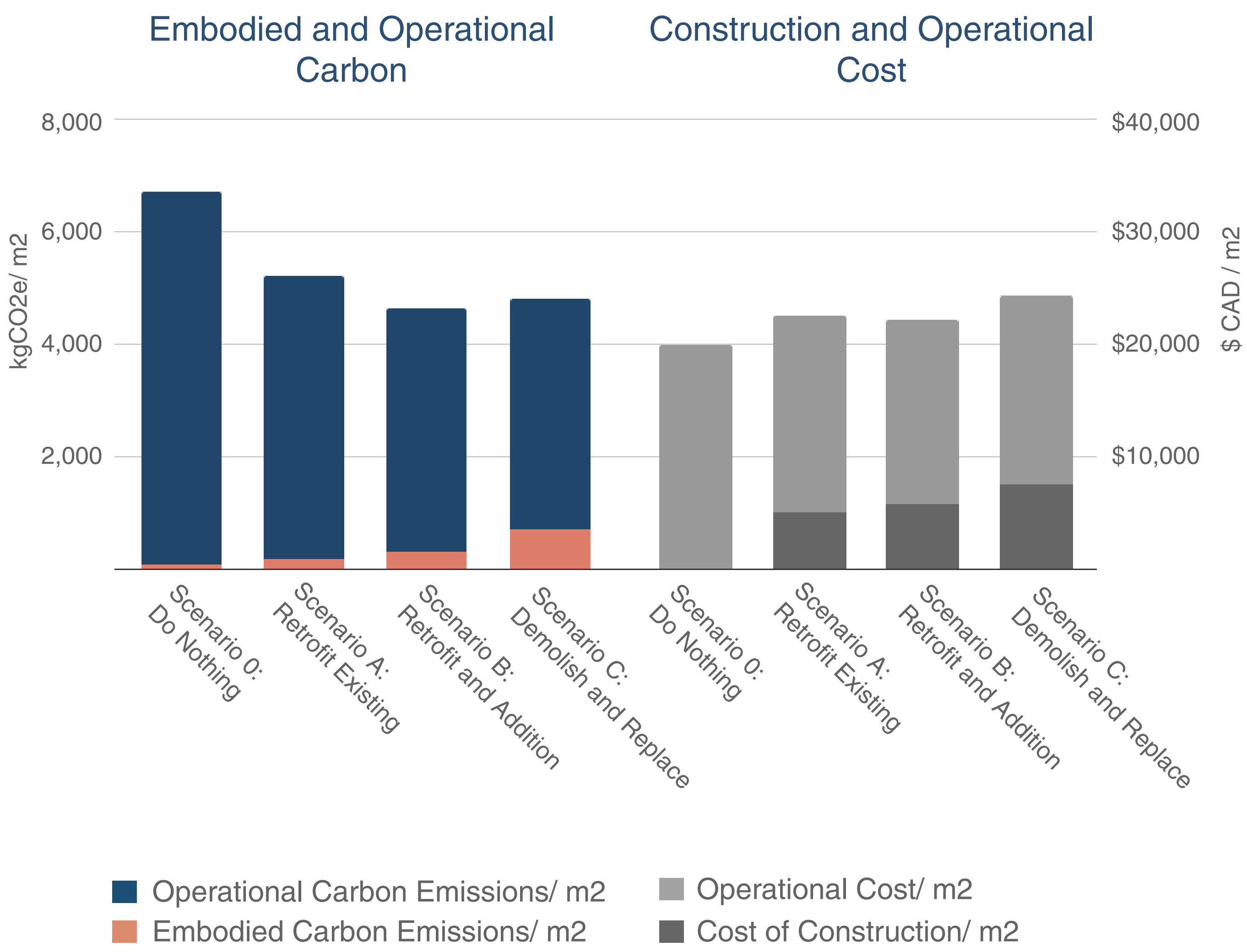
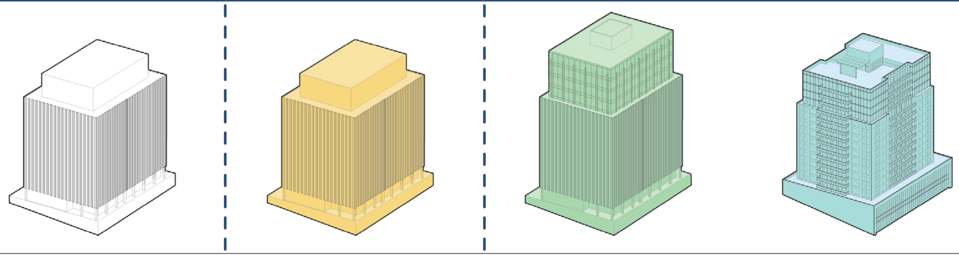


Figure 5.4. Cost of Construction and Operational Cost in comparison to Operational and Embodied Carbon Emissions. All values are expressed per square metre of gross floor area.



	Scenario 0: Do Nothing	Scenario A: Retrofit Existing (As Built)	Scenario B: Retrofit and Addition	Scenario C: Demolish and Replace
Primary Use	Office	Residential	Residential	Residential
Gross Floor Area (m^2)	16,075 m2	16,075 m2	19,915 m2	16,370 m2
Subgrade Parking	1.5 Levels	1.5 Levels	1.5 Levels	3 Levels
Above Grade Storeys	12	12	15	16
Window to Wall Ratio	42%	42%	48%	49%
WLC Emissions (tCO^2e)	205,878	83,846	92,567	78,807
WLC Intensity ($kgCO_2e/m^2$)	6,719	5,216	4,648	4,814
EC Intensity ($kgCO_2e/m^2$)	78	184	306	704
OC Intensity ($kgCO_2e/m^2$)	6,641	5,302	4,342	4,110
Total Construction Cost (CAD $)	$0	$82,163,000	$115,680,000	$124,524,000
Construction Cost Rate (CAD $/ m^2)	$0	$5,111	$5,809	$7,607
Total Operational Cost* (CAD $)	$320,098,063	$281,518,304	$327,169,709	$274,237,486
Operational Cost Rate (CAD $/ m^2)	$19,913	$17,513	$16,428	$16,752

*Total Operational Cost: Initial hard construction based on Q4 2025 + Operational Carbon Costs over 60 Year Ownership.

Figure 5.5. Overview of results across all Halifax scenarios.

Scenario A:
Retrofit Existing

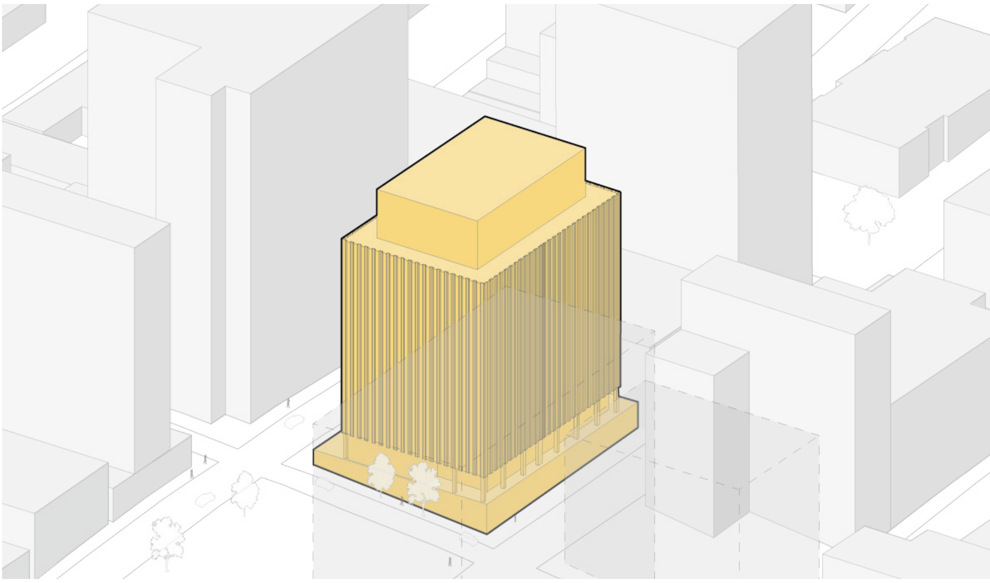


Figure 5.6. Halifax Scenario A shown in context

The scope of the retrofit included the following major interventions, summarized per building component.

Structure	The existing building comprises reinforced concrete foundations, columns, slabs and cores. In the retrofit all existing structure, including elevator and stair cores are retained. Minor strengthening works in foundations and new steel columns introduced at ground level.
Envelope	The existing building's precast concrete siding,insulation, air and vapour barriers and steel stud wall framing are all retained. Original IGU units are replaced by double glazed IGUs with thermally broken aluminium frames. Roof replaced, with 2-ply modified bitumen and additional insulation. Walls: RSI = 1.5, Roofs: RSI = 2.7, Fenestration: RSI = 0.2 (All RSI values are "effective") Air Leakage Rate: 2.5 L/s/m2 @ 75 Pa.
Interiors	All existing interiors were replaced. Full interior retrofit, with new partition walls to accommodate residential floor layout. Exposed concrete ceiling and floor finishes.
Mechanical and Electrical	All existing systems were replaced. Central VRF air source heat pump heating system installed with hydronic piping to individual units. ERV in each unit, with electric baseboard backup heating. All new electrical feeders, panels and fixtures. Low GWP refrigerant R454B is assumed for all systems.
Demolition	Removal of all interior partitions, mechanical, electrical and plumbing systems. Removal of existing roof , penthouse walls and original IGUs.

Whole Life Carbon

For Scenario A, the whole life carbon profile is shaped by relatively modest embodied emissions paired with high operational impacts. At the end of practical completion for the retrofit, the upfront EC is associated with structural reinforcement, roof replacement, and new windows, while demolition is limited to interior partitions and outdated mechanical systems. Over the 60-year study period, additional embodied emissions arise incrementally from periodic maintenance and replacement, but these never outweigh the initial construction impact.

The main carbon impact is from the operational carbon emissions, which are modelled as per current emissions factor of 0.7 kgCO2e/kWh, as per “Emissions Factors and Reference Values” published by the Government of Canada in October 2025. Due to the current Nova Scotia grid being 60% based on fossil fuels, operational emissions intensity per year remains high despite updated systems and building electrification. The cumulative OC intensity over 60 years for the retrofit scenario is 5032 kgCO2e/m2, which makes up 96% of the cumulative WLC emissions intensity of 5,216 kgCO2e/m2.

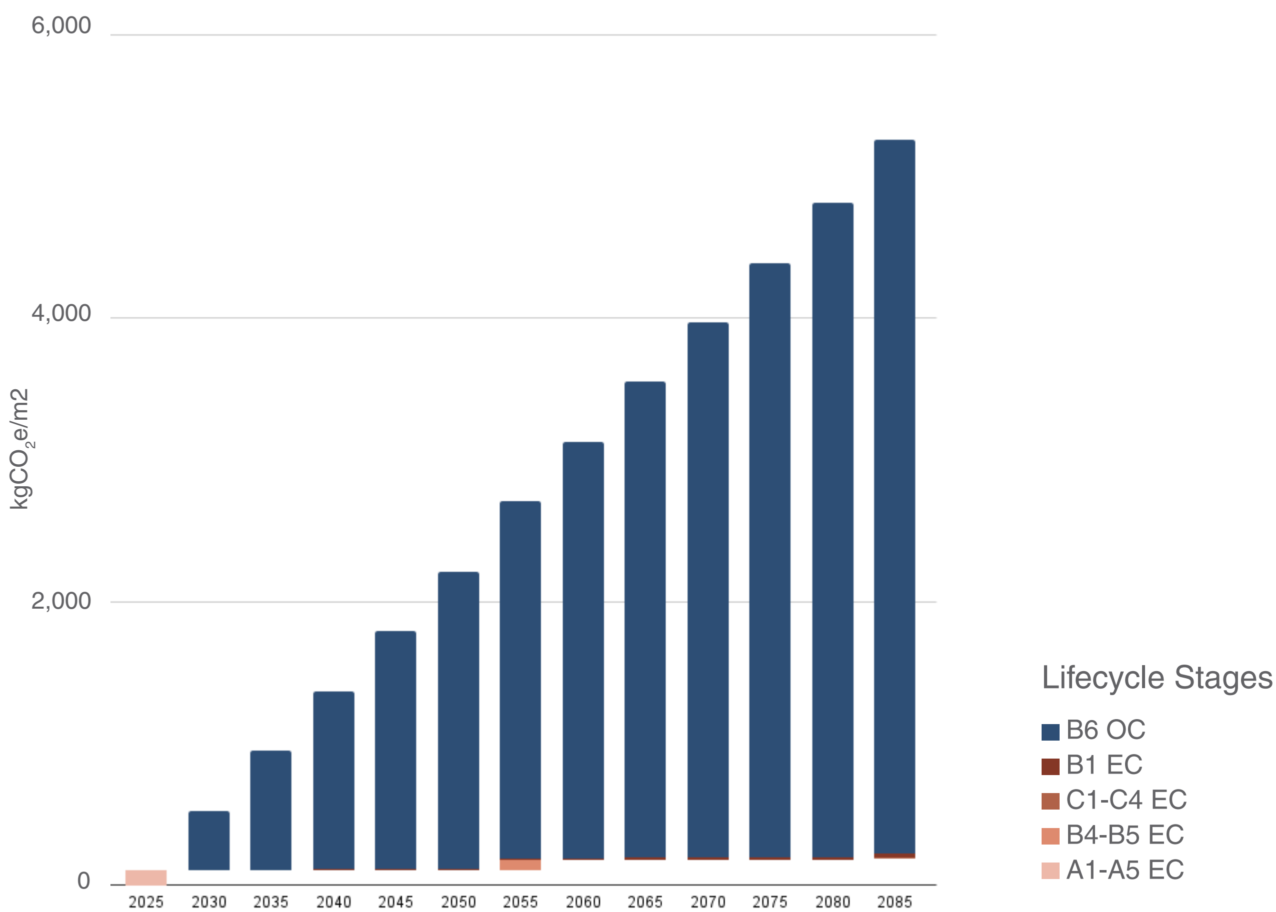


Figure 5.7. Whole Life Carbon graph for Halifax Scenario A. Reference Figure 3.1. for Lifecycle Stages.

Grid Decarbonization

It is important to consider how the balance between embodied and operational emissions is likely to change as the power grid decarbonizes. The province of Nova Scotia has a Clean Power Plan, which has a target of generating 80% of its power from renewable sources such as hydro, wind and solar by the year 2030. Another version of the whole life carbon emissions for Scenario A was modelled based on projected decrease in grid emission factors over the 60 year analysis period.

In this WLC model, the cumulative OC intensity over 60 years reduces dramatically from 5032 kgCO2e/m2 to 529 kgCO2e/m2. This brings down the whole life carbon intensity from 5,216 kgCO2e/m2 to 713 kgCO2/m2. The operational carbon impact is still dominant at 74% of total emissions, but embodied carbon occupies a significantly larger part of the emissions pie.

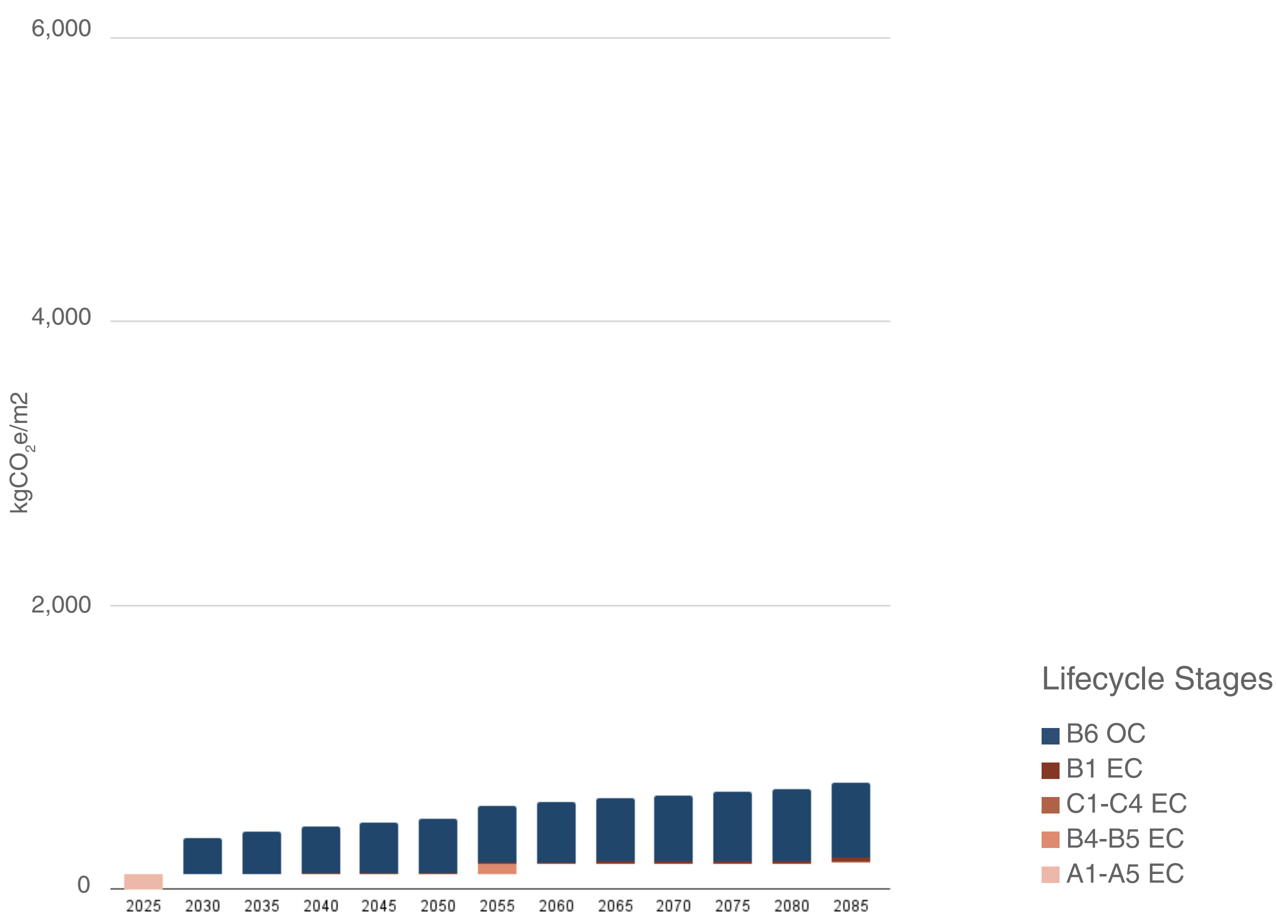


Figure 5.8. Whole Life Carbon graph for Scenario A if the grid in Halifax was decarbonized.

Embodied Carbon Intensity by Component

In the Retrofit, interiors were the most extensively replaced, and concurrently make up 50% of embodied carbon emissions. New mechanical systems and building envelope replacements have the next highest impacts on the retrofit embodied carbon. Both demolition and structure have a low impact, given that almost the entire existing structure was retained and reused.

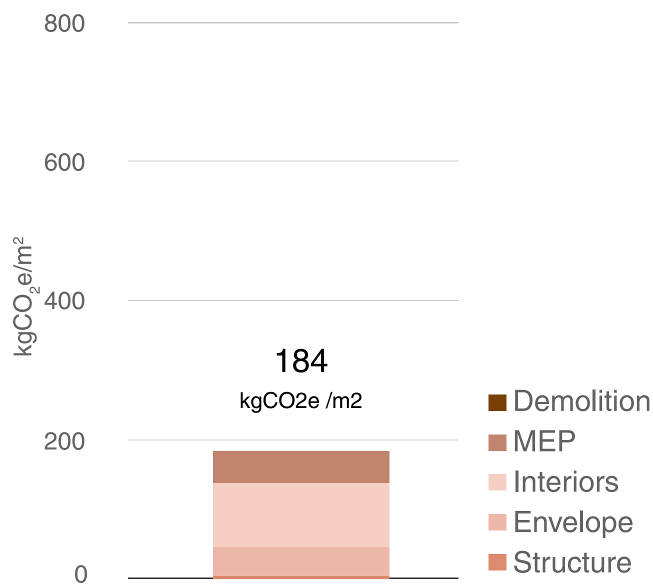


Figure 5.9. Embodied Carbon Intensity by Component for Halifax Scenario A.

Operational Energy Use Breakdown

The total energy use for the retrofitted building is 1,926 mWh/year which correlates to an annual operation carbon emission of 1,348,095 kgCO2e/year and an OC intensity of 84 kgCO2e/m2.year. This is a result of the current grid being heavily reliant on fossil fuels. Space heating is the highest contributor, followed by the domestic hot water system

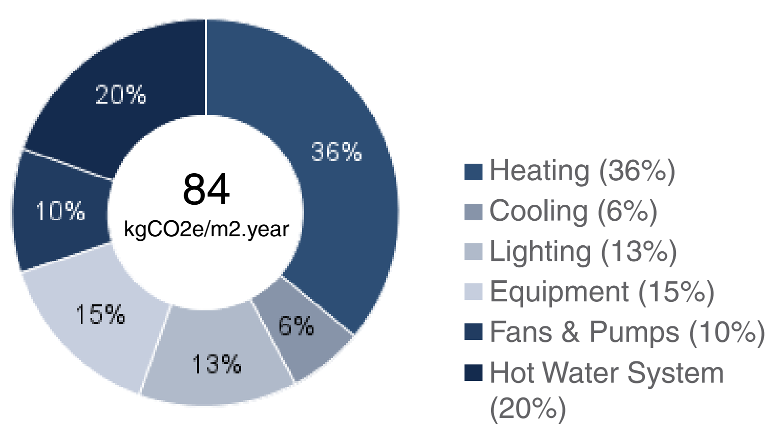


Figure 5.10. Operational Energy Use Breakdown for Halifax Scenario A.

Upfront Cost of Construction

Costs are concentrated in interiors and MEP systems which were entirely replaced, followed by costs associated with envelope upgrades. These costs mirror the same categories that drive embodied carbon. Costs associated with structure and demolition are comparatively small. Contingencies and markups make up 34% of the total rate of construction cost which is $5,111 CAD/m2 for Scenario A

Operational Cost Over 60 Years

The total cost of operations over a 60-year period for Scenario A is $17,513 CAD/m2 for Scenario A. Costs associated with replacing parts of the building envelope, interiors and systems that will occur periodically make up 72% of the total. Costs associated with regular maintenance, servicing and repairs make up 11% of the operational cost, and the remaining 17% comprises inflation over 60 years. Operational carbon costs are minimal in comparison.

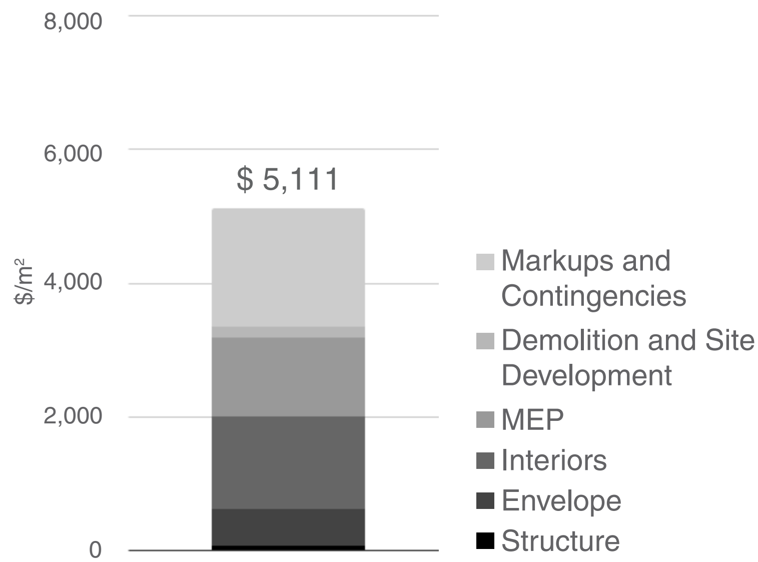


Figure 5.11. Rate of Upfront Construction Cost for Halifax Scenario A.

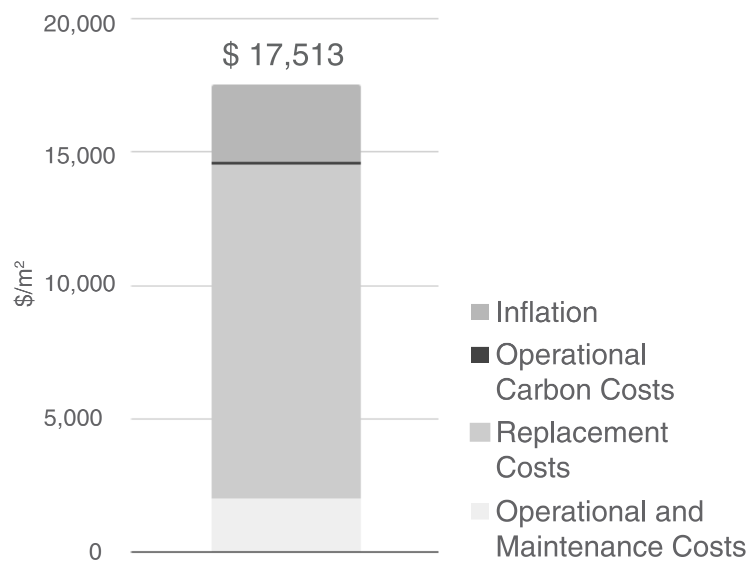


Figure 5.12. Operational Cost Over 60 Years for Halifax Scenario A.

Scenario B:

Retrofit and Addition

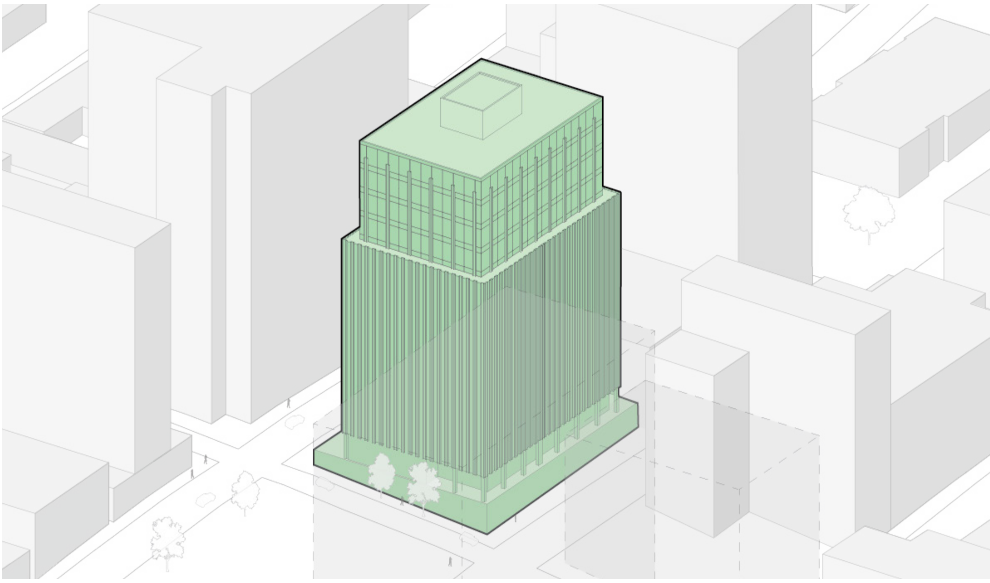


Figure 5.13. Halifax Scenario B shown in context.

The scope of the retrofit and addition included the following major interventions, summarized per building component.

Structure	The existing building comprises reinforced concrete foundations, columns, slabs and cores. In the retrofit all existing structure, including elevator and stair cores are retained. Four storey addition with steel framing, metal deck with concrete topped slabs, and extension of concrete cores.
Envelope	The existing building's precast concrete siding,insulation, air and vapour barriers and steel stud wall framing are all retained. Original IGU units are replaced by double glazed IGUs with thermally broken aluminium frames. Roof replaced, with 2-ply modified bitumen and additional insulation. A four storey addition is clad in aluminium framed curtain wall. Walls: RSI = 1.5, Roofs: RSI = 3.4, Fenestration: RSI =0.2, Curtainwall: RSI = 0.4. (All RSI values are "effective") Air Leakage Rate: 2.5 L/s/m2 @ 75 Pa.
Interiors	All existing interiors were replaced. Full interior retrofit, with new partition walls to accommodate residential floor layout. Exposed concrete ceiling and floor finishes.
Mechanical and Electrical	All existing systems were replaced. New central air source heat pump and cooling tower connected to water source heat pumps and ERVs in suite, with electric boilers for back up heating. All new electrical feeders, panels and fixtures. Low GWP refrigerant R454B is assumed for all systems.
Demolition	Concrete slab removal in upper floors in order to build additional structure.,Removal of all interior partitions, mechanical, electrical and plumbing systems. Removal of existing roof , penthouse walls and original IGUs.

Whole Life Carbon

For Scenario B, the whole life carbon profile is shaped by low embodied emissions paired with high operational impacts. At the end of practical completion for the retrofit and addition project, the upfront EC is 137 kgCO2e/m2 associated with structural reinforcement, roof replacement, and new windows, and addition of steel structure and curtainwall. Over the 60-year study period, additional embodied emissions arise incrementally from periodic maintenance and replacement, but these never outweigh the initial construction impact.

The main carbon impact is from the operational carbon emissions, which are modelled as per current emissions factor of 0.7 kgCO2e/kWh, as per "Emissions Factors and Reference Values" published by the Government of Canada in October 2025. Due to the current Nova Scotia grid being 60% based on fossil fuels, operational emissions intensity per year remains high despite updated systems and building electrification. The cumulative OC intensity over 60 years for the retrofit scenario is 4,342 kgCO2e/m2, which makes up 93% of the cumulative WLC emissions intensity, which is at 4,648 kgCO2e/m2.

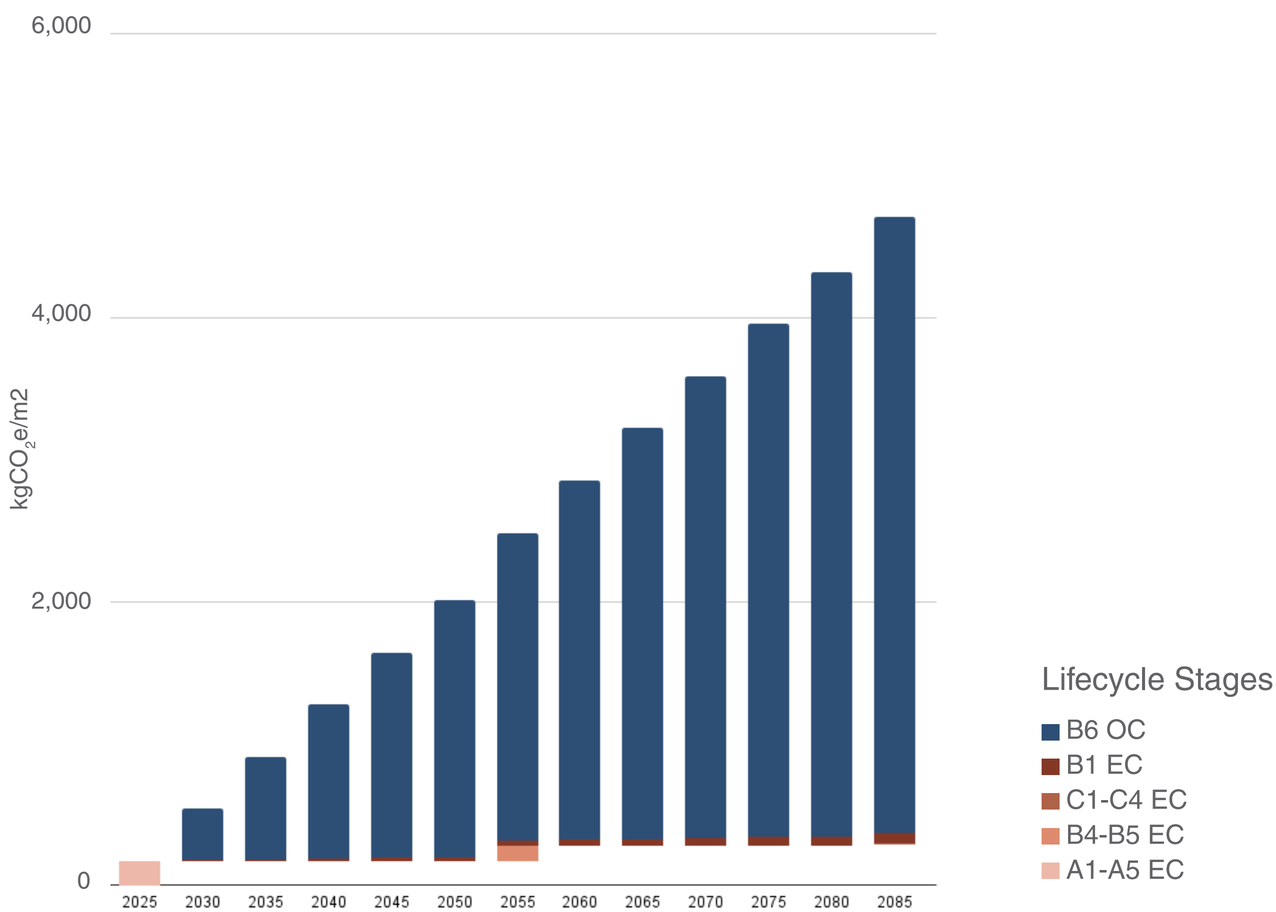


Figure 5.14. Whole Life Carbon graph for Halifax Scenario B. Refer to Figure 3.1. for Lifecycle Stages.

Grid Decarbonization

It is important to consider how the balance between embodied and operational emissions is likely to change as the power grid decarbonizes. The province of Nova Scotia has a Clean Power Plan, which has a target of generating 80% of its power from renewable sources such as hydro, wind and solar by the year 2030. Another version of the whole life carbon emissions for Scenario B was modelled based on projected decrease in grid emission factors over the 60 year analysis period.

In this WLC model, the cumulative OC intensity over 60 years reduces dramatically from 4,342 kgCO2e/m2 to 456 kgCO2e/m2. This brings down the whole life carbon intensity from 4,648 kgCO2e/m2 to 762 kgCO2/m2. The operational carbon impact is still dominant at 60% of total emissions, but embodied carbon occupies a significantly larger part of the emissions pie.

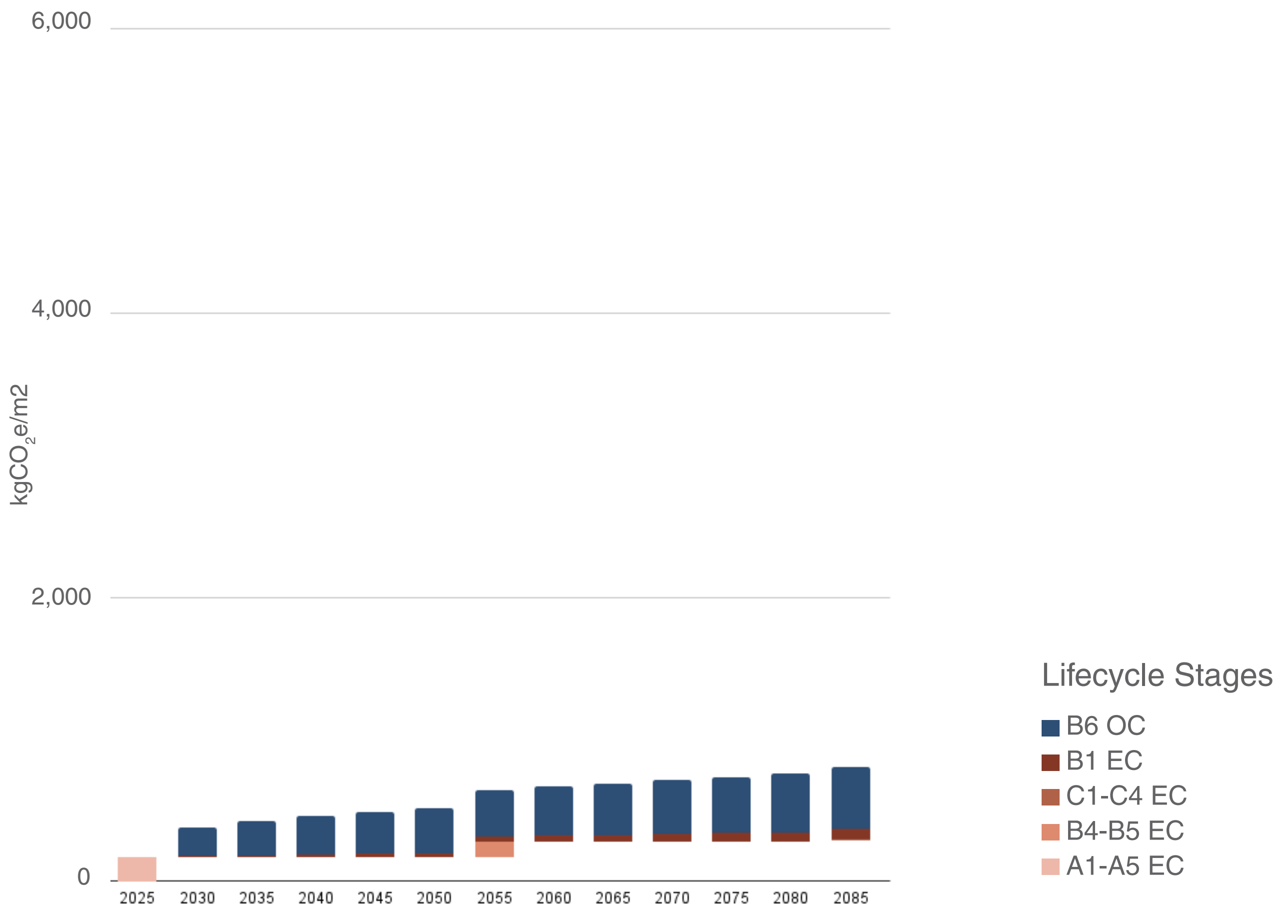


Figure 5.15. Whole Life Carbon graph for Scenario B if the grid in Halifax was decarbonized.

Embodied Carbon Intensity by Component

In the retrofit and addition scenario, mechanical systems were updated to be more efficient than the systems used in Scenario A, and have the highest impact on embodied carbon at 40%. New interiors and additions and upgrades to building envelope have the next highest impacts on embodied carbon intensity. Limited demolition and the addition of steel superstructure for the additional floors add up to the remaining 10% of EC.

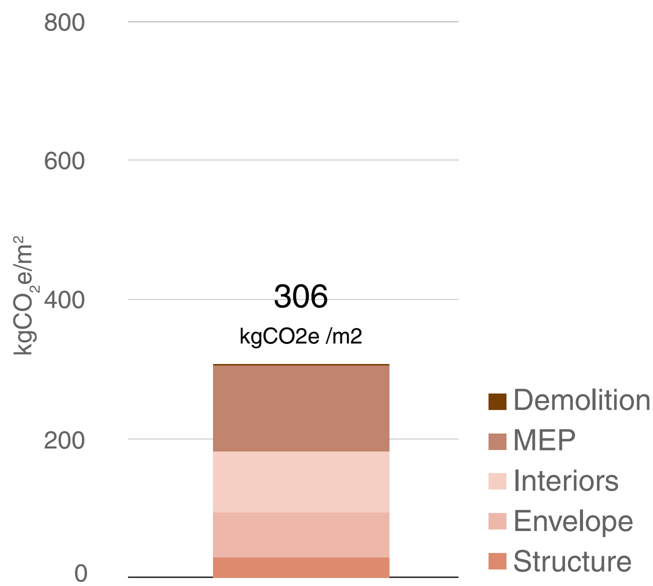


Figure 5.16. Embodied Carbon Intensity by Component for Halifax Scenario B.

Operational Energy Use Breakdown

The total energy use for the retrofitted building is 2,058 mWh/year which correlates to an annual operational carbon emission of 1,441,236 kgCO2e/year and an OC intensity of 72 kgCO2e/m2.year. On a per m2 basis the retrofit and addition scenario performs better than the retrofit modelled in Scenario A. Space heating is the highest contributor, followed by the domestic hot water system, equipment loads and lighting.

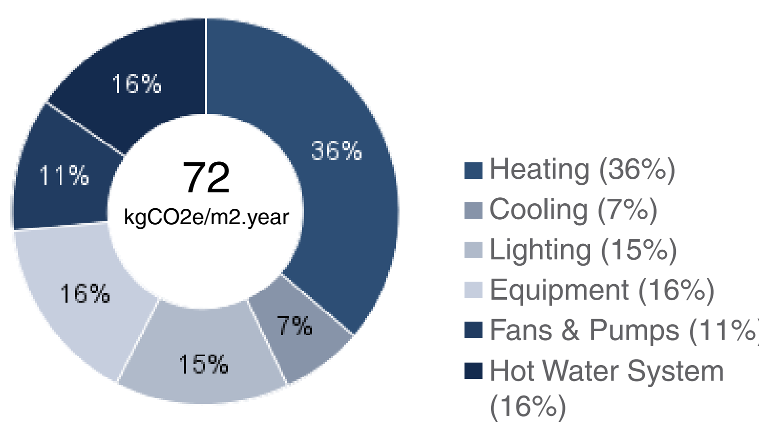


Figure 5.17. Operational Energy Use Breakdown for Halifax Scenario B.

Upfront Cost of Construction

Costs are concentrated in interiors and MEP systems which were entirely replaced, followed by costs associated with envelope upgrades. These costs mirror the same categories that drive embodied carbon. Costs associated with structure and demolition are higher than Scenario A, but still the smallest contributors. Contingencies and markups make up 32% of the total rate of construction cost, which is $5,809 CAD/m2 for Scenario B.

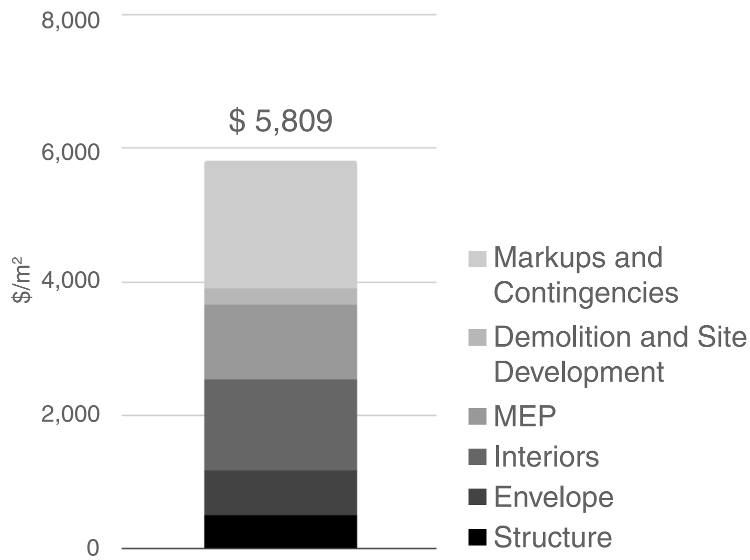


Figure 5.18. Rate of Upfront Construction Cost of Halifax Scenario B.

Operational Carbon Cost Over 60 Years

The total cost of operations over a 60-year period for Scenario B is $16,428 CAD/ m2, the lowest of the three scenarios. Costs associated with replacing parts of the building envelope, interiors and systems that will occur periodically make up 73% of the total. Costs associated with regular maintenance, servicing and repairs make up 10% of the operational cost, and the remaining 17% comprises inflation over 60 years. Operational carbon costs are minimal in comparison.

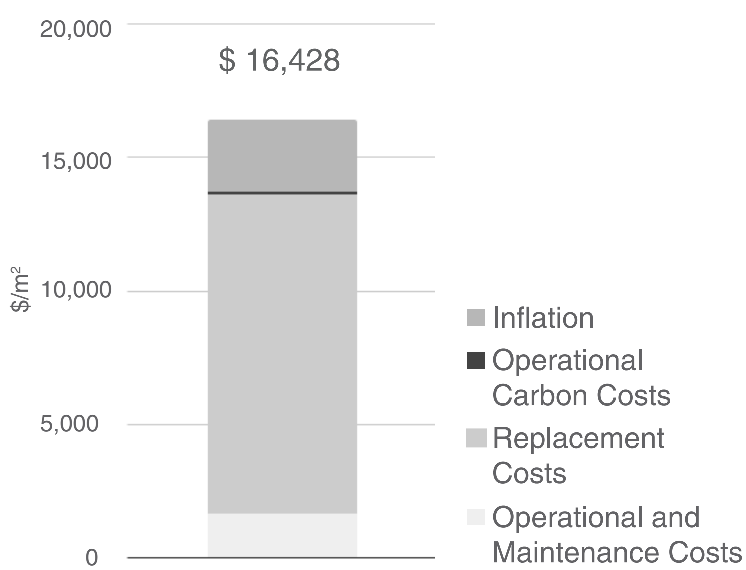


Figure 5.19. Operational Cost Over 60 Years of Halifax Scenario B.

Scenario C:

Demolish and Replace

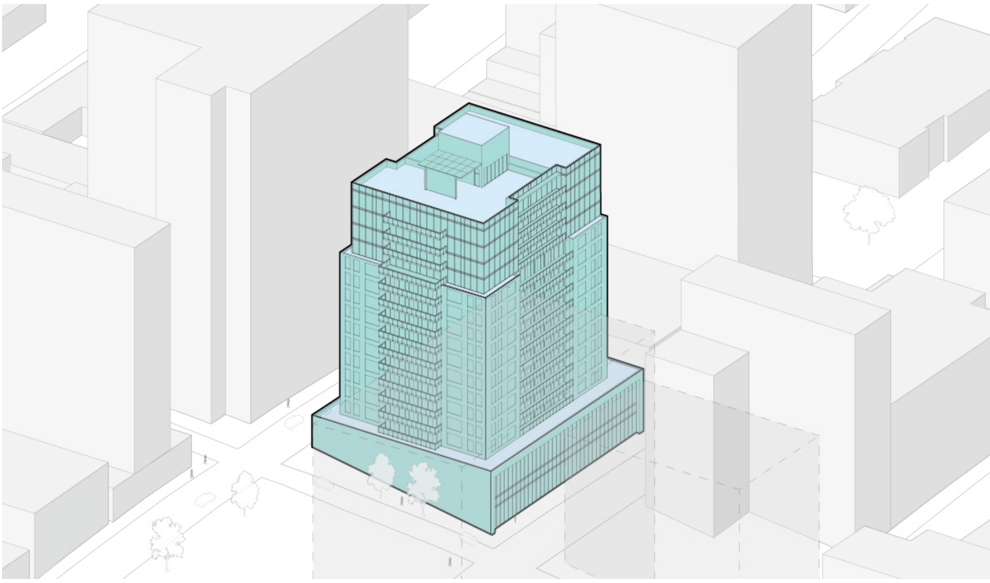


Figure 5.20. Halifax Scenario A shown in context.

The construction scope is summarized per building component.

Structure	The existing building consisting of reinforced concrete foundations, columns, slabs and cores, is demolished in its entirety and replaced with a new concrete frame building, with 3 levels of underground parking sitting atop concrete footings. Concrete flat slab floors and concrete cores for stairs and elevators. Transfer slab assumed at level 2 to transition between residential and ground floor commercial.
Envelope	The existing building's precast concrete siding,insulation, air and vapour barriers and steel stud wall framing are demolished. New building's exterior opaque walls are aluminium cladding,mineral wool insulation and gypsum sheathing on steel stud. Window wall with double glazed IGUs and thermally broken aluminium frames. New built up flat roof with 2-ply modified bitumen and additional insulation. Walls: RSI = 1.0, Roofs: RSI = 3.2, Fenestration: RSI = 0.4. (All RSI values are "effective") Air Leakage Rate: 1.5 L/s/m2
Interiors	All existing interior partitions and finishes are demolished. New GWB and steel stud partition walls and all new interior finishes including paint, tile, and engineered wood flooring.
Mechanical and Electrical	All existing systems were replaced. New central air source heat pump and cooling tower connected to water source heat pumps and ERVs in suite, with electric boilers for back up heating. All new electrical feeders, panels and fixtures. Low GWP refrigerant R454B is assumed for all systems
Demolition	Complete demolition of existing building before commencing new construction.

Whole Life Carbon

For Scenario C, the whole life carbon profile is still shaped by high operational impacts, but there is a significant spike in upfront EC emissions due to complete demolition and construction of a new 16 storey concrete frame building with 3 levels of underground parking. At the end of practical completion for the new build project, the upfront EC is 455 kgCO2e/m2. The bulk of these emissions lie in the new concrete structure, followed by mechanical systems, building envelope and interiors. Over the 60-year study period, additional embodied emissions arise incrementally from periodic maintenance and replacement.

The main carbon impact is from the operational carbon emissions, which are modelled as per current emissions factor of 0.7 kgCO2e/kWh,as per “Emissions Factors and Reference Values” published by the Government of Canada in October 2025. Due to the current Nova Scotia grid being 60% based on fossil fuels, operational emissions intensity per year remains high despite updated systems and building electrification. The cumulative OC intensity over 60 years for the demolish and replace scenario is 4,110 kgCO2e/m2, which makes up 85% of the cumulative WLC emissions intensity, which is at 4,814 kgCO2e/m2.

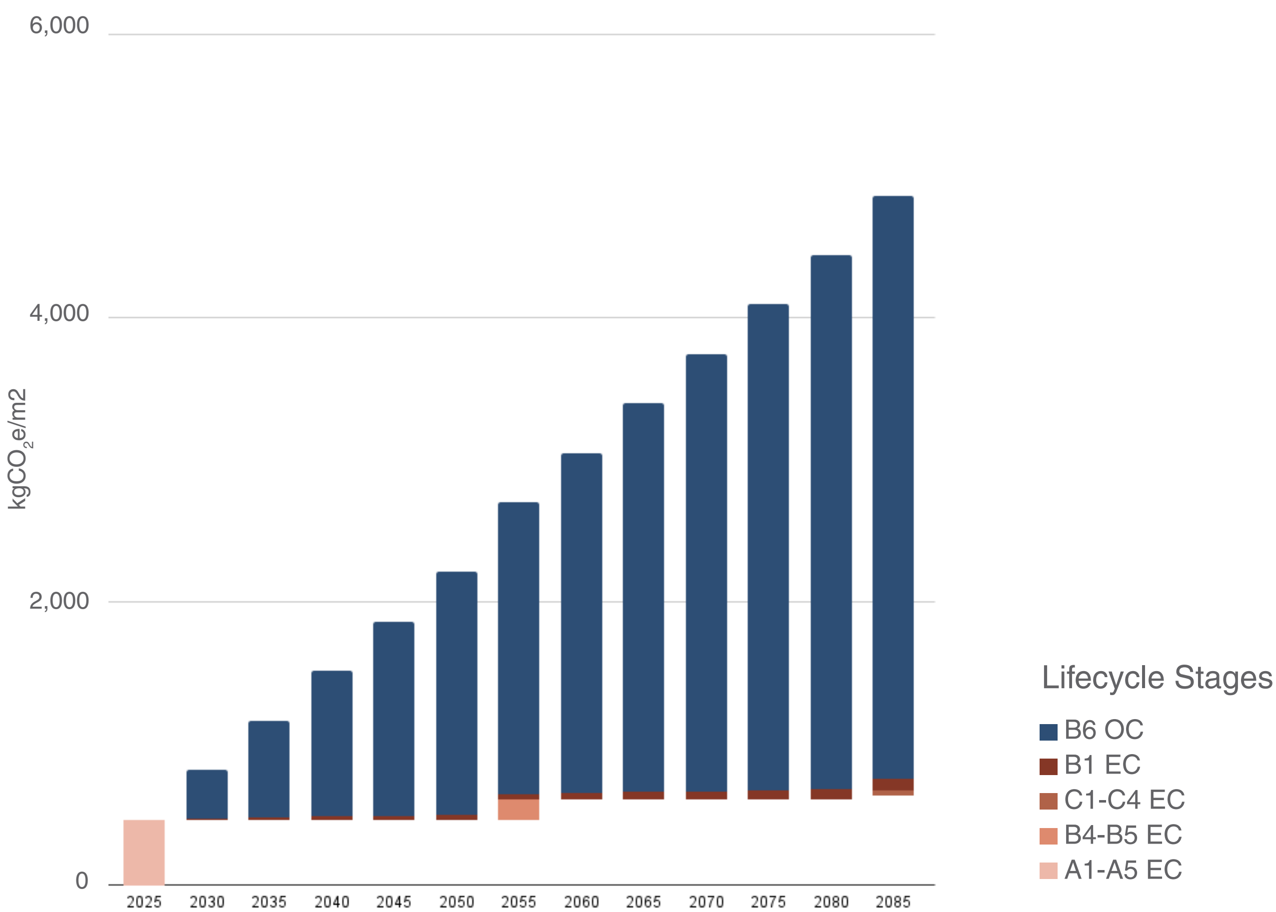


Figure 5.21. Whole Life Carbon graph for Halifax Scenario C. Refer to Figure 3.1. for Lifecycle Stages.

Grid Decarbonization

In the Demolish and Replace Scenario, it becomes crucial to consider grid decarbonization and the impact it has on shifting the balance of emissions to embodied carbon. The province of Nova Scotia has a Clean Power Plan, which has a target of generating 80% of its power from renewable sources such as hydro, wind and solar by the year 2030. Another version of the whole life carbon emissions for Scenario C was modelled based on projected decrease in grid emission factors over the 60 year analysis period.

In this WLC model, the cumulative OC intensity over 60 years reduces dramatically from 4,110 kgCO2e/m2 to 432 kgCO2e/m2. This brings down the whole life carbon intensity from 4,814 kgCO2e/m2 to 1136 kgCO2/m2. The embodied carbon impact is dominant in this scenario, accounting for 62% of the total whole life carbon emissions over 60 years.

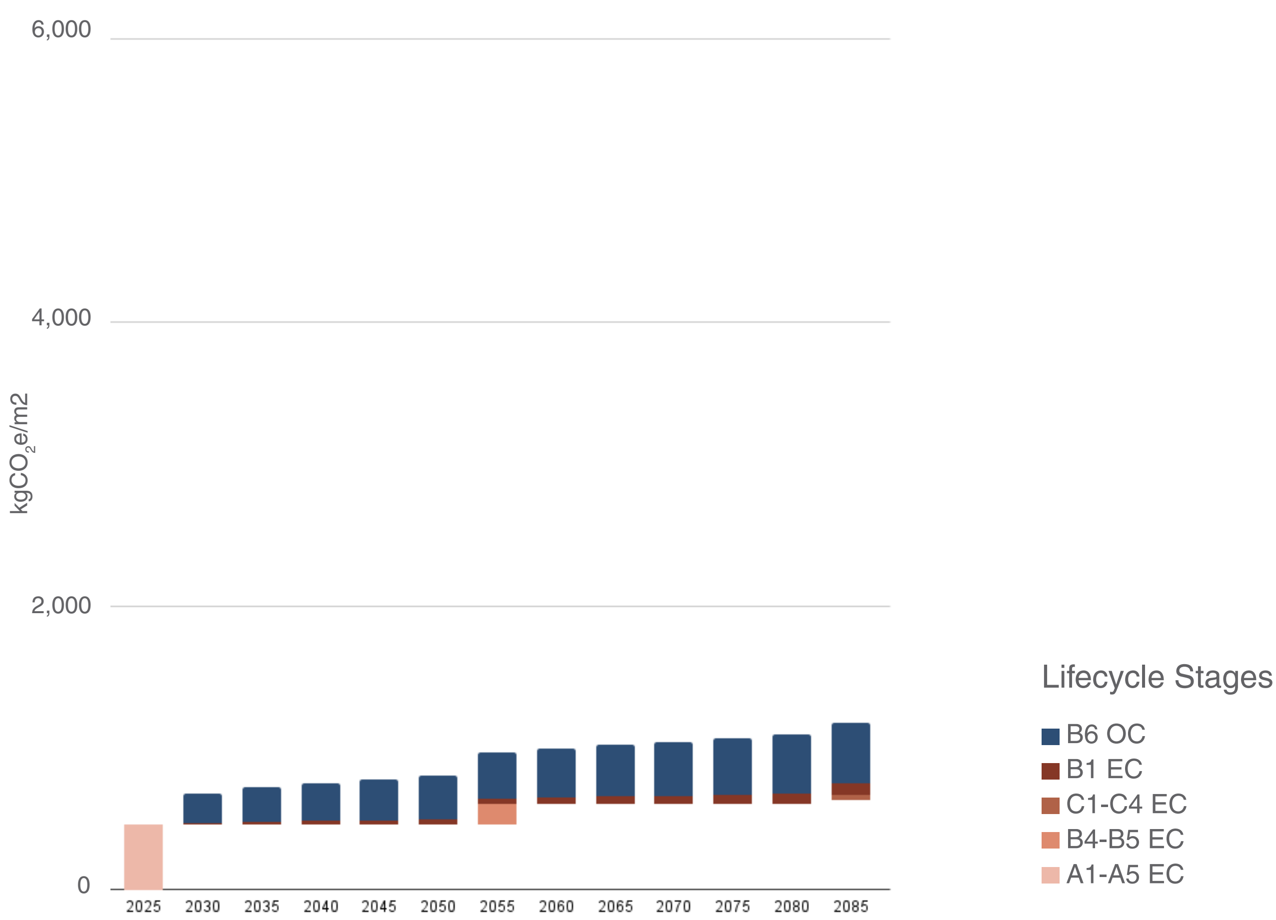


Figure 5.22. Whole Life Carbon graph for Halifax Scenario C if the grid in Halifax was decarbonized.

Embodied Carbon Intensity by Component

The A-C embodied carbon intensity for Scenario C is 704 kgCO2e/m2 – this includes EC impacts from demolition of the existing building, new construction, projected repair and replacements and end of life. The new structure makes up 43% of the EC emissions,followed by mechanical systems and building envelope. Proportionally, in the new construction interiors make up just 13%, in spite of more frequent maintenance and replacement cycles. This analysis clearly shows how impactful it is to reuse and retrofit existing structures as was done in Scenarios A and B as a means of reducing EC impact.

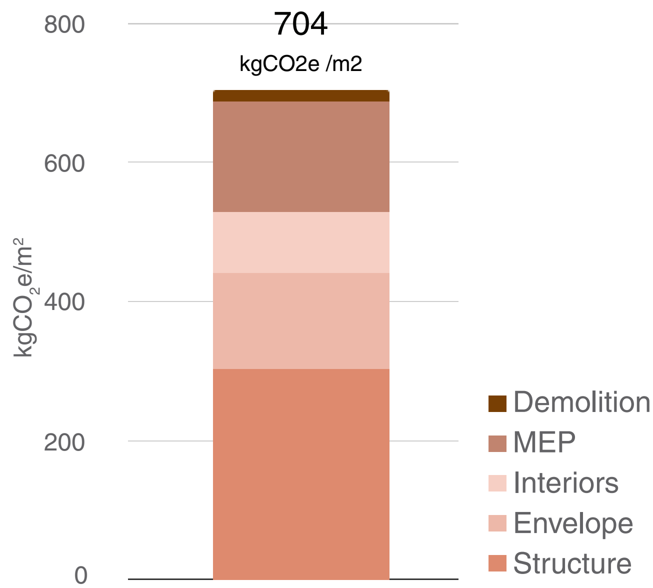


Figure 5.23. Embodied Carbon Intensity by Component for Halifax Scenario C..

Operational Energy Use Breakdown

The total energy use for the new building is 1,602 mWh/year which correlates to an annual operational carbon emission of 1,121,357 kgCO2e/year and an OC intensity of 69 kgCO2e/m2.year. Operationally the new building is the most efficient. The impact of space heating is reduced to 22%. Equipment loads and domestic hot water systems, and lighting are the next highest contributors to energy use.

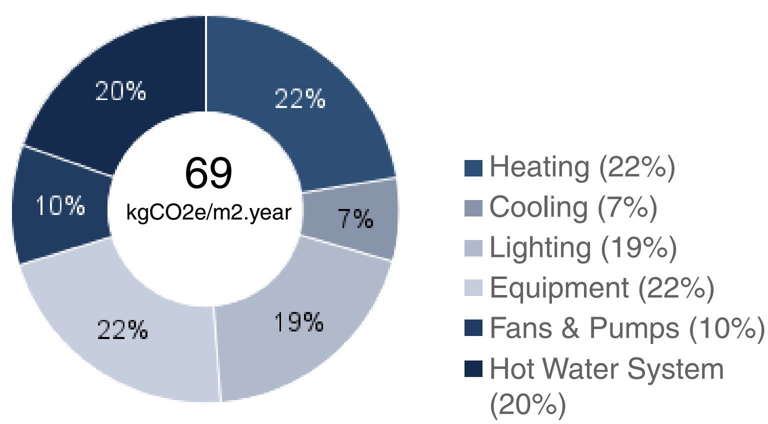


Figure 5.24. Operational Energy Use Breakdown for Halifax Scenario C.

Upfront Cost of Construction

The demolish and replace scenario has the highest upfront cost of construction per square meter of rentable area, as compared to the two retrofit scenarios. High impact categories for cost of construction are building interiors followed by structure and MEP systems. The cost of demolition, excavation and site development is also significantly higher in this scenario than the retrofit scenarios. Contingencies and markups make up 31% of the upfront construction cost, which is $7,607 CAD/m2 for Scenario C.

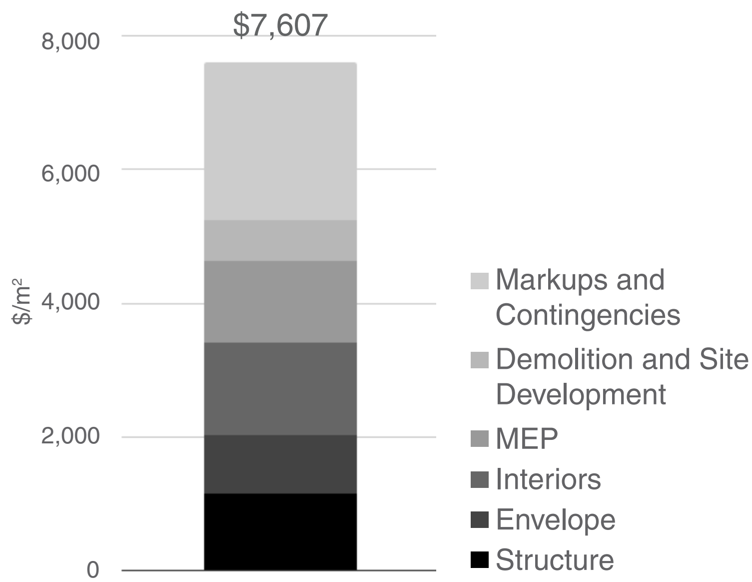


Figure 5.25. Rate of Upfront Construction Cost for Halifax Scenario C.

Operational Costs Over 60 Years

The total cost of operations over a 60-year period for Scenario C is $16,752 CAD/m2. Costs associated with replacing parts of the building envelope, interiors and systems that will occur periodically make up 72% of the total. Costs associated with regular maintenance, servicing and repairs make up 11% of the operational cost, and the remaining 17% comprises inflation over 60 years. Operational carbon costs are minimal in comparison.

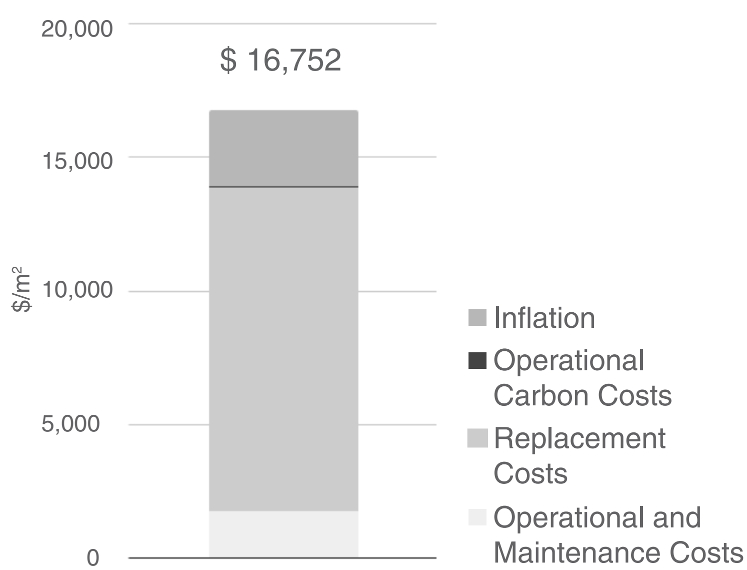


Figure 5.26. Operational Cost Over 60 Years for Halifax Scenario C.

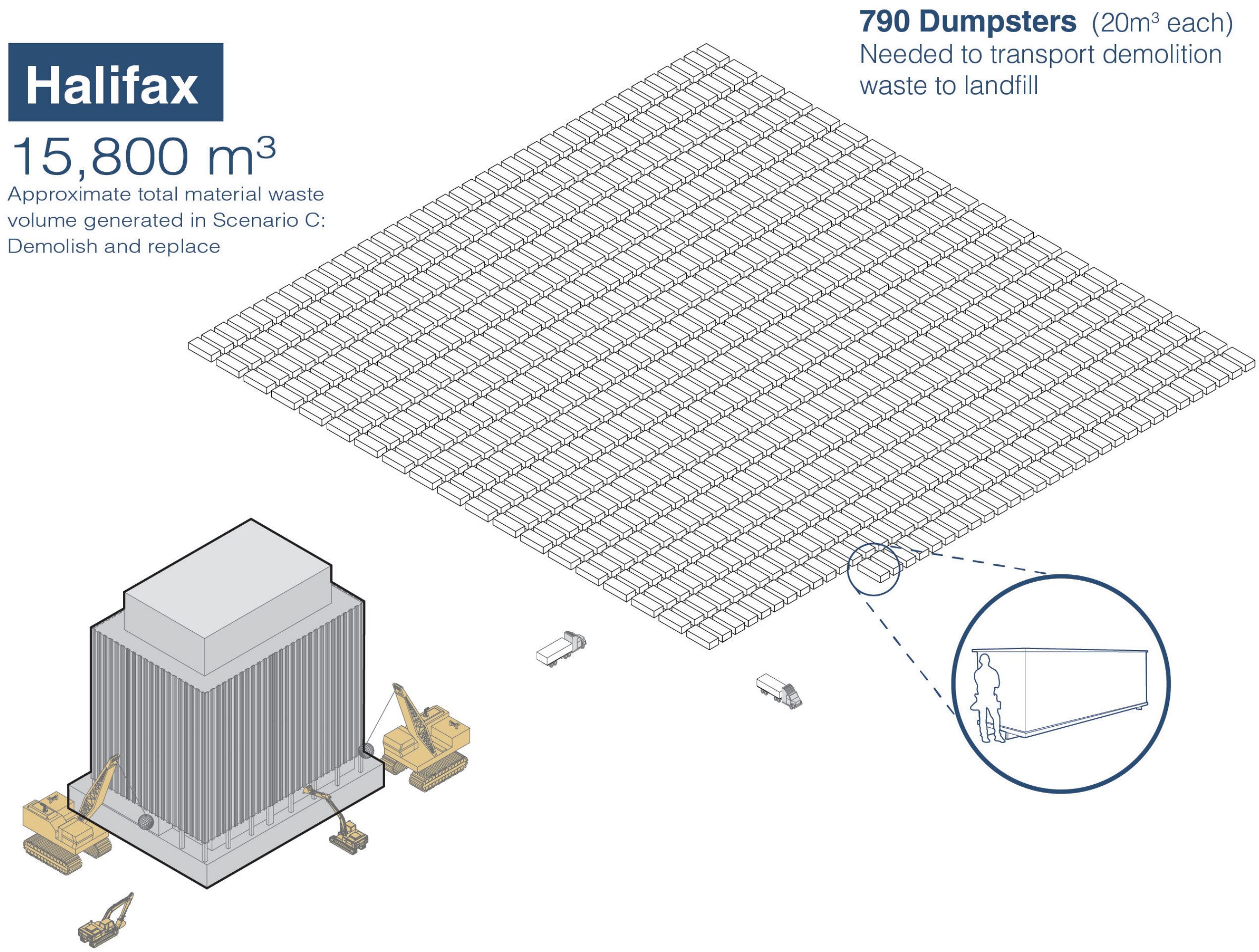


Figure 5.27. Demolishing the Halifax office building will generate roughly 15,800 m^3 of waste, enough to fill about 790 dumpsters (20 m^3 each) to be sent to a landfill.

5.2 Case Study 2 | Montréal

Address	7250 rue Marconi, Montreal
Owner	Group Montoni
Date of Construction	C. 1945
Original Use	Textile Factory
Adaptive Reuse	Office
Architect	paralem architecture

Project Context

Originally built as a two-storey industrial building around 1945, Édifice Marconi was converted to a multi-unit office building in 2014 with the addition of a third floor and roof terrace.

Figure 5.28. Montréal industrial building converted to office use with a third floor addition.

Credit: Groupe Montoni, 7250 Marconi (groupemontoni.com)

Scenario A:
Retrofit

Scenario B:
Retrofit and Addition

Scenario C:
Demolish and Replace

As Built: Scenario B, Retrofit and Addition

Working with an unfinished industrial space, the retrofit focused on meeting egress requirements and adding partitions and sanitary cores appropriate for open-plan offices. The third-floor addition is a self-contained office suite with a small terrace. Building on top of the existing brick envelope and hybrid timber-steel frame, the addition is framed in steel and clad in opaque metal walls with curtain wall glazing.

Overview of Results

Québec's electricity grid is over 99 percent hydroelectric, making it one of the cleanest in North America. For Édifice Marconi, this greatly reduces operational emissions from heating, cooling, and lighting, shifting the long-term climate impact toward embodied carbon in construction materials. The "Do Nothing" Scenario, however, assumes the building continues to operate on its original natural gas system, which results in significantly higher operational emissions than if it were electrified on the Québec grid.

In the "Do Nothing" Scenario, the existing textile factory locks in very high operational intensity at 919 kgCO2e/m² over 60 years, or more than 135 tCO2e in total. This option carries only a small amount of embodied impact, limited to repair and replacement activities during the use phase and future end-of-life emissions. With no upfront cost, it avoids new construction impacts but results in the poorest climate outcome overall.

Retrofitting the existing structure cuts operational emissions to only 14 kgCO2e/ m², while embodied carbon rises to 233 kgCO2e/ m² from construction interventions. At $5,380 per square metre (about $47 million total), this approach halves whole life carbon compared to doing nothing, with moderate costs.

Adding an addition provides more usable space with similarly low operational emissions (13 kgCO2e/m²), but embodied carbon increases to 275 kgCO2e/m² and costs rise to $5,953 per square metre ($77 million). This shows how additional area brings higher carbon and financial burdens, even with efficient performance.

Demolition and replacement delivers the lowest operational emissions at only 9 kgCO2e/m², but at enormous upfront cost and life cycle carbon. Embodied emissions reach 654 kgCO2e/m², and costs escalate to $6,924 per square metre ($149 million). On a per square metre basis, this is both the most carbon intensive and most expensive option, effectively negating the advantage of Québec's clean electricity.

Overall, the scenarios illustrate that operational efficiency alone is not enough in a hydro-powered context. Retrofitting,while adding density to the site, achieves the strongest balance of low life cycle carbon and reasonable cost, while new construction performs worst on both metrics per square metre.

Note: For more information on the assumptions and methodology behind the data in this chapter, see Appendix B - Costing Reports, Appendix C - Engineering Reports, and Appendix D - Energy Modeling Reports.

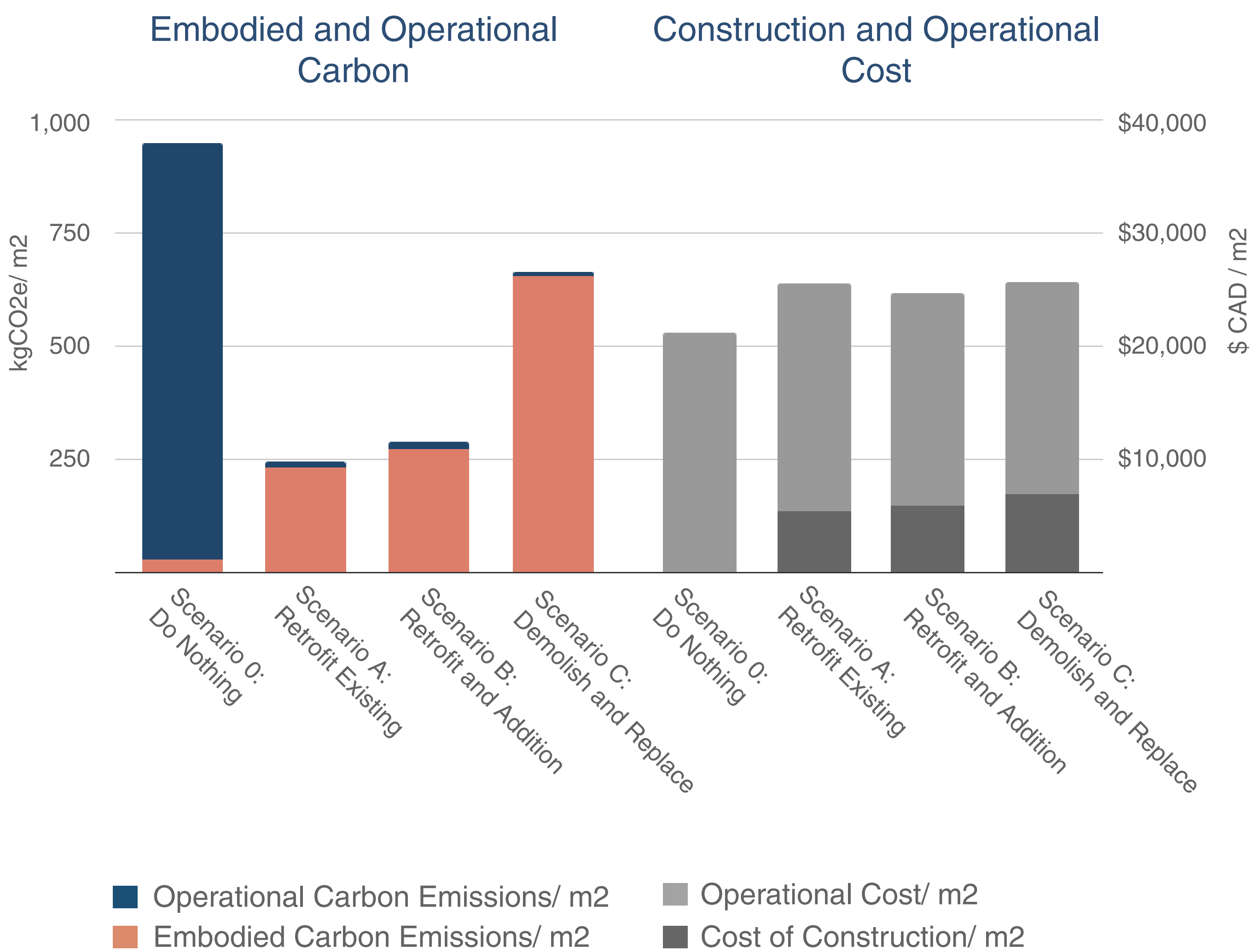
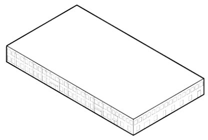
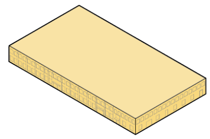
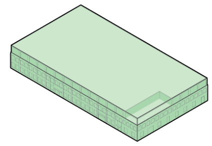
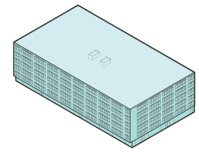


Figure 5.29. Cost of Construction and Operational Cost in comparison to Operational and Embodied Carbon Emissions. All values are expressed per square metre of gross floor area.

	Scenario 0: Do Nothing	Scenario A: Retrofit Existing	Scenario B: Retrofit and Addition (As Built)	Scenario C: Demolish and Replace
				
Primary Use	Textile Factory	Multi Unit Office	Multi Unit Office	Multi Unit Office
Gross Floor Area (m^2)	8,800 m2	8,800 m2	12,930 m2	21, 573 m2
Subgrade Parking	None	None	None	1 Level
Above Grade Storeys	2	2	3	6
Window to Wall Ratio	32%	32%	35%	54%
WLC Emissions (tCO^2e)	8,090	2,171	3,719	14,299
WLC Intensity ($kgCO_2e/m^2$)	949	247	288	663
EC Intensity ($kgCO_2e/m^2$)	30	233	275	654
OC Intensity ($kgCO_2e/m^2$)	919	14	13	9
Total Construction Cost (CAD $)	$0	$47,340,000	$76,664,000	$149,368,000
Construction Cost Rate (CAD $/ m^2)	$0	$5,380	$5,929	$6,924
Total Operational Cost* (CAD $)	$186,411,551	$177,190,000	$241,870,000	$405,946,000
Operational Cost Rate (CAD $/m2)	$21,183	$20,135	$18,706	$18,817

*Total Operational Cost: Initial hard construction based on Q4 2025 + Operational Carbon Costs over 60 Year Ownership.

Figure 5.30. Overview of results across all Montréal Scenarios.

Scenario A:

Retrofit Existing

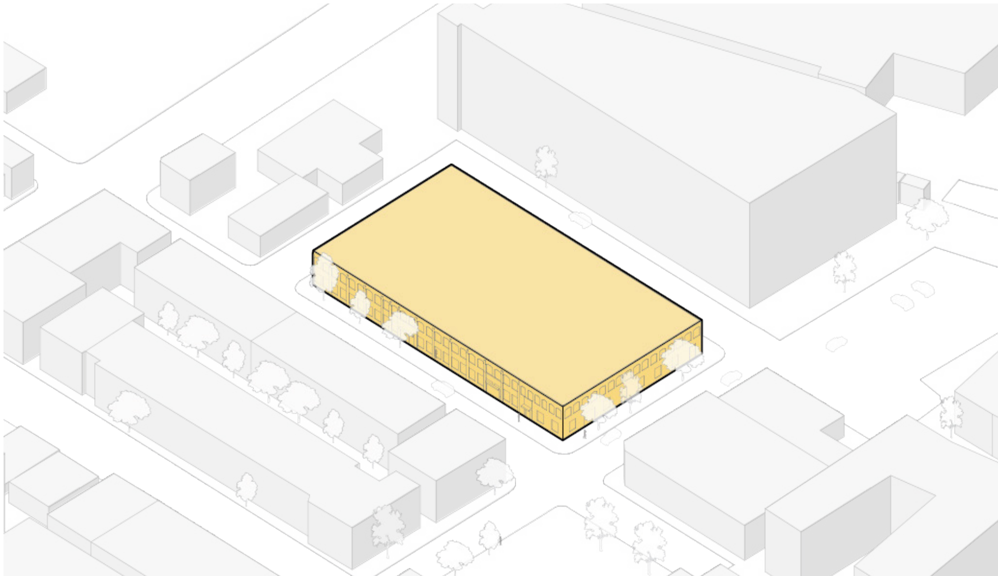


Figure 5.31. Montréal Scenario A shown in context.

The scope of the retrofit included the following major interventions, summarized per building component.

Structure	The existing building comprises reinforced concrete foundations and a 2 storey brick structure with steel framing and nail laminated timber floors .In the retrofit all existing structure is retained, and mortar is repointed. The old elevator shaft is demolished and replaced with new elevator and stair cores.
Envelope	The existing building's multi-wythe brick facade is retained. Original single pane windows are replaced by double glazed IGUs with thermally broken aluminium frames. Roof replaced, with TPO (thermoplastic polyolefin) membrane and additional insulation, on metal deck. Walls: RSI = 0.9, Roofs: RSI = 2.8, Fenestration: RSI = 2.3. (All RSI values are "effective") Air Leakage Rate: 3.0 L/s/m2 @ 75 Pa
Interiors	All existing interior partitions and finishes were demolished. Full interior retrofit with improved street level access. Exposed concrete columns and ceilings, raised access flooring, painted partitions and tiled washrooms.
Mechanical and Electrical	All existing systems were replaced. Rooftop units for air source heat pumps connected to ducted supply air in the building. ERV added to RTUs for preheating fresh air. Electric baseboard backup heating. All new electrical feeders, panels and fixtures. Low GWP refrigerant R454B is assumed for all systems.
Demolition	Removal of all interior partitions, mechanical, electrical and plumbing systems. Demolition of existing elevator cores and smokestack.

Whole Life Carbon

For Scenario A, the whole life carbon profile is shaped by relatively modest embodied emissions paired with very low operational impacts. Upfront embodied carbon is primarily associated with structural reinforcement, roof replacement, and new windows, while demolition is limited to interior partitions and outdated mechanical systems. Over the 60-year study period, additional embodied emissions arise incrementally from periodic maintenance and replacement, but these never outweigh the initial construction impact.

As per "Emissions Factors and Reference Values" published by the Government of Canada in October 2025, the current grid emissions factor in Montreal is minimal at 0.0017 $kgCO_2e/kWh$. Because the building is electrified and connected to Québec's hydro grid, operational emissions remain minimal at just 14 $kgCO_2e/m^2$, or less than 2 tCO_2e total. This represents a dramatic reduction compared to the "Do Nothing" Scenario, in which the building continues to rely on natural gas. Overall, Scenario A achieves a balanced profile: it avoids the massive upfront embodied carbon of new construction while still delivering substantial operational savings through electrification and selective upgrades.

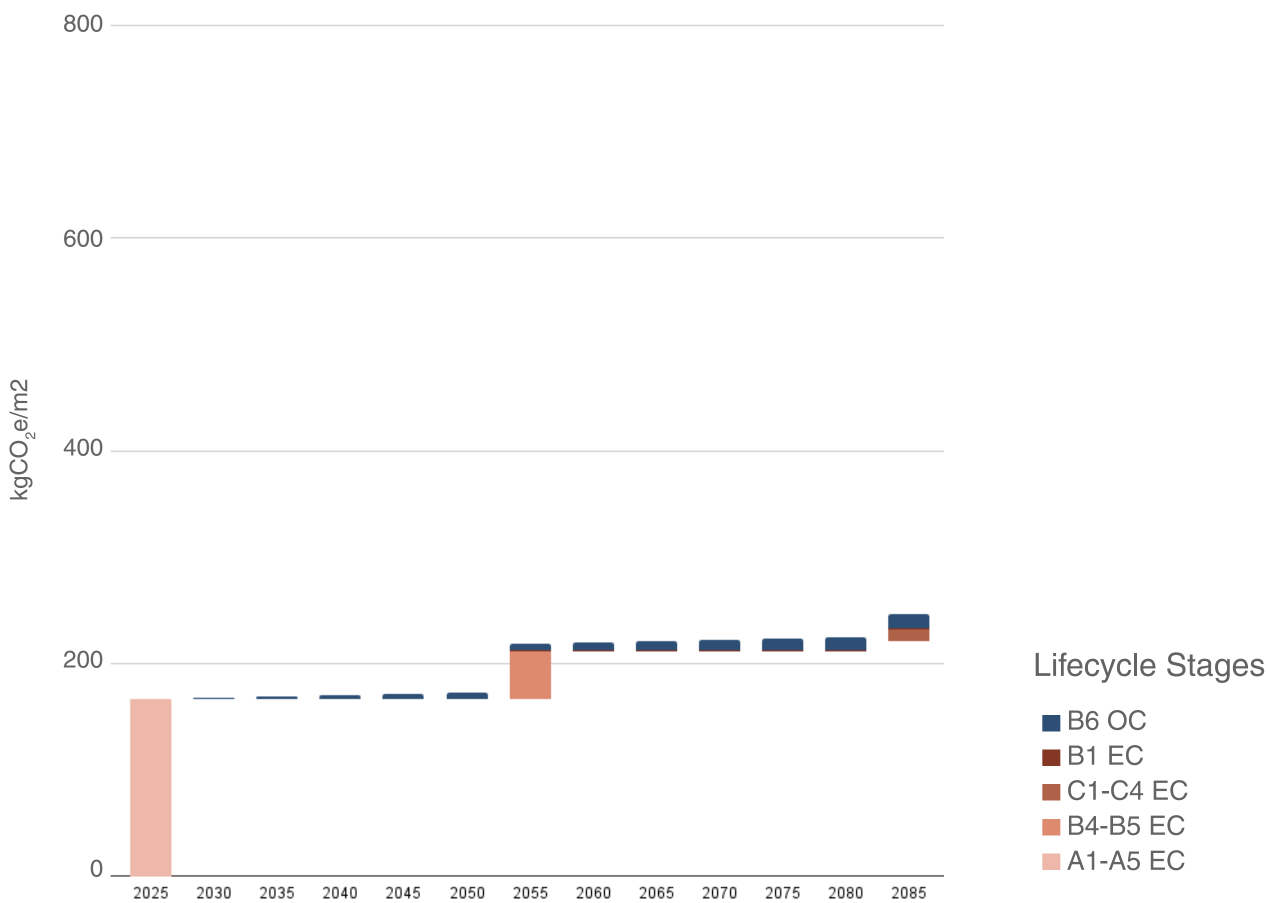


Figure 5.32. Whole Life Carbon graph for Montreal Scenario A. Refer to Figure 3.1. for Lifecycle Stages.

Embodied Carbon Intensity by Component

The A-C embodied carbon intensity for Scenario A is 233 kgCO2e/m2. Envelope and interiors make up the largest share of embodied emissions, with structure and MEP contributing less. Demolition is minor, showing how finishes and façade work drive impacts in retrofit projects.

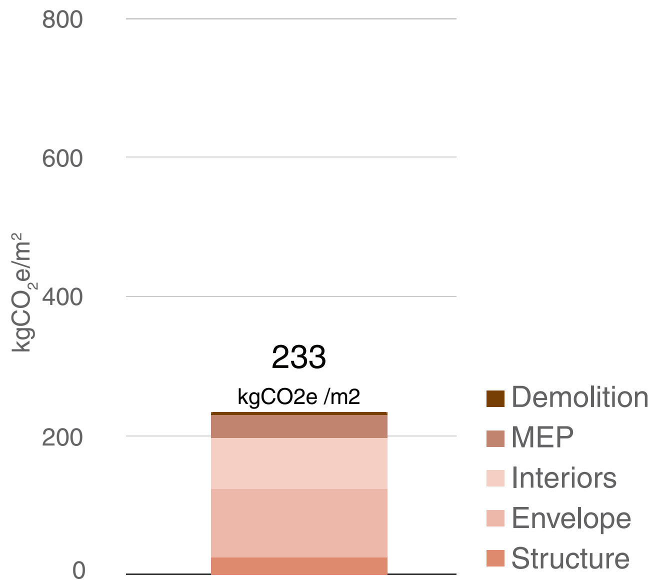


Figure 5.33. Embodied Carbon Intensity by Component for Montréal Scenario A.

Operational Energy Use Breakdown

The total energy use for the retrofitted building is 1,190 mWh/year which correlates to an annual operational carbon emission of 2,023 kgCO2e/year and an OC intensity of 0.23 kgCO2e/m2.year. This number is so low because of the Quebec grid being almost entirely based on hydroelectric power. Space heating has the highest impact, making up 36% of the energy use, followed by domestic hot water and lighting loads.

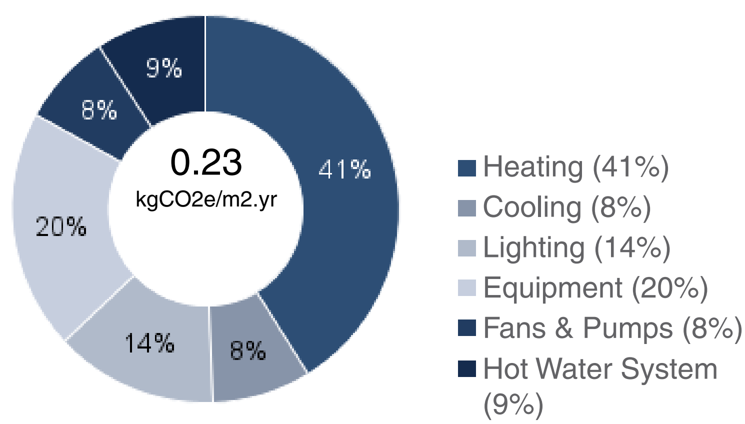


Figure 5.34. Operational Energy Use Breakdown for Montréal Scenario A.

Upfront Cost of Construction

Costs are concentrated in interiors and MEP systems which were entirely replaced, followed by costs associated with envelope upgrades. These costs mirror the same categories that drive embodied carbon. Costs associated with structure and demolition are comparatively small. Contingencies and markups make up 34% of the total rate of construction cost which is $5,380 CAD/m2 for Scenario A.

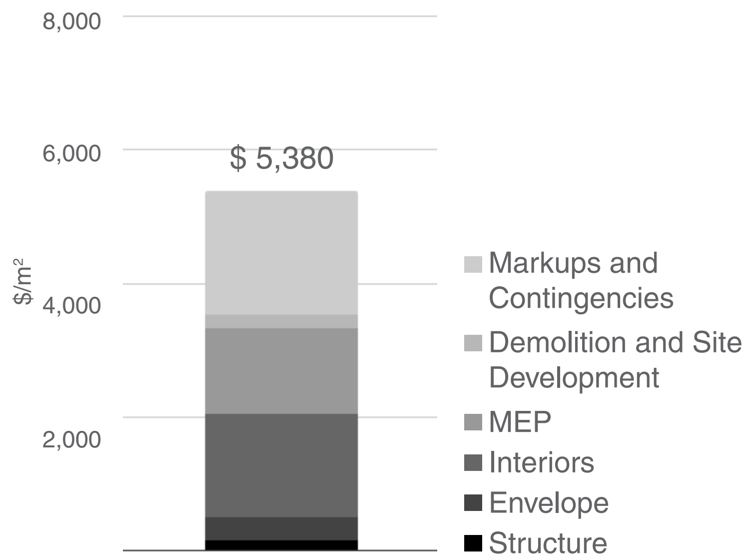


Figure 5.35. Rate of Upfront Construction Cost for Montréal Scenario A.

Operational Cost Over 60 Years

The total cost of operations over a 60-year period for Scenario A is $ 20,135 CAD/m2 for Scenario A. Costs associated with replacing parts of the building envelope, interiors and systems that will occur periodically make up 66% of the total. Costs associated with regular maintenance, servicing and repairs make up 18% of the operational cost, and the remaining 16% comprises inflation over 60 years. Operational carbon costs are minimal in comparison.

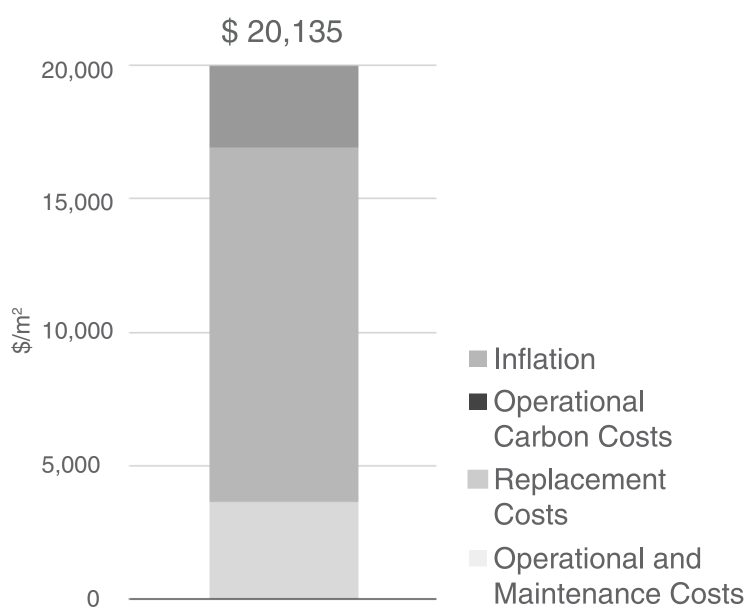


Figure 5.36. Operational Cost Over 60 Years for Montréal Scenario A.

Scenario B:

Retrofit and Addition

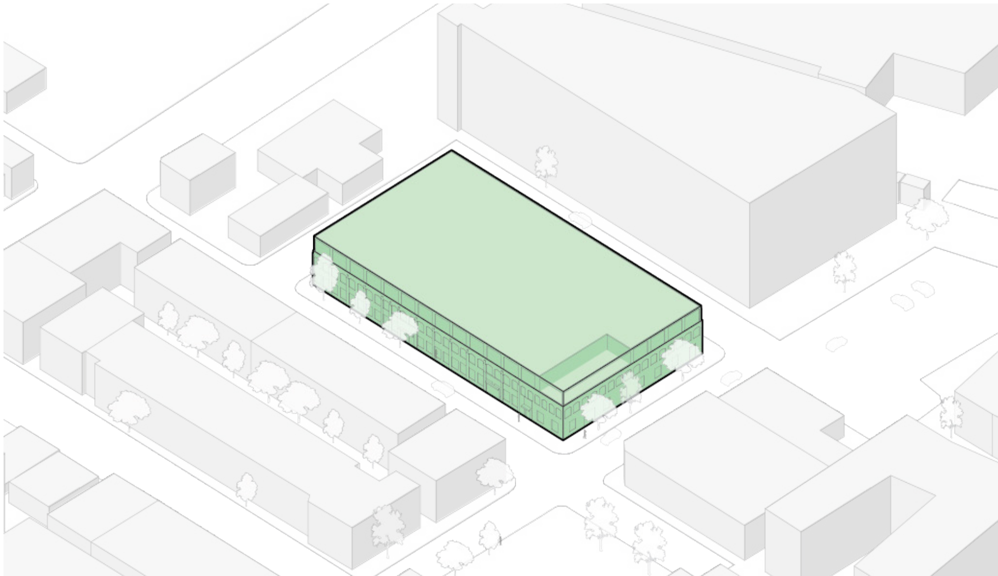


Figure 5.37. Montréal Scenario B shown in context.

The scope of the retrofit and addition included the following major interventions, summarized per building component.

Structure	The existing building comprises reinforced concrete foundations and a 2 storey brick structure with steel framing and nail laminated timber floors .In the retrofit all existing structure is retained, and mortar is repointed. The old elevator shaft is demolished and replaced with new elevator and stair cores. Third storey addition with steel framing and concrete composite deck slab floor.
Envelope	The existing building's multi-wythe brick facade is retained. Original single pane windows are replaced by double glazed IGUs with thermally broken aluminium frames. The third floor addition is clad in curtainwall. Roof replaced, with TPO (thermoplastic polyolefin) membrane and additional insulation, on metal deck. Walls: RSI = 2.2, Roofs: RSI = 3.4, Fenestration: RSI = 0.3, Curtainwall: RSI = 0.4. (All RSI values are "effective") Air Leakage Rate:2.5 L/s/m2 @ 75 Pa
Interiors	All existing interior partitions and finishes were demolished. Full interior retrofit with improved street level access. Exposed concrete columns and ceilings, raised access flooring, painted partitions and tiled washrooms.
Mechanical and Electrical	All existing systems were replaced. Rooftop units for air source heat pumps connected to ducted supply air in the building. ERV added to RTUs for preheating fresh air. Electric baseboard backup heating. All new electrical feeders, panels and fixtures. Low GWP refrigerant R454B is assumed for all systems.
Demolition	Removal of all interior partitions, mechanical, electrical and plumbing systems. Demolition of existing roof elevator cores and smokestack, to make way for additional floor.

Whole Life Carbon

The retrofit with addition results in a higher embodied carbon footprint than retrofit-only, reflecting the structural steel and envelope assemblies required for the vertical extension. Embodied carbon emissions rise to 275 kgCO2e/m², around 20 percent greater than Scenario A. Over the 60-year service life, further contributions from replacement cycles add incrementally to this already larger base, making the cumulative emissions higher than retrofit-only.

As per "Emissions Factors and Reference Values" published by the Government of Canada in October 2025, the current grid emissions factor in Montreal is minimal at 0.0017 kgCO2e/kWh. Operational emissions remain extremely low at 13 kgCO2e/m² due to Québec's clean grid, but the increase in gross floor area means total operational carbon is higher in absolute terms. Even so, the scenario remains well below demolition and replacement in whole life terms.

Scenario B demonstrates how additions can deliver valuable new space and maintain a low operational profile, but at a higher carbon cost and with greater financial intensity than a straightforward retrofit.

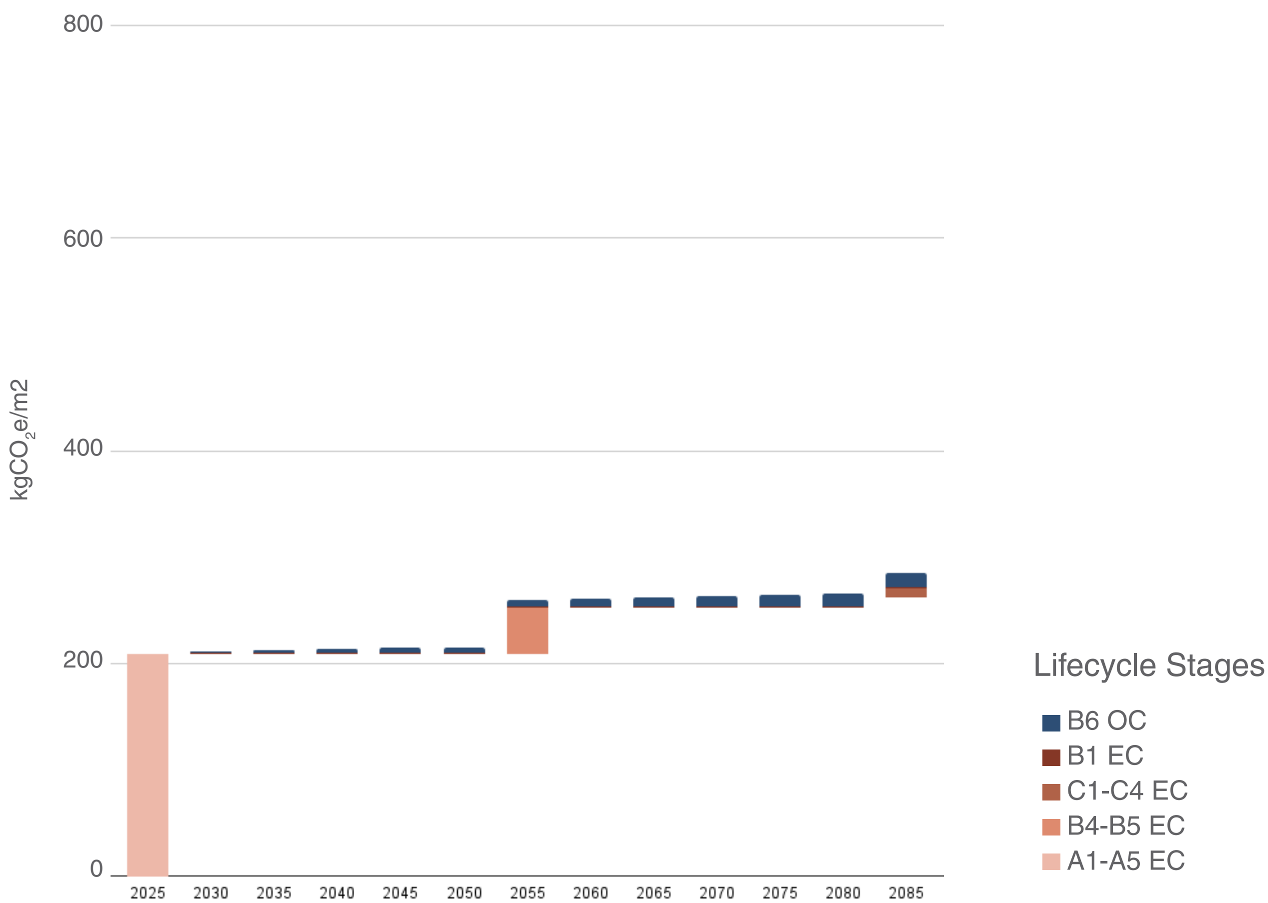


Figure 5.38. Whole Life Carbon graph for Scenario B. Refer to Figure 3.1. for Lifecycle Stages.

Embodied Carbon Intensity by Component

The A-C embodied carbon intensity for Scenario B is 275 kgCO2e/m2. Structure and envelope emissions rise sharply compared to retrofit-only, driven by the steel third floor and new façade. Interiors and MEP are similar to Scenario A, while demolition stays minor, showing how expansions amplify material-intensive categories.

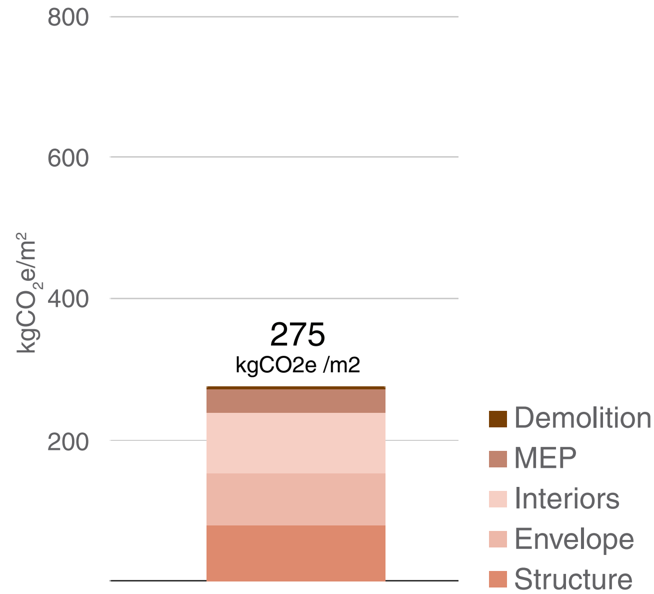


Figure 5.39. Embodied Carbon Intensity by Component for Montréal Scenario B.

Operational Energy Use Breakdown

The total energy use for the retrofit and addition building is 1,660 mWh/year which correlates to an annual operational carbon emission of 2,824 kgCO2e/year and an OC intensity of 0.22 kgCO2e/m2.year. This number is comparable to the operational energy performance in Scenario A, and is so low because of the Quebec grid being almost entirely based on hydroelectric power. Space heating has the highest impact, making up 36% of the energy use, followed by domestic hot water and lighting loads.

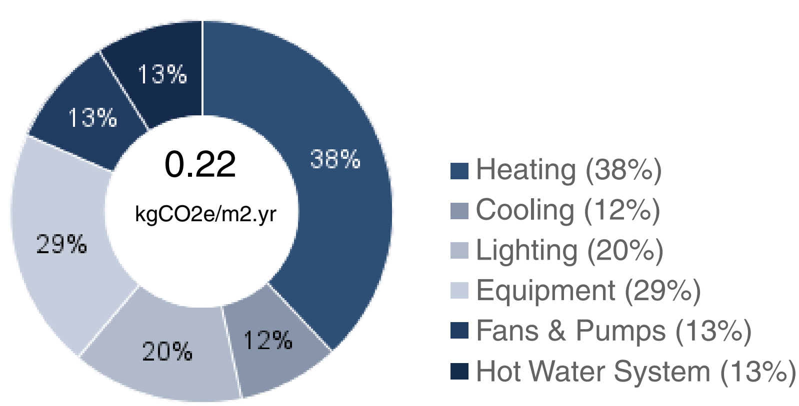


Figure 5.40. Operational Energy Use Breakdown for Montréal Scenario B.

Upfront Cost of Construction

Costs are concentrated in interiors and MEP systems which were entirely replaced, followed by costs associated with envelope upgrades. These costs mirror the same categories that drive embodied carbon. Costs associated with structure and demolition are higher than Scenario A, but still the smallest contributors. Contingencies and markups make up 32% of the total rate of construction cost, which is $5,929 CAD/m2 for Scenario B.

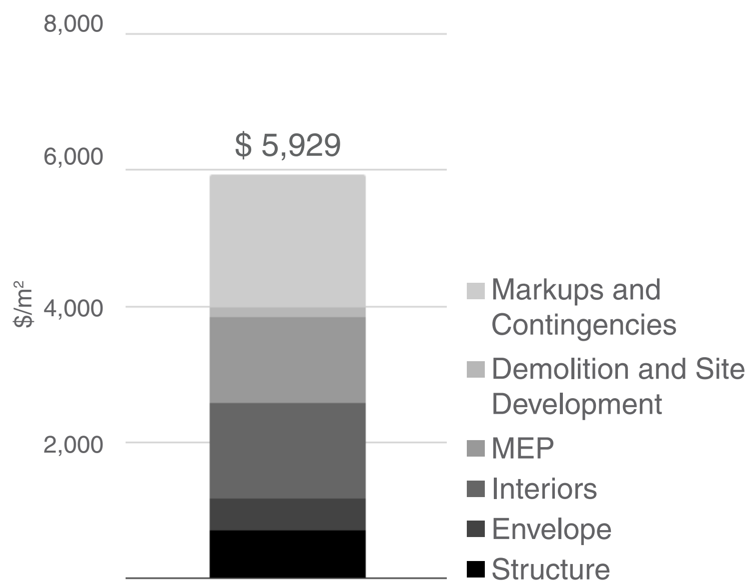


Figure 5.41. Rate of Upfront Construction Cost for Montréal Scenario B.

Operational Costs Over 60 Years

The total cost of operations over a 60-year period for Scenario B is $18,706 CAD/m2, the lowest of the three scenarios. Costs associated with replacing parts of the building envelope, interiors and systems that will occur periodically make up 66% of the total. Costs associated with regular maintenance, servicing and repairs make up 18% of the operational cost, and the remaining 16% comprises inflation over 60 years. Operational carbon costs are minimal in comparison.

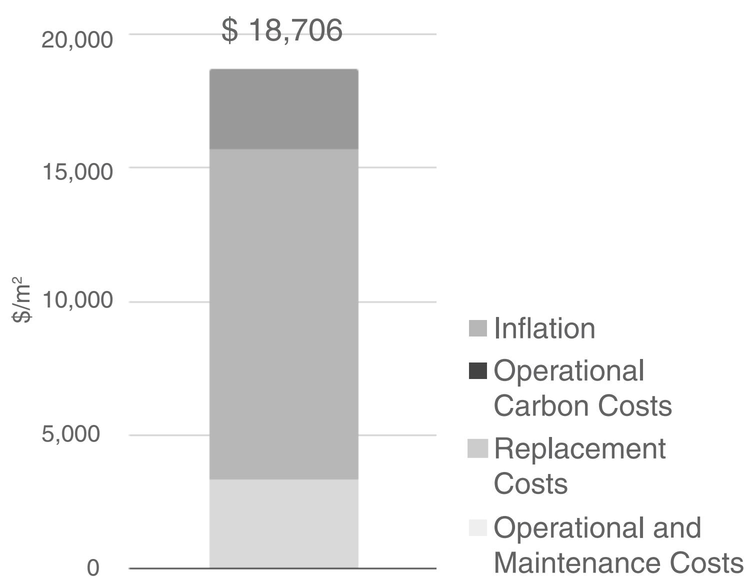


Figure 5.42. Operational Cost Over 60 Years for Montréal Scenario B.

Scenario C:

Demolish and Replace

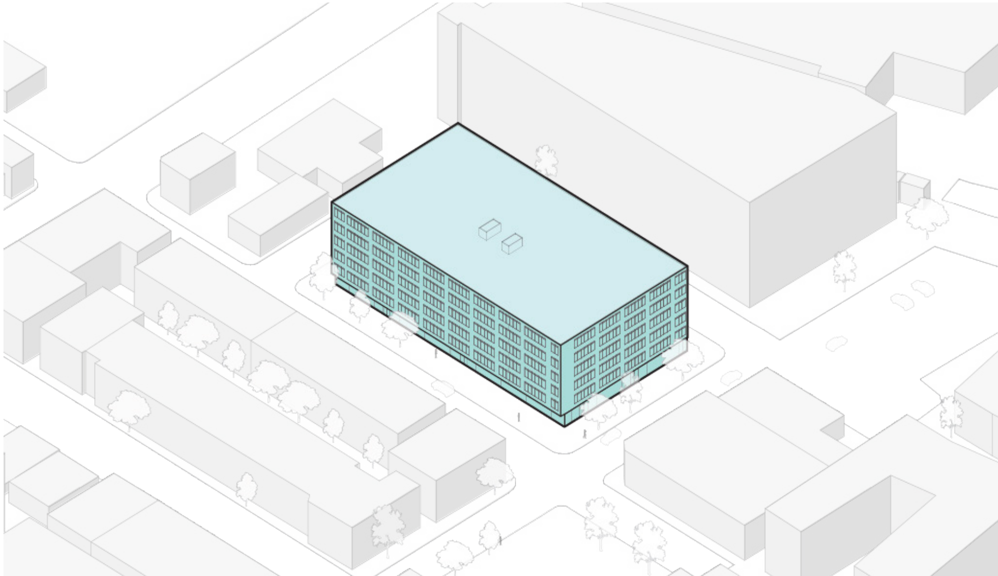


Figure 5.43. Montréal Scenario C shown in context.

The construction scope is summarized per building component.

Structure	The existing building consisting of reinforced concrete foundations and a 2 storey brick structure with steel framing and nail laminated timber floors, is demolished in its entirety. The new building is a 6 storey steel frame structure, with 1 level of underground parking sitting atop concrete slab and footings. Concrete shear walls and stair cores with concrete composite deck slabs as floors.
Envelope	The existing building's multi-wythe brick exterior wall, single pane windows and roof are all demolished. New building's exterior opaque walls are brick veneer,XPS insulation and gypsum sheathing on steel stud. Double glazed IGUs with thermally broken aluminium frames. New built up flat roof with 2-ply SBS modified bitumen and additional insulation. Walls: RSI = 3.2, Roofs: RSI = 3.5, Fenestration: RSI = 0.5. (All RSI values are "effective") Air Leakage Rate:1.5 L/s/m2 @ 75 Pa.
Interiors	All existing interior partitions and finishes were demolished. Full interior retrofit with improved street level access. Exposed concrete columns and ceilings, raised access flooring, painted partitions and tiled washrooms.
Mechanical and Electrical	All existing systems were replaced. Central 4-pipe rooftop ASHP serving chilled water and heating water for fan coil units and hydronic radiant panels, with heat recovery. All new electrical feeders, panels and fixtures. Low GWP refrigerant R454B is assumed for all systems.
Demolition	Complete demolition of existing building before commencing new construction.

Whole Life Carbon

Scenario C has the highest whole life carbon profile of all scenarios, dominated by embodied emissions from a full rebuild of structure, envelope, and systems. Embodied carbon reaches 654 kgCO2e/m², nearly triple the retrofit-only option and more than double retrofit with addition. Over 60 years, additional replacement cycles compound this initial impact, bringing total embodied carbon to more than 14,000 tonnes.

As per "Emissions Factors and Reference Values" published by the Government of Canada in October 2025, the current grid emissions factor in Montreal is minimal at 0.0017 kgCO2e/kWh. While operational emissions fall slightly to 9 kgCO2e/m² due to efficient new systems and envelope design, these savings are insignificant compared to the massive upfront burden. In Québec's hydro-powered context, where operational emissions are already minimal, Scenario C performs worst environmentally, while also carrying the highest cost per square metre. This underscores how demolition and replacement can negate the carbon advantage of a clean electricity grid by front-loading emissions in new construction materials

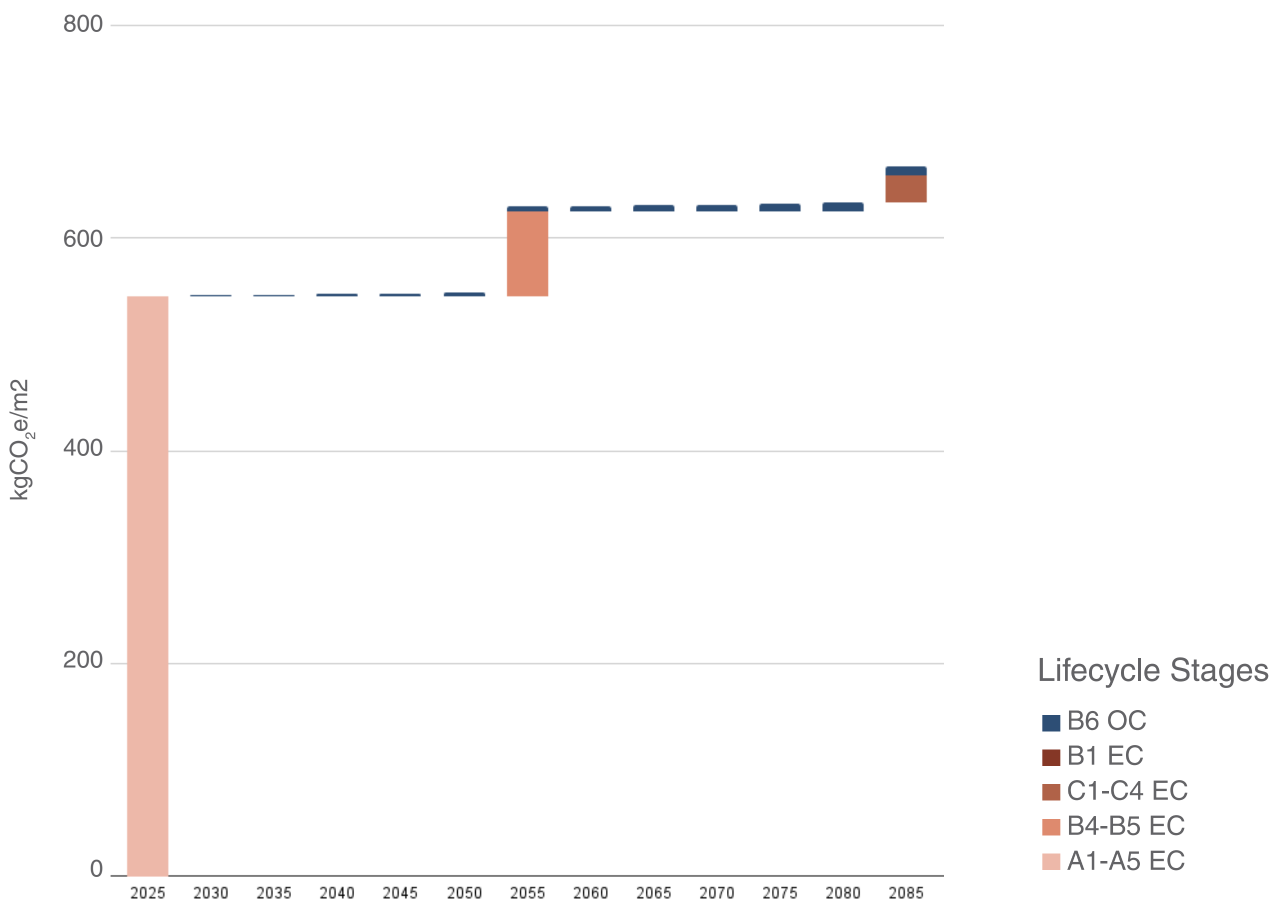


Figure 5.44. Whole Life Carbon graph for Montréal Scenario C. Refer to Figure 3.1. for Lifecycle Stages.

Embodied Carbon Intensity by Component

The A-C embodied carbon intensity for Scenario C is 654 kgCO2e/m2. Structure is the largest source of embodied carbon in this scenario, far exceeding envelope and interiors. MEP and demolition add smaller but still notable contributions. Compared to retrofit options, the impact of a full structural rebuild makes Scenario C much more carbon intensive.

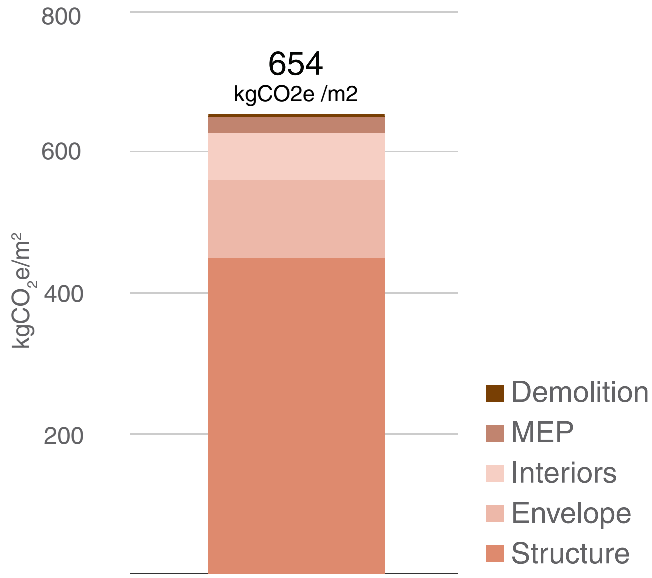


Figure 5.45. Embodied Carbon Intensity by Component Montréal Scenario C.

Operational Energy Use Breakdown

The total energy use for the new building is 1,888 mWh/year which correlates to an annual operational carbon emission of 3,210 kgCO2e/year and an OC intensity of 0.15 kgCO2e/m2.year. Operationally the new building is the most efficient, due to its improved thermal envelope performance and airtightness. The impact of space heating is reduced to 14%. Equipment loads and lighting occupy the highest shares of energy use, followed by cooling and domestic hot water.

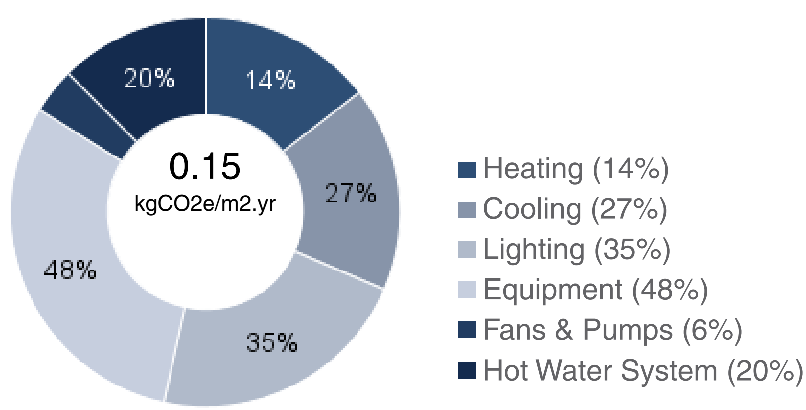


Figure 5.46. Operational Energy Use Breakdown Montréal Scenario C.

Upfront Cost of Construction

The demolish and replace scenario has the highest upfront cost of construction per square meter of rentable area, as compared to the two retrofit scenarios. High impact categories for cost of construction are MEP systems, followed by building interiors and structure. Contingencies and markups make up 31% of the upfront construction cost, which is $6,924 CAD/m2 for Scenario C.

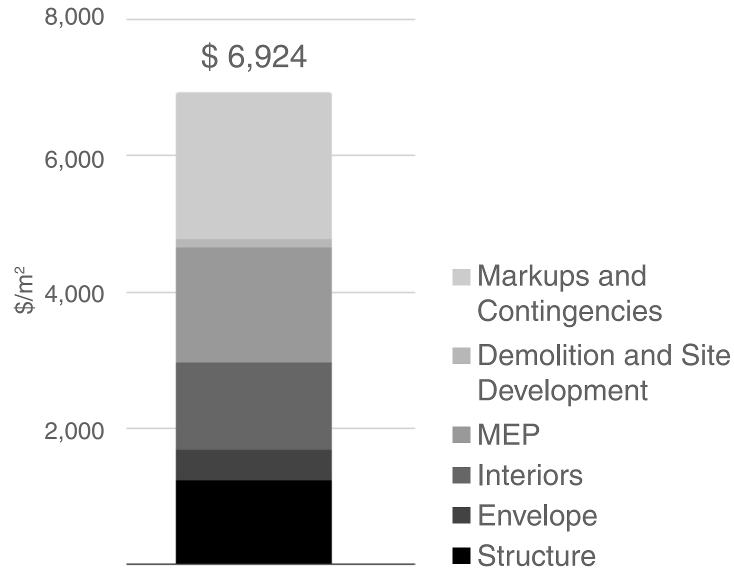


Figure 5.47. Rate of Upfront Construction Cost Montréal Scenario C.

Operational Costs Over 60 Years

The total cost of operations over a 60-year period for Scenario C is $18,817 CAD/m2. Costs associated with replacing parts of the building envelope, interiors and systems that will occur periodically make up 69% of the total. Costs associated with regular maintenance, servicing and repairs make up 15% of the operational cost, and the remaining 16% comprises inflation over 60 years. Operational carbon costs are minimal in comparison.

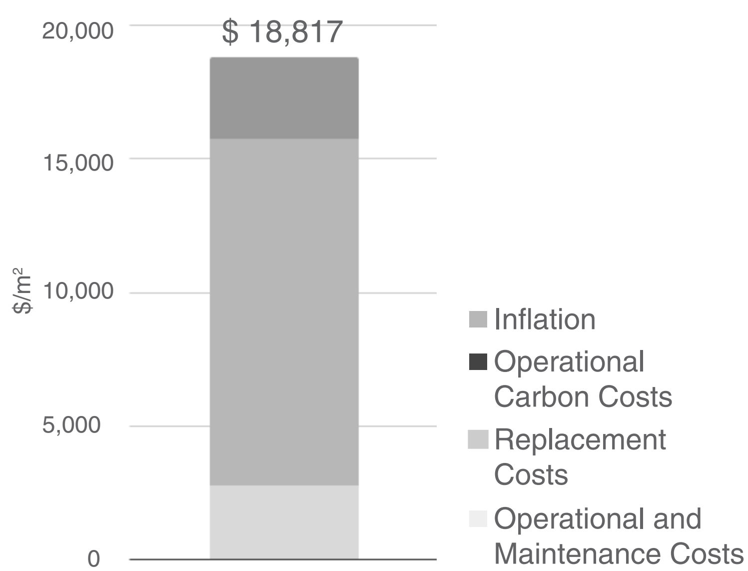


Figure 5.48. Operational Cost Over 60 Years for Montréal Scenario C.

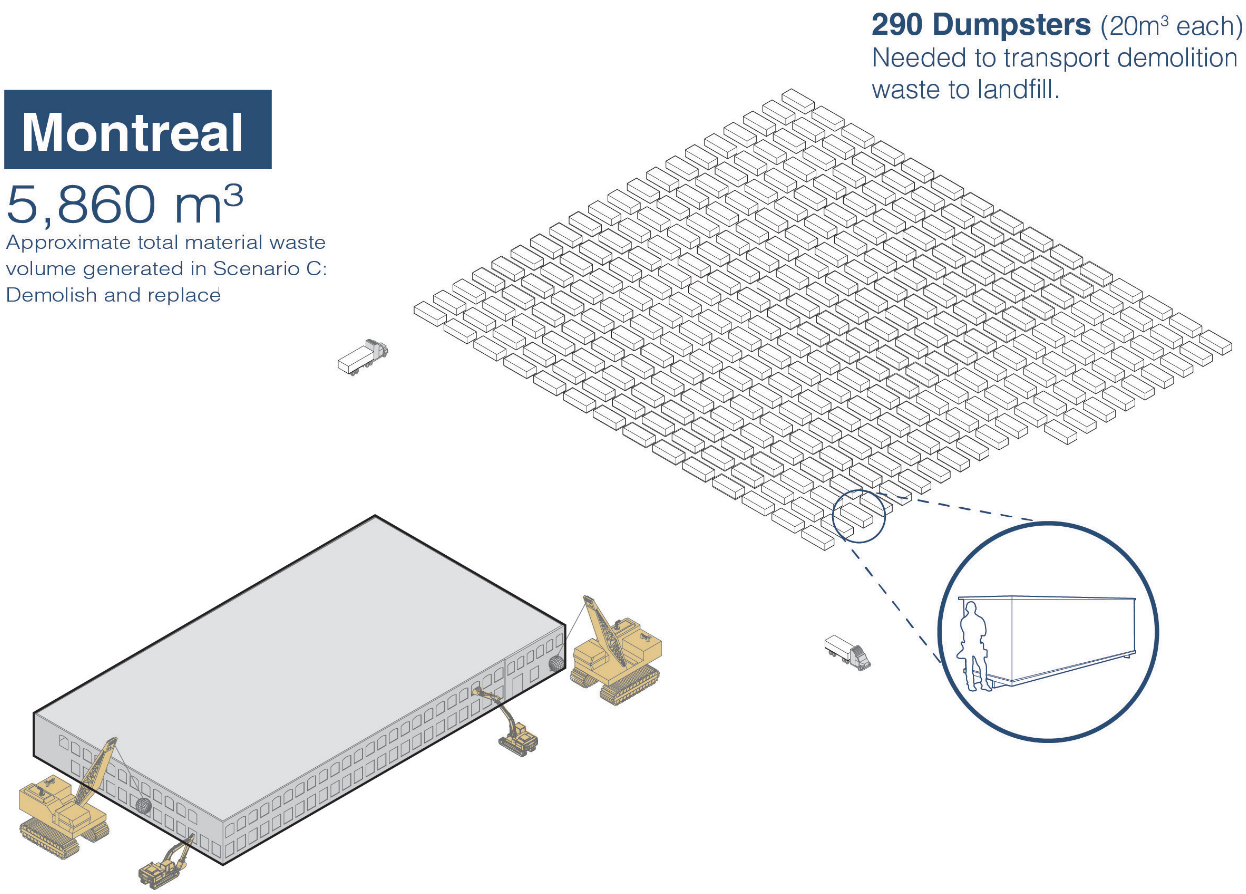


Figure 5.49. Demolishing the Montréal textile factory building will generate roughly 5,860 m^3 of waste, enough to fill about 290 dumpsters (20 m^3 each) to be sent to a landfill.

5.3 Case Study 3 | Vancouver

Address	Union Street, Vancouver
Owner	Private Owner
Construction Date	1898
Original Use	Residential
Adaptive Reuse	Residential
Architect	MA+HG Architects

Project Context

The house was originally built in 1898 as a 2.5 storey, wood frame, single-family home built atop a concrete crawlspace. It was purchased in 2014 with the intent of restoration, by which time the building was in extremely poor condition and needed extensive work. The work completed in 2020, transformed the site from a single dwelling to a 4 unit development including a new basement suite, a converted attic and an infill duplex unit at the back of the lot.

Figure 5.50. Vancouver historic residential building renovated and restored in 2020.

Credit: Photo by Janis Nicolay, Canadian Architect.

Scenario A:

Retrofit

Scenario B:

Retrofit and Addition

Scenario C:

Demolish and Replace

As Built: Scenario B, Retrofit and Addition
An extensive rehabilitation of the existing house was undertaken, beginning with a full interior gut to accommodate an entirely new layout. The entire building was temporarily lifted off of its early concrete foundations, and a new foundation was poured to accommodate a walk-in basement suite. Two small bump-outs were added to the ground floor, and an original dormer was reinstated, serving the attic space, which was converted into a bedroom. The new infill duplex was constructed with a basement accessory space and two side-by-side units above.

The as-built scenario's infill duplex is designed with a high level of architectural excellence and distinctive features. The project has received multiple awards and is widely recognized for its quality. For this study, the project team explored an alternative design for the addition, reflecting more typical architectural design and construction methods to ensure broader applicability and serve as a practical tool for stakeholders. The proposed infill design is based on the BC Standardized Housing Designs Catalogue published by the Ministry of Housing.

Overview of Results

The Vancouver Case Study, shows that embodied carbon is the dominant factor in the building's whole life carbon emissions over 60 years once the systems have been electrified. This is because in British Columbia, like in Quebec, 98% of power generated comes from hydroelectricity, and there continues to be investment in other renewables such as wind, solar and biomass.

In the "Do Nothing" Scenario, the existing single family house locks in very high operational carbon intensity at 3,118 kgCO2e/m² over 60 years, or more than 639 tCO2e in total. The assumption is that the building continues to run on gas heating, with no upgrade to mechanical systems or building envelope.

Scenario A, in which the building retrofit is modelled, shows that the operational carbon intensity over a period of 60 years reduces dramatically to 125 kgCO2e/m2 due to upgrades in envelope, building electrification and installation of ductless split VRF systems for heating and cooling. Operational carbon accounts for only 18% of whole life carbon emissions. The remaining 82% is the embodied carbon intensity of 560 kgCO2/m2 which is dominated by new HVAC systems and upgrades to building envelope.

In Scenario B, 260 m2 of GFA is added to the site by modelling the addition of a basement unit, as well as an infill duplex at the back of the lot. This retrofit plus addition scenario has an embodied carbon intensity of 584 kgCO2e/m2 and an improved operational carbon intensity of 98 kgCO2e/m2. In terms of whole life carbon emissions per square meter of GFA this is the best performing scenario, with the lowest WLC intensity at 682 kgCO2e/m2 as well as the highest residential density at 4 units.

The new build delivers the lowest operational emissions at 82 kgCO2e/m², but a much higher embodied carbon intensity at 725 kgCO2e/m2. From a WLC perspective, when we stack the impacts of embodied carbon and operational carbon over 60 years we see that the Demolish and Replace Scenario performs the worst at 807 kgCO2e/m2.

When compared with the Halifax and Montreal case studies there are interesting differences in the results due to variation in building type, scale and materials. While the other case studies were much larger structures, made of highly intensive materials like concrete, steel and brick, the Vancouver precedent is a light, wood-framed single family home. As a result its embodied carbon is not concentrated in its structure, but largely in its mechanical systems for heating and cooling, as well as in the building's cladding, insulation, windows and doors. The assumption of R32 refrigerant in the ductless VRF systems, and their projected leakage over 60 years is also a big driver.

Note: For more information on the assumptions and methodology behind the data in this chapter, see Appendix B - Costing Reports, Appendix C - Engineering Reports, and Appendix D - Energy Modeling Reports.

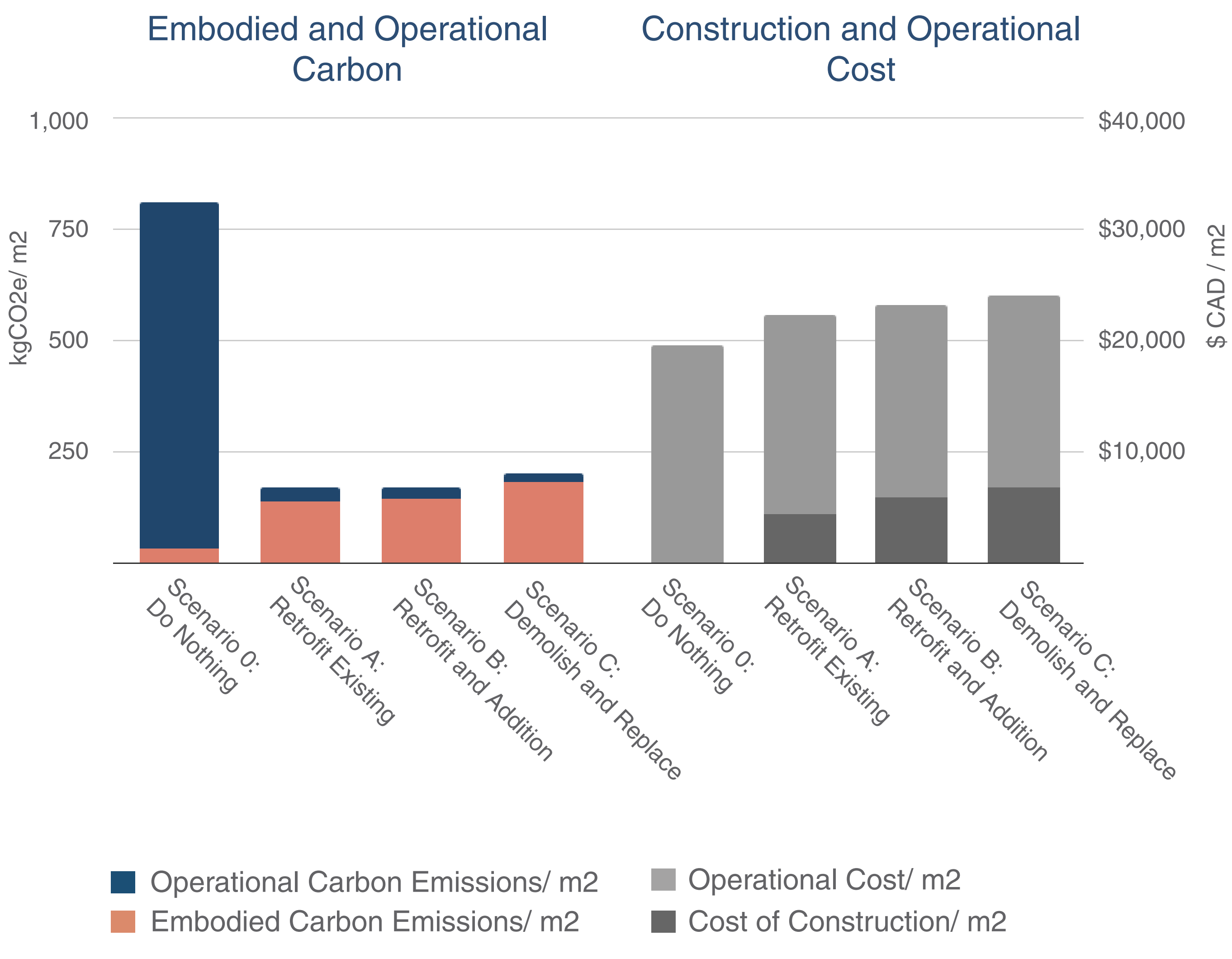
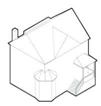
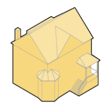
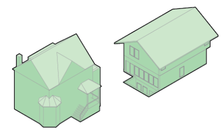
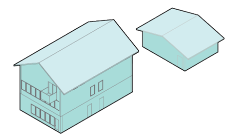


Figure 5.51. Cost of Construction and Operational Cost in comparison to Operational and Embodied Carbon Emissions. All values are expressed per square metre of gross floor area.

	Scenario 0: Do Nothing	Scenario A: Retrofit Existing	Scenario B: Retrofit and Addition (As Built)	Scenario C: Demolish and Replace
				
Primary Use	Residential	Residential	Residential	Residential
Gross Floor Area (m^2)	205 m2	205 m2	465 m2	412 m2
Basement	None	None	Yes	Yes
Above Grade Storeys	3	3	3	3
Window to Wall Ratio	17%	17%	14%	15%
WLC Emissions ($tCO^{2}e$)	697	140	317	333
WLC Intensity ($kgCO_2e/m^2$)	3243	685	682	807
EC Intensity ($kgCO_2e/m^2$)	125	560	584	725
OC Intensity ($kgCO_2e/m^2$)	3118	125	98	82
Total Construction Cost (CAD $)	$0	$912,000	$2,775,000	$2,827,000
Construction Cost Rate (CAD $/ m^2)	$0	$4,449	$5,968	$6,862
Total Operational Cost* (CAD $)	$4,100,005	$3,665,304	$8,032,524	$7,089,935
Operational Cost Rate(CAD $/$m^2$)	$20,000	$17,880	$17,274	$17,209

*Total Operational Cost: Initial hard construction based on Q4 2025 + Operational Carbon Costs over 60 Year Ownership.

Figure 5.52. Overview of results across all Vancouver scenarios

Scenario A:

Retrofit Existing

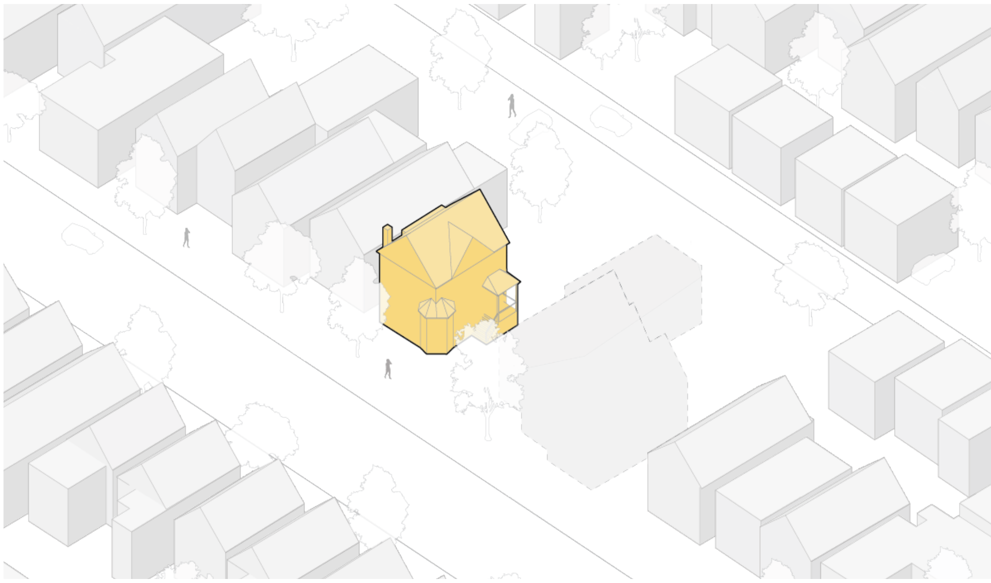


Figure 5.53. Vancouver Scenario A shown in context.

The scope of the retrofit included the following major interventions, summarized per building component.

Structure	The existing building comprises light wood frame superstructure on a concrete subbase. In the retrofit all existing structure is retained. No structural interventions are modeled.
Envelope	The existing building's horizontal wood lap siding, sheathing, and main structural framing was assumed to be salvaged and re-used, while adding additional insulation interior and exterior of the sheathing layer. Window frames were also assumed to be re-used, with replacement of more efficient double-glazed units. Walls: RSI = 2.5, Roofs: RSI = 3.2, Fenestration: RSI = 0.6. (All RSI values are "effective") Air Leakage Rate: 2.5 L/s/m2 @ 75 Pa
Interiors	All existing interiors were replaced. Full interior retrofit, with new partition walls to accommodate residential floor layout. Exposed concrete ceiling and floor finishes.
Mechanical and Electrical	All existing systems were replaced. Ductless VRF air source heat pumps in each room and ERV in each principal suite. Electric baseboard backup heating. All new electrical feeders, panels and fixtures. Refrigerant R32 is assumed for all systems.
Demolition	Removal of all interior partitions, mechanical, electrical and plumbing systems. Removal of existing roof and original IGUs.

Whole Life Carbon

For Scenario A, the whole life carbon profile is shaped by relatively modest operational emissions paired with high embodied impacts. At the end of practical completion for the retrofit, the upfront EC is 560 kgCO2e/m2 associated with new mechanical systems and envelope upgrades like roof replacement, new IGUs, and additional insulation. Over the 60-year study period, additional embodied emissions arise incrementally from periodic maintenance and replacement, but these never outweigh the initial construction impact.

Carbon impact from the operational emissions is modelled as per current emissions factor of 0.015 kgCO2e/kWh, as per “Emissions Factors and Reference Values” published by the Government of Canada in October 2025. The cumulative OC intensity over 60 years for the retrofit scenario is relatively low at 125 kgCO2e/m2, which makes up 18% of the cumulative WLC emissions intensity at 685 kgCO2e/m2.

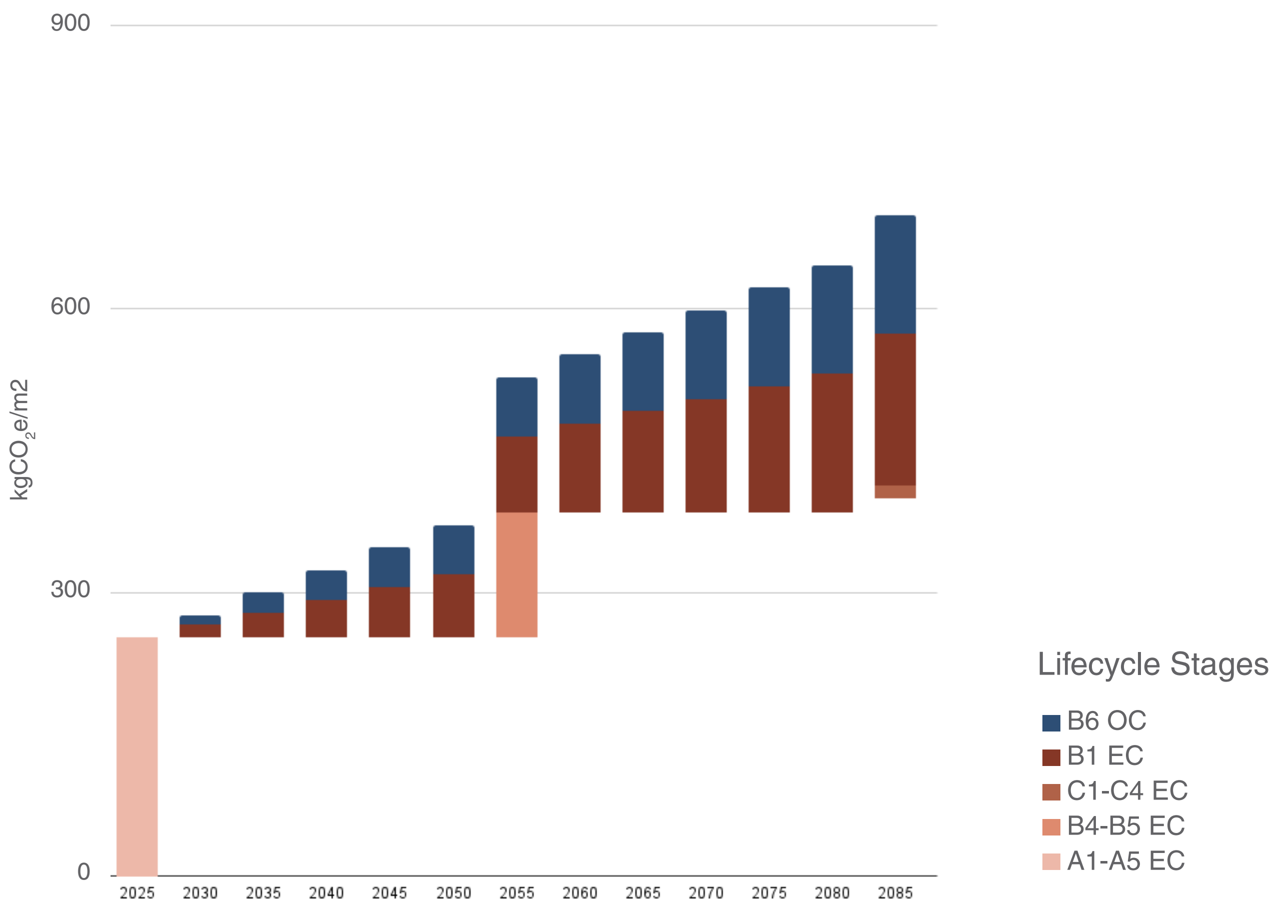


Figure 5.54. Whole Life Carbon graph for Vancouver Scenario A. Refer to Figure 3.1. for Lifecycle Stages.

Embodied Carbon Intensity by Component

The A-C embodied carbon intensity for Scenario A is 560 kgCO2e/m2. In the Retrofit, embodied carbon emissions are driven by new HVAC comprising ductless VRF systems with R32 refrigerant, which make up 47% . Upgrades to building envelope have the next highest impacts on the retrofit embodied carbon, followed by interiors, structure and demolition.

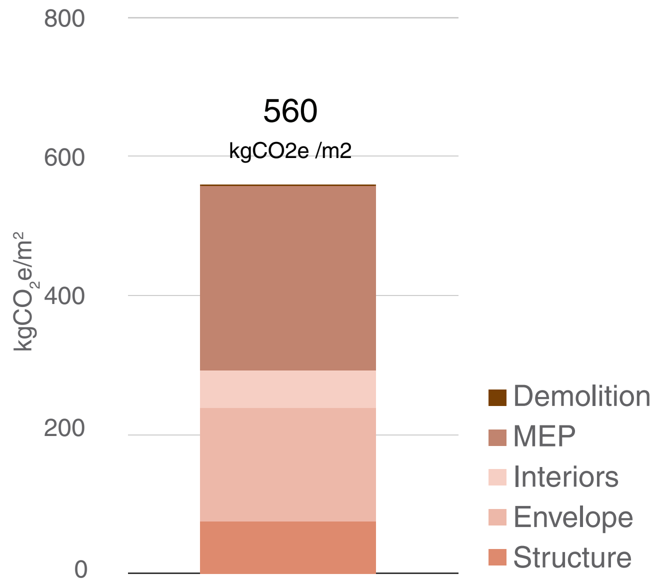


Figure 5.55. Embodied Carbon Intensity by Component for Vancouver Scenario A.

Operational Energy Use Breakdown

The total energy use for the retrofitted building is 28 mWh/ year which correlates to an annual operation carbon emission of 428 kgCO2e/ year and an OC intensity of 2.09 kgCO2e/m2.year. This is a result of building electrification and the current grid being powered almost entirely by renewable energy sources. Space heating is the highest contributor, followed by the domestic hot water and equipment loads.

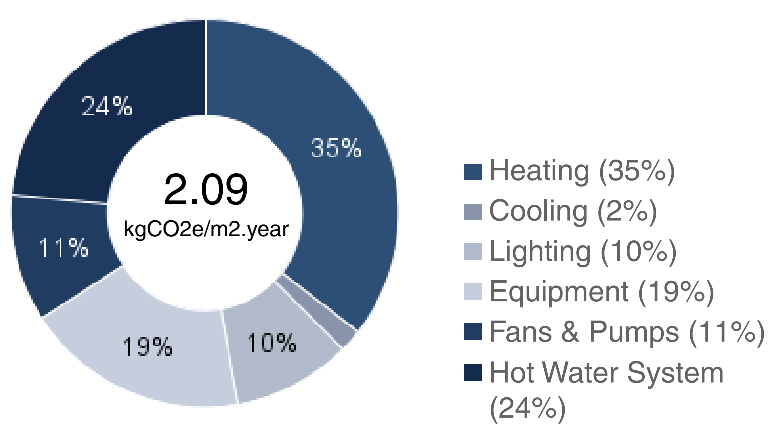


Figure 5.56. Operational Energy Use Breakdown for Vancouver Scenario A.

Upfront Cost of Construction

Contingencies and markups make up 34% of the total rate of construction cost which is $4,449 CAD/m2 for Scenario A. Material costs are concentrated in the all new MEP systems which were entirely replaced, followed by costs associated with interior upgrades, demolition and site development. Costs associated with structure and envelope are comparatively small.

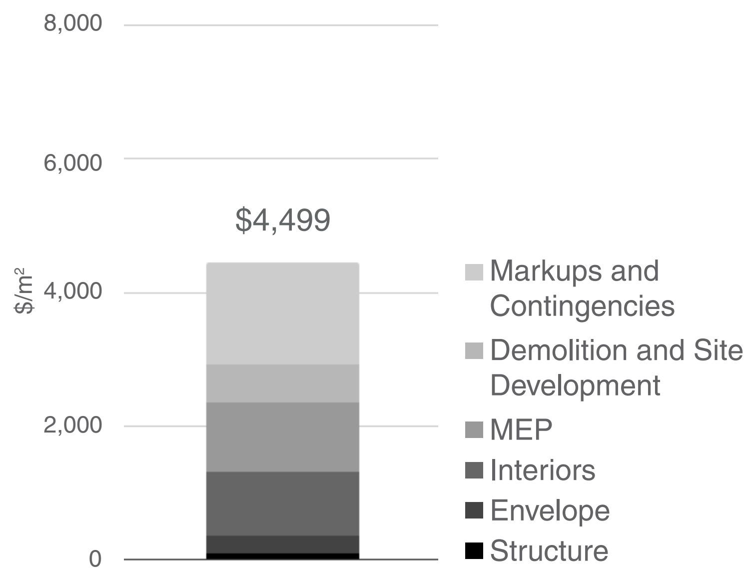


Figure 5.57. Rate of Upfront Construction Cost for Vancouver Scenario A.

Operational Costs Over 60 Years

The total cost of operations over a 60-year period for Scenario A is $ 17,880 CAD/m2. Costs associated with replacing parts of the building envelope, interiors and systems that will occur periodically make up 64% of the total. Costs associated with regular maintenance, servicing and repairs make up 20% of the operational cost, and the remaining 16% comprises inflation over 60 years. Operational carbon costs are minimal in comparison.

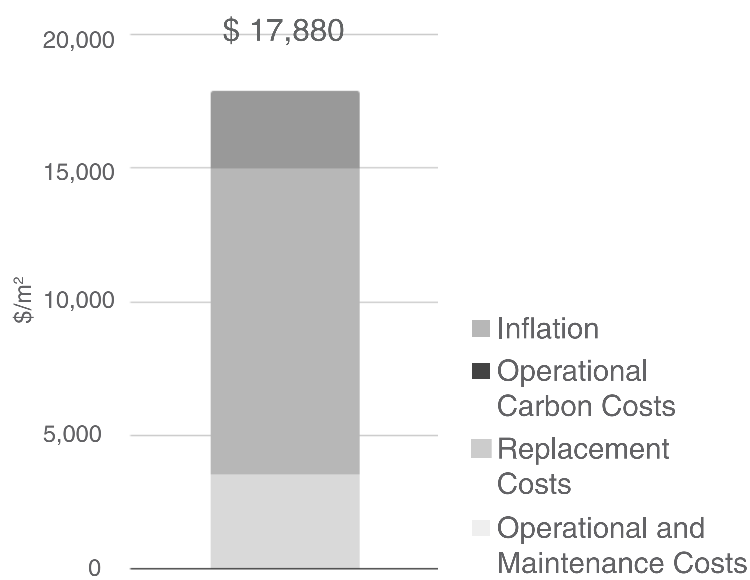


Figure 5.58. Operational Cost Over 60 Years for Vancouver Scenario A.

Scenario B:

Retrofit and Addition

Figure 5.59. Vancouver Scenario B shown in context.

The scope of the retrofit and addition included the following major interventions, summarized per building component.

Structure	The existing building comprises light wood frame superstructure on a concrete sub-base. The existing foundation is replaced with a new, seismic concrete foundation for the new for the creation of a basement suite. Extension to the north face of the building and new stairs to the basement. New concrete foundations, and light wood structural frame for new infill building.
Envelope	The existing building's horizontal wood lap siding, sheathing, and main structural framing was assumed to be salvaged and re-used, while adding additional insulation interior and exterior of the sheathing layer. Window frames were also assumed to be re-used, with replacement of more efficient double-glazed units. The addition and infill assume fiber cement siding, stonewool batt insulation, and AVB membranes on plywood sheathing for exterior walls. Asphalt shingles is assumed for roofing, with 8.5" batt insulation filling the truss cavity. (Addition) Walls: RSI = 3.8, Roofs: RSI = 3.6, Fenestration: RSI = 0.5. (Infill) Walls: RSI = 3.5, Roofs: RSI = 3.7, Fenestration: RSI = 0.9. (All RSI values are "effective") Air Leakage Rate: 1.5 L/s/m2 @ 75 Pa
Interiors	All existing interiors were replaced. Full interior retrofit, with new partition walls to accommodate residential floor layout. Exposed concrete ceiling and floor finishes.
Mechanical and Electrical	All existing systems were replaced. Ductless VRF air source heat pumps in each room and ERV in each principal suite. Electric baseboard backup heating. All new electrical feeders, panels and fixtures. Refrigerant R32 is assumed for all systems.
Demolition	Removal of all interior partitions, mechanical, electrical and plumbing systems. Removal of existing roof and original IGUs. Excavation for new infill building.

Whole Life Carbon

For Scenario B, the whole life carbon profile is shaped by relatively modest operational emissions paired with high embodied impacts. At the end of practical completion for the retrofit, the upfront embodied carbon is 584 kgCO2e/m2 associated with new mechanical systems and envelope upgrades like roof replacement, new IGUs, and additional insulation. The additional structure for the infill building has a relatively low impact.Given the light wood construction, the majority of structural emissions lie in the concrete foundations and basement.
Carbon impact from the operational emissions is modelled as per current emissions factor of 0.015 kgCO2e/kWh, as per “Emissions Factors and Reference Values” published by the Government of Canada in October 2025. The cumulative OC intensity over 60 years for the retrofit scenario is relatively low at 98 kgCO2e/m2, which makes up 14% of the cumulative WLC emissions intensity at 682 kgCO2e/m2.

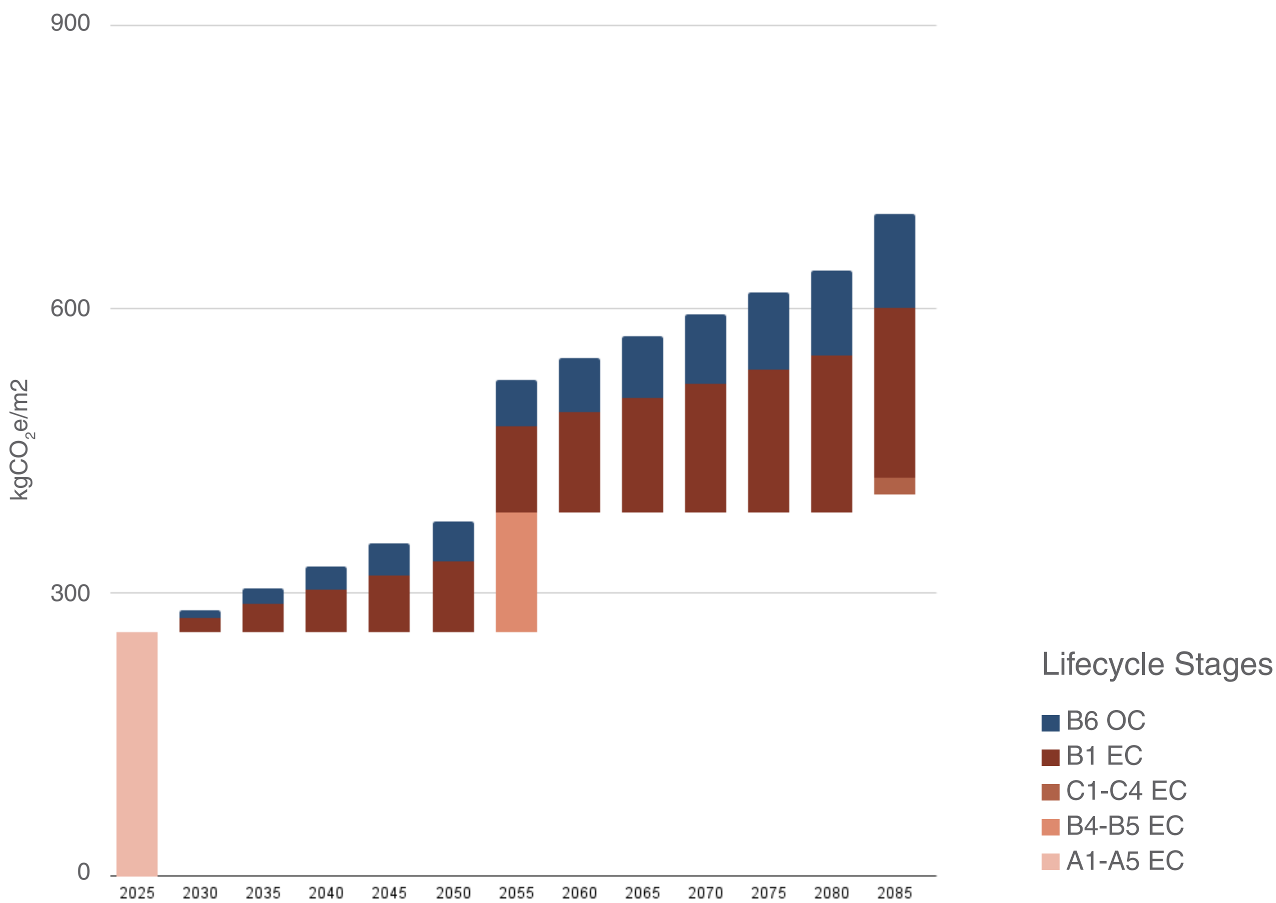


Figure 5.60. Whole Life Carbon graph for Vancouver Scenario B. Refer to Figure 3.1. for Lifecycle Stages.

Embodied Carbon Intensity by Component

The A-C embodied carbon intensity for Scenario B is 584 kgCO2e/m2. In the Retrofit, embodied carbon emissions are driven by new HVAC comprising ductless VRF systems with R32 refrigerant, which make up 50% . Building envelope, made up asphalt shingle roofs, and fibre cement clad walls with stone wool insulation have the next highest impacts on the embodied carbon of the Retrofit and Addition Scenario. There is a slight increase in the percentage of structural impacts due to new concrete foundations for the infill building.

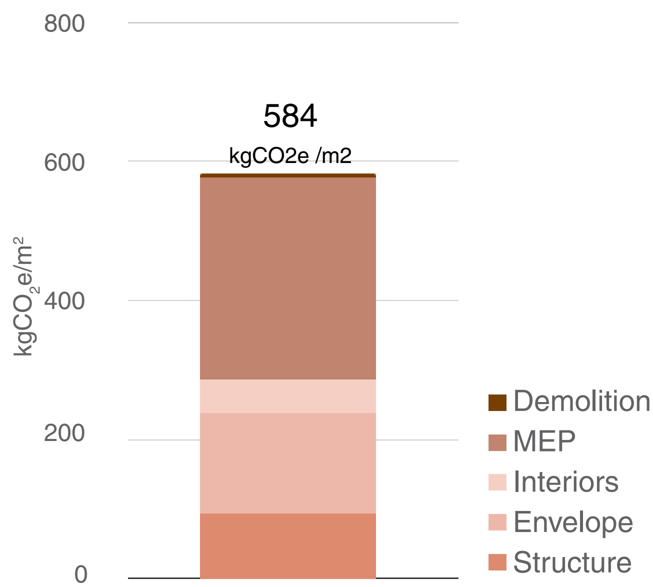


Figure 5.61. Embodied Carbon Intensity by Component for Vancouver Scenario B.

Operational Energy Use Breakdown

The energy use for the retrofit building and infill building considered together is 51 mWh/year which correlates to an annual operation carbon emission of 763 kgCO2e/year and an OC intensity of 1.64 kgCO2e/m2.year.The new infill building and additional spaces have an improved airtightness and envelope thermal performance, which helps reduce the heating demand and overall energy use intensity from Scenario A.Space heating is still the highest contributor, followed by the domestic hot water and equipment loads.

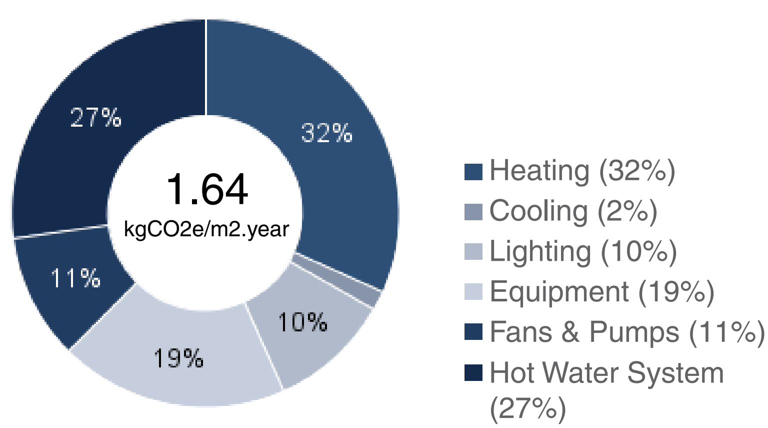


Figure 5.62. Operational Energy Use Breakdown for Vancouver Scenario B.

Upfront Cost of Construction

Contingencies and markups make up 33% of the total rate of construction cost which is $5,968 CAD/m2 for Scenario B. Material costs are concentrated in the all new MEP systems which were entirely replaced, followed by costs associated with interior upgrades, demolition and site development. Costs associated with structure and envelope have increased significantly from Scenario A, due to the construction of an all new infill building.

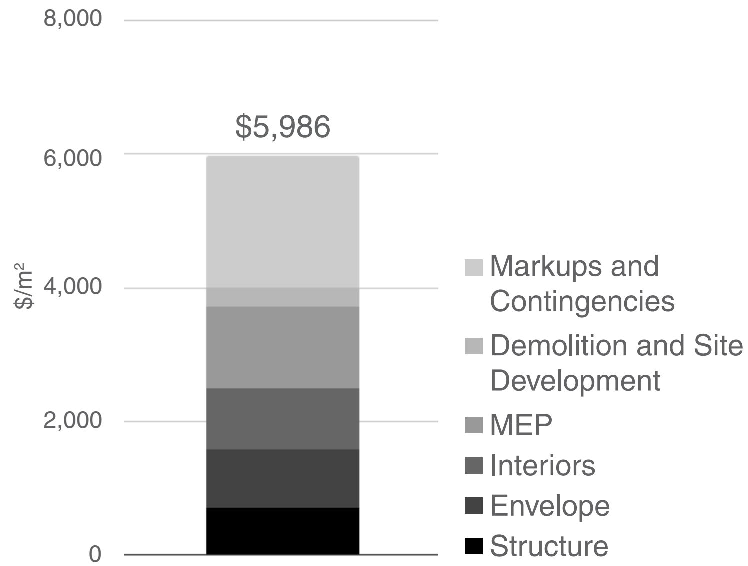


Figure 5.63. Rate of Upfront Construction Cost for Vancouver Scenario B.

Operational Costs Over 60 Years

The total cost of operations over a 60-year period for Scenario B is $17,274 CAD/m2, the lowest of the three scenarios. Costs associated with replacing parts of the building envelope, interiors and systems that will occur periodically make up 69% of the total. Costs associated with regular maintenance, servicing and repairs make up 15% of the operational cost, and the remaining 16% comprises inflation over 60 years. Operational carbon costs are minimal in comparison.

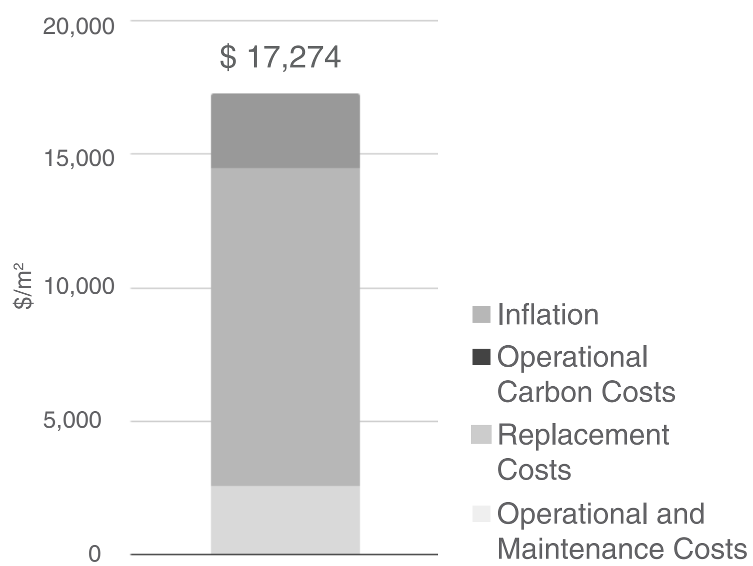


Figure 5.64. Operational Cost Over 60 Years for Vancouver Scenario B.

Scenario C:

Demolish and Replace

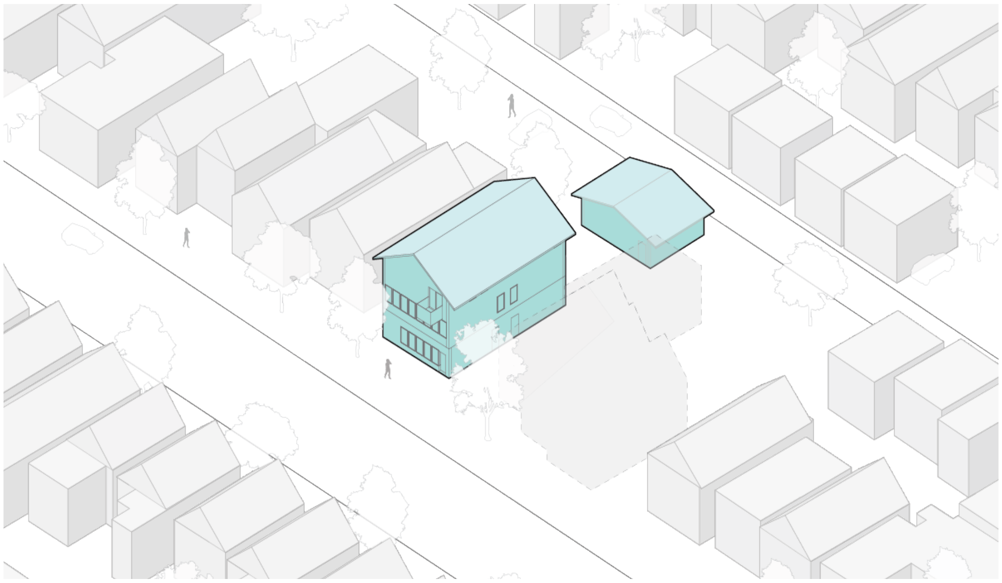


Figure 5.65. Vancouver Scenario C shown in context.

The construction scope is summarized per building component.

Structure	The existing building is demolished in its entirety and replaced with a new 3 storey multiplex structure. Light framed wood walls and floors with plywood sheathing. Concrete foundations and footings. Concrete parking garage at the back of the lot. King post truss system assumed for roofs of both main building and garage.
Envelope	The existing building's roof and walls are demolished in its entirety. New building's exterior opaque walls are fibre cement siding, AV barrier, stonewall batt insulation and GWB interior surfaces. New windows are assumed to be double pane and vinyl framed. Asphalt shingles is assumed for roofing, with 8.5" batt insulation filling the truss cavity. Walls: RSI = 3.8, Roofs: RSI = 3.7, Fenestration: RSI = 0.5. (All RSI values are "effective") Air Leakage Rate: 1.5 L/s/m2 @ 75 Pa
Interiors	All existing interior partitions and finishes are demolished. New GWB and wood stud partition walls and all new interior finishes including paint, tile, and engineered wood flooring.
Mechanical and Electrical	All existing systems were replaced. Ductless VRF air source heat pumps in each room and ERV in each principal suite. Electric baseboard backup heating. All new electrical feeders, panels and fixtures. Refrigerant R32 is assumed for all systems.
Demolition	Complete demolition of existing building before commencing new construction.

Whole Life Carbon

For Scenario C, the whole life carbon profile is shaped by a spike in embodied carbon impacts that is driven by the demolition, and landfilling of the existing wood structure, the pouring of new concrete foundations, materials for the building's envelope and interiors and especially its updated HVAC systems. At the building's end-of-life, the embodied carbon is 725 kgCO2e/m2.

Carbon impact from the operational emissions is modelled as per current emissions factor of 0.015 kgCO2e/kWh, as per “Emissions Factors and Reference Values” published by the Government of Canada in October 2025. The cumulative OC intensity over 60 years for the Demolish and Replace scenario is even lower at 82 kgCO2e/m2, which makes up 10% of the cumulative WLC emissions intensity at 807 kgCO2e/m2.

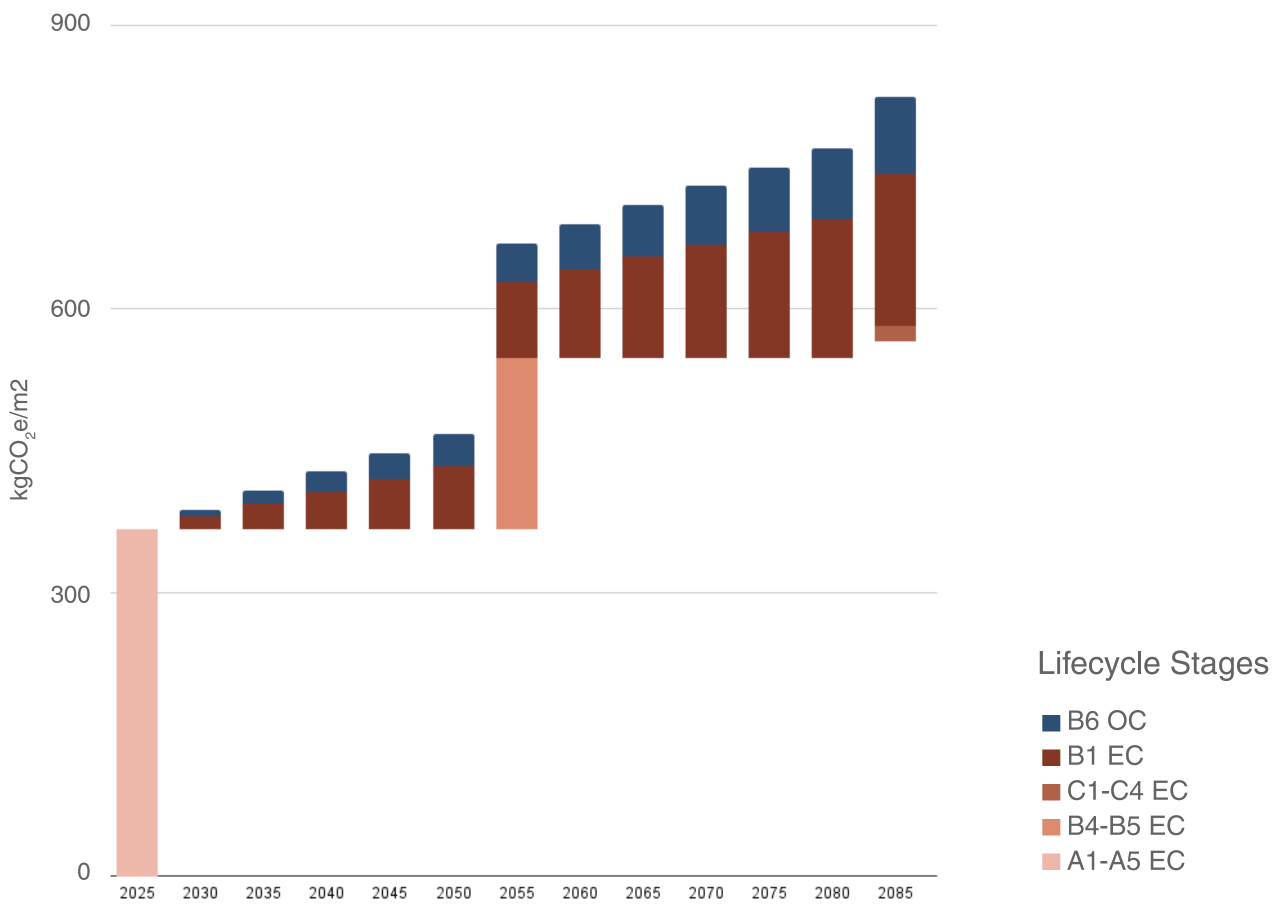


Figure 5.66. Whole Life Carbon graph for Vancouver Scenario C. Refer to Figure 3.1. for Lifecycle Stages.

Embodied Carbon Intensity by Component

The A-C embodied carbon intensity for Scenario C is 725 kgCO2e/m2. In the new building, as with Scenarios A and B, embodied carbon emissions are driven by new HVAC comprising ductless VRF systems with R32 refrigerant, which make up 50%. Building envelope, made up asphalt shingle roofs, and fibre cement clad walls with stone wool insulation have the next highest impacts on the embodied carbon. Due to the superstructure being wood, its EC impact is a lot lower than in case studies with concrete or steel structural frames.There is a slight increase in the percentage of demolition impacts, as we account for the release of the biogenic carbon stored in the existing building, as in a business as usual situation the demolished structure would be landfilled.

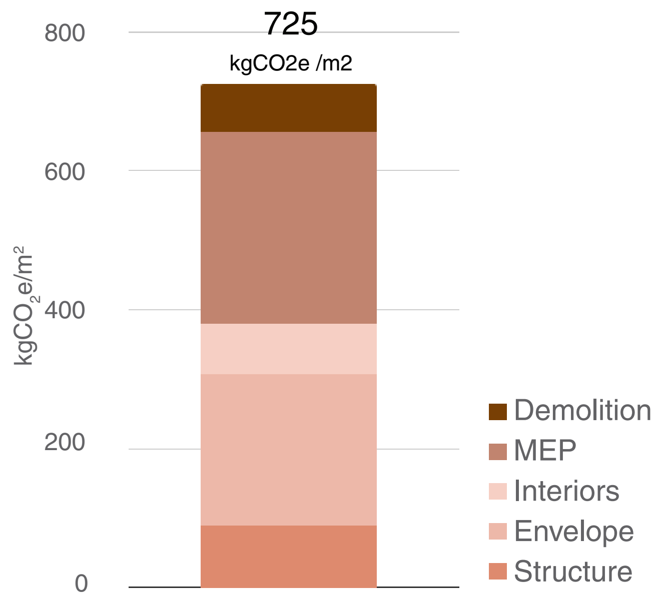


Figure 5.67. Embodied Carbon Intensity by Component for Vancouver Scenario C.

Operational Energy Use Breakdown

The energy use for the retrofit building and infill building considered together is 38 mWh/year which correlates to an annual operation carbon emission of 564 kgCO2e/year and an Energy Use Intensity of 1.37 kgCO2e/m2.year. The new building has a reduced envelope area to floor area ratio (Vfar) as compared to the Retrofit and Addition Scenario which is essentially 2 buildings. The impact of space heating is thus reduced to only 24% in this scenario, which is the same as equipment loads and slightly exceeded by the footprint of the Hot Water System at 26%.

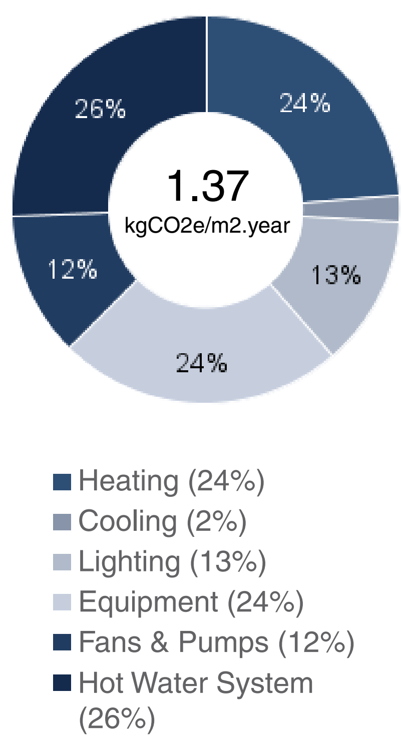


Figure 5.68. Operational Energy Use Breakdown for Vancouver Scenario C.

Upfront Cost of Construction

Contingencies and markups make up 31% of the total rate of construction cost which is $6,862 CAD/m2 for Scenario C. Material costs are concentrated in the all new structure, envelope and MEP systems, followed by costs associated with interior upgrades, demolition and site development.

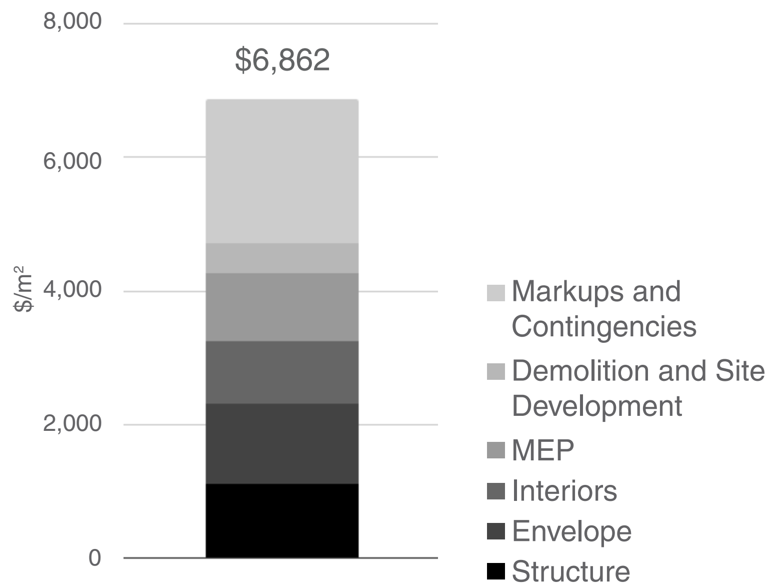


Figure 5.69. Rate of Upfront Construction Cost for Vancouver Scenario C.

Operational Costs Over 60 Years

The total cost of operations over a 60-year period for Scenario C is $17,209 CAD/m2. Costs associated with replacing parts of the building envelope, interiors and systems that will occur periodically make up 69% of the total. Costs associated with regular maintenance, servicing and repairs make up 14% of the operational cost, and the remaining 17% comprises inflation over 60 years. Operational carbon costs are minimal in comparison.

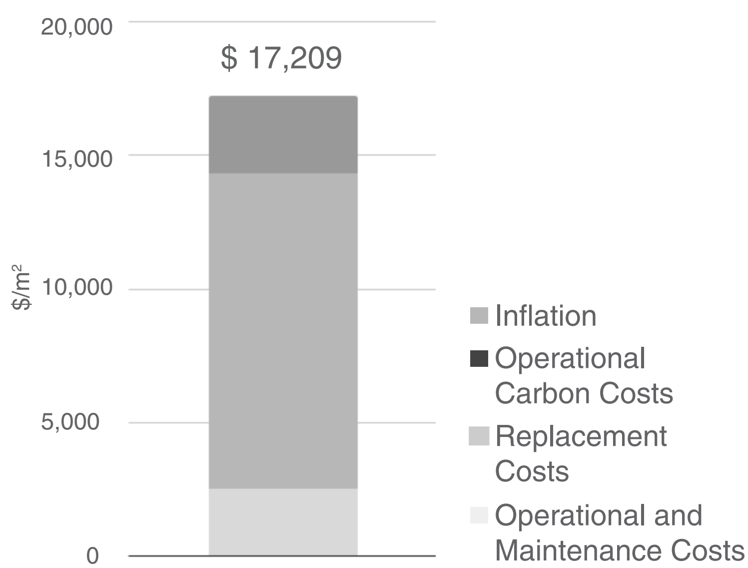


Figure 5.70. Operational Cost Over 60 Years for Vancouver Scenario C.

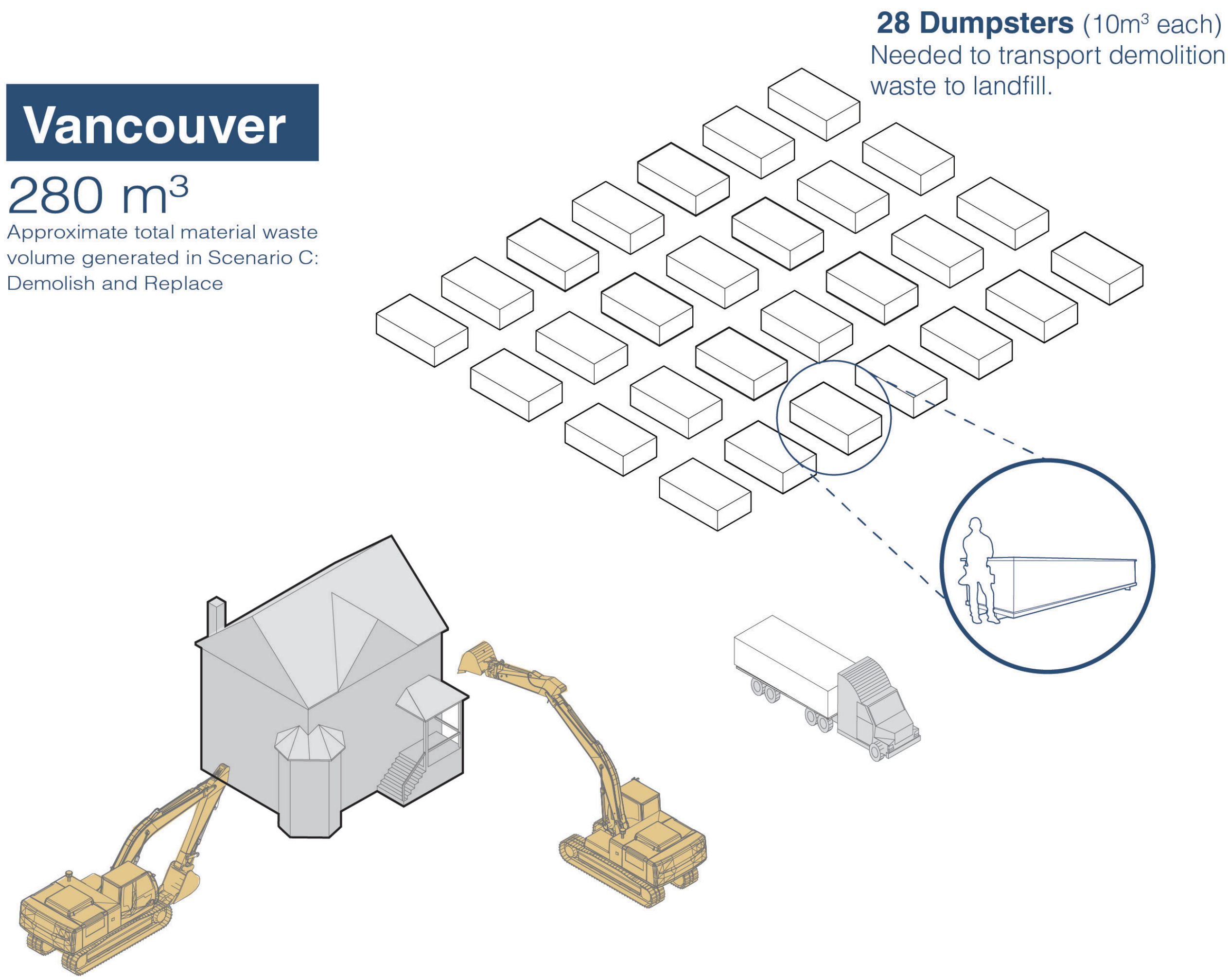


Figure 5.71. Demolishing the Vancouver house will generate roughly 280 m^3 of waste, enough to fill about 28 dumpsters (10 m^3 each) to be sent to a landfill.

06
Key Takeaways

By comparing whole life carbon profile, rate of upfront construction and operational costs results from all scenarios across the three case studies, the following key takeaways were formed:

Key Takeaways

- **The reuse of existing buildings adds density while saving carbon and cost**
- **Whole life carbon outcomes depend on local energy grids**
- **Clean energy grids shift focus to embodied carbon**
- **Retrofits deliver economic and carbon savings**
- **Expanded policy is needed for existing and heritage buildings**
- **Code for existing buildings must adapt to contextual differences**
- **Heritage conservation is a climate strategy**

The reuse of existing buildings adds density while saving carbon and cost

Adding density to an existing structure is one of the most carbon and cost-efficient strategies for development. By reusing the existing building fabric and foundations, the embodied carbon associated with new materials and demolition is significantly reduced. This approach makes use of the building's existing embodied energy while accommodating new functions or additional floor area within the same footprint. Construction costs are typically lower, as structural reuse minimizes excavation, and the use of concrete and steel. Avoiding site preparation and excavation also contributes to faster project timelines. Increasing density through adaptive reuse maximizes the value of serviced land, existing infrastructure, and urban investment—delivering both environmental and economic efficiency while extending the life of the building.

Whole life carbon outcomes depend on local energy grids

The energy grid in Halifax is approximately 60% reliant on fossil fuels, in contrast to the predominantly renewable grids of Montreal and Vancouver. This energy mix has a significant influence on whole life carbon outcomes. In Halifax, all scenarios, Retrofit, Retrofit and Addition, and Demolish and Replace, result in comparatively higher whole life carbon emissions, primarily due to the carbon intensity of the operational energy required over time. By comparison, Montreal and Vancouver benefit from low-carbon hydroelectric power, meaning that operational emissions over a 60-year building lifespan are minimal. In these cities, the majority of total carbon impact instead stems from embodied carbon—the emissions associated with material production, construction processes, and future replacements—highlighting the growing importance of material efficiency and reuse strategies in regions with clean energy grids.

Clean energy grids shift focus to embodied carbon

As energy grids become increasingly decarbonized through the shift to renewable energy sources, the relative importance of embodied carbon—the emissions from manufacturing, transporting, and assembling building materials—grows significantly. In this context, reducing operational emissions alone is no longer sufficient to meet climate targets. Retrofit and building reuse emerge as powerful strategies to mitigate embodied carbon impacts, as they retain much of the existing structure and materials, avoiding the emissions associated with demolition and new construction. By extending the life of existing buildings, reusing foundations, and minimizing the demand for carbon-intensive materials like concrete and steel, these approaches drastically reduce total lifecycle emissions. In contrast, demolition and new builds reset the carbon clock, generating large up-front emissions that can take decades to offset, even with a clean energy grid.

Retrofits deliver economic and carbon savings

The business case for retrofitting existing buildings—especially when adding density—is strong. Construction costs are lower because retrofits require less demolition, excavation, and fewer new materials. While operational costs over 60 years are modeled to be slightly lower for new buildings, these savings are outweighed by the much higher upfront construction expenses. Across all three case studies, the Demolish and Replace Scenario is consistently the most expensive overall. In contrast, the Retrofit and Addition Scenario delivers the best cost performance, balancing affordability with extended use of the existing structure. Retrofit-only projects also show costs comparable to, and often lower than, new construction. When combined with the substantial carbon savings achieved through material reuse, retrofits offer both economic and environmental advantages, making them the most desirable and sustainable development pathway.

Evidence from recent Canadian data shows job creation, local multipliers, equity, and heritage value are meaningful co-benefits that strengthen the retrofit case.

Expanded policy is needed for existing and heritage buildings

Delivery risks in retrofit and adaptive reuse projects can be reduced through stronger policy support for financing, skilled labour, and building codes that recognize the realities of existing buildings. In Canada, most code requirements are written for new construction, which creates a degree of uncertainty when adapting older structures. More flexible pathways for upgrades would give project teams greater confidence in their decisions. Improved access to grants or low-cost financing can ease financial pressure, particularly for community and non-profit developments. Expanding training opportunities also helps ensure contractors and trades can work safely and efficiently with older materials and complex site conditions. Together, these measures could make retrofit-focused densification more predictable and practical.

Code for existing buildings must adapt to contextual differences

Code for existing buildings must recognize and adapt to contextual differences, since retrofit choices depend on localized climate, energy systems, and construction practices. Across Canada, electricity grids vary widely in carbon intensity, meaning the whole-life carbon impact of upgrades can differ dramatically by region. Time also influences outcomes: as grids decarbonize and equipment is replaced, the carbon impact of envelope improvements, high-performance windows, and low-GWP refrigerants shifts. Costs follow similar patterns, changing with future energy prices, maintenance needs, and the durability of different systems. Local labour capacity and material availability further shape what solutions are practical or affordable. A code that accounts for these regional and temporal factors can guide upgrades that truly reduce emissions and manage costs, rather than applying uniform rules that are designed largely for new construction.

Heritage conservation is a climate strategy

Retention of existing buildings preserves cultural continuity and avoids demolition plus new build emissions, aligning conservation with affordability and resilience goals. Heritage conservation prioritizes the retention, repair, and adaptive reuse of existing buildings. Every historic structure embodies a vast amount of energy and carbon already invested in its materials, fabrication, and construction. When these buildings are maintained and upgraded rather than demolished and replaced, that embodied carbon is conserved, and the significant emissions associated with new construction are avoided. Extending the life cycle of existing structures aligns directly with circular economy principles, ensuring that material and cultural resources remain in use for generations.

Beyond material efficiency, heritage conservation sustains cultural continuity and social resilience. Historic buildings embody local knowledge about climate-responsive design (eg. passive ventilation, durable materials) while their conservation fosters community identity and adaptability. By integrating heritage conservation into carbon accounting and policy frameworks, we can recognize that conserving the past is also an investment in a low-carbon future.

07
Recommendations to NBC and NECB

To accelerate Canada's transition to climate-aligned retrofit practices, building codes must evolve to address the unique challenges and opportunities presented by existing and heritage buildings. This section is organized into three parts: Local Regulation and Code Enablers by Case Study, Alignments with Work Underway, and National Code and Policy Recommendations.

The first subsection highlights regulatory approaches identified as beneficial through the case studies. The second examines how these findings align with work already underway in Code Development Committees. The final subsection outlines additional recommendations for advancing building code updates across Canada.

7.1 Local Regulation and Code Enablers by Case Study

This subsection highlights local regulations and code enablers that have demonstrated a positive impact on the retrofit and adaptive reuse projects presented as case studies in this report. Each item reflects specific mechanisms such as zoning flexibilities or retrofit-focused pathways from provincial building or energy codes that helped reduce barriers, streamline processes, or improve outcomes for projects involving existing and heritage buildings.

Halifax (Nova Scotia)

Planning that rewards retention and compatible additions: Halifax's *Centre Plan* and downtown *Heritage Conservation District* guidelines encourage revitalization and compatible massing, allowing additional floors and adaptive reuse within heritage areas. These frameworks directly supported the viability of the Retrofit and Addition Scenario.

Provincial NBC adoption with retrofit flexibility: The *Nova Scotia Building Code Regulations* adopts the National Building Code of Canada (NBC) with localized provisions for alterations and changes of use. This provides a recognized compliance pathway for major renovations without defaulting to demolition.

Montréal (Québec)

Part 10 of the Québec Construction Code: Québec uniquely applies *Part 10 – Existing Buildings*, which defines proportionate requirements for repair, alteration, and change of occupancy. This provision legitimizes adaptive-reuse projects like Édifice Marconi and removes the need for full new-build compliance.

Energy-efficiency provisions for additions: *Chapter I.1 – Energy Efficiency* of the Québec Construction Code (NECB-based) establishes clear performance thresholds for additions to existing buildings. This clarity supported modelling of Retrofit and Addition Scenarios using consistent and achievable standards.

Vancouver (British Columbia)

VBBL Part 11 – Existing Buildings: The *Vancouver Building By-law* includes tailored upgrade triggers and defines acceptable performance objectives related to life safety, fire protection, health, and energy. It enables proportionate, risk-based compliance for retrofits, allowing heritage buildings to meet intent without requiring full reconstruction.

Energy and emissions requirements for alterations: *Section 11.7* of the VBBL sets explicit energy and emissions requirements for building alterations. These provisions guide retrofit projects toward measurable performance improvements while accommodating existing-building constraints.

Cross-Cutting National Context

NECB 2020 scope: The *National Energy Code of Canada for Buildings (2020)* applies to new construction and additions, but not to existing buildings. Provincial and municipal frameworks such as Québec Part 10 and Vancouver Part 11 bridge this gap, demonstrating viable models for a future national *Retrofit Code* or *Existing Buildings Part* that could standardize proportional compliance across Canada.

7.2 Alignments with Work Underway

This subsection outlines alignments between the findings of this study with work already underway through committees and organizations across the country, including the Canadian Board for Harmonized Construction Codes and Heritage BC. These committees are actively working to streamline the relationship between the National Model Codes and provincial regulations, and developing new code provisions that better respond to emerging and established needs for existing buildings across Canada. These ongoing efforts complement or form part of many of the recommendations in this report, emphasizing the essentiality of this work toward more consistent, flexible, and retrofit-supportive building codes. A summary of key ongoing initiatives is presented below.

National Model Codes Committee on Harmonization of Alteration of Existing Buildings

The National Model Codes Committee (NMCC) on Harmonization of Alteration of Existing Buildings – as well as the committees described below – is established by, and reports to the Canadian Board for Harmonized Construction Codes (CBHCC). Where presently the National Building Code does not contain clear, holistic code requirements for existing buildings, this Committee is mandated to expand and harmonize provisions for alterations to existing buildings within the National Model Codes, replacing the patchwork of regulations introduced across the country. This includes updating and introducing Part 10 of the National Building Code of Canada (NBC), expanding Part 13 of the National Energy Code for Buildings (NECB), and introducing a new section in the National Plumbing Code (NPC). These new Parts are like the provincial Parts 10 and 11 described as enablers for adaptive reuse as described in this section. The committee's work focuses on integrating relevant provincial and territorial requirements including those related to fire protection, accessibility, egress, change of use, structural and seismic design, and housing and small buildings into a consistent national framework.

National Model Codes Committee on Indoor Environment

The National Model Codes Committee on Indoor Environment is tasked with strengthening and harmonizing provisions that safeguard indoor environmental quality in both new and existing buildings. Its mandate focuses on mitigating risks such as radon ingress, legionella in water systems, and the transmission of aerosol pathogens by enhancing requirements for HVAC and plumbing system design across the National Model Codes. The committee is charged with developing code changes that improve ventilation performance, address air quality challenges resulting from increased airtightness, and enhance protective measures in care and treatment occupancies. These mandates generally align with the work of this report, recognizing that most mechanical and electrical systems are extensively modified or replaced in an adaptive reuse project.

National Model Codes Committee on Climate Change Mitigation

The National Model Codes Committee on Climate Change Mitigation is tasked with advancing and harmonizing requirements in the National Model Codes to reduce both operational and embodied greenhouse gas emissions from new and existing buildings. Its mandate encompasses updating energy and emissions-related provisions across the National Building Code of Canada and energy codes, as well as developing new requirements where gaps exist. Key mandates which align with the work of this report include developing approaches to minimize embodied emissions for Part 3 and Part 9 buildings, as well as implicit reduction in embodied emissions through the creation of new compliance paths for alterations to existing buildings for energy efficiency and GHG emissions.

National Model Codes Committee on Fire and Life Safety

This committee is responsible for advancing updates to the National Model Codes that address fire protection and life-safety provisions for both new and existing buildings. Its mandate includes addressing fire-safety barriers that currently limit energy-retrofit measures in existing Part 9 buildings, such as the addition of exterior insulation, reduced limiting distances, and the use of spray foam to improve thermal performance. The committee is also tasked with developing national technical requirements for emerging technologies and building practices that affect both new construction and retrofits, including encapsulated mass timber construction, energy storage systems, and electric vehicle charging infrastructure.

National Model Codes Committee on Housing Supply

The National Model Codes Committee on Housing Supply is tasked with advancing code provisions that support emerging housing solutions. Its work on building relocation aligns closely with the objectives of this report by addressing regulatory gaps that affect the safe and consistent reuse of existing structures. The Committee's mandate includes developing definitions and technical requirements for relocated buildings such as fire protection, structural performance, and energy efficiency, and identifying enforcement and coordination needs to ensure these provisions integrate effectively with the National Building Code.

National Model Codes Committee on Referenced Documents

This committee is responsible for reviewing and maintaining the standards and documents referenced in the National Model Codes. Its mandate includes assessing proposed changes to new and existing referenced documents, identifying and resolving conflicts in coordination with other NMCCs, and recommending replacements for superseded or withdrawn standards. The Committee also reviews referenced documents proposed for inclusion, develops code change proposals where appropriate, and considers impacts, enforcement implications, and provincial/territorial variations. Through this committee's work and collaboration with other committees, there is potential to adopt existing documents which are already in use elsewhere, or informally, which can act as enablers for further reuse of existing buildings.

Heritage BC

Between 2020 and 2022, Heritage BC wrote a series of letters to the Building and Safety Standards Branch, which include recommendations for changes at the provincial level through the British Columbia Building Code.

The recommendations included in these letters were developed through consultation with industry professionals including architects, engineers and heritage consultants, and are specific to the challenges faced in the context of heritage buildings and full building code compliance. Some of the recommendations included in these letters underpin recommendations included within this section.

7.3 National Building Code Recommendations

In light of the ongoing work related to this study and informed by the barriers and opportunities highlighted across the case studies in this report, the following recommendations outline proposed changes to the National Building Codes and related policies. Taken together, these recommendations are intended to serve as key enablers for climate-aligned retrofit practices across Canada, as they are adopted by the Provinces and Territories.

A. Code Structure and Scope

- Create consolidated, dedicated Retrofit and Reuse Parts within the NBC and NECB that provide alternative compliance paths for existing and heritage buildings, based on proportional performance improvements rather than full prescriptive compliance.
- Clearly define existing buildings and heritage buildings within the NBC and NECB as related but distinct categories, with characteristics that warrant separate and appropriately tailored compliance pathways.
- Introduce heritage-sensitive provisions or equivalencies that allow retention of character-defining elements while achieving equivalent performance through compensatory measures.
  Establish building reuse and renovation as explicit objectives of the National Building Code, with corresponding Objectives and Functional Statements that support and enable the reuse of existing buildings.
- Establish heritage conservation as an explicit objective of the National Building Code. Develop corresponding Objectives and Functional Statements that align with the Standards and Guidelines for the Conservation of Historic Places in Canada.
- Allow for innovative solutions that can be demonstrated to achieve the intended performance of a code requirement, without limiting compliance to standard prescriptive, off-the-shelf approaches.

B. Energy and Carbon Performance

- Adopt a Whole-Life Carbon (WLC) metric in parallel with energy metrics, requiring the reporting of both embodied and operational carbon at major permit stages.
- Define embodied-carbon accounting protocols aligned with ISO 21930 and EN 15978 to ensure consistency across retrofit projects.
- Enable performance-based energy compliance for retrofits using calibrated energy models, post-occupancy verification, and metered-savings approaches.
- Establish energy-intensity benchmarks for existing buildings with tiered targets for envelope upgrades, electrification, and mechanical system retrofits.
- Mandate commissioning and measurement & verification (M&V) for major retrofits, including seasonal tuning and sub-metering, to confirm that modelled and actual performance align.
- Set refrigerant Global Warming Potential (GWP) thresholds and require leak testing, maintenance documentation, and equipment labelling for all HVAC systems.
- Incentivize electrification of existing systems through tariff structures, retrofit-ready service upgrades, and standardized cost-recovery mechanisms.

C. Circularity, Material Reuse and Repair

- Integrate deconstruction and reuse provisions requiring pre-demolition audits, salvage plans, and minimum diversion rates for major projects.
- Recognize reuse credits within future Retrofit and Reuse Parts or permitting frameworks to reward verified recovery and on-site reintegration of materials.
- Allow, to an appropriate degree, for the repair of building components in accordance with best practices, including the replacement of elements when original fabric cannot be effectively repaired.
- Provide for the recognition and documentation of existing building material performance, including the development of resources such as a database detailing the characteristics and aged performance of older insulation, wood structural members and other legacy materials.
- Acknowledge, within codes and supporting guidance, that properly identified legacy building materials may possess performance characteristics that exceed those of certain contemporary materials, and provide for their appropriate recognition and continued use.

D. Equity, Capacity, and Implementation

- Embed equity conditions within incentive programs to ensure benefits reach lower-income, non-profit, and heritage housing sectors while preventing displacement.
- Invest in workforce development to expand expertise in envelope diagnostics, electrification, deconstruction, and heritage craft trades.
- Align finance and policy tools—green loans, retrofit tax credits, and density or parking relief—with lifecycle carbon performance outcomes and verified operational savings.
- Promote targeted education and training for Authorities Having Jurisdiction, code experts, municipal permitting staff, and related professionals on historic building assemblies and legacy materials to support informed and consistent decision-making.
- Require public disclosure of whole-building energy and carbon data to enable transparency, benchmarking, and continuous improvement across jurisdictions.
- Develop or adopt and issue formal guidance for the assessment of existing buildings that is distinct from standards intended for new construction. This guidance should address the evaluation of existing and heritage materials and structural systems that remain in service and exhibit no signs of distress, ensuring that practitioners have consistent, nationally aligned methods for determining their structural capacity without relying on informally recognized external or foreign codes.

E. Life Safety

- Ensure that all requirements and exemptions applicable to Existing and Heritage Buildings uphold an acceptable standard of life safety while also enabling the retention and conservation of heritage building fabric.
- Clarify that all upgrade requirements for Existing and Heritage Buildings are to be governed by the Retrofit and Reuse Parts of the Building Code, and that Part 3 applies solely to new construction.
- Provide authoritative information on the performance of historic fire-rated assemblies and materials that continue to function effectively but lack formal fire-resistance ratings due to the absence of contemporary testing or available documentation. This should include making out-of-print or archival resources accessible to support accurate assessment of these legacy assemblies.

F. Heritage Conservation

- Incorporate the Standards and Guidelines for the Conservation of Historic Places in Canada (Parks Canada, 2010) and Building Resilience: Practical Guidelines for the Sustainable Rehabilitation of Buildings in Canada (2016) as referenced documents within the National Building Code.
- Allow, to an appropriate degree, for exemptions to retrofit performance requirements on a case-by-case evaluation of Heritage Buildings in order to balance energy performance objectives with the conservation of historic building fabric.
- Corresponding to the distinction for heritage buildings, clarify that conservation work including preservation, restoration, rehabilitation, and the repair of heritage elements does not trigger full compliance with Part 3.
- Allow, to an appropriate degree, for the repair of heritage building components in accordance with best practices outlined in the *Standards and Guidelines for the Conservation of Historic Places in Canada*, including the in-kind replacement or reconstruction of elements when original fabric cannot be repaired.

7.4 Local Policy Recommendations

Municipalities should use zoning, planning, and financial tools to reduce barriers and improve the feasibility of building reuse. Flexible zoning, expedited permitting, and incentives such as density bonuses or tax relief can help support adaptive reuse and retrofit projects.
Because retention and reuse projects often face the perception of high upfront costs and limited financial returns, municipalities should also deploy targeted financial mechanisms such as tax increment grants or similar incentives to offset early-stage expenses. Research shows that traditional ROI models often overlook non-energy benefits, underscoring the need for municipal policies that strengthen the business case for reuse.

7.5 Conclusion

The research undertaken in this project provides examples of how existing and heritage buildings interact with Canada's current building and energy codes, and how upcoming retrofit codes can more effectively support their reuse. Through whole-life carbon analyses of three case studies, the research highlights the significant value of retaining and upgrading existing buildings both in terms of embodied carbon savings and the broader benefits associated with conservation and adaptive reuse. The examples examined here also demonstrate that several municipal and provincial models already provide workable pathways for retrofits, offering practical precedents for national adoption.

The findings of this report point to a clear need for coordinated, retrofit-focused code development that reflects the realities of existing buildings and enables compliance. Doing so will not only help unlock the carbon, cultural, and economic value of Canada's existing building stock, but will also build capacity and support market readiness for the next generation of national building and energy codes. As Canada moves toward more ambitious climate and housing goals, existing buildings must be recognized as essential assets, with retrofit codes and policy as critical tools.

Appendices

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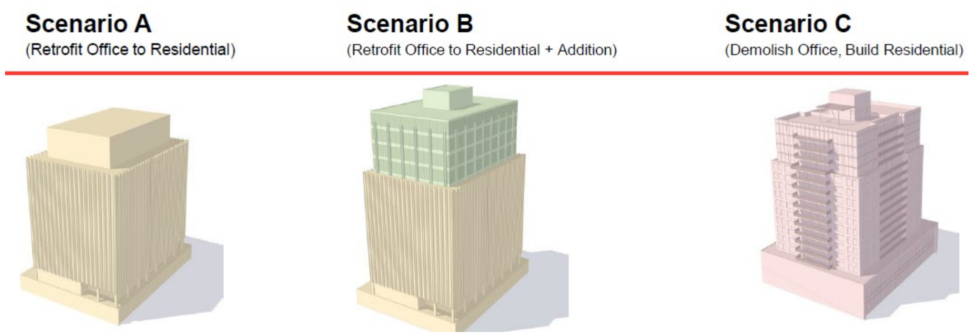
B - Costing Reports

CAHP Existing Heritage Buildings, Carbon & Building Code Study - Case Study 1 - Halifax

Order of Magnitude Estimate (Rev.2)



Prepared for:

Giaimo

Prepared by:

A.W. HOOKER®
QUANTITY SURVEYORS

2904 South Sheridan Way, Suite 202
Oakville, ON L6J 7L7
T 905.823.8111

info@awhooker.com
www.awhooker.com

November 19, 2025

A.W. HOOKER®
QUANTITY SURVEYORS
2904 South Sheridan Way,
Suite 202, Oakville, ON, L6J 7L7
T 905.823.8111
info@awhooker.com
www.awhooker.com

THE PEOPLE | THE DIFFERENCE®

November 19, 2025

Giaimo
213 Sterling Road, Unit 204
Toronto, ON M6R 2B2

Re: CAHP Existing Heritage Buildings – Case Study 1 – Halifax (R.2)

Dear Giaimo,

Please find enclosed our Order of Magnitude Estimate for the above project. The estimate is based on design drawings and information provided by Giaimo received on April 17, 2025. The latest report reflects updates based on meeting discussions, as well as additional information shared throughout those sessions.

This estimate is meant to reflect the fair market value for the construction of this project; it is not intended to be the prediction of the lowest bid and should be representative of the median bid amount received in a competitive bidding scenario.

We recommend that the owner and/or the design team carefully review the cost estimate report, including line item descriptions, unit price clarifications, exclusions, inclusions and assumptions, contingencies, escalation, and mark-ups. This is to ensure that the design intent is captured within the content of the report.

Please refer to the preamble of our cost report for all exclusions, assumptions, and information pertaining to the estimate.

Requests for modifications of any apparent errors or omissions to this document must be made to A.W. Hooker Associates Ltd. within ten (10) business days of receipt of this estimate. Otherwise, it will be understood that the contents in this estimate have been concurred with and accepted as final version of the cost report.

We trust our work will assist in the decision making process and look forward to our continued involvement in this important project.

Sincerely,
A.W. Hooker Associates Ltd.

Weger Barwari, PQS, C.Tech
Associate

Sincerely,
A.W. Hooker Associates Ltd

Bineesh Susamma, PMP, PQS
Associate (Mechanical)

Encl. (OM Estimate – Case Study 1, Scenario A, B, C & 0 (R,2) – November 19, 2025)

Table of Contents

1. Introduction to the Estimate

1.1 Project Description

This project involves research, developing capacity-building resources, and disseminating findings to prepare Canadian markets for the future release and prompt adoption of retrofit codes for three (3) building case studies (Halifax, Montreal and Vancouver). AWH role is to determine the full building cost for each of the three scenarios, a high-level cost for the existing building condition, a

The carbon analysis will include three (3) scenarios:
1. Scenario 1: adaptive reuse renovation (no addition)
2. Scenario 2: adaptive reuse renovation (with addition)
3. Scenario 3: demolition and replacement with new building

An additional scenario as been provided for current market valuation of existing building.

1.2 Type of Estimate

This Order of Magnitude Estimate is intended to establish a realistic elemental estimate of the hard construction costs based on the level of design information provided. Detailed quantities have been measured from drawings where possible for the proposed building and associated site development. This estimate reflects our opinion as to the fair market value for the hard construction of this project.

The accuracy of the estimate is based on the documentation provided and design stage is intended to be +/- 30%-100%. This accuracy is based on the definition for Estimate Classifications (Class D) outlined in the *Guide to Cost Predictability in Construction prepared by the Joint Federal Government & an Industry Cost Predictability Taskforce. Contingencies are included to offset the accuracy risk, to the extent that the estimated amount represents the current opinion of the likely fair market value at the time of tender.

The intention of the estimate is not to predict the low bid price received; typically based on historical tender results estimates are more likely to be towards the median value of bids received under competitive conditions as per common practice based CIQS guidelines. This is a deliberate methodology due to the inherent risk in attempting to predict the low bid and numerous factors which can contribute to lower than anticipated tender submissions which are beyond our control.

Cost Estimate Classification Systems					
AACE *(1)	Class 5	Class 4	Class 3	Class 2	Class 1
DND *(2)			Indicative	Substantive	
RAIC*(3)	OME	Sketch Design	Design Development	Contract Documents	Tender Documents
GOC *(4)	OME	D	C	B	A
Design Documentation % Complete					
		12.5%	25.0%	95.0%	100.0%
Cost Estimate Accuracy (+ or - Percentage)					
	+/- 30%-100%	+/- 20%-30%	+/- 15%-20%	+/- 10%-15%	+/- 5%-10%

Legend
***(1)** AACE Association for the Advancement Of Cost Engineering
***(2)** OND Department of National Defense
***(3)** RAIC Royal Architectural Institute Of Canada
***(4)** GOC Government

*Reference: https://cacqs.ca/wp-content/uploads/2024/10/best-practices-guide-2024.pdf

2. Basis of the Estimate

2.1 General Information

From the design information provided, we have measured quantities where possible and applied typical unit rates for each of the specific elements based on the project specifications. Where specific design information has not been provided, unit rates are based on historical cost data for this type of project. In some instances where design information is limited, we have made reasonable assumptions based on our experience with projects of a similar scope and design. Estimates for mechanical and electrical systems are developed based on information prepared by the project engineers, historical projects and experience.

Significant changes to the basis of design will impact the estimate value; this is particularly critical where changes are made after the final estimate prior to tender. We recommend that all major design or scope changes be reviewed for their cost, time and constructability impact prior to incorporation in a finalized tender package.

2.2 Location Cost Base

The location cost base for this estimate is Halifax, NS.

2.3 Unit Rates

The unit rates in the preparation of the elemental estimate include labour and material, equipment, and subcontractors overheads and profits. We have assumed for pricing purposes that union contractors would perform the work. We have assumed the fair wage policy would be in effect. The unit rates for each of the elements are based on typical mid-range costs for the type of design, construction, and materials proposed.

Unit rates in all estimates combine the material, labour, and equipment components for a single unit cost for ease of presentation. This estimate is not a prediction of low bid. Pricing assumes competitive bidding for every aspect of the work.

2.4 Taxes

Harmonized Sales Tax (HST) is excluded from our estimate.

2.5 Construction Schedule

The estimate has been prepared on the assumption that the work will be performed within the timelines of a normal construction schedule. The duration of the schedule would be based on the work being performed during regular daytime work hours. We have assumed the structural components of the building would be constructed in predominantly non-winter months. No allowances have been included for premium time and after hours work associated with an accelerated construction schedule.

2.6 General Requirements and Fees

The General Requirements for the General Contractor are included as a percentage of the hard construction cost. This estimate of the prime contractor's site overheads includes site supervision and labour, access to the site, site accommodations, site protection, temporary utilities, clean up, equipment, and other miscellaneous project requirements provided by the General Contractor.

The Fee element of the estimate is meant to cover the General Contractor's fee to perform the work. The fee would be based on the competitive nature of the bidding process and the market conditions at the time of tender.

2.7 Bonding and Insurance

We have included the median estimated costs for 50% Performance, 50% Labour and Materials. These are the traditional bonding requirements commonly requested by the owner. The actual final bonding costs will vary depending on the selected contractors' performance history.

The estimate includes an allowance for general liability and builder's risk insurance based on an average cost per $1,000 of estimated hard construction costs. The actual insurance costs would be subject to the insurance requirements for the project.

2.8 Procurement

It was assumed for the preparation of this estimate that the project would be tendered to a prequalified list of bidders with a project specific lump sum contract. Pricing is based on competitive tender results with a minimum of four (preferably six tender submissions) at General Contractor's and major trade level. Pre-qualification with a restrictive list of contractors or subcontractors may result in a higher tendered cost due to the inherent reduction in competitiveness. Tenders receiving two or less submissions (occasionally three) historically tend to have a much higher risk of an overrun in cost when compared to the budget established in an estimate. Ensuring adequate bonafide bidders is a prerequisite for competitive bidding scenarios, on which the estimate is predicated.

2.9 Specifications

Where detailed and comprehensive specifications are unavailable, we have assumed that no onerous special requirements will be applicable to this project. It was assumed that all materials and equipment could be substituted with an alternative product to avoid sole-sourcing which results in a non-competitive market condition.

2.10 Soft Costs

The estimated soft costs have been excluded in this estimate.

These costs include items traditionally funded by the owner and separate from the hard construction costs which would be applicable to the contractor. The soft costs include items such as consultant fees; disbursements; project management fees; independent inspection and testing; third party commissioning; legal fees; permits and development charges; operational and moving expenses; financing and loan fees; owner supplied furnishings, fixtures, and equipment; land acquisition costs; and Harmonized Sales Tax.

2.11 Life Cycle Costing Assessment (LCCA)

As part of the study, we have also been tasked with preparing a high-level Life Cycle Cost Assessment (LCCA) for each scenario. This assessment evaluates the total cost of ownership over a 60-year period, encompassing initial capital, operational energy cost, maintenance, replacement, and operational carbon costs. All costs are presented in Net Present Value (NPV) terms, calculated based on assumptions and parameters mutually agreed upon by the client, design team, and engineering consultants.

- 4% Capital inflation
- 2% Energy Inflation

The costing framework is informed by the following reference documents:

- ASHRAE Guidelines
- WSP Building Envelope Renewal Cycle
- WSP Building Structure Renewal Cycle
- Environment and Climate Change Canada (ECCC) Data Catalogue
- Various other publications and manufacture recommendations

3. Contingencies

3.1 Design and Pricing Contingency

A design and pricing contingency has been included in the estimate as a percentage of the hard construction costs including the general requirements and fees. This contingency is meant to cover design and pricing unknowns in the preparation of this estimate and reflect the incomplete nature of the design information provided at the time the estimate is prepared.

The estimate includes the following design and pricing contingencies by discipline:

Design Contingencies		
Architectural	-	20%
Structural	-	20%
Mechanical	-	20%
Electrical	-	20%
Siteworks	-	20%

The contingency where included in our estimate is not meant to cover significant additional program space or quality modifications, but rather to provide some flexibility as the design develops. The design contingency typically decreases as the design progresses and more definition and detail is available to refine the basis of the cost estimate. If the owner anticipates significant changes to the basis of design we recommend additional contingency be retained as a reserve for the scope modifications.

3.2 Escalation Contingency

The estimate excludes an allowance for escalation. This allowance, when included, is meant to provide for increases in construction costs due to changes in market conditions between the time of the estimate and the potential construction commencement. For projects with a schedule in excess of 12 months, the contingency is based on a timeframe that takes escalation to the midpoint of the construction phase.

Escalation during construction is included in the unit rates; essentially this allowance is the risk carried by the general contractor and trades with a fixed price made years before the work is completed or carried out for some trades.

3.3 Construction Contingency (Post Contract Changes)

The estimate includes a contingency for the construction phase of the project. This contingency is meant to cover the potential cost of post contract changes that may occur after the project is tendered.

The following allowances are to provide for increases in construction costs due to Change Orders issued during construction.

Case study 1 - Halifax
Scenario A: 10%
Scenario B: 7.5%
Scenario C: 5%
Existing Building: 5%

This contingency excludes any major program or scope requests by the client; these should form part of an overall project management reserve or be reflected in increased funding

4. General Liability

4.1 Statement of Probable Costs

A.W. Hooker Associates Ltd. (HOOKER) has no control over the cost of labour and materials, the general contractors or any subcontractors' methods of determining prices, or competitive bidding and market conditions. This opinion of probable cost of construction is based on the experience, qualifications, and best judgment of the professional consultant familiar with the construction industry. HOOKER does not warranty that proposals or actual construction costs will not vary from this or subsequent estimates.

4.2 Ongoing Cost Control

A.W. Hooker Associates Ltd. recommends that the owner and/or the design team carefully review the cost estimate report, including line item descriptions, unit price clarifications, exclusions, inclusions and assumptions, contingencies, escalation, and mark-ups. This is to ensure that the design intent is captured within the content of the report. This is especially important at early stage estimates which tend to be based on a lesser level of design completion.

If the project is over budget or there are unresolved budget issues, alternative systems or schemes should ideally be evaluated before proceeding with the design phase. We recommend that cost control be implemented throughout the various stages of the design process to ensure the proposed design remains within the overall budget. It is recommended that the final estimate be produced by HOOKER using Bid Documents to determine overall cost changes, which may have occurred since the preparation of this estimate. The final update estimate will address changes and additions to the documents as well as addenda issued during the bidding process. HOOKER cannot reconcile bid results to any estimate not produced from bid documents including all addenda.

5. Estimate Scope Clarifications

5.1 List of Exclusions

1. Harmonized Sales Tax (HST)
2. Project Soft Costs (as described in item 2.10 above)
3. Furniture, furnishings, and equipment (except as noted in the estimate)
4. Premium time / after hours work
5. Accelerated construction schedule
6. Abatement and handling of asbestos and other hazardous materials
7. Handling and removal of contaminated soils
8. Special foundation systems such as caissons or pile foundations
9. Premium for construction management or alternate approaches to procurement
10. Sole sourced equipment or control systems
11. Consumption costs for any utilities used during construction (gas, water, hydro etc.)
12. Tariffs and risks of potential additional tariffs due to geopolitical uncertainty

5.2 List of Assumptions

Architectural / Structural / Landscaping:

1. The existing soils on the site are adequate to support standard strip and pad foundations to the minimum depth required for frost. No allowances have been made for larger or special foundations such as caissons or piles due to poor soil conditions.
2. The existing site is relatively flat and the finished floor and site elevations were set to work with the existing grades to avoid major cut and fill.
3. We have assumed the majority of the work to be performed during regular day shifts (unrestricted access to the building during the hours of 8AM to 6 PM Monday to Friday).

4. Contractor will clean up daily to general housekeeping standards.
5. Work is assumed to be completed in one continuous phase.
6. We have assumed the relocation of any existing loose furniture and equipment prior to demolition (chairs, tables, desks, filing cabinets, machinery etc.) is to be by Owner.
7. Foundation:
    a. Scenario A: minor reinforcement of existing foundation including patch and repair to existing SOG.
    b. Scenario B: minor reinforcement of existing foundation including patch and repair to existing SOG.
    c. Scenario C: new shallow foundation including strip footings, walls, pier and pad footings assumed 2 months dewatering, 4 months winter heating.
8. Upper Floor & Roof Construction:
    a. Scenario A: allowance for patch and repair to existing structure, spray fireproofing to upper floor structure, new stairs and elevators.
    b. Scenario B: allowance for patch and repair to existing roof structure which is to be converted into upper floor, new structural steel roof, spray fireproofing to upper floor structure, new stairs and elevators.
    c. Scenario C: structural steel upper floor and roof construction, spray fireproofing to upper floor structure, stairs and elevators.
9. Exterior Enclosure:
    a. Scenario A: cleaning of existing granite masonry, existing aluminum framed windows and spandrels to be replaced.
    b. Scenario B: cleaning of existing granite masonry, existing aluminum framed windows and spandrels to be replaced. Aluminum composite panels at new penthouse levels.
    c. Scenario C: precast cladding, aluminum composite panels, aluminum framed curtainwall, windows and spandrels.
10. Door count and type are assumed based on as-built drawings, location and count for barrier free operator is assumed. Bollards included at overhead doors.
11. New 2 ply mod bit roofing for all three scenarios.
12. New terrace included for all three scenarios.
13. New balconies, sliding doors and glass railing for scenario C.
14. An allowance has been included for building signage.
15. Interior partitions: Combination of CMU, gypsum board, and aluminum glazed screens.
16. Floor Finishes: combination of porcelain, ceramic tiles, carpet, resilient sheet flooring, wood flooring, rubber sport flooring, and concrete sealer
17. Ceiling Finishes: combination of suspended gypsum board, act, baffle ceiling and paint to exposed structure.
18. Wall Finishes: combination of paint finish, ceramic tiles.
19. An allowance had been included for gypsum board bulkheads.
20. An allowance has been included for miscellaneous steel.
21. We have included an allowance for millwork cabinetry.
22. An allowance has been included for two (4) passenger elevators and one (1) service elevator.
23. We have included allowances for site preparation work, hard landscape, site improvements, and soft landscape works.
24. Demolition:
    a. Scenario A: full gut of interior scope with exception of core structure (stairs and elevators), exterior doors, windows and curtain wall.
    b. Scenario B: full gut of interior scope with exception of core structure (stairs and elevators), exterior doors, windows and curtain wall.
    c. Scenario C: demolish and dispose of the existing building.

Mechanical:

25. Work will be conducted by union or fair wage contractors.
26. The estimate includes upgrades to the existing mechanical site services, assuming that all services will be upsized for each option, except for storm drainage, which is assumed to be reused.
27. The estimate includes repurposing the existing building storm drainage system for Scenarios A and B, while a full new system is included only for Scenario C.
28. The estimate assumes booster pumps for domestic water and fire water services for all scenarios.

29. The estimate assumes PEX piping within individual suites for domestic water services and hydronic services associated with the hybrid VRF system (scenario 1). All piping outside the suites, including risers, and corridor/common areas, is assumed to be Copper Type L or ACR pipe, as applicable.
30. The estimate includes modifications to fire sprinkler and fire hose coverage for Scenarios A and B to accommodate the retrofit scope, and new services for Scenario C.
31. Scenario A includes POU in-suite water heaters, while Scenarios B and C include central systems.
32. Electric heating is generally assumed for all heating applications, and natural gas service is not required for any scenario.
33. The central ventilation unit is an ASHP RTU mixed-air system with electric backup heating, and no ERV is included in any scenario.
34. An allowance for a hybrid VRF system has been included as a placeholder only (scenario A), as no reference installations are available and no supplier quotes were obtained from past projects.
35. The estimate includes electric heaters for the common area heating.
36. Stand alone and in-suite thermostatic control are included for all scenarios.
37. Third party tests, certifications etc. are excluded.
38. Please see our back up estimates for the various assumptions we have considered.

Electrical:

39. Work will be performed by unionized labor during regular hours.
40. Dimmable LED lighting will be provided throughout and controlled via central low voltage lighting control system.
41. A new addressable fire alarm system in new building and replacing existing fire alarm system in existing building have been included in the estimate.
42. Supply and installation of security system has been included in the estimate.
43. Supply and installation of AV system has been excluded from the estimate.
44. Refer to estimate for additional scope specific assumptions.

General:

45. Various assumptions have been made based on the design information available and our experience with projects of a similar nature. Please refer to the specific items within the estimate for the detailed assumptions made.

6. Documentation Received

Drawings and design documentation were prepared by Giaimo:

Pages	Documentation	Documentation Received
	1660 Hollis CIB Energy Model Report	April 17, 2025
	1660 Hollis Developments - IFC Drawings Package (Arch, Elect, Mech, and Struct Inc.)	August 14, 2025
	1660 Hollis_Embodied Carbon Summary_FINAL	April 17, 2025
	CAHP Case Studies Summary_Halifax.2025-07-10	July 30, 2025
	Door Sch (Marked)	August 19, 2025
	Halifax_BOQ	July 30, 2025
	Emails	Various

A.W. HOOKER ®
QUANTITY SURVEYORS

MULTIPLE ESTIMATE SUMMARY

CAHP - CASE STUDY 1 - HALIFAX

OM ESTIMATE (Rev.2)
NOVEMBER 19, 2025

Hard Construction Costs		Scenario A		Scenario B		Scenario C		Current Market Valuation of Existing Building
1 Sub-Structure		$318,000		$318,000		$1,966,027		$8,847,120
2 Structure		$675,350		$9,597,800		$16,678,925		$16,378,358
3 Exterior Enclosure		$9,025,682		$13,264,514		$14,449,684		$14,189,290
4 Interiors		$22,156,706		$27,347,924		$22,652,709		$22,156,706
5 Mechanical		$12,726,660		$14,757,510		$13,984,665		$12,359,386
6 Electrical		$5,831,615		$7,141,490		$5,772,967		$5,102,040
7 Site Development		$35,000		$150,000		$489,680		$489,680
8 Mechanical Site Services		$118,000		$118,000		$118,000		$118,000
9 Electrical Site Services		$199,934		$223,658		$199,934		$199,934
10 Demolition		$2,881,000		$4,832,350		$9,374,400		Excluded
Sub Total Before Mark-Ups		**$53,967,947**		**$77,751,247**		**$85,686,990**		**$79,840,513**
11 General Requirements	10.9%	$5,883,000	10.9%	$8,475,000	10.9%	$9,342,000	10.9%	$8,703,000
12 Fees	4.0%	$2,394,000	4.0%	$3,449,000	4.0%	$3,802,000	4.0%	$3,542,000
General Requirements		**$8,277,000**		**$11,924,000**		**$13,144,000**		**$12,245,000**
Sub Total Incl. General Requirement		**$62,244,947**		**$89,675,247**		**$98,830,990**		**$92,085,513**
13 Design & Pricing Contingency	20.0%	$12,449,000	20.0%	$17,934,000	20.0%	$19,763,000	20.0%	$18,417,000
14 Escalation Contingency		Excluded		Excluded		Excluded		Excluded
15 Construction Contingency	10.0%	$7,469,000	7.5%	$8,071,000	5.0%	$5,930,000	5.0%	$5,525,000
Contingencies		**$19,918,000**		**$26,005,000**		**$25,693,000**		**$23,942,000**
Total Estimated Hard Construction Cost Incl. Mark-ups and Contingencies (A)		**$82,163,000**		**$115,680,000**		**$124,524,000**		**$116,028,000**
Gross Floor Area		**16,075 m2**		**19,915 m2**		**16,370 m2**		**16,075 m2**
		$5,111 /m2		**$5,809 /m2**		**$7,607 /m2**		**$7,218 /m2**
		$475 /SF		**$540 /SF**		**$707 /SF**		**$671 /SF**

Life Cycle Costing Assessment (LCCA)		Scenario A		Scenario B		Scenario C		Current Market Valuation of Existing Building
16 Operational & Maintenance Costs (60 years cycle)		$31,890,483		$33,096,830		$28,795,417		$33,754,766
17 Replacement Costs (60 years cycle)		$201,847,241		$238,198,105		$198,091,758		$229,681,611
18 Operational Carbon Costs		$1,278,960		$1,471,819		$1,145,702		$3,713,386
19 Total Inflation (60 years cycle)		$46,501,620		$54,402,955		$46,204,609		$52,948,300
Total Operational Cost (B)		**$281,518,304**		**$327,169,710**		**$274,237,486**		**$320,098,062**
Total Ownership Cost Over 60 Years - Post-Inflation (A + B)		**$363,681,304**		**$442,849,710**		**$398,761,486**		**$436,126,062**
Net Present Value		**$185,950,097**		**$235,971,810**		**$223,009,947**		**$120,805,688**

ELEMENTAL SUMMARY

CASE STUDY 1 - HALIFAX - SCENARIO A

OM ESTIMATE (Rev.2)
NOVEMBER 19, 2025

A.W. HOOKER®
QUANTITY SURVEYORS

Gross Floor Area 16,075 m2

Description Element\Sub-Element	Ratio	Quantity	Unit	Unit Rate	Elemental Cost: Sub Element	Elemental Cost: Element Total	$ per m2 Sub Element	$ per m2 Element	%
A. SHELL									
A1. Sub-Structure						**$318,000**		$19.78	0.4%
A1.1 Foundations	0.12	1,921	m2	$165.54	$318,000		$19.78		
A1.2 Basement Excavation	0.12	1,921	m2	$0.00	$0		$0.00		
A2. Structure						**$675,350**		$42.01	0.8%
A2.1 Lowest Floor Construction	0.12	1,921	m2	$117.70	$226,100		$14.07		
A2.2 Upper Floor Construction	0.88	14,154	m2	$25.33	$358,500		$22.30		
A2.3 Roof Construction	0.08	1,210	m2	$75.00	$90,750		$5.65		
A3. Exterior Enclosure						**$9,025,682**		$561.47	11.0%
A3.1 Walls Below Grade	0.00	0	m2	$0.00	$0		$0.00		
A3.2 Walls Above Grade	0.27	4,317	m2	$968.15	$4,179,502		$260.00		
A3.3 Windows & Entrances	0.12	2,000	m2	$2,051.09	$4,101,750		$255.16		
A3.4 Roof Finish	0.08	1,210	m2	$539.23	$652,470		$40.59		
A3.5 Projections	1.00	16,075	m2	$5.72	$91,960		$5.72		
B. INTERIORS									
B1 Partitions & Doors						**$8,613,890**		$535.86	10.5%
B1.1 Partitions	1.20	19,290	m2	$234.67	$4,526,720		$281.60		
B1.2 Doors	0.15	2,388	m2	$1,711.29	$4,087,170		$254.26		
B2 Finishes						**$5,601,441**		$348.46	6.8%
B2.1 Floor Finishes	0.90	14,468	m2	$121.50	$1,757,801		$109.35		
B2.2 Ceiling Finishes	0.90	14,468	m2	$150.12	$2,171,840		$135.11		
B2.3 Wall Finishes	2.00	32,150	m2	$52.00	$1,671,800		$104.00		
B3 Fittings & Equipment						**$7,941,375**		$494.02	9.7%
B3.1 Fittings & Fixtures	1.00	16,075	m2	$285.00	$4,581,375		$285.00		
B3.2 Equipment				Excluded			$0.00		
B3.3 Conveying Systems	1.00	16,075	m2	$209.02	$3,360,000		$209.02		
C. SERVICES									
C1 Mechanical						**$12,726,660**		$791.71	15.5%
C1.1 Plumbing & Drainage	1.00	16,075	m2	$353.55	$5,683,300		$353.55		
C1.2 Fire Protection	1.00	16,075	m2	$62.16	$999,150		$62.16		
C1.3 HVAC	1.00	16,075	m2	$364.00	$5,851,310		$364.00		
C1.4 Controls	1.00	16,075	m2	$12.00	$192,900		$12.00		
C2 Electrical						**$5,831,615**		$362.78	7.1%
C2.1 Service & Distribution	1.00	16,075	m2	$136.95	$2,201,433		$136.95		
C2.2 Lighting, Devices & Heating	1.00	16,075	m2	$148.50	$2,387,114		$148.50		
C2.3 Systems & Ancillaries	1.00	16,075	m2	$77.33	$1,243,068		$77.33		
D. SITE & ANCILLARY WORK									
D1 Site Work						**$352,934**		$21.96	0.4%
D1.1 Site Development	0.10	1,684	m2	$20.78	$35,000		$2.18		
D1.2 Mechanical Site Services	0.10	1,684	m2	$70.07	$118,000		$7.34		
D1.3 Electrical Site Services	0.10	1,684	m2	$118.73	$199,934		$12.44		
D2 Ancillary Work						**$2,881,000**		$179.22	3.5%
D2.1 Demolition	1.00	16,075	m2	$179.22	$2,881,000		$179.22		
D2.2 Alterations	0.00	0	m2	$0.00	$0		$0.00		
Z. GENERAL REQUIREMENTS & CONTINGENCIES									
Z1 General Requirements & Fees						**$8,277,000**		$514.90	10.1%
Z1.1 General Requirements	1.00	16,075	m2	$365.97	$5,883,000		$365.97		
Z1.2 Fees	1.00	16,075	m2	$148.93	$2,394,000		$148.93		
Z2 Allowances						**$19,918,300**		$1,239.09	24.2%
Z2.1 Design & Pricing Contingency	1.00	16,075	m2	$774.43	$12,448,900		$774.43		
Z2.2 Escalation Contingency				Excluded			$0.00		
Z2.3 Construction Contingency	1.00	16,075	m2	$464.66	$7,469,400		$464.66		
TOTAL ESTIMATED CONSTRUCTION COST (nearest ,000)						**$82,163,000**		**$5,111.24**	**100.0%**

ELEMENTAL SUMMARY
CASE STUDY 1 - HALIFAX - SCENARIO B
OM ESTIMATE (Rev.2)
NOVEMBER 19, 2025

A.W. HOOKER ®
QUANTITY SURVEYORS

Gross Floor Area 19,915 m2

Description Element\Sub-Element	Ratio	Quantity	Unit	Unit Rate	Elemental Cost Sub Element	Elemental Cost Element Total	$ per m2 Sub Element	$ per m2 Element	%
A. SHELL									
A1. Sub-Structure						**$318,000**		$15.97	0.3%
A1.1 Foundations	0.10	1,921	m2	$165.54	$318,000		$15.97		
A1.2 Basement Excavation	0.00	0	m2	$0.00	$0		$0.00		
A2. Structure						**$9,597,800**		$481.94	8.3%
A2.1 Lowest Floor Construction	0.10	1,921	m2	$117.70	$226,100		$11.35		
A2.2 Upper Floor Construction	0.90	17,994	m2	$477.11	$8,585,200		$431.09		
A2.3 Roof Construction	0.06	1,210	m2	$650.00	$786,500		$39.49		
A3. Exterior Enclosure						**$13,264,514**		$666.06	11.5%
A3.1 Walls Below Grade	0.00	0	m2	$0.00	$0		$0.00		
A3.2 Walls Above Grade	0.24	4,857	m2	$1,321.05	$6,416,022		$322.17		
A3.3 Windows & Entrances	0.15	2,958	m2	$2,013.43	$5,956,623		$299.10		
A3.4 Roof Finish	0.06	1,210	m2	$537.03	$649,810		$32.63		
A3.5 Projections	1.00	19,915	m2	$12.15	$242,060		$12.15		
B. INTERIORS									
B1 Partitions & Doors						**$12,915,108**		$648.51	11.2%
B1.1 Partitions	1.20	23,898	m2	$272.17	$6,504,239		$326.60		
B1.2 Doors	0.15	2,959	m2	$2,166.64	$6,410,869		$321.91		
B2 Finishes						**$6,867,041**		$344.82	5.9%
B2.1 Floor Finishes	0.90	17,924	m2	$117.26	$2,101,673		$105.53		
B2.2 Ceiling Finishes	0.90	17,924	m2	$150.32	$2,694,208		$135.29		
B2.3 Wall Finishes	2.00	39,830	m2	$52.00	$2,071,160		$104.00		
B3 Fittings & Equipment						**$7,565,775**		$379.90	6.5%
B3.1 Fittings & Fixtures	1.00	19,915	m2	$285.00	$5,675,775		$285.00		
B3.2 Equipment				Excluded			$0.00		
B3.3 Conveying Systems	1.00	19,915	m2	$94.90	$1,890,000		$94.90		
C. SERVICES									
C1 Mechanical						**$14,757,510**		$741.02	12.8%
C1.1 Plumbing & Drainage	1.00	19,915	m2	$327.23	$6,516,780		$327.23		
C1.2 Fire Protection	1.00	19,915	m2	$62.15	$1,237,730		$62.15		
C1.3 HVAC	1.00	19,915	m2	$338.64	$6,744,105		$338.64		
C1.4 Controls	1.00	19,915	m2	$13.00	$258,895		$13.00		
C2 Electrical						**$7,141,490**		$358.60	6.2%
C2.1 Service & Distribution	1.00	19,915	m2	$131.06	$2,610,030		$131.06		
C2.2 Lighting, Devices & Heating	1.00	19,915	m2	$150.61	$2,999,316		$150.61		
C2.3 Systems & Ancillaries	1.00	19,915	m2	$76.93	$1,532,144		$76.93		
D. SITE & ANCILLARY WORK									
D1 Site Work						**$491,658**		$24.69	0.4%
D1.1 Site Development	0.08	1,684	m2	$89.07	$150,000		$7.53		
D1.2 Mechanical Site Services	0.08	1,684	m2	$70.07	$118,000		$5.93		
D1.3 Electrical Site Services	0.08	1,684	m2	$132.81	$223,658		$11.23		
D2 Ancillary Work						**$4,832,350**		$242.65	4.2%
D2.1 Demolition	1.00	19,915	m2	$242.65	$4,832,350		$242.65		
D2.2 Alterations	0.00	0	m2	$0.00	$0		$0.00		
Z. GENERAL REQUIREMENTS & CONTINGENCIES									
Z1 General Requirements & Fees						**$11,924,000**		$598.74	10.3%
Z1.1 General Requirements	1.00	19,915	m2	$425.56	$8,475,000		$425.56		
Z1.2 Fees	1.00	19,915	m2	$173.19	$3,449,000		$173.19		
Z2 Allowances						**$26,004,700**		$1,305.78	22.5%
Z2.1 Design & Pricing Contingency	1.00	19,915	m2	$900.53	$17,934,000		$900.53		
Z2.2 Escalation Contingency				Excluded			$0.00		
Z2.3 Construction Contingency	1.00	19,915	m2	$405.26	$8,070,700		$405.26		
TOTAL ESTIMATED CONSTRUCTION COST (nearest ,000)						**$115,680,000**		**$5,808.68**	**100.0%**

ELEMENTAL SUMMARY

CASE STUDY 1 - HALIFAX - SCENARIO C

OM ESTIMATE (Rev.2)
NOVEMBER 19, 2025

A.W. HOOKER ®
QUANTITY SURVEYORS

Gross Floor Area 16,370 m2

Description Element\Sub-Element	Ratio	Quantity	Unit	Unit Rate	Elemental Cost Sub Element	Elemental Cost Element Total	$ per m2 Sub Element	$ per m2 Element	%
A. SHELL									
A1. Sub-Structure						**$1,966,027**		$120.10	1.6%
A1.1 Foundations	0.12	1,921	m2	$835.97	$1,605,898		$98.10		
A1.2 Basement Excavation	0.12	1,921	m2	$187.47	$360,129		$22.00		
A2. Structure						**$16,678,925**		$1,018.87	13.4%
A2.1 Lowest Floor Construction	0.12	1,921	m2	$275.30	$528,855		$32.31		
A2.2 Upper Floor Construction	0.88	14,449	m2	$1,079.49	$15,597,570		$952.81		
A2.3 Roof Construction	0.05	850	m2	$650.00	$552,500		$33.75		
A3. Exterior Enclosure						**$14,449,684**		$882.69	11.6%
A3.1 Walls Below Grade	0.01	153	m2	$6,384.00	$976,752		$59.67		
A3.2 Walls Above Grade	0.27	4,396	m2	$1,370.78	$6,026,244		$368.13		
A3.3 Windows & Entrances	0.18	2,915	m2	$1,572.74	$4,584,809		$280.07		
A3.4 Roof Finish	0.05	850	m2	$483.90	$411,319		$25.13		
A3.5 Projections	1.00	16,370	m2	$149.70	$2,450,560		$149.70		
B. INTERIORS									
B1 Partitions & Doors						**$10,370,734**		$633.52	8.3%
B1.1 Partitions	1.20	19,644	m2	$272.17	$5,346,442		$326.60		
B1.2 Doors	0.15	2,432	m2	$2,065.75	$5,024,292		$306.92		
B2 Finishes						**$5,726,523**		$349.82	4.6%
B2.1 Floor Finishes	0.90	14,733	m2	$122.73	$1,808,219		$110.46		
B2.2 Ceiling Finishes	0.90	14,733	m2	$150.40	$2,215,824		$135.36		
B2.3 Wall Finishes	2.00	32,740	m2	$52.00	$1,702,480		$104.00		
B3 Fittings & Equipment						**$6,555,452**		$400.46	5.3%
B3.1 Fittings & Fixtures	1.00	16,370	m2	$285.00	$4,665,450		$285.00		
B3.2 Equipment				Excluded			$0.00		
B3.3 Conveying Systems	1.00	16,370	m2	$115.46	$1,890,002		$115.46		
C. SERVICES									
C1 Mechanical						**$13,984,665**		$854.29	11.2%
C1.1 Plumbing & Drainage	1.00	16,370	m2	$379.13	$6,206,350		$379.13		
C1.2 Fire Protection	1.00	16,370	m2	$78.18	$1,279,860		$78.18		
C1.3 HVAC	1.00	16,370	m2	$381.97	$6,252,905		$381.97		
C1.4 Controls	1.00	16,370	m2	$15.00	$245,550		$15.00		
C2 Electrical						**$5,772,967**		$352.66	4.6%
C2.1 Service & Distribution	1.00	16,370	m2	$140.74	$2,303,927		$140.74		
C2.2 Lighting, Devices & Heating	1.00	16,370	m2	$137.97	$2,258,561		$137.97		
C2.3 Systems & Ancillaries	1.00	16,370	m2	$73.94	$1,210,479		$73.94		
D. SITE & ANCILLARY WORK									
D1 Site Work						**$807,614**		$49.33	0.6%
D1.1 Site Development	0.10	1,684	m2	$290.78	$489,680		$29.91		
D1.2 Mechanical Site Services	0.10	1,684	m2	$70.07	$118,000		$7.21		
D1.3 Electrical Site Services	0.10	1,684	m2	$118.73	$199,934		$12.21		
D2 Ancillary Work						**$9,374,400**		$572.66	7.5%
D2.1 Demolition	1.00	16,370	m2	$572.66	$9,374,400		$572.66		
D2.2 Alterations	0.00	0	m2	$0.00	$0		$0.00		
Z. GENERAL REQUIREMENTS & CONTINGENCIES									
Z1 General Requirements & Fees						**$13,141,000**		$802.75	10.6%
Z1.1 General Requirements	1.00	16,370	m2	$570.56	$9,340,000		$570.56		
Z1.2 Fees	1.00	16,370	m2	$232.19	$3,801,000		$232.19		
Z2 Allowances						**$25,696,000**		$1,569.70	20.6%
Z2.1 Design & Pricing Contingency	1.00	16,370	m2	$1,207.45	$19,766,000		$1,207.45		
Z2.2 Escalation Contingency				Excluded			$0.00		
Z2.3 Construction Contingency	1.00	16,370	m2	$362.25	$5,930,000		$362.25		
TOTAL ESTIMATED CONSTRUCTION COST (nearest ,000)						**$124,524,000**		**$7,606.84**	**100.0%**

CAHP Existing Heritage Buildings, Carbon & Building Code Study - Case Study 2 - Montreal

Order of Magnitude Estimate (Rev.3)

Prepared for:

Giaimo

Prepared by:

A.W. HOOKER ®
QUANTITY SURVEYORS

2904 South Sheridan Way, Suite 202
Oakville, ON L6J 7L7
T 905.823.8111

info@awhooker.com
www.awhooker.com

November 19, 2025

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THE PEOPLE | THE DIFFERENCE®

November 19, 2025

Giaimo
213 Sterling Road, Unit 204
Toronto, ON M6R 2B2

Re: CAHP Existing Heritage Buildings – Case Study 2 – Montreal (R.3)

Dear Giaimo,

Please find enclosed our Order of Magnitude Estimate for the above project. The estimate is based on design drawings and information provided by Giaimo received on April 17, 2025. The latest report reflects updates based on meeting discussions, as well as additional information shared throughout those sessions.

This estimate is meant to reflect the fair market value for the construction of this project; it is not intended to be the prediction of the lowest bid and should be representative of the median bid amount received in a competitive bidding scenario.

We recommend that the owner and/or the design team carefully review the cost estimate report, including line item descriptions, unit price clarifications, exclusions, inclusions and assumptions, contingencies, escalation, and mark-ups. This is to ensure that the design intent is captured within the content of the report.

Please refer to the preamble of our cost report for all exclusions, assumptions, and information pertaining to the estimate.

Requests for modifications of any apparent errors or omissions to this document must be made to A.W. Hooker Associates Ltd. within ten (10) business days of receipt of this estimate. Otherwise, it will be understood that the contents in this estimate have been concurred with and accepted as final version of the cost report.

We trust our work will assist in the decision making process and look forward to our continued involvement in this important project.

Sincerely,
A.W. Hooker Associates Ltd.

Weger Barwari, PQS, C.Tech
Senior Quantity Surveyor

Sincerely,
A.W. Hooker Associates Ltd

Bineesh Susamma, PMP, PQS
Associate (Mechanical)

Encl. (OM Estimate - Scenario A, B, C & 0 (R.3) – November 19, 2025)

Table of Contents

1. Introduction to the Estimate

1.1 Project Description

This project involves research, developing capacity-building resources, and disseminating findings to prepare Canadian markets for the future release and prompt adoption of retrofit codes for three (3) building case studies (Halifax, Montreal and Vancouver). AWH role is to determine the full building cost for each of the three scenarios, a high-level cost for the existing building condition, a

The carbon analysis will include three (3) scenarios:
1. Scenario 1: adaptive reuse renovation (no addition)
2. Scenario 2: adaptive reuse renovation (with addition)
3. Scenario 3: demolition and replacement with new building

An additional scenario as been provided for current market valuation of existing building.

1.2 Type of Estimate

This Order of Magnitude Estimate is intended to establish a realistic elemental estimate of the hard construction costs based on the level of design information provided. Detailed quantities have been measured from drawings where possible for the proposed building and associated site development. This estimate reflects our opinion as to the fair market value for the hard construction of this project.

The accuracy of the estimate is based on the documentation provided and design stage is intended to be +/- 30%-100%. This accuracy is based on the definition for Estimate Classifications (Class D) outlined in the *Guide to Cost Predictability in Construction prepared by the Joint Federal Government & an Industry Cost Predictability Taskforce. Contingencies are included to offset the accuracy risk, to the extent that the estimated amount represents the current opinion of the likely fair market value at the time of tender.

The intention of the estimate is not to predict the low bid price received; typically based on historical tender results estimates are more likely to be towards the median value of bids received under competitive conditions as per common practice based CIQS guidelines. This is a deliberate methodology due to the inherent risk in attempting to predict the low bid and numerous factors which can contribute to lower than anticipated tender submissions which are beyond our control.

Cost Estimate Classification Systems					
AACE *(1)	Class 5	Class 4	Class 3	Class 2	Class 1
DND *(2)			Indicative	Substantive	
RAIC*(3)	OME	Sketch Design	Design Development	Contract Documents	Tender Documents
GOC *(4)	OME	D	C	B	A
Design Documentation % Complete					
		12.5%	25.0%	95.0%	100.0%
Cost Estimate Accuracy (+ or - Percentage)					
	+/- 30%-100%	+/- 20%-30%	+/- 15%-20%	+/- 10%-15%	+/- 5%-10%

Legend
***(1)** AACE Association for the Advancement Of Cost Engineering
***(2)** OND Department of National Defense
***(3)** RAIC Royal Architectural Institute Of Canada
***(4)** GOC Government

*Reference: https://cacqs.ca/wp-content/uploads/2024/10/best-practices-guide-2024.pdf

2. Basis of the Estimate

2.1 General Information

From the design information provided, we have measured quantities where possible and applied typical unit rates for each of the specific elements based on the project specifications. Where specific design information has not been provided, unit rates are based on historical cost data for this type of project. In some instances where design information is limited, we have made reasonable assumptions based on our experience with projects of a similar scope and design. Estimates for mechanical and electrical systems are developed based on information prepared by the project engineers, historical projects and experience.

Significant changes to the basis of design will impact the estimate value; this is particularly critical where changes are made after the final estimate prior to tender. We recommend that all major design or scope changes be reviewed for their cost, time and constructability impact prior to incorporation in a finalized tender package.

2.2 Location Cost Base

The location cost base for this estimate is Montreal, QC.

2.3 Unit Rates

The unit rates in the preparation of the elemental estimate include labour and material, equipment, and subcontractors overheads and profits. We have assumed for pricing purposes that union contractors would perform the work. We have assumed the fair wage policy would be in effect. The unit rates for each of the elements are based on typical mid-range costs for the type of design, construction, and materials proposed.

Unit rates in all estimates combine the material, labour, and equipment components for a single unit cost for ease of presentation. This estimate is not a prediction of low bid. Pricing assumes competitive bidding for every aspect of the work.

2.4 Taxes

Harmonized Sales Tax (HST) is excluded from our estimate.

2.5 Construction Schedule

The estimate has been prepared on the assumption that the work will be performed within the timelines of a normal construction schedule. The duration of the schedule would be based on the work being performed during regular daytime work hours. We have assumed the structural components of the building would be constructed in predominantly non-winter months. No allowances have been included for premium time and after hours work associated with an accelerated construction schedule.

2.6 General Requirements and Fees

The General Requirements for the General Contractor are included as a percentage of the hard construction cost. This estimate of the prime contractor's site overheads includes site supervision and labour, access to the site, site accommodations, site protection, temporary utilities, clean up, equipment, and other miscellaneous project requirements provided by the General Contractor.

The Fee element of the estimate is meant to cover the General Contractor's fee to perform the work. The fee would be based on the competitive nature of the bidding process and the market conditions at the time of tender.

2.7 Bonding and Insurance

We have included the median estimated costs for 50% Performance, 50% Labour and Materials. These are the traditional bonding requirements commonly requested by the owner. The actual final bonding costs will vary depending on the selected contractors' performance history.

The estimate includes an allowance for general liability and builder's risk insurance based on an average cost per $1,000 of estimated hard construction costs. The actual insurance costs would be subject to the insurance requirements for the project.

2.8 Procurement

It was assumed for the preparation of this estimate that the project would be tendered to a prequalified list of bidders with a project specific lump sum contract. Pricing is based on competitive tender results with a minimum of four (preferably six tender submissions) at General Contractor's and major trade level. Pre-qualification with a restrictive list of contractors or subcontractors may result in a higher tendered cost due to the inherent reduction in competitiveness. Tenders receiving two or less submissions (occasionally three) historically tend to have a much higher risk of an overrun in cost when compared to the budget established in an estimate. Ensuring adequate bonafide bidders is a prerequisite for competitive bidding scenarios, on which the estimate is predicated.

2.9 Specifications

Where detailed and comprehensive specifications are unavailable, we have assumed that no onerous special requirements will be applicable to this project. It was assumed that all materials and equipment could be substituted with an alternative product to avoid sole-sourcing which results in a non-competitive market condition.

2.10 Soft Costs

The estimated soft costs have been excluded in this estimate.

These costs include items traditionally funded by the owner and separate from the hard construction costs which would be applicable to the contractor. The soft costs include items such as consultant fees; disbursements; project management fees; independent inspection and testing; third party commissioning; legal fees; permits and development charges; operational and moving expenses; financing and loan fees; owner supplied furnishings, fixtures, and equipment; land acquisition costs; and Harmonized Sales Tax.

2.11 Life Cycle Costing Assessment (LCCA)

As part of the study, we have also been tasked with preparing a high-level Life Cycle Cost Assessment (LCCA) for each scenario. This assessment evaluates the total cost of ownership over a 60-year period, encompassing initial capital, operational energy cost, maintenance, replacement, and operational carbon costs. All costs are presented in Net Present Value (NPV) terms, calculated based on assumptions and parameters mutually agreed upon by the client, design team, and engineering consultants.

- 4% Capital inflation
- 2% Energy Inflation

The costing framework is informed by the following reference documents:

- ASHRAE Guidelines
- WSP Building Envelope Renewal Cycle
- WSP Building Structure Renewal Cycle
- Environment and Climate Change Canada (ECCC) Data Catalogue
- Various other publications and manufacture recommendations

3. Contingencies

3.1 Design and Pricing Contingency

A design and pricing contingency has been included in the estimate as a percentage of the hard construction costs including the general requirements and fees. This contingency is meant to cover design and pricing unknowns in the preparation of this estimate and reflect the incomplete nature of the design information provided at the time the estimate is prepared.

The estimate includes the following design and pricing contingencies by discipline:

Design Contingencies		
Architectural	-	20%
Structural	-	20%
Mechanical	-	20%
Electrical	-	20%
Siteworks	-	20%

The contingency where included in our estimate is not meant to cover significant additional program space or quality modifications, but rather to provide some flexibility as the design develops. The design contingency typically decreases as the design progresses and more definition and detail is available to refine the basis of the cost estimate. If the owner anticipates significant changes to the basis of design we recommend additional contingency be retained as a reserve for the scope modifications.

3.2 Escalation Contingency

The estimate excludes an allowance for escalation. This allowance, when included, is meant to provide for increases in construction costs due to changes in market conditions between the time of the estimate and the potential construction commencement. For projects with a schedule in excess of 12 months, the contingency is based on a timeframe that takes escalation to the midpoint of the construction phase.

Escalation during construction is included in the unit rates; essentially this allowance is the risk carried by the general contractor and trades with a fixed price made years before the work is completed or carried out for some trades.

3.3 Construction Contingency (Post Contract Changes)

The estimate includes a contingency for the construction phase of the project. This contingency is meant to cover the potential cost of post contract changes that may occur after the project is tendered.

The following allowances are to provide for increases in construction costs due to Change Orders issued during construction.

Case study 2 - Montreal
Scenario A: 10%
Scenario B: 7.5%
Scenario C: 5%
Existing Building: 5%

This contingency excludes any major program or scope requests by the client; these should form part of an overall project management reserve or be reflected in increased funding

4. General Liability

4.1 Statement of Probable Costs

A.W. Hooker Associates Ltd. (HOOKER) has no control over the cost of labour and materials, the general contractors or any subcontractors' methods of determining prices, or competitive bidding and market conditions. This opinion of probable cost of construction is based on the experience, qualifications, and best judgment of the professional consultant familiar with the construction industry. HOOKER does not warranty that proposals or actual construction costs will not vary from this or subsequent estimates.

4.2 Ongoing Cost Control

A.W. Hooker Associates Ltd. recommends that the owner and/or the design team carefully review the cost estimate report, including line item descriptions, unit price clarifications, exclusions, inclusions and assumptions, contingencies, escalation, and mark-ups. This is to ensure that the design intent is captured within the content of the report. This is especially important at early stage estimates which tend to be based on a lesser level of design completion.

If the project is over budget or there are unresolved budget issues, alternative systems or schemes should ideally be evaluated before proceeding with the design phase. We recommend that cost control be implemented throughout the various stages of the design process to ensure the proposed design remains within the overall budget. It is recommended that the final estimate be produced by HOOKER using Bid Documents to determine overall cost changes, which may have occurred since the preparation of this estimate. The final update estimate will address changes and additions to the documents as well as addenda issued during the bidding process. HOOKER cannot reconcile bid results to any estimate not produced from bid documents including all addenda.

5. Estimate Scope Clarifications

5.1 List of Exclusions

1. Harmonized Sales Tax (HST)
2. Project Soft Costs (as described in item 2.10 above)
3. Furniture, furnishings, and equipment (except as noted in the estimate)
4. Premium time / after hours work
5. Accelerated construction schedule
6. Abatement and handling of asbestos and other hazardous materials
7. Handling and removal of contaminated soils
8. Special foundation systems such as caissons or pile foundations
9. Premium for construction management or alternate approaches to procurement
10. Sole sourced equipment or control systems
11. Consumption costs for any utilities used during construction (gas, water, hydro etc.)
12. Tariffs and risks of potential additional tariffs due to geopolitical uncertainty
13. End of Life Costs/Disposal Costs
14. Residual/Salvage Costs
15. Embodied Costs

5.2 List of Assumptions

Architectural / Structural / Landscaping:

1. The existing soils on the site are adequate to support standard strip and pad foundations to the minimum depth required for frost. No allowances have been made for larger or special foundations such as caissons or piles due to poor soil conditions.
2. The existing site is relatively flat and the finished floor and site elevations were set to work with the existing grades to avoid major cut and fill.
3. We have assumed the majority of the work to be performed during regular day shifts (unrestricted access to the building during the hours of 8AM to 6 PM Monday to Friday).
4. Contractor will clean up daily to general housekeeping standards.
5. Work is assumed to be completed in one continuous phase.
6. We have assumed the relocation of any existing loose furniture and equipment prior to demolition (chairs, tables, desks, filing cabinets, machinery etc.) is to be by Owner.
7. Foundation:
    a. Scenario A: existing to remain with patch and repair to existing SOG. Add for new elevator and stair foundation. The existing foundation is adequate and does not require strengthening.
    b. Scenario B: Add for new elevator and stair foundation. Patch and repair to existing SOG. The existing foundation is adequate and does not require strengthening.
    c. Scenario C: new shallow isolated foundation including strip footings, walls, pier and pad footings to parking level, assumed 2 months dewatering, 4 months winter heating.
8. Upper Floor & Roof Construction:
    a. Scenario A: assumed existing mass timber structure to remain.
    b. Scenario B: assumed existing mass timber upper floor to remain. New mass timber floor and roof at new addition.
    c. Scenario C: structural steel upper floor and roof construction, 76mm steel deck, spray fireproofing to upper floor structure, stairs and elevators.
9. Exterior Enclosure:
    a. Scenario A: repoint existing brick masonry, new aluminum framed windows and spandrels.
    b. Scenario B: repoint existing brick masonry, new prefinished metal panels, new aluminum framed curtainwall, windows and spandrels.
    c. Scenario C: brick masonry cladding, prefinished metal panels, aluminum framed curtainwall, windows and spandrels.
10. Roof:
    a. Scenario A: new TPO membrane roofing on 100mm XPS insulation
    b. Scenario B: new TPO membrane roofing on 100mm XPS insulation on the main roof. Roof terraces includes 2-ply SBS roofing, on 125mm XPS insulation, poly vapour, and 16mm densglass sheathing.
    c. Scenario C: new 2-ply SBS roofing, on 6mm protection board, 100mm XPS insulation, poly vapour barrier, and 12mm densglass sheathing.
11. Door count and type are assumed based on as-built drawings, location and count for barrier free operator is assumed. Bollards included at overhead doors.
12. New dome skylight glazing.
13. An allowance has been included for building signage.
14. Interior partitions: Combination of concrete shear walls, CMU, gypsum board, and aluminum glazed screens.
15. Floor Finishes: combination of porcelain, ceramic tiles, carpet, resilient sheet flooring, wood flooring, rubber sport flooring, and concrete sealer
16. Ceiling Finishes: combination of suspended gypsum board, act, baffle ceiling and paint to exposed structure.
17. Wall Finishes: combination of paint finish, ceramic tiles.
18. An allowance has been included for feature walls.
19. An allowance had been included for gypsum board bulkheads.
20. An allowance has been included for miscellaneous steel.
21. We have included an allowance for millwork cabinetry.
22. We have included allowances for specialty items and raised access floor system.

23. An allowance has been included for two (2) passenger elevators and one (1) service elevator.
24. We have included allowances for site preparation work, hard landscape, site improvements, and soft landscape works.
25. Demolition:
    a. Scenario A: selective removal of existing slab on grade for new elevators and stairs.
    b. Scenario B: selective removal of existing slab on grade for new elevators and stairs. Demolish existing roof structure to accommodate new additions.
    c. Scenario C: demolish and dispose of the existing building.

Mechanical:

26. Work will be conducted by union or fair wage contractors.
27. The estimate for Scenario A includes minor upgrades to the mechanical utility services, assuming that the existing service sizing is within a similar range as required for the new two-story building, whereas scenario B and C would require major repurposing of the existing services.
28. The estimate includes repurposing the existing storm drainage system for Scenarios A and B, while a full new system is included only for Scenario C.
29. The estimate assumes booster pumps for domestic water and fire water services in Scenarios B and C.
30. The estimate includes modifying fire sprinkler and fire hose coverage for both scenario A&B to suit new layout.
31. The estimate includes in-row DX precision cooling units for the computer/server/data rack rooms on each floor and assumes these rooms are protected with a pre-action fire suppression system. Clean agent fire suppression system is not included.
32. Gas detection system is included in the loading dock area.
33. The estimate excludes hydronic heating and cooling, assuming that all building heating, cooling and ventilation requirements will be met through RTUs for scenario A&B. For Scenario C, the estimate includes a central air-source heat pump system providing heating and cooling, supplemented by decentralized terminal units for space conditioning. Ventilation in Scenario C is provided by a central ERV connected to dedicated compartment units on each floor and local VAV boxes with CO_2 sensors provide demand-controlled ventilation to each zone. The estimate also allows for an electric boiler to supplement the central heating plant if required.
34. For Scenarios A&B, the estimate includes electric baseboard perimeter heating. For Scenario C, perimeter heating is provided by hydronic radiant panels.
35. VAV terminals are included to control zone-level heating, cooling and ventilation; however, no reheat coils or duct-mounted heaters are included.
36. New building automation system is included for all scenarios.
37. Third party tests, certifications etc. are excluded.
38. Estimate excludes the smoke exhaust and stair pressurization systems in all scenarios.
39. Please see our back up estimates for the various assumptions we have considered.

Electrical:

40. Work will be performed by unionized labor during regular hours.
41. New 347/600V diesel generator has been included in the estimate.
42. Dimmable LED lighting will be provided throughout and controlled via central low voltage lighting control system.
43. A new addressable fire alarm system in new building and replacing existing fire alarm system in existing building have been included in the estimate.
44. Supply and installation of security system has been included in the estimate.
45. Supply and installation of AV system has been excluded from the estimate.
46. Refer to estimate for additional scope specific assumptions.

General:

47. Various assumptions have been made based on the design information available and our experience with projects of a similar nature. Please refer to the specific items within the estimate for the detailed assumptions made.

6. Documentation Received

Drawings and design documentation were prepared by Giaimo:

Pages	Documentation	Documentation Received
7 Pages	CAHP Case Studies Summary_Montreal.2025-06-13	July 29, 2025
7 Pages	CAHP Case Studies Summary_Halifax.2025-07-10	July 29, 2025
A-100-800	7250 Marconi - Architectural	April 24, 2025
5 Drawings	7250 Marconi - HVAC	April 24, 2025
1 Excel File	Montreal_BOQ	April 24, 2025
	Emails	Various

MULTIPLE ESTIMATE SUMMARY
CAHP - CASE STUDY 2 - MONTREAL
OM ESTIMATE (Rev.2)
NOVEMBER 19, 2025

A.W. HOOKER®
QUANTITY SURVEYORS

Hard Construction Costs	%	Scenario A	%	Scenario B	%	Scenario C	%	Current Market Valuation of Existing Building
1 Sub-Structure		$190,000		$190,000		$4,527,937		$2,716,762
2 Structure		$1,136,800		$8,830,300		$21,798,705		$7,266,235
3 Exterior Enclosure		$3,036,142		$6,075,129		$9,723,460		$3,241,153
4 Interiors		$13,564,077		$18,087,469		$27,851,115		$13,564,077
5 Mechanical		$6,835,600		$9,728,315		$24,406,326		$9,955,763
6 Electrical		$4,374,330		$6,388,123		$11,385,643		$4,644,401
7 Site Development		$267,826		$267,826		$344,166		$344,166
8 Mechanical Site Services		$46,500		$183,500		$301,000		$301,000
9 Electrical Site Services		$185,390		$217,872		$277,282		$277,282
10 Demolition		$1,458,000		$1,558,500		$2,168,000		Excluded
Sub Total Before Mark-Ups		**$31,094,664**		**$51,527,034**		**$102,783,633**		**$42,310,838**
11 General Requirements	10.9%	$3,390,000	10.9%	$5,616,000	10.9%	$11,201,000	10.9%	$4,613,000
12 Fees	4.0%	$1,379,000	4.0%	$2,286,000	4.0%	$4,561,000	4.0%	$1,877,000
General Requirements		**$4,769,000**		**$7,902,000**		**$15,762,000**		**$6,490,000**
Sub Total Incl. General Requirement		**$35,863,664**		**$59,429,034**		**$118,545,633**		**$48,800,838**
13 Design & Pricing Contingency	20.0%	$7,172,500	20.0%	$11,886,000	20.0%	$23,709,500	20.0%	$9,760,000
14 Escalation Contingency		Excluded		Excluded		Excluded		Excluded
15 Construction Contingency	10.0%	$4,304,000	7.5%	$5,349,000	5.0%	$7,113,000	5.0%	$2,928,000
Contingencies		**$11,476,500**		**$17,235,000**		**$30,822,500**		**$12,688,000**
Total Estimated Hard Construction Cost Incl. Mark-ups and Contingencies (A)		**$47,340,000**		**$76,664,000**		**$149,368,000**		**$61,489,000**

	Scenario A	Scenario B	Scenario C	Current Market Valuation of Existing Building
Gross Floor Area	**8,800 m2**	**12,930 m2**	**21,573 m2**	**8,800 m2**
	$5,380 /m2	**$5,929 /m2**	**$6,924 /m2**	**$6,987 /m2**
	$500 /SF	**$551 /SF**	**$643 /SF**	**$649 /SF**

Life Cycle Costing Assessment (LCCA)	Scenario A	Scenario B	Scenario C	Current Market Valuation of Existing Building
16 Operational & Maintenance Costs (60 years cycle)	$31,949,000	$43,313,000	$60,063,000	$30,438,373
17 Replacement Costs (60 years cycle)	$117,043,000	$159,880,000	$279,606,000	$125,178,920
18 Operational Carbon Costs (minimal)	$12,000	$16,000	$18,000	$855,000
19 Total Inflation (60 years cycle)	$28,186,000	$38,661,000	$66,259,000	$29,939,258
Total Operational Cost (B)	**$177,190,000**	**$241,870,000**	**$405,946,000**	**$186,411,551**
Total Ownership Cost Over 60 Years - Post-Inflation (A + B)	**$224,530,000**	**$318,534,000**	**$555,314,000**	**$247,900,551**
Net Present Value	**$115,094,149**	**$168,670,242**	**$301,969,599**	**$120,805,688**

ELEMENTAL SUMMARY

CASE STUDY 2 - MONTREAL - SCENARIO A

OM ESTIMATE (Rev.2)
NOVEMBER 19, 2025

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Gross Floor Area 8,800 m2

Description Element\Sub-Element	Ratio	Quantity	Unit	Unit Rate	Elemental Cost Sub Element	Elemental Cost Element Total	$ per m2 Sub Element	$ per m2 Element	%
A. SHELL									
A1. Sub-Structure						**$190,000**		$21.59	0.4%
A1.1 Foundations	0.50	4,400	m2	$43.18	$190,000		$21.59		
A1.2 Basement Excavation	0.50	4,400	m2	$0.00	$0		$0.00		
A2. Structure						**$1,136,800**		$129.18	2.4%
A2.1 Lowest Floor Construction	0.50	4,400	m2	$115.00	$506,000		$57.50		
A2.2 Upper Floor Construction	0.50	4,400	m2	$68.36	$300,800		$34.18		
A2.3 Roof Construction	0.50	4,400	m2	$75.00	$330,000		$37.50		
A3. Exterior Enclosure						**$3,036,142**		$345.02	6.4%
A3.1 Walls Below Grade	0.00	0	m2	$0.00	$0		$0.00		
A3.2 Walls Above Grade	0.30	2,612	m2	$112.00	$292,590		$33.25		
A3.3 Windows & Entrances	0.01	70	m2	$3,523.01	$246,000		$27.95		
A3.4 Roof Finish	0.50	4,400	m2	$404.75	$1,780,900		$202.38		
A3.5 Projections	1.00	8,800	m2	$81.44	$716,652		$81.44		
B. INTERIORS									
B1 Partitions & Doors						**$3,137,977**		$356.59	6.6%
B1.1 Partitions	0.52	4,567	m2	$514.29	$2,348,777		$266.91		
B1.2 Doors	0.03	253	m2	$3,119.16	$789,200		$89.68		
B2 Finishes						**$3,712,100**		$421.83	7.8%
B2.1 Floor Finishes	0.95	8,360	m2	$142.00	$1,187,120		$134.90		
B2.2 Ceiling Finishes	0.95	8,360	m2	$210.03	$1,755,860		$199.53		
B2.3 Wall Finishes	1.20	10,560	m2	$72.83	$769,120		$87.40		
B3 Fittings & Equipment						**$6,714,000**		$762.95	14.2%
B3.1 Fittings & Fixtures	1.00	8,800	m2	$728.86	$6,414,000		$728.86		
B3.2 Equipment				Excluded			$0.00		
B3.3 Conveying Systems	1.00	8,800	m2	$34.09	$300,000		$34.09		
C. SERVICES									
C1 Mechanical						**$6,835,600**		$776.77	14.4%
C1.1 Plumbing & Drainage	1.00	8,800	m2	$138.90	$1,222,300		$138.90		
C1.2 Fire Protection	1.00	8,800	m2	$77.03	$677,900		$77.03		
C1.3 HVAC	1.00	8,800	m2	$495.84	$4,363,400		$495.84		
C1.4 Controls	1.00	8,800	m2	$65.00	$572,000		$65.00		
C2 Electrical						**$4,374,330**		$497.08	9.2%
C2.1 Service & Distribution	1.00	8,800	m2	$119.24	$1,049,272		$119.24		
C2.2 Lighting, Devices & Heating	1.00	8,800	m2	$218.08	$1,919,075		$218.08		
C2.3 Systems & Ancillaries	1.00	8,800	m2	$159.77	$1,405,983		$159.77		
D. SITE & ANCILLARY WORK									
D1 Site Work						**$499,715**		$56.79	1.1%
D1.1 Site Development	0.05	426	m2	$628.70	$267,826		$30.43		
D1.2 Mechanical Site Services	0.05	426	m2	$109.15	$46,500		$5.28		
D1.3 Electrical Site Services	0.05	426	m2	$435.19	$185,390		$21.07		
D2 Ancillary Work						**$1,458,000**		$165.68	3.1%
D2.1 Demolition	1.00	8,800	m2	$165.68	$1,458,000		$165.68		
D2.2 Alterations	0.00	0	m2	$0.00	$0		$0.00		
Z. GENERAL REQUIREMENTS & CONTINGENCIES									
Z1 General Requirements & Fees						**$4,769,000**		$541.93	10.1%
Z1.1 General Requirements	1.00	8,800	m2	$385.23	$3,390,000		$385.23		
Z1.2 Fees	1.00	8,800	m2	$156.70	$1,379,000		$156.70		
Z2 Allowances						**$11,476,400**		$1,304.14	24.2%
Z2.1 Design & Pricing Contingency	1.00	8,800	m2	$815.09	$7,172,800		$815.09		
Z2.2 Escalation Contingency				Excluded			$0.00		
Z2.3 Construction Contingency	1.00	8,800	m2	$489.05	$4,303,600		$489.05		
TOTAL ESTIMATED CONSTRUCTION COST (nearest ,000)						**$47,340,000**		**$5,380**	**100.0%**

ELEMENTAL SUMMARY

CASE STUDY 2 - MONTREAL - SCENARIO B

OM ESTIMATE (Rev.2)
NOVEMBER 19, 2025

A.W. HOOKER ®
QUANTITY SURVEYORS

Gross Floor Area 12,930 m2

Description Element\Sub-Element	Ratio	Quantity	Unit	Unit Rate	Elemental Cost Sub Element	Elemental Cost Element Total	$ per m2 Sub Element	$ per m2 Element	%
A. SHELL									
A1. Sub-Structure						$190,000		$14.69	0.2%
A1.1 Foundations	0.34	4,400	m2	$43.18	$190,000		$14.69		
A1.2 Basement Excavation	0.00	0	m2	$0.00	$0		$0.00		
A2. Structure						$8,830,300		$682.93	11.5%
A2.1 Lowest Floor Construction	0.34	4,400	m2	$115.00	$506,000		$39.13		
A2.2 Upper Floor Construction	0.32	4,130	m2	$1,110.00	$4,584,300		$354.55		
A2.3 Roof Construction	0.34	4,400	m2	$850.00	$3,740,000		$289.25		
A3. Exterior Enclosure						$6,075,129		$469.85	7.9%
A3.1 Walls Below Grade	0.00	0	m2	$0.00	$0		$0.00		
A3.2 Walls Above Grade	0.30	3,919	m2	$817.27	$3,202,566		$247.68		
A3.3 Windows & Entrances	0.01	77	m2	$3,626.30	$277,600		$21.47		
A3.4 Roof Finish	0.34	4,400	m2	$406.86	$1,790,181		$138.45		
A3.5 Projections	1.00	12,930	m2	$62.24	$804,782		$62.24		
B. INTERIORS									
B1 Partitions & Doors						$4,662,020		$360.56	6.1%
B1.1 Partitions	0.55	7,048	m2	$519.17	$3,659,140		$283.00		
B1.2 Doors	0.03	333	m2	$3,013.25	$1,002,880		$77.56		
B2 Finishes						$5,363,749		$414.83	7.0%
B2.1 Floor Finishes	0.95	12,323	m2	$134.83	$1,661,478		$128.50		
B2.2 Ceiling Finishes	0.95	12,284	m2	$209.67	$2,575,440		$199.18		
B2.3 Wall Finishes	1.20	15,516	m2	$72.62	$1,126,832		$87.15		
B3 Fittings & Equipment						$8,061,700		$623.49	10.5%
B3.1 Fittings & Fixtures	1.00	12,930	m2	$588.69	$7,611,700		$588.69		
B3.2 Equipment				Excluded			$0.00		
B3.3 Conveying Systems	1.00	12,930	m2	$34.80	$450,000		$34.80		
C. SERVICES									
C1 Mechanical						$9,728,315		$752.38	12.7%
C1.1 Plumbing & Drainage	1.00	12,930	m2	$122.50	$1,583,960		$122.50		
C1.2 Fire Protection	1.00	12,930	m2	$88.01	$1,137,960		$88.01		
C1.3 HVAC	1.00	12,930	m2	$480.87	$6,217,665		$480.87		
C1.4 Controls	1.00	12,930	m2	$61.00	$788,730		$61.00		
C2 Electrical						$6,388,123		$494.05	8.3%
C2.1 Service & Distribution	1.00	12,930	m2	$112.66	$1,456,646		$112.66		
C2.2 Lighting, Devices & Heating	1.00	12,930	m2	$220.64	$2,852,832		$220.64		
C2.3 Systems & Ancillaries	1.00	12,930	m2	$160.76	$2,078,645		$160.76		
D. SITE & ANCILLARY WORK									
D1 Site Work						$669,198		$51.76	0.9%
D1.1 Site Development	0.03	426	m2	$628.70	$267,826		$20.71		
D1.2 Mechanical Site Services	0.03	426	m2	$430.75	$183,500		$14.19		
D1.3 Electrical Site Services	0.03	426	m2	$511.44	$217,872		$16.85		
D2 Ancillary Work						$1,558,500		$120.53	2.0%
D2.1 Demolition	1.00	12,930	m2	$120.53	$1,558,500		$120.53		
D2.2 Alterations	0.00	0	m2	$0.00	$0		$0.00		
Z. GENERAL REQUIREMENTS & CONTINGENCIES									
Z1 General Requirements & Fees						$7,902,000		$611.14	10.3%
Z1.1 General Requirements	1.00	12,930	m2	$434.34	$5,616,000		$434.34		
Z1.2 Fees	1.00	12,930	m2	$176.80	$2,286,000		$176.80		
Z2 Allowances						$17,234,600		$1,332.92	22.5%
Z2.1 Design & Pricing Contingency	1.00	12,930	m2	$919.26	$11,886,000		$919.26		
Z2.2 Escalation Contingency				Excluded			$0.00		
Z2.3 Construction Contingency	1.00	12,930	m2	$413.66	$5,348,600		$413.66		
TOTAL ESTIMATED CONSTRUCTION COST (nearest ,000)						**$76,664,000**		**$5,929**	**100.0%**

ELEMENTAL SUMMARY

CASE STUDY 2 - MONTREAL - SCENARIO C

OM ESTIMATE (Rev.2)

NOVEMBER 19, 2025

A.W. HOOKER QUANTITY SURVEYORS ®

Gross Floor Area 21,573 m2

Description Element\Sub-Element	Ratio	Quantity	Unit	Unit Rate	Elemental Cost Sub Element	Elemental Cost Element Total	$ per m2 Sub Element	$ per m2 Element	%
A. SHELL									
A1. Sub-Structure						**$4,527,937**		$209.89	3.0%
A1.1 Foundations	0.20	4,243	m2	$779.08	$3,305,650		$153.23		
A1.2 Basement Excavation	0.20	4,243	m2	$288.07	$1,222,287		$56.66		
A2. Structure						**$21,798,705**		$1,010.46	14.6%
A2.1 Lowest Floor Construction	0.20	4,243	m2	$298.19	$1,265,200		$58.65		
A2.2 Upper Floor Construction	0.80	17,330	m2	$1,025.71	$17,775,555		$823.97		
A2.3 Roof Construction	0.20	4,243	m2	$650.00	$2,757,950		$127.84		
A3. Exterior Enclosure						**$9,723,460**		$450.72	6.5%
A3.1 Walls Below Grade	0.06	1,233	m2	$1,128.60	$1,391,560		$64.50		
A3.2 Walls Above Grade	0.24	5,225	m2	$1,030.00	$5,381,568		$249.46		
A3.3 Windows & Entrances	0.004	77	m2	$3,756.93	$287,600		$13.33		
A3.4 Roof Finish	0.20	4,243	m2	$437.89	$1,857,950		$86.12		
A3.5 Projections	1.00	21,573	m2	$37.31	$804,782		$37.31		
B. INTERIORS									
B1 Partitions & Doors						**$8,131,288**		$376.92	5.4%
B1.1 Partitions	0.49	10,671	m2	$565.00	$6,029,088		$279.47		
B1.2 Doors	0.03	750	m2	$2,802.62	$2,102,200		$97.45		
B2 Finishes						**$8,701,657**		$403.36	5.8%
B2.1 Floor Finishes	0.95	20,494	m2	$123.07	$2,522,317		$116.92		
B2.2 Ceiling Finishes	0.95	20,494	m2	$209.48	$4,293,185		$199.01		
B2.3 Wall Finishes	1.20	25,888	m2	$72.86	$1,886,155		$87.43		
B3 Fittings & Equipment						**$11,018,170**		$510.74	7.4%
B3.1 Fittings & Fixtures	1.00	21,573	m2	$469.02	$10,118,170		$469.02		
B3.2 Equipment				Excluded			$0.00		
B3.3 Conveying Systems	1.00	21,573	m2	$41.72	$900,000		$41.72		
C. SERVICES									
C1 Mechanical						**$24,406,326**		$1,131.34	16.3%
C1.1 Plumbing & Drainage	1.00	21,573	m2	$144.91	$3,126,110		$144.91		
C1.2 Fire Protection	1.00	21,573	m2	$83.73	$1,806,410		$83.73		
C1.3 HVAC	1.00	21,573	m2	$814.33	$17,567,506		$814.33		
C1.4 Controls	1.00	21,573	m2	$88.37	$1,906,300		$88.37		
C2 Electrical						**$11,385,643**		$527.77	7.6%
C2.1 Service & Distribution	1.00	21,573	m2	$129.36	$2,790,771		$129.36		
C2.2 Lighting, Devices & Heating	1.00	21,573	m2	$231.65	$4,997,405		$231.65		
C2.3 Systems & Ancillaries	1.00	21,573	m2	$166.76	$3,597,467		$166.76		
D. SITE & ANCILLARY WORK									
D1 Site Work						**$922,447**		$42.76	0.6%
D1.1 Site Development	0.02	426	m2	$807.90	$344,166		$15.95		
D1.2 Mechanical Site Services	0.02	426	m2	$706.57	$301,000		$13.95		
D1.3 Electrical Site Services	0.02	426	m2	$650.90	$277,282		$12.85		
D2 Ancillary Work						**$2,168,000**		$100.50	1.5%
D2.1 Demolition	1.00	21,573	m2	$100.50	$2,168,000		$100.50		
D2.2 Alterations	0.00	0	m2	$0.00	$0		$0.00		
Z. GENERAL REQUIREMENTS & CONTINGENCIES									
Z1 General Requirements & Fees						**$15,762,000**		$730.64	10.6%
Z1.1 General Requirements	1.00	21,573	m2	$519.31	$11,203,000		$519.31		
Z1.2 Fees	1.00	21,573	m2	$211.33	$4,559,000		$211.33		
Z2 Allowances						**$30,822,000**		$1,428.73	20.6%
Z2.1 Design & Pricing Contingency	1.00	21,573	m2	$1,099.01	$23,709,000		$1,099.01		
Z2.2 Escalation Contingency				Excluded			$0.00		
Z2.3 Construction Contingency	1.00	21,573	m2	$329.72	$7,113,000		$329.72		
TOTAL ESTIMATED CONSTRUCTION COST (nearest ,000)						**$149,368,000**		**$6,924**	**100.0%**

CAHP Existing Heritage Buildings, Carbon & Building Code Study - Case Study 3 - Vancouver

Order of Magnitude Estimate (Rev.3)

Prepared for:

Giaimo

Prepared by:

A.W. HOOKER®
QUANTITY SURVEYORS

2904 South Sheridan Way, Suite 202
Oakville, ON L6J 7L7
T 905.823.8111

info@awhooker.com
www.awhooker.com

November 19, 2025

A.W. HOOKER ®
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2904 South Sheridan Way,
Suite 202, Oakville, ON, L6J 7L7
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www.awhooker.com

THE PEOPLE | THE DIFFERENCE®

November 19, 2025

Giaimo
213 Sterling Road, Unit 204
Toronto, ON M6R 2B2

Re: CAHP Existing Heritage Buildings – Case Study 3 – Vancouver (R.3)

Dear Giaimo,

Please find enclosed our Order of Magnitude Estimate for the above project. The estimate is based on design drawings and information provided by Giaimo received on September 15, 2025. The latest report reflects updates based on meeting discussions, as well as additional information shared throughout those sessions.

This estimate is meant to reflect the fair market value for the construction of this project; it is not intended to be the prediction of the lowest bid and should be representative of the median bid amount received in a competitive bidding scenario.

We recommend that the owner and/or the design team carefully review the cost estimate report, including line item descriptions, unit price clarifications, exclusions, inclusions and assumptions, contingencies, escalation, and mark-ups. This is to ensure that the design intent is captured within the content of the report.

Please refer to the preamble of our cost report for all exclusions, assumptions, and information pertaining to the estimate.

Requests for modifications of any apparent errors or omissions to this document must be made to A.W. Hooker Associates Ltd. within ten (10) business days of receipt of this estimate. Otherwise, it will be understood that the contents in this estimate have been concurred with and accepted as final version of the cost report.

We trust our work will assist in the decision making process and look forward to our continued involvement in this important project.

Sincerely,
A.W. Hooker Associates Ltd

Weger Barwari

Weger Barwari, PQS, C.Tech
Associate

Sincerely,
A.W. Hooker Associates Ltd

Bineesh Susamma, PMP, PQS
Associate (Mechanical)

Encl. (OM Estimate - Scenario A, B, C & 0 (R.2) – November 19, 2025)

Table of Contents

1. Introduction to the Estimate

1.1 Project Description

This project involves research, developing capacity-building resources, and disseminating findings to prepare Canadian markets for the future release and prompt adoption of retrofit codes for three (3) building case studies (Halifax, Montreal and Vancouver). AWH role is to determine the full building cost for each of the three scenarios, a high-level cost for the existing building condition, a

The carbon analysis will include three (3) scenarios:
1. Scenario 1: adaptive reuse renovation (no addition)
2. Scenario 2: adaptive reuse renovation (with addition)
3. Scenario 3: demolition and replacement with new building

An additional scenario as been provided for current market valuation of existing building.

1.2 Type of Estimate

This Order of Magnitude Estimate is intended to establish a realistic elemental estimate of the hard construction costs based on the level of design information provided. Detailed quantities have been measured from drawings where possible for the proposed building and associated site development. This estimate reflects our opinion as to the fair market value for the hard construction of this project.

The accuracy of the estimate is based on the documentation provided and design stage is intended to be +/- 30%-100%. This accuracy is based on the definition for Estimate Classifications (Class D) outlined in the *Guide to Cost Predictability in Construction prepared by the Joint Federal Government & an Industry Cost Predictability Taskforce. Contingencies are included to offset the accuracy risk, to the extent that the estimated amount represents the current opinion of the likely fair market value at the time of tender.

The intention of the estimate is not to predict the low bid price received; typically based on historical tender results estimates are more likely to be towards the median value of bids received under competitive conditions as per common practice based CIQS guidelines. This is a deliberate methodology due to the inherent risk in attempting to predict the low bid and numerous factors which can contribute to lower than anticipated tender submissions which are beyond our control.

Cost Estimate Classification Systems					
AACE *(1)	Class 5	Class 4	Class 3	Class 2	Class 1
DND *(2)			Indicative	Substantive	
RAIC*(3)	OME	Sketch Design	Design Development	Contract Documents	Tender Documents
GOC *(4)	OME	D	C	B	A
Design Documentation % Complete					
		12.5%	25.0%	95.0%	100.0%
Cost Estimate Accuracy (+ or - Percentage)					
	+/- 30%-100%	+/- 20%-30%	+/- 15%-20%	+/- 10%-15%	+/- 5%-10%

Legend
***(1)** AACE Association for the Advancement Of Cost Engineering
***(2)** OND Department of National Defense
***(3)** RAIC Royal Architectural Institute Of Canada
***(4)** GOC Government

*Reference: https://cacqs.ca/wp-content/uploads/2024/10/best-practices-guide-2024.pdf

2. Basis of the Estimate

2.1 General Information

From the design information provided, we have measured quantities where possible and applied typical unit rates for each of the specific elements based on the project specifications. Where specific design information has not been provided, unit rates are based on historical cost data for this type of project. In some instances where design information is limited, we have made reasonable assumptions based on our experience with projects of a similar scope and design. Estimates for mechanical and electrical systems are developed based on information prepared by the project engineers, historical projects and experience.

Significant changes to the basis of design will impact the estimate value; this is particularly critical where changes are made after the final estimate prior to tender. We recommend that all major design or scope changes be reviewed for their cost, time and constructability impact prior to incorporation in a finalized tender package.

2.2 Location Cost Base

The location cost base for this estimate is Vancouver, BC.

2.3 Unit Rates

The unit rates in the preparation of the elemental estimate include labour and material, equipment, and subcontractors overheads and profits. We have assumed for pricing purposes that union contractors would perform the work. We have assumed the fair wage policy would be in effect. The unit rates for each of the elements are based on typical mid-range costs for the type of design, construction, and materials proposed.

Unit rates in all estimates combine the material, labour, and equipment components for a single unit cost for ease of presentation. This estimate is not a prediction of low bid. Pricing assumes competitive bidding for every aspect of the work.

2.4 Taxes

Harmonized Sales Tax (HST) is excluded from our estimate.

2.5 Construction Schedule

The estimate has been prepared on the assumption that the work will be performed within the timelines of a normal construction schedule. The duration of the schedule would be based on the work being performed during regular daytime work hours. We have assumed the structural components of the building would be constructed in predominantly non-winter months. No allowances have been included for premium time and after hours work associated with an accelerated construction schedule.

2.6 General Requirements and Fees

The General Requirements for the General Contractor are included as a percentage of the hard construction cost. This estimate of the prime contractor's site overheads includes site supervision and labour, access to the site, site accommodations, site protection, temporary utilities, clean up, equipment, and other miscellaneous project requirements provided by the General Contractor.

The Fee element of the estimate is meant to cover the General Contractor's fee to perform the work. The fee would be based on the competitive nature of the bidding process and the market conditions at the time of tender.

2.7 Bonding and Insurance

We have included the median estimated costs for 50% Performance, 50% Labour and Materials. These are the traditional bonding requirements commonly requested by the owner. The actual final bonding costs will vary depending on the selected contractors' performance history.

The estimate includes an allowance for general liability and builder's risk insurance based on an average cost per $1,000 of estimated hard construction costs. The actual insurance costs would be subject to the insurance requirements for the project.

2.8 Procurement

It was assumed for the preparation of this estimate that the project would be tendered to a prequalified list of bidders with a project specific lump sum contract. Pricing is based on competitive tender results with a minimum of four (preferably six tender submissions) at General Contractor's and major trade level. Pre-qualification with a restrictive list of contractors or subcontractors may result in a higher tendered cost due to the inherent reduction in competitiveness. Tenders receiving two or less submissions (occasionally three) historically tend to have a much higher risk of an overrun in cost when compared to the budget established in an estimate. Ensuring adequate bonafide bidders is a prerequisite for competitive bidding scenarios, on which the estimate is predicated.

2.9 Specifications

Where detailed and comprehensive specifications are unavailable, we have assumed that no onerous special requirements will be applicable to this project. It was assumed that all materials and equipment could be substituted with an alternative product to avoid sole-sourcing which results in a non-competitive market condition.

2.10 Soft Costs

The estimated soft costs have been excluded in this estimate.

These costs include items traditionally funded by the owner and separate from the hard construction costs which would be applicable to the contractor. The soft costs include items such as consultant fees; disbursements; project management fees; independent inspection and testing; third party commissioning; legal fees; permits and development charges; operational and moving expenses; financing and loan fees; owner supplied furnishings, fixtures, and equipment; land acquisition costs; and Harmonized Sales Tax.

2.11 Life Cycle Costing Assessment (LCCA)

As part of the study, we have also been tasked with preparing a high-level Life Cycle Cost Assessment (LCCA) for each scenario. This assessment evaluates the total cost of ownership over a 60-year period, encompassing initial capital, operational energy cost, maintenance, replacement, and operational carbon costs. All costs are presented in Net Present Value (NPV) terms, calculated based on assumptions and parameters mutually agreed upon by the client, design team, and engineering consultants.

- 4% Capital inflation
- 2% Energy Inflation

The costing framework is informed by the following reference documents:

- ASHRAE Guidelines
- WSP Building Envelope Renewal Cycle
- WSP Building Structure Renewal Cycle
- Environment and Climate Change Canada (ECCC) Data Catalogue
- Various other publications and manufacture recommendations

3. Contingencies

3.1 Design and Pricing Contingency

A design and pricing contingency has been included in the estimate as a percentage of the hard construction costs including the general requirements and fees. This contingency is meant to cover design and pricing unknowns in the preparation of this estimate and reflect the incomplete nature of the design information provided at the time the estimate is prepared.

The estimate includes the following design and pricing contingencies by discipline:

Design Contingencies		
Architectural	-	20%
Structural	-	20%
Mechanical	-	20%
Electrical	-	20%
Siteworks	-	20%

The contingency where included in our estimate is not meant to cover significant additional program space or quality modifications, but rather to provide some flexibility as the design develops. The design contingency typically decreases as the design progresses and more definition and detail is available to refine the basis of the cost estimate. If the owner anticipates significant changes to the basis of design we recommend additional contingency be retained as a reserve for the scope modifications.

3.2 Escalation Contingency

The estimate excludes an allowance for escalation. This allowance, when included, is meant to provide for increases in construction costs due to changes in market conditions between the time of the estimate and the potential construction commencement. For projects with a schedule in excess of 12 months, the contingency is based on a timeframe that takes escalation to the midpoint of the construction phase.

Escalation during construction is included in the unit rates; essentially this allowance is the risk carried by the general contractor and trades with a fixed price made years before the work is completed or carried out for some trades.

3.3 Construction Contingency (Post Contract Changes)

The estimate includes a contingency for the construction phase of the project. This contingency is meant to cover the potential cost of post contract changes that may occur after the project is tendered.

The following allowances are to provide for increases in construction costs due to Change Orders issued during construction.

Case study 3 - Vancouver
Scenario A: 10%
Scenario B: 7.5%
Scenario C: 5%
Existing Building: 5%

This contingency excludes any major program or scope requests by the client; these should form part of an overall project management reserve or be reflected in increased funding

4. General Liability

4.1 Statement of Probable Costs

A.W. Hooker Associates Ltd. (HOOKER) has no control over the cost of labour and materials, the general contractors or any subcontractors' methods of determining prices, or competitive bidding and market conditions. This opinion of probable cost of construction is based on the experience, qualifications, and best judgment of the professional consultant familiar with the construction industry. HOOKER does not warranty that proposals or actual construction costs will not vary from this or subsequent estimates.

4.2 Ongoing Cost Control

A.W. Hooker Associates Ltd. recommends that the owner and/or the design team carefully review the cost estimate report, including line item descriptions, unit price clarifications, exclusions, inclusions and assumptions, contingencies, escalation, and mark-ups. This is to ensure that the design intent is captured within the content of the report. This is especially important at early stage estimates which tend to be based on a lesser level of design completion.

If the project is over budget or there are unresolved budget issues, alternative systems or schemes should ideally be evaluated before proceeding with the design phase. We recommend that cost control be implemented throughout the various stages of the design process to ensure the proposed design remains within the overall budget. It is recommended that the final estimate be produced by HOOKER using Bid Documents to determine overall cost changes, which may have occurred since the preparation of this estimate. The final update estimate will address changes and additions to the documents as well as addenda issued during the bidding process. HOOKER cannot reconcile bid results to any estimate not produced from bid documents including all addenda.

5. Estimate Scope Clarifications

5.1 List of Exclusions

1. Harmonized Sales Tax (HST)
2. Project Soft Costs (as described in item 2.10 above)
3. Furniture, furnishings, and equipment (except as noted in the estimate)
4. Premium time / after hours work
5. Accelerated construction schedule
6. Abatement and handling of asbestos and other hazardous materials
7. Handling and removal of contaminated soils
8. Special foundation systems such as caissons or pile foundations
9. Premium for construction management or alternate approaches to procurement
10. Sole sourced equipment or control systems
11. Consumption costs for any utilities used during construction (gas, water, hydro etc.)
12. Tariffs and risks of potential additional tariffs due to geopolitical uncertainty

5.2 List of Assumptions

Architectural / Structural / Landscaping:

1. The existing soils on the site are adequate to support standard strip and pad foundations to the minimum depth required for frost. No allowances have been made for larger or special foundations such as caissons or piles due to poor soil conditions.
2. We have assumed the majority of the work to be performed during regular day shifts (unrestricted access to the building during the hours of 8AM to 6 PM Monday to Friday).
3. Contractor will clean up daily to general housekeeping standards.
4. Work is assumed to be completed in one continuous phase.
5. We have assumed the relocation of any existing loose furniture and equipment prior to demolition (chairs, tables, desks, filing cabinets, machinery etc.) is to be by Owner.
6. For the purpose of this report, it is assumed under hypothetical situation that the new addition in the back (North end) does not exist and therefore we have not included in costs related to demo and retrofit of this building to accommodate work in each scenario.
7. Foundation:
    a. Scenario A: existing to remain. The existing foundation is adequate and does not require strengthening.
    b. Scenario B: shallow foundation and slab at new extension. The existing foundation is adequate and does not require strengthening. assumed 1 months dewatering, 1 months winter heating. Allowance for temporary shoring due to close proximity of nearby buildings. Allowance for underpinning of existing foundations, assumed 6 meters.
    c. Scenario C: new shallow isolated foundation including strip footings, walls, pier and pad footings, assumed 2 months dewatering, 2 months winter heating.
8. Upper Floor & Roof Construction:
    a. Scenario A: assumed existing wood frame structure to remain.
    b. Scenario B: assumed existing wood frame structure to remain.
    c. Scenario C: new wood frame structure at upper floors and roof construction.
9. Exterior Enclosure:
    a. Scenario A: existing wood cladding to remain. Replacement of existing doors and windows.
    b. Scenario B: new below grade CIP concrete walls at basement access. Replace existing wood cladding with new fiber cement siding including back-up assembly. Replacement of existing doors and windows.
    c. Scenario C: new fiber cement siding including back-up assembly.
10. Roof:
    a. Scenario A: replace existing with new asphalt shingle roof.
    b. Scenario B: replace existing with new asphalt shingle roof.
    c. Scenario C: new asphalt shingle roof.
11. Door count and type are assumed based on as-built drawings.
12. Interior partitions: gypsum board.
13. Floor Finishes: combination of ceramic tiles, carpet, vct flooring, wood flooring, and concrete sealer.
14. Ceiling Finishes: combination of suspended gypsum board and paint to exposed structure.
15. Wall Finishes: combination of paint finish, ceramic tiles.
16. We have included an allowance for millwork cabinetry.
17. We have included allowances for specialty items.
18. We have included allowances for site preparation work, hard landscape, site improvements, and soft landscape works.
19. Demolition:
    a. Scenario A: selective demolition of interior works and associated M&E scope.
    b. Scenario B: selective demolition of interior works, opening in basement foundation walls for new basement access, and associated M&E scope.
    c. Scenario C: demolish and dispose of the existing building.

Mechanical:

20. Work will be conducted by union or fair wage contractors.
21. The estimates for Scenarios A and B include minor upgrades to the mechanical utility services, based on the assumption that existing service sizes are generally adequate for the new building. Scenario C would require repurposing of the existing service
22. Electric tank water heaters are included for each washroom group and kitchen.
23. Scenario C garage building is unheated and has no ventilation.
24. In-suite heating and cooling will be provided by a VRF heat pump system with ERV units for ventilation. Ductless split units are included for each primary space and connected to outdoor-mounted ASHP VRF units. Supplemental back-up baseboard heaters, interlocked with the indoor units, are provided for peak winter conditions.
25. The estimate incudes an allowance for selective demolition of existing mechanical system in place, disconnection and making safe.
26. Standalone/thermostatic controls included, central BAS excluded.
27. Third party tests, certifications etc. are excluded.
28. Please see our back up estimates for the various assumptions we have considered.

Electrical:

29. Work will be performed by fare wage labor during regular hours.
30. New 120/240V incoming service for both scenario B and C has been included in the estimate.
31. New sub panels and sub meters have been included in the estimate.
32. An allowance of $15,000 for utility service for scenario B has been included in the estimate.
33. An allowance of $20,000 for utility service for scenario C has been included in the estimate
34. LED lighting will be provided throughout.
35. Stand alone smoke detector has been included in the estimate.
36. Allowance for rough-in only for security, communication and doorbell systems has been included in the estimate.
37. Refer to estimate for additional scope specific assumptions.

General:

38. Various assumptions have been made based on the design information available and our experience with projects of a similar nature. Please refer to the specific items within the estimate for the detailed assumptions made.

6. Documentation Received

Drawings and design documentation were prepared by Giaimo:

Pages	Documentation	Documentation Received
7 Drawings	250714_Vancouver Case Study_Scenario C	September 15, 2025
8 Drawings	250715_Vancouver Case Study_Scenario B	September 15, 2025
38 Pages	CAHP Case Studies Summary	September 15, 2025
	Emails	Various

MULTIPLE ESTIMATE SUMMARY
CAHP - CASE STUDY 3 - VANCOUVER
OM ESTIMATE (Rev.3)
NOVEMBER 19, 2025

A.W. HOOKER QUANTITY SURVEYORS ®

Hard Construction Costs		Scenario A		Scenario B		Scenario C		Current Market Valuation of Existing Building
1 Sub-Structure		$0		$150,255		$219,788		$131,873
2 Structure		$16,660		$174,310		$236,700		$117,775
3 Exterior Enclosure		$57,311		$406,199		$492,996		$197,945
4 Interiors		$193,606		$432,252		$384,685		$193,606
5 Mechanical		$161,700		$384,005		$254,875		$145,530
6 Electrical		$44,500		$111,422		$99,417		$40,050
7 Site Development		$74,057		$98,482		$108,442		$74,057
8 Mechanical Site Services		$0		$25,000		$25,000		$25,000
9 Electrical Site Services		$8,821		$40,228		$40,228		$40,228
10 Demolition		$42,350		$42,350		$83,250		Excluded
Sub Total Before Mark-Ups		**$599,004**		**$1,864,503**		**$1,945,381**		**$966,064**
General Requirements								
11 General Requirements	10.9%	$65,000	10.9%	$203,000	10.9%	$212,000	10.9%	$105,000
12 Fees	4.0%	$27,000	4.0%	$83,000	4.0%	$86,000	4.0%	$43,000
Sub-Total General Requirements & Fees		**$92,000**		**$286,000**		**$298,000**		**$148,000**
Sub Total Incl. General Requirement & Fees		**$691,004**		**$2,150,503**		**$2,243,381**		**$1,114,064**
Contingencies								
13 Design & Pricing Contingency	20.0%	$137,500	20.0%	$431,000	20.0%	$449,000	20.0%	$223,000
14 Escalation Contingency		Excluded		Excluded		Excluded		Excluded
15 Construction Contingency	10.0%	$83,000	7.5%	$193,600	5.0%	$135,000	5.0%	$67,000
Sub-Total Contingencies		**$220,500**		**$624,600**		**$584,000**		**$290,000**
Total Estimated Hard Construction Cost Incl. Mark-ups and Contingencies (A)		**$912,000**		**$2,775,000**		**$2,827,000**		**$1,404,000**
Gross Floor Area		**205 m2**		**465 m2**		**412 m2**		**205 m2**
		$4,449 /m2		**$5,968 /m2**		**$6,862 /m2**		**$6,849 /m2**
		$413 /SF		**$554 /SF**		**$637 /SF**		**$636 /SF**

Life Cycle Costing Assessment (LCCA)		Scenario A		Scenario B		Scenario C		Current Market Valuation of Existing Building
16 Operational & Maintenance Costs (60 years cycle)		$729,607		$1,195,253		$1,027,356		$636,308
17 Replacement Costs (60 years cycle)		$2,342,181		$5,537,974		$4,881,899		$2,750,679
18 Operational Carbon Costs		$2,437		$4,347		$3,209		$52,724
19 Total Inflation (60 years cycle)		$591,079		$1,294,951		$1,177,472		$660,294
Total Operational Cost (B)		**$3,665,304**		**$8,032,524**		**$7,089,935**		**$4,100,005**
Total Ownership Cost Over 60 Years - Post-Inflation (A + B)		**$4,577,304**		**$10,807,524**		**$9,916,935**		**$5,504,005**
Net Present Value		**$2,332,790**		**$5,844,778**		**$5,467,903**		**$3,002,635**

ELEMENTAL SUMMARY

CASE STUDY 3 - VANCOUVER - SCENARIO A

OM ESTIMATE (Rev.3)
NOVEMBER 19, 2025

A.W. HOOKER ®
QUANTITY SURVEYORS

Gross Floor Area 205 m2

Description Element\Sub-Element	Ratio	Quantity	Unit	Unit Rate	Elemental Cost: Sub Element	Elemental Cost: Element Total	$ per m2 Sub Element	$ per m2 Element	%
A. SHELL									
A1. Sub-Structure						**$0**		$0.00	0.0%
A1.1 Foundations	0.00	0	m2	$0.00	$0		$0.00		
A1.2 Basement Excavation	0.00	0	m2	$0.00	$0		$0.00		
A2. Structure						**$16,660**		$81.27	1.8%
A2.1 Lowest Floor Construction	0.00	0	m2	$0.00	$0		$0.00		
A2.2 Upper Floor Construction	0.00	0	m2	$0.00	$0		$0.00		
A2.3 Roof Construction	0.58	119	m2	$140.00	$16,660		$81.27		
A3. Exterior Enclosure						**$57,311**		$279.57	6.3%
A3.1 Walls Below Grade	0.00	0	m2	$0.00	$0		$0.00		
A3.2 Walls Above Grade	0.81	167	m2	$68.00	$11,356		$55.40		
A3.3 Windows & Entrances	0.06	12	m2	$937.05	$11,000		$53.66		
A3.4 Roof Finish	0.58	119	m2	$245.00	$29,155		$142.22		
A3.5 Projections	1.00	205	m2	$28.29	$5,800		$28.29		
B. INTERIORS									
B1 Partitions & Doors						**$66,585**		$324.80	7.3%
B1.1 Partitions	1.20	246	m2	$197.50	$48,585		$237.00		
B1.2 Doors	0.09	18	m2	$1,016.65	$18,000		$87.80		
B2 Finishes						**$92,171**		$449.61	10.1%
B2.1 Floor Finishes	0.95	195	m2	$164.00	$31,939		$155.80		
B2.2 Ceiling Finishes	0.95	195	m2	$270.54	$52,688		$257.01		
B2.3 Wall Finishes	1.60	328	m2	$23.00	$7,544		$36.80		
B3 Fittings & Equipment						**$34,850**		$170.00	3.8%
B3.1 Fittings & Fixtures	1.00	205	m2	$170.00	$34,850		$170.00		
B3.2 Equipment				Excluded			$0.00		
B3.3 Conveying Systems	0.00	0	m2	$0.00	$0		$0.00		
C. SERVICES									
C1 Mechanical						**$161,700**		$788.78	17.7%
C1.1 Plumbing & Drainage	1.00	205	m2	$322.44	$66,100		$322.44		
C1.2 Fire Protection	0.00	0	m2	$0.00	$0		$0.00		
C1.3 HVAC	1.00	205	m2	$435.12	$89,200		$435.12		
C1.4 Controls	1.00	205	m2	$31.22	$6,400		$31.22		
C2 Electrical						**$44,500**		$217.07	4.9%
C2.1 Service & Distribution	1.00	205	m2	$49.60	$10,168		$49.60		
C2.2 Lighting, Devices & Heating	1.00	205	m2	$139.94	$28,688		$139.94		
C2.3 Systems & Ancillaries	1.00	205	m2	$27.53	$5,644		$27.53		
D. SITE & ANCILLARY WORK									
D1 Site Work						**$82,878**		$404.28	9.1%
D1.1 Site Development	2.59	530	m2	$139.73	$74,057		$361.25		
D1.2 Mechanical Site Services	0.00	0	m2	$0.00	$0		$0.00		
D1.3 Electrical Site Services	2.59	530	m2	$16.64	$8,821		$43.03		
D2 Ancillary Work						**$42,350**		$206.59	4.6%
D2.1 Demolition	1.00	205	m2	$206.59	$42,350		$206.59		
D2.2 Alterations	0.00	0	m2	$0.00	$0		$0.00		
Z. GENERAL REQUIREMENTS & CONTINGENCIES									
Z1 General Requirements & Fees						**$92,000**		$448.78	10.1%
Z1.1 General Requirements	1.00	205	m2	$317.07	$65,000		$317.07		
Z1.2 Fees	1.00	205	m2	$131.71	$27,000		$131.71		
Z2 Allowances						**$221,100**		$1,078.54	24.2%
Z2.1 Design & Pricing Contingency	1.00	205	m2	$674.15	$138,200		$674.15		
Z2.2 Escalation Contingency				Excluded			$0.00		
Z2.3 Construction Contingency	1.00	205	m2	$404.39	$82,900		$404.39		
TOTAL ESTIMATED CONSTRUCTION COST (nearest ,000)						**$912,000**		**$4,449**	**100.0%**

ELEMENTAL SUMMARY

CASE STUDY 3 - VANCOUVER - SCENARIO B

OM ESTIMATE (Rev.3)
NOVEMBER 19, 2025

A.W. HOOKER® QUANTITY SURVEYORS

Gross Floor Area 465 m2

Description Element\Sub-Element	Ratio	Quantity	Unit	Unit Rate	Elemental Cost Sub Element	Elemental Cost Element Total	$ per m2 Sub Element	$ per m2 Element	%
A. SHELL									
A1. Sub-Structure						**$150,255**		$323.13	5.4%
A1.1 Foundations	0.26	120	m2	$704.41	$84,529		$181.78		
A1.2 Basement Excavation	0.26	120	m2	$547.72	$65,726		$141.35		
A2. Structure						**$174,310**		$374.86	6.3%
A2.1 Lowest Floor Construction	0.26	120	m2	$290.00	$34,800		$74.84		
A2.2 Upper Floor Construction	0.45	211	m2	$425.83	$89,850		$193.23		
A2.3 Roof Construction	0.54	251	m2	$197.85	$49,660		$106.80		
A3. Exterior Enclosure						**$406,199**		$873.55	14.6%
A3.1 Walls Below Grade	0.28	132	m2	$800.00	$105,600		$227.10		
A3.2 Walls Above Grade	0.75	348	m2	$373.00	$129,804		$279.15		
A3.3 Windows & Entrances	0.13	58	m2	$1,329.94	$77,700		$167.10		
A3.4 Roof Finish	0.54	251	m2	$245.00	$61,495		$132.25		
A3.5 Projections	1.00	465	m2	$67.96	$31,600		$67.96		
B. INTERIORS									
B1 Partitions & Doors						**$144,205**		$310.12	5.2%
B1.1 Partitions	1.20	558	m2	$197.50	$110,205		$237.00		
B1.2 Doors	0.07	33	m2	$1,016.65	$34,000		$73.12		
B2 Finishes						**$208,997**		$449.45	7.5%
B2.1 Floor Finishes	0.95	442	m2	$164.00	$72,447		$155.80		
B2.2 Ceiling Finishes	0.95	442	m2	$270.37	$119,438		$256.85		
B2.3 Wall Finishes	1.60	744	m2	$23.00	$17,112		$36.80		
B3 Fittings & Equipment						**$79,050**		$170.00	2.8%
B3.1 Fittings & Fixtures	1.00	465	m2	$170.00	$79,050		$170.00		
B3.2 Equipment				Excluded			$0.00		
B3.3 Conveying Systems	1.00	465	m2	$0.00	$0		$0.00		
C. SERVICES									
C1 Mechanical						**$384,005**		$825.82	13.8%
C1.1 Plumbing & Drainage	1.00	465	m2	$295.28	$137,305		$295.28		
C1.2 Fire Protection	1.00	465	m2	$0.00	$0		$0.00		
C1.3 HVAC	1.00	465	m2	$506.02	$235,300		$506.02		
C1.4 Controls	1.00	465	m2	$24.52	$11,400		$24.52		
C2 Electrical						**$111,422**		$239.62	4.0%
C2.1 Service & Distribution	1.00	465	m2	$59.92	$27,865		$59.92		
C2.2 Lighting, Devices & Heating	1.00	465	m2	$157.47	$73,223		$157.47		
C2.3 Systems & Ancillaries	1.00	465	m2	$22.22	$10,334		$22.22		
D. SITE & ANCILLARY WORK									
D1 Site Work						**$163,710**		$352.06	5.9%
D1.1 Site Development	0.92	427	m2	$230.64	$98,482		$211.79		
D1.2 Mechanical Site Services	0.92	427	m2	$58.55	$25,000		$53.76		
D1.3 Electrical Site Services	0.92	427	m2	$94.21	$40,228		$86.51		
D2 Ancillary Work						**$42,350**		$91.08	1.5%
D2.1 Demolition	0.44	205	m2	$206.59	$42,350		$91.08		
D2.2 Alterations	0.00	0	m2	$0.00	$0		$0.00		
Z. GENERAL REQUIREMENTS & CONTINGENCIES									
Z1 General Requirements & Fees						**$286,000**		$615.05	10.3%
Z1.1 General Requirements	1.00	465	m2	$436.56	$203,000		$436.56		
Z1.2 Fees	1.00	465	m2	$178.49	$83,000		$178.49		
Z2 Allowances						**$624,600**		$1,343.23	22.5%
Z2.1 Design & Pricing Contingency	1.00	465	m2	$926.88	$431,000		$926.88		
Z2.2 Escalation Contingency				Excluded			$0.00		
Z2.3 Construction Contingency	1.00	465	m2	$416.34	$193,600		$416.34		
TOTAL ESTIMATED CONSTRUCTION COST (nearest ,000)						**$2,775,000**		**$5,968**	**100.0%**

ELEMENTAL SUMMARY

CASE STUDY 3 - VANCOUVER - SCENARIO C

OM ESTIMATE (Rev.3)

NOVEMBER 19, 2025

A.W. HOOKER QUANTITY SURVEYORS ®

Gross Floor Area 412 m2

Description Element\Sub-Element	Ratio	Quantity	Unit	Unit Rate	Elemental Cost Sub Element	Elemental Cost Element Total	$ per m2 Sub Element	$ per m2 Element	%
A. SHELL									
A1. Sub-Structure						**$219,788**		$533.47	7.8%
A1.1 Foundations	0.27	111	m2	$1,380.24	$153,207		$371.86		
A1.2 Basement Excavation	0.27	111	m2	$599.83	$66,581		$161.60		
A2. Structure						**$236,700**		$574.51	8.4%
A2.1 Lowest Floor Construction	0.42	174	m2	$219.37	$38,170		$92.65		
A2.2 Upper Floor Construction	0.58	238	m2	$551.68	$131,300		$318.69		
A2.3 Roof Construction	0.68	279	m2	$240.97	$67,230		$163.18		
A3. Exterior Enclosure						**$492,996**		$1,196.59	17.4%
A3.1 Walls Below Grade	0.47	195	m2	$800.00	$156,000		$378.64		
A3.2 Walls Above Grade	1.07	442	m2	$373.00	$164,866		$400.16		
A3.3 Windows & Entrances	0.19	78	m2	$1,179.28	$92,200		$223.79		
A3.4 Roof Finish	0.61	252	m2	$245.00	$61,740		$149.85		
A3.5 Projections	1.00	412	m2	$44.15	$18,190		$44.15		
B. INTERIORS									
B1 Partitions & Doors						**$123,020**		$298.59	4.4%
B1.1 Partitions	1.22	503	m2	$196.86	$99,020		$240.34		
B1.2 Doors	0.06	24	m2	$1,016.65	$24,000		$58.25		
B2 Finishes						**$184,125**		$446.90	6.5%
B2.1 Floor Finishes	0.95	391	m2	$161.25	$63,113		$153.19		
B2.2 Ceiling Finishes	0.95	391	m2	$270.44	$105,850		$256.92		
B2.3 Wall Finishes	1.60	659	m2	$23.00	$15,162		$36.80		
B3 Fittings & Equipment						**$77,540**		$188.20	2.7%
B3.1 Fittings & Fixtures	1.00	412	m2	$188.20	$77,540		$188.20		
B3.2 Equipment				Excluded			$0.00		
B3.3 Conveying Systems	1.00	412	m2	$0.00	$0		$0.00		
C. SERVICES									
C1 Mechanical						**$254,875**		$618.63	9.0%
C1.1 Plumbing & Drainage	1.00	412	m2	$221.78	$91,375		$221.78		
C1.2 Fire Protection	1.00	412	m2	$0.00	$0		$0.00		
C1.3 HVAC	1.00	412	m2	$380.46	$156,750		$380.46		
C1.4 Controls	1.00	412	m2	$16.38	$6,750		$16.38		
C2 Electrical						**$99,417**		$241.30	3.5%
C2.1 Service & Distribution	1.00	412	m2	$68.04	$28,032		$68.04		
C2.2 Lighting, Devices & Heating	1.00	412	m2	$152.88	$62,986		$152.88		
C2.3 Systems & Ancillaries	1.00	412	m2	$20.39	$8,399		$20.39		
D. SITE & ANCILLARY WORK									
D1 Site Work						**$173,670**		$421.53	6.1%
D1.1 Site Development	1.18	487	m2	$222.67	$108,442		$263.21		
D1.2 Mechanical Site Services	1.18	487	m2	$51.33	$25,000		$60.68		
D1.3 Electrical Site Services	1.18	487	m2	$82.60	$40,228		$97.64		
D2 Ancillary Work						**$83,250**		$202.06	2.9%
D2.1 Demolition	0.50	205	m2	$406.10	$83,250		$202.06		
D2.2 Alterations	0.00	0	m2	$0.00	$0		$0.00		
Z. GENERAL REQUIREMENTS & CONTINGENCIES									
Z1 General Requirements & Fees						**$298,000**		$723.30	10.5%
Z1.1 General Requirements	1.00	412	m2	$514.56	$212,000		$514.56		
Z1.2 Fees	1.00	412	m2	$208.74	$86,000		$208.74		
Z2 Allowances						**$584,000**		$1,417.48	20.7%
Z2.1 Design & Pricing Contingency	1.00	412	m2	$1,089.81	$449,000		$1,089.81		
Z2.2 Escalation Contingency				Excluded			$0.00		
Z2.3 Construction Contingency	1.00	412	m2	$327.67	$135,000		$327.67		
TOTAL ESTIMATED CONSTRUCTION COST (nearest ,000)						**$2,827,000**		**$6,863**	**100.0%**

C - Engineering Reports

Existing Buildings, Carbon, and Building Codes

Case Study Assumptions

November 2025

Document Distribution

Existing Buildings, Carbon, and Building CodesCarbon, and Building Codes

Case Study Assumptions

November 2025

CA0047539.1574

Prepared for

Canadian Association of Heritage Professionals (CAHP) and Government of Canada's Code Acceleration Fund (CAF)

Submitted to

Giaimo + Associates Architects Inc.

Prepared by

WSP Canada Inc.
25 York Street
Toronto, ON, M5J 2V5

Issued

2025-10-01

Revisions

Rev	Date	Details

Table of Contents

Abbreviations

Abbreviation	Description
ASHP	Air Source Heat Pump
CFM (L/s)	Cubic Feet per Minute (Liters per Second)
CO_2	Carbon Dioxide
C/W	Complete With
DCW	Domestic Cold Water
DHW	Domestic Hot Water
DX	Direct Expansion
ERV	Energy Recovery Ventilator
FCU	Fan Coil Unit
GHG	Green House Gas
GWP	Global Warming Potential
HRV	Heat Recovery Ventilator
IGU	Insulated Glass Unit
LED	Light Emitting Diode
MAU	Make-up Air Unit
RTU	Rooftop Unit
SBS	Styrene-Butadiene-Styrene
SPF	Spray Polyurethane Foam
VAV	Variable Air Volume
VRF	Variable Refrigerant Flow
WSHP	Water Source Heat Pump
XPS	Extruded Polystyrene Insulation

Case Study Summary

The following case studies and scenarios were presented to WSP to explore development pathways of **retrofit**, **retrofit plus addition**, and **demolish and rebuild**. Three locations were chosen to represent a variety of scenarios across different regions in Canada. In each case study, one scenario was implemented to simulate a real-world condition. WSP was tasked to assess the real-world case study and assist with providing assumptions for the other hypothetical scenarios.

The assumptions for the CAHP project were primarily derived from the as-built drawings provided in the case studies for Halifax, Montreal, and Vancouver. These assumptions were carefully reviewed and adjusted to reflect typical construction practices and ensure compliance with applicable building codes such as NBC and NECB.

The assumptions for each scenario were developed collaboratively by a multidisciplinary team, including structural, mechanical, electrical, building envelope and code consultants.

The case studies presented are as follows, with as-built scenarios underlined:

Case Study 1 – Halifax

- Scenario A: Retrofit Office to Residential
- Scenario B: Retrofit Office to Residential + Addition
- Scenario C: Demolish Office, Build New Office Tower

Case Study 2 – Montreal

- Scenario A: Retrofit Factory to Office
- Scenario B: Retrofit Factory to Office + Addition
- Scenario C: Demolish Factory, Build New Office Tower

Case Study 3 – Vancouver

- Scenario A: Retrofit Residential
- Scenario B: Retrofit Residential + Addition + Infill
- Scenario C: Demolish Residential, Build New Residential

Halifax – Structural

The drawings that were provided reflected Scenario A and were used to form the basis for Scenario A and B. The structural intervention works specified for Scenarios A and B were undertaken on the basis that the existing structure was in good condition and would require nominal repair works. See the table on the next page.

Based on what was shown in the construction set of drawings for Scenario A, it was assumed that the vertical structural framing would require no structural interventions, with the exception of the addition of new steel columns to be added at the ground floor, to break-up the transfer structure from what was originally a commercial ground floor to a more typical floor plate construction as is typical of residential buildings (e.g. No large open commercial spaces and floorplans). For Scenario B, the vertical structural framing was similarly assumed to have sufficient structural capacity to support the light-weight vertical extension on the top. For Scenario B, the light-weight machinery two storey penthouse was assumed to be demolished and replaced with a newer 4 storey light-weight steel-framed addition. The columns of the original machine rooms and shear walls for the elevator shaft were assumed to be kept as-is to support the construction of the vertical expansion.

For both Scenarios A and B it was assumed that the existing shear walls and elevator shaft had sufficient capacity for the lateral load resisting system, as was reflected in the IFC drawing set for Scenario A. For Scenario B, the reinforced concrete shear wall was specified as having a dowelled extension above to allow for the vertical expansion of the elevator shaft and to be used to extend the lateral stability system upwards.

Scenario C was developed using standard practice construction for residential layouts, provided by Giaimo. A standard floor grid was developed where a maximum floor span was determined to be 7m. Both steel framing and reinforced concrete framing was reviewed and assessed for the design of Scenario C, however it was determined that a more conventional structural design would involve the design of two-way flat slabs and columns above ground, rather than a steel framed structure with composite concrete-steel decking. Three levels of below-ground parking was provided with a standard 9m x 9m reinforced concrete column grid and two way slabs, with slab on grade and shallow footings for the columns. A steel deck roof system was assumed for the top of the structure. The lateral stability system for Scenario C was developed assuming that the elevator core and shaft would act as the structural shear walls, as is typical in reinforced concrete high-rise residential construction.

The Loading Assumptions were based off requirements from the National Building Code of Canada as shown below:

- Residential loading: SDL = 2.0 kPa, LIVE = 1.9 kPa
- Retail loading: SDL = 2 kPa, LIVE = 4.8 kPa
- Roof loading: SDL = 1.5 kPa, SNOW = 2.5 kPa
- Parking garage loading: SDL = 1.5 kPa, LIVE = 2.4 kPa
- Material properties
    - Concrete density = 2400 kg/m^3
    - Column steel reinforcement density = 300 kg/m^3
    - Shear wall steel reinforcement density = 65 kg/m^3
    - Slab steel reinforcement density = 100 kg/m^3
    - Foundation steel reinforcement density = 80 kg/m^3
    - Stairway steel reinforcement density = 130 kg/m^3

Halifax – Structural

The detailed assumptions and overall structural geometry, notes and volumes are shown below:

	Scenario A (Retrofit Office to Residential)	**Scenario B** (Retrofit Office to Residential)	**Scenario C** (Demolish Office, Build Residential)
Main Geometry	Floor span: 6m Floor to floor height: 3.5m Foundation: spread footings and slab on grade	Floor span: 6m Floor to floor height: 3.5m Foundation: spread footings and slab on grade	Floor span: 7m Floor to floor height: 3m Foundation: Slab on grade supporting 3 levels of underground parking and isolated footings
Gravity System	Existing ground floor system, nominal changes. New structural sections are introduced between existing columns at select locations for strengthening. New steel columns introduced at ground level.	Steel framing on 6 x 6 m grid (vertical extension) Slab: Composite concrete on steel deck with steel beams and girders (vertical extension) Existing ground floor system, including concrete slab and columns below	Concrete flat slab system on varied grid spacing (Maximum 7m x 6.5m) above ground level. Two-way concrete flat slab (9m x 9m) between columns at ground floor and parking levels.
Lateral System	Existing concrete cores and shear walls for elevators and stairwells.	Existing concrete cores and shear walls for elevators and stairwells. Vertical extension of concrete core by 1 floor for extension.	Concrete cores at elevator and stairwell
Foundations	Existing concrete foundations, minor strengthening works for localized openings into structure for mechanical/electrical and architectural requirements, repair, and replacement work for select existing footings.	Existing concrete foundations, minor strengthening works for localized openings into structure for mechanical/electrical and architectural requirements, repair, and replacement work for select existing footings	Shallow isolated concrete footings under new parking level concrete slab.
Additional And Demolition	Openings into concrete slab and concrete shear walls for increased mechanical and electrical requirements. Concrete curb removal along exterior walls.	Openings into concrete slab and concrete shear walls for increased mechanical and electrical requirements. Structural slab volume at L12 upwards to be demolished for construction of steel framed vertical extension. Concrete core and columns to remain.	Include entire volume of original building being lost because of the demo

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Halifax – Structural

	Scenario A (Retrofit Office to Residential)	Scenario B (Retrofit Office to Residential)	Scenario C (Demolish Office, Build Residential)
Gravity System	**New Steel Columns:** 700kg **New Steel Beams:** 17000kg	**Horizontal Framing– Extension:** W310x39 beams on W310x45 girders (80000kg steel) at typical floor, W310x24 beams on W310x28 girders (16500kg steel) at new roof **Slab – Extension:** 89 concrete on 76 steel deck at typical floor, 76 steel deck at roof **Vertical Framing – Extension:** W250 columns from existing structure to new roof (15000kg steel)	**Horizontal Framing:** 350mm concrete flat slab with 3000x3000x175 drop panels at ground and parking levels, 200mm flat slab with 2300x2300x150mm drop panels (17,400,000kg concrete, 885,000kg steel reinforcement) **Vertical Framing:** 750x750 concrete columns at parking, 350x350 to roof level (800,000kg concrete, 32,000kg steel reinforcement)
Lateral System	Existing	**Shear Walls:** 37m at 300mm thick (105000kg concrete) **Stairs:** Average 280mm concrete depth (71000kg concrete)	**Shear Walls:** 470m at 350mm thick (1,380,000kg concrete, 13,000kg steel reinforcement) **Exterior Walls:** 680m at 450mm thick (1,830,000kg concrete, 95,000kg steel reinforcement) **Stairs:** Average 280mm concrete depth (460,000kg concrete)
Foundations	**Footing Replacement:** 1000kg concrete (two 760x760) **Column Replacement:** 900kg concrete	**Footing Replacement:** 1000kg concrete (two 760x760) **Column Replacement:** 900kg concrete	**Isolated Footings:** 1000mm deep, 500mm thick, 3000x3000 (185,000kg concrete, 6000kg steel reinforcement) **Foundation Walls:** 194m at 300mm thick (735,000kg concrete, 20,000kg steel reinforcement
Additional And Demolition	**Demolition:** 8.2m of block wall removal (3.5m height), 18.3m^2 concrete slab removal, 17.7m^2 concrete hole formation	**Total New Steel:** 168,000kg (including steel deck), 33,000kg reinforcement **Total New Concrete:** 1,350,000kg **Demolition:** 8.2m of block wall removal (3.5m height), 1080m^2 concrete slab removal, 17.7m^2 concrete hole formation	**Total New Steel:** 14500kg steel deck, 1,100,000kg reinforcement **Total New Concrete:** 22,750,000kg (including walls, stairs, columns, slab, foundation) **Demolition:** All existing
Additional Assumptions	Thickness of demolished block walls = 300mm Height of columns replaced at the foundation is 1000mm	Existing roof assembly is demolished and replaced with new concrete on deck for residential flooring All exterior and interior walls are demolished at Level 12 upwards, but existing columns, shear walls, and stairs are maintained and integrated with new addition	Transfer slab assumed at Level 2 to transition column spacing at residential levels to 9m by 9m spacing at the ground floor commercial and parking garage levels. Transfer slab reinforcement concentration is increased to 150kg/m^3 from the

		Only one additional level of new concrete core is required to be constructed over the existing core Existing slab volume demolished at Level 12 upwards and replaced with new steel framed construction Additional perimeter braces not required at extension, new shear walls over existing core are sufficient for lateral force transfer to lower levels Existing foundations are adequate for addition of new structure apart from the minor strengthening interventions specified in the IFC drawing package	100kg/m^3 assumed for typical floor slabs. At foundation, footings assumed to extend below each of the P3 parking garage columns, and strip footings under the perimeter walls

Halifax – Envelope

All assemblies were selected to meet NECB minimum performance path. Air leakage rates were standardized across scenarios using NECB thresholds. Although green roofs, solar panels, overcladding, or recycled materials are common in some current construction, these studies were excluded from scope due to their complexity and variability. The focus remained on baseline construction practices with heritage preservation in mind.

Scenario A used assemblies based on the building's as-built drawings, excluding any additions. Windows were substituted with new since the change of use from office to residential requires code minimums for ventilation and emergency egress. We assumed the existing windows have poor thermal resistance and air leakage, and expect they will need to be upgraded within the service life of the building. Opaque service door quantities were minimal and assumed to be negligible, therefore, doors were counted as part of the glazing calculations.

Scenario B descriptions show the addition portion only. The remaining assemblies are expected to have gone through the same retrofit as Scenario A.

In Scenario C, windows were changed to window wall in lieu of curtain wall as a more typical window system. This is also based on the ability to install onto the building from scratch. In addition, the basement was redesigned to be parking only and unheated. Therefore, the insulation values for foundations below grade are not as high as Scenarios A or B. Scenario C also assumed the new building can achieve tighter envelope performance with lower U-values and higher RSI-values compared to retrofit scenarios with new construction practices.

	Scenario A (Retrofit Office to Residential)	**Scenario B** (Retrofit Office to Residential)	**Scenario C** (Demolish Office, Build Residential)
Walls	Aluminum composite panel Vertical girts 1" (25mm) semi-rigid mineral wool Air and vapour barrier 5/8" (16mm) exterior gypsum sheathing Steel stud 16" (400mm) o.c. 3" (75mm) closed cell SPF ½" (13mm) gypsum wall board Existing precast siding Existing air and vapour barrier Existing steel stud 16" (400mm) o.c. 2.5" (64mm) semi-rigid mineral wool ½" (13mm) gypsum wall board	Addition is made up of curtain wall. See Fenestration/Doors.	1/8" (3mm) solid aluminum panel 1" (25mm) hat channel Z-girts on thermally broken clip system 6" (150mm) semi-rigid mineral wool Air and vapour barrier 5/8" (16mm) exterior gypsum sheathing Steel stud 400mm o.c., ½" (13mm) gypsum
Fenestration/ Doors	**Windows:** Double glazed IGU with low-E coating in thermally broken aluminum frame curtain wall **Spandrel Panels:** ¼" (6mm) glazing 4" (100mm) mineral wool Painted aluminum backpan **Doors:** Glazed doors part of aluminum frame	**Windows:** Double glazed IGU with low-E coating in thermally broken aluminum frame curtain wall **Spandrel Panels:** ¼" (6mm) glazing 4" (100mm) mineral wool Painted aluminum backpan **Doors:** Glazed doors part of aluminum frame	**Windows:** Double glazed IGU with low-E coating in thermally broken aluminum frame window wall **Spandrel Panels:** ¼" (6mm) glazing 4" (100mm) mineral wool Painted aluminum backpan **Doors:** Glazed doors part of aluminum frame

Roof	**Main Roof:** 2-ply modified bitumen ¼” (6mm) protection board 4” (100mm) XPS insulation Existing asphaltic vapour barrier Existing concrete roof slab **Roof Terrace:** Tile on pedestal system Filter fabric Drainage mat Filter fabric 4” (100mm) XPS insulation Protection sheet Hot applied rubberized asphalt Existing concrete slab	**Main Roof:** 2-ply modified bitumen ¼” (6mm) protection board 4” (100mm) XPS insulation Vapour barrier Concrete roof slab **Roof Terrace:** Tile on pedestal system Filter fabric Drainage mat Filter fabric 4” (100mm) XPS insulation Protection sheet Hot applied rubberized asphalt Concrete slab	**Main Roof:** 2-ply modified bitumen ¼” (6mm) protection board 4” (100mm) XPS insulation Vapour barrier Concrete roof slab **Roof Terrace:** Tile on pedestal system Filter fabric Drainage mat Filter fabric 4” (100mm) XPS insulation Protection sheet Hot applied rubberized asphalt Concrete slab
Soffit	Acrylic panel 3” (75mm) air space Vapour permeable air and vapour barrier 5/8” (16mm) exterior gypsum sheathing Steel studs 400mm o.c.	N/A	N/A
Foundation Wall (Above Grade)	Granite veneer 1” (25mm) air space Waterproofing membrane Existing concrete foundation wall Steel stud 16” (400mm) o.c. 4” (100mm) closed cell SPF 5/8” (16mm) gypsum	N/A	Precast siding 3” (75mm) air space 4” (100mm) XPS insulation Waterproofing membrane Concrete foundation wall
Foundation Wall (Below Grade)	Drainage board 4” (100mm) XPS insulation Waterproofing membrane, Existing concrete foundation wall 3.5” (89mm) steel stud 16” (400mm) o.c. 5/8” (16mm) gypsum	N/A	Drainage board 2” (50mm) XPS insulation Waterproofing membrane Concrete foundation wall
Slab on grade	Existing 4” (100mm) XPS insulation Existing concrete slab on grade	N/A	4” (100mm) XPS insulation Concrete slab on grade

Halifax – Envelope

The table below shows the effective U- and R-Values for all 3 scenarios. Note, Scenario B only shows the addition portion. The remaining values are expected to be the same as Scenario A.

	Scenario A (Retrofit Office to Residential)			Scenario B (Retrofit Office to Residential)			Scenario C (Demolish Office, Build Residential)		
Air Leakage Rate at 75Pa	2.5 L/s/m^2			2.5 L/s/m^2			1.5 L/s/m^2		
	Area (m^2)	**U-Value**	**RSI-Value (R-Value)**	**Area (m^2)**	**U-Value**	**RSI-Value (R-Value)**	**Area (m^2)**	**U-Value**	**RSI-Value (R-Value)**
Overall	10053	1.2	0.7 (R3.7)	2414	1.5	0.7 (R3.8)	12403	1.2	0.8 (R4.8)
Walls	3380	0.7	1.5 (R8.4)	N/A	N/A	N/A	3948	1.0	1.0 (R5.5)
Roofs	1814	0.4	2.7 (R15.5)	956	0.3	3.4 (R19.3)	2992	0.3	3.2 (R18.3)
Fenestration	2766	4.2	0.2 (R.1.4)	1458	2.2	0.4 (R2.5)	3690	2.4	0.4 (R2.4)
Soffits	145	1.3	0.7 (R4.2)	N/A	N/A	N/A	N/A	N/A	N/A
Slab on grade	1697	0.3	3.0 (R16.9)	N/A	N/A	N/A	1772	0.3	3.0 (R17.0)
Below grade walls	250	0.3	3.8 (R21.7)	N/A	N/A	N/A	2658	0.4	2.5 (R13.9)

Halifax – HVAC

Based on the provided as-built drawings, we assumed a VRF type system in our study for Scenario A. New low GWP refrigerants for VRF system will be phased in by manufacturers starting in 2026. The new refrigerants generally have higher flammability rating compared to current refrigerants and therefore have more restrictions for the maximum volume of refrigerant allowed in a system when installed in occupiable spaces. Therefore, we opted for a hybrid VRF system consisting of outdoor units connected with refrigerant piping to control boxes on each floor and hydronic piping using water is distributed on each floor from the control boxes to ducted indoor units inside each resident suite. This system benefits from eliminating refrigerants inside occupiable spaces as well as reducing the total refrigerant volume in each system, reducing potential GHG emissions due to refrigerant leaks.

For Scenarios B and C, there are many different solutions that can be implemented for heating and cooling inside the residential suites. The most common solutions are 2-pipe hydronic fan coil units and WSHP fan coil units. We included the WSHP fan coil units for this study as we find this type of system is becoming more common in new residential building construction and has many benefits compared to 2-pipe hydronic fan coil unit systems. The primary benefit of the WSHP fan coil units is each individual suite can choose heating or cooling at any time and if there is a mix of units in the building using heating and cooling, they will transfer heat between the units for added energy savings. In comparison, 2-pipe fan coil units operate with a seasonal switchover where the entire building must be switched to either in heating or cooling. The WSHP are piped to a heat pump loop which can be either connected to a geothermal system or to an air source system for a source of heat injection and rejection to the system. Connecting to a geothermal system provides the highest overall system energy efficiency but can have a high initial construction cost and may not be suitable for all sites. While we encourage all owners and developers to consider geothermal when undertaking a major construction project such as the one in this case study, to capture the widest audience we have considered an air source system.

The air source system consists of a fluid cooler used in summer to reject heat from the heat pump loop and an ASHP to inject heat into the heat pump loop in winter. The ASHP should be sized to capture most heating degree days based on local weather data and utilize either a gas-fired boiler or electric boiler to supplement on colder days when the ASHP is not able to produce enough heat to meet the building's heating demands.

For ventilation, many manufacturers of WSHP fan coil units offer the option for a built-in ERV which will supply ventilation air directly to the fan coil unit and exhaust from the washrooms and kitchen can be ducted to it for energy recovery.

For any common amenity spaces such as recreation rooms or gyms, it has been assumed they will be served by the same WSHP fan coil units with built-in ERVs as are used in the residential suites for Scenarios B and C and dedicated split VRF heat pump units in Scenario A. Multiple units may be necessary to meet the loads for larger spaces.

Corridor ventilation air must be provided to each floor to maintain the corridors with slightly positive pressure and minimize migrations of smells between resident suites and meet the minimum ventilation requirements by the local building codes. For Scenario A we have assumed an ASHP MAU which will be capable of providing cooling and heating and an electric resistance heater for supplement and back-up. The ASHP MAU can operate more efficiently for heating during the majority of annual heating hours but are more expensive compared to a packaged DX cooling MAU with gas or electric heating. For this study, we have assumed an ASHP MAU with electric resistance heater for supplement/back-up. Gas supplement/back-up can be provided if there is limited peak electrical capacity in the building. For Scenarios B and C, we have assumed a WSHP MAU which can be connected to the common heat pump loop to provide heated and cooled ventilation air and does not require any back-up source of heating.

Any non-residential spaces that may be included in the building have been excluded from this study analysis. If non-residential spaces are provided, it is assumed these spaces will have separate dedicated HVAC systems provided by the individual owners/tenants occupying these spaces.

	Scenario A (Retrofit Office to Residential)	Scenario B (Retrofit Office to Residential)	Scenario C (Demolish Office, Build Residential)
In-Suite	Split hybrid VRF ducted indoor units, one per suite Outdoor units located on the roof and 10th floor terrace Refrigerant piping between outdoor units and control boxes on each floor Hydronic water piping between control boxes on each floor and ducted indoor units in each suite Supply ductwork distribution to each principal room. ERV installed in each suite serving washroom and kitchen exhaust, fresh air ducted to return of ducted indoor unit. Electric baseboard heaters in any rooms with an exterior wall or roof exposure not served by the ducted fan coil unit.	WSHP FCUs with built-in ERVs in each resident suite connected to heat pump loop risers. New heat pump supply and return risers and condensate drain risers for each super-imposed unit. ERV exhaust ducted from washroom and general kitchen exhaust. Fresh air intake and exhaust ducted to exterior, maintaining minimum clearances to other building openings as per local code requirements. Electric baseboard heaters in any rooms with an exterior wall or roof exposure not served by the ducted fan coil unit.	WSHP FCUs with built-in ERVs in each resident suite connected to heat pump loop risers. New heat pump supply and return risers and condensate drain risers for each super-imposed unit. ERV exhaust ducted from washroom and general kitchen exhaust. Fresh air intake and exhaust ducted to exterior, maintaining minimum clearances to other building openings as per local code requirements. Electric baseboard heaters in any rooms with an exterior wall or roof exposure not served by the ducted fan coil unit.
Central Plant	N/A	Fluid cooler, air to water heat pumps, and electric boilers connected to central heat pump loop.	Fluid cooler, air to water heat pumps, and electric boilers connected to central heat pump loop.
Central Ventilation	ASHP MAU with electric resistance heater back-up	WSHP MAU	WSHP MAU

Halifax – Plumbing

For Scenarios A and B we assume all existing plumbing fixtures, piping and sanitary drains will be demolished back to the main incoming water meter room. The size of the existing incoming water service and sewer main must be reviewed to determine if they have enough capacity to serve the new residential occupancy and it may be necessary to coordinate with the local municipality to provide a new water service, water meter and sanitary main.

For all scenarios, new DCW booster pumps will be necessary to provide the necessary water pressure to the top of the building with adequate flow to meet the additional water consumption of a residential building compared to the original office building.

Based on our review of the provided as-built drawings, there is not much space provided for any mechanical rooms, therefore, we assumed a distributed DHW system with electric DHW storage tank heaters installed in each resident suite for supplying DHW in Scenario A. In Scenarios B and C, we assumed the addition to the building and the new building will be designed with adequate mechanical space for a central DHW system in a penthouse level mechanical room. We have included in our study analysis for large capacity central electric tank heaters sized to meet the full building DHW demand. For added energy efficiency, we assumed a double wall heat exchanger can be connected to the central heat pump loop to pre-heat the DCW make-up to the DHW system.

All new plumbing fixtures are assumed to be low flow fixtures.

Any non-residential spaces included in the building are assumed to be provided with a DCW connection only and will provide their own separate DHW system to suit their needs.

	Scenario A (Retrofit Office to Residential)	**Scenario B** (Retrofit Office to Residential)	**Scenario C** (Demolish Office, Build Residential)
Domestic Hot Water (DHW)	Electric tank heaters inside each suite located inside a service closet. Local DHW distribution within each suite.	Central DHW system located in penthouse mechanical room connected to new DHW risers for each superimposed suite. Provide double wall heat exchanger connected to the heat pump loop for pre-heating the DCW make-up to the DHW system. DHW system shall be large capacity electric tank heaters.	Central DHW system located in penthouse mechanical room connected to new DHW risers for each superimposed suite. Provide double wall heat exchanger connected to the heat pump loop for pre-heating the DCW make-up to the DHW system. DHW system shall be large capacity electric tank heaters.
Domestic Cold Water (DCW)	New water service, meter, backflow preventer, and booster pumps sized for new building water consumption. New main DCW riser up building to penthouse level with distribution into risers for each typical superimposed suite.	New water service, meter, backflow preventer, and booster pumps sized for new building water consumption and additional floors. New main DCW riser up building to penthouse level with distribution into risers for each typical superimposed suite.	New water service, meter, backflow preventer, and booster pumps sized for new building. New main DCW riser up building to penthouse level with distribution into risers for each typical superimposed suite.
Sanitary and Storm Drainage	New sanitary drainage connection to the building as required. Provide new sanitary drain risers based on specific architectural layouts for each typical superimposed suite.	New sanitary drainage connection to the building as required. Provide new sanitary drain risers based on specific architectural layouts for each typical superimposed suite.	New sanitary and storm drain connection to the new building. Provide new sanitary drain risers based on specific architectural layouts for each typical superimposed suite.

	Storm drains can be generally re-used. Location of rainwater leaders to be reviewed and may require relocation to suit new architectural floorplan layout.	Extend existing rainwater leaders to new roof and provide new roof drains as required. Location of rainwater leaders to be reviewed and may require relocation to suit new architectural floorplan layouts.	Provide new storm drain rain water leaders as required for new roof drains. An on-site storm water management system may be necessary based on local municipal by-laws and code requirements.

Halifax – Fire Protection

Based on typical office buildings of this size, we assume the existing building is already fully sprinklered and has a standpipe system. The existing sprinkler and standpipe system will need to be reviewed by the design team and/or a fire protection contractor and modified to suit the new occupancy and floor plan layouts and meet the local code requirements.

For Scenarios B and C where the building height is increasing, a flow test will be required to be completed to confirm the city pressure and new fire pumps and/or standpipe pumps may be necessary.

Fire alarm systems in commercial buildings are typically designed as single stage or two-stage, depending on building height and occupancy classification. Alarm devices (horns, strobes, speakers) are installed in common areas such as corridors, lobbies, meeting rooms, and mechanical spaces. Detection devices include smoke detectors and pull stations. Residential buildings are typically single stage. Audible/visual devices are provided in common areas (corridors, lobbies, stairwells) and also within each individual suite and sometimes within bedrooms, depending on code requirements. Detection devices include smoke alarms and carbon monoxide detectors, with an emphasis on early detection in living areas.

	Scenario A (Retrofit Office to Residential)	**Scenario B** (Retrofit Office to Residential)	**Scenario C** (Demolish Office, Build Residential)
Sprinkler System	Modify existing sprinkler coverage on all floors to meet local code requirements based on the revised occupancy classification. Review system flow and pressure and provide a fire pump as required.	Modify existing sprinkler coverage and extend coverage to additional floors to meet local code requirements based on the revised occupancy classification. Review system flow and pressure and provide a fire pump as required.	Provide new sprinkler system to meet local code requirements.
Standpipe System	Provide new fire hose cabinets as required to suit new building layout and egress routes. Review system flow and pressure and provide a new fire pump as required.	Provide new fire hose cabinets on all floors as required to suit new building layout, and egress routes. Review system flow and pressure and provide a new fire pump as required.	Provide new standpipe system to meet local code requirements.
Fire Alarm	Fire Alarm system to be revised to suit residential building as per Local Building Code. Individual alarm and initiation devices to be installed in suites as per code requirements.	Fire Alarm system to be revised to suit residential building as per Local Building Code. Individual alarm and initiation devices to be installed in suites as per code requirements.	Provide new fire alarm system as per Local Building Code. Individual alarm and initiation devices to be installed in suites as per code requirements.

Halifax – Electrical

The property is undergoing a change of use from an office building to a residential building for all three scenarios. This transition requires significant modifications to the electrical distribution and lighting systems to accommodate the functional and regulatory requirements of a residential occupancy.

In commercial and office buildings, power distribution is generally designed around centralized infrastructure. Electrical service is delivered to the building's main electrical room, from which distribution is carried through bus ducts or large distribution panels. These systems typically supply power to tenant panels or floor-level distribution boards, sized to meet the collective demand of open office layouts, workstations, and building services.

Residential buildings require a more decentralized approach. Each dwelling unit must be provided with its own dedicated electrical panel to ensure safe, independent, and equitable power distribution. These panels are typically located within individual suites and are fed from corridor electrical closets housing distribution panels or risers. A comprehensive electrical load study is required as part of the design process to accurately determine the revised service size based on the total number of suites, expected demand factors, and building height. The results of this study will guide coordination with the local utility provider to confirm service capacity and any necessary upgrades to incoming feeders, transformer capacity, or switchgear.

Metering design also differs substantially between commercial and residential buildings. Commercial occupancies often utilize whole-building metering or, in multi-tenant arrangements, meter at the tenant level, depending on lease agreements. Residential occupancies, however, require **individual metering for each suite** to allow unit-specific billing. Lighting requirements also shift considerably when converting from office to residential use.

Commercial Lighting: Office environments are typically designed with uniform base-building fixtures providing illumination levels in accordance with recommended practices. Fixtures are generally standardized, with neutral color temperatures and layouts intended for open office plans. Landlords typically provide these as part of the base building infrastructure. For residential design, common areas such as lobbies, corridors, and amenity spaces often feature decorative or architectural lighting to enhance the occupant experience. Within suites, lighting layouts are tailored to the intended function of each space, with fixtures provided for living areas, kitchens, bedrooms, and washrooms.

	Scenario A (Retrofit Office to Residential)	**Scenario B** (Retrofit Office to Residential)	**Scenario C** (Demolish Office, Build Residential)
Electrical Service and Distribution	Review existing electrical service capacity and coordinate with the local utility provider to upgrade the service as required to suit the new building electrical loads. Modify existing or provide new main distribution boards in main electrical room to accommodate the new electrical loads in the building. Provide all new electrical distribution feeders and distribution panels as required, including new panels in penthouse mechanical room serving new mechanical equipment. Provide new electrical distribution panels for each suite, sized for 100A. Distribution panels to be installed in corridors to feed	Review existing electrical service capacity and coordinate with the local utility provider to upgrade the service as required to suit the new building electrical loads. Modify existing or provide new main distribution boards in main electrical room to accommodate the new electrical loads in the building. Provide all new electrical distribution feeders and distribution panels as required, including new panels in penthouse mechanical room serving new mechanical equipment. Provide new electrical distribution panels for each suite, sized for 100A. Distribution panels to be installed in corridors to feed	Coordinate with local utility provider for new electrical service. Provide complete new electrical power distribution system for new building including individual 100A panels for each suite with sub-meters.

	downstream panels in the suites complete with sub-meters.	downstream panels in the suites complete with sub-meters.	
Lighting	Provide new LED light fixtures in common areas and suites to meet minimum lighting requirements for a residential building. Provide new exit lighting and emergency lighting in compliance with Nova Scotia Building Code to suit new egress routes.	Provide new LED light fixtures in common areas and suites to meet minimum lighting requirements for a residential building. Provide new exit lighting and emergency lighting in compliance with Nova Scotia Building Code to suit new egress routes.	Provide new LED light fixtures in common areas and suites to meet minimum lighting requirements for a residential building. Provide new exit lighting and emergency lighting in compliance with Nova Scotia Building Code.

Montreal – Structural

The drawings that were provided reflected the Scenario B case and it was used as the basis for the design work done on Scenario B. As such, and due to the omission of existing structural drawings from either the completed Scenario B or the original construction of the factory, assumptions regarding the extent of interventions that were undertaken for the vertical expansion had to be made.

It was assumed that the overall vertical structural framing, inclusive of the steel perimeter columns below the vertical extension shown in the drawings for Scenario B, were original, and not part of the expansion works, and therefore the original vertical load path for the structure was primarily steel framing for Scenario A. This assumption was based off the presence of a steel beam floor structure supporting Nail Laminated Timber flooring that appeared to be original. This floor structure was supported by steel columns throughout the building footprint. It was therefore assumed that no structural interventions to the vertical structure of the building required strengthening works to be undertaken to support the vertical extension.

The assumptions for interventions in the existing structure between Scenario A and B were therefore predominantly the same, where it was assumed that a full replacement of the lateral load resisting system was undertaken. This was due to what is typically required in Montreal as adaptive reuse cases requiring significant seismic upgrading on historic structures for adaptive reuse, regardless of extension requirements. It was also assumed that the existing nail laminated (NLT) floor structure could be strengthened using a ply installation to transfer lateral loading to the new reinforced concrete shear walls.

Additional interventions that were assumed for Scenario A and B were that, wherever there was a modification to the window dimension or framing, that the replacement of the window support structure (e.g. Lintel or arch) was required, and so typical steel sections were quantified for the interventions into the windows.

Scenario C was developed using standard practice construction for typical office buildings in Montreal. This included the use of a steel gravity load resisting system (columns, beams) and a light-weight composite steel and concrete metal floor decking for the structure above ground. It included one floor of below ground parking, where the columns, ground slab and main floor slab between the parking garage and main floor are conventional reinforced concrete. The grid spacing for the column layout was based on architectural inputs and standard practice for newly constructed office buildings.

The Loading Assumptions were based off requirements from the National Building Code of Canada as shown below:

- Office loading: SDL = 2 kPa, LIVE = 2.4 kPa
- Retail loading: SDL = 2 kPa, LIVE = 4.8 kPa
- Roof loading: SDL = 1.5 kPa, SNOW = 2.5 kPa
- Material properties
    - Concrete density = 2400 kg/m^3
    - Column steel reinforcement density = 300 kg/m^3
    - Shear wall steel reinforcement density = 65 kg/m^3
    - Slab steel reinforcement density = 100 kg/m^3
    - Foundation steel reinforcement density = 80 kg/m^3
    - Stairway steel reinforcement density = 130 kg/m^3

Montreal – Structural

The detailed assumptions and overall structural geometry, notes and volumes are shown below:

	Scenario A (Retrofit Factory to Office)	**Scenario B** (Retrofit Factory to Office + Addition)	**Scenario C** (Demolish Factory, Build Office)
Main Geometry	Floor span: 6m Floor to floor height: 4m Foundation: spread footings and ground slab	Floor span: 6m Floor to floor height: 4m Foundation: spread footings and ground slab	Floor span: 9m Floor to floor height: 4m Foundation: Slab on grade supporting 1 floor underground parking and isolated footings
Gravity System	Existing ground floor system, nominal changes except assumption that the same lintels are required as in Scenario B for the same openings	Steel framing on 6 x 6 m grid (vertical extension included) Slab: Concrete slab on steel beams on all floors Perimeter walls below extension: brick masonry New steel lintels where openings are modified	Steel framing on 9 x 9m grid above ground level. Composite concrete on steel deck at floor levels. Two-way concrete slab between columns at ground floor and parking.
Lateral System	New Concrete cores for elevators and stairwells New concrete stairs full height One exterior reinforced concrete access ramp	New Concrete cores for elevators and stairwells New concrete stairs full height One exterior reinforced concrete access ramp	Steel braced bays along perimeter framing Concrete cores at elevator and stairwell.
Foundations	Assumed to be existing concrete foundations.	Assumed to be existing concrete foundations, lightweight extension does not require strengthening	Shallow isolated concrete footings under new parking level concrete slab.
Additional And Demolition	Reinforced concrete stairs at exterior Original lintels removed where openings were modified Openings into concrete slab Demo of old elevator shaft Mortar repointing generally Brick loss from widening of openings	Reinforced concrete stairs at exterior Original lintels removed where openings were modified Openings into concrete slab Demo of old elevator shaft Mortar repointing generally Brick loss from widening of openings	Include entire volume of original building being lost because of the demo

Montreal – Structural

	Scenario A (Retrofit Factory to Office)	Scenario B (Retrofit Factory to Office + Addition)	Scenario C (Demolish Factory, Build Office)
Gravity System	**New Lintels:** Double angles (apx 2000 kg steel) **Roof Level:** Roof strengthening may be required for insulation of roof and additional snow loading.	**New Lintels:** Double angles (apx 2000kg steel) **Horizontal – Roof Extension:** W310x24 beams on W310x28 girders (54000kg steel) **Slab – Roof Extension:** 76 steel deck **Vertical – Roof Extension:** W200x42 columns spanning from L3 to new roof (27000kg steel)	**Horizontal Framing:** W460x52 beams on W610x92 girders(625,000kg steel) **Slab:** 89 concrete on 76 steel deck above ground, 350 concrete slab ground - below **Vertical Framing:** W360 Steel columns above ground floor (123000kg steel)
Lateral System	**Shear Walls:** 87m at 300mm thick (842,000kg concrete) **Stairs:** Average 280mm concrete depth (120,000kg concrete) **Floor:** Addition of 25mm plywood sheathing on all floors to tie Nail Laminated Timber (NLT) into shear walls.	**Shear Walls:** 87m at 300mm thick (842,000kg concrete) **Stairs:** Average 280mm concrete depth (120,000kg concrete) **Floor:** Addition of 25mm plywood sheathing on all floors to tie NLT into shear walls.	**Steel Bracing:** HSS152x152s (20,000kg) **Shear Walls:** 100m at 300mm thick (2,790,000kg concrete, 75000kg steel reinforcement) **Stairs:** Average 280mm concrete depth (100,000kg concrete)
Foundations	Existing	Existing	**Isolated Footings:** 1000mm deep, 500mm thick, 3000x3000 (500,000kg concrete, 16,600kg steel reinforcement)
Additional And Demolition	**Total New Steel:** 9600kg (including reinforcement **Total New Concrete:** 962,000kg **Demolition:** 29.4m of brick wall (4m height), 10m of steel lintel, 91m^2 of concrete slab, 14 steel columns, 106m^2 of concrete hole formation	**Total New Steel:** 400,000kg (including reinforcement, steel deck, and above) **Total New Concrete:** 962,000kg **Demolition:** 29.4m of brick wall (4m height), 10m of steel lintel, 91m^2 of concrete slab, 14 steel columns, 106m^2 of concrete hole formation	**Total New Steel:** 1,394,000 kg (including reinforcement, steel deck) **Total New Concrete:** 14,575,000 kg (including walls, stairs, deck, foundation) **Demolition:** All existing
Additional Assumptions	- Thickness of demolished brick walls = 337mm - Concrete shaft wall thickness = 300mm - L102x102x7.9 double angles utilized for window strengthening - Existing gravitational load system (columns, beams and slab) have sufficient load carrying capacity for the proposed future loading. - Existing structure is generally found to be in good condition.	- Thickness of demolished brick walls = 337mm - Concrete shaft wall thickness = 300mm - L102x102x7.9 double angles utilized for window strengthening - Additional perimeter braces not required, new shear walls over existing core are sufficient for lateral force transfer to lower levels - Perimeter steel columns are part of original construction	- Six (6) vertical braces at each level - 2 braced bays at the north and south perimeter walls - 1 braced bay at the east and west perimeter walls - Additional 53m of shear walls assumed at ground level to take lateral load from braces to foundation

	- In the absence of existing roof structure information, the existing roof structure is assumed to consist of W310x24 beams on W310x28 girders providing adequate strength under assumed roof loading of 1.5kPa SDL and 2.5kPa snow loads	- Existing gravitational load system (columns, beams, and slab) have sufficient load carrying capacity for the proposed future loading. - Existing structure is generally found to be in good condition.	

Montreal – Envelope

All assemblies were selected to meet NECB minimum performance path, and air leakage rates were standardized across scenarios using NECB thresholds. Although green roofs, solar panels, overcladding, or recycled materials are common in some construction, these studies were excluded from scope due to their complexity and variability. The focus remained on baseline construction practices with heritage preservation in mind.

Scenario A wall assembly was based on the as-built drawings. No insulation on the exterior was studied to preserve the exterior façade, and no interior insulation was studied due to potential damage through freeze-thaw cycles. As each building and climate vary, not all existing buildings will be feasible to add additional insulation. A proper study will be required in each application and therefore we have assumed to standardize this study so that no additional insulation would be added to the existing building wall portions in Scenario A or B. Since the change of use is from factory to office, we have assumed that the windows would need to be replaced for increased energy efficiency and thermal comfort (as per the as-built drawings), however, a separate study can review the alternate of preserving the single glazed aluminum framed windows.

Scenario B descriptions show the addition portion only. The remaining retrofit is expected to have gone through the same retrofit as Scenario A.

In Scenario C, the cladding material was chosen to reflect the character of the Montreal skyline and therefore uses brick veneer with a modern rainscreen wall assembly. The roof membrane material was switched to a typical material for an office building. Scenario C also assumed the new building can insulate below grade as per typical construction.

	Scenario A (Retrofit Factory to Office)	**Scenario B** (Retrofit Factory to Office + Addition)	**Scenario C** (Demolish Factory, Build Office)
Walls	Existing 12” (305mm) multi-wythe brick masonry wall	Steel cladding 6” (150mm) air space 5/8” (16mm) exterior gypsum sheathing 1” (25mm) polyurethane spray foam 6” (150mm) horizontal metal uprights @ 12” (300mm) o.c., filled with batt insulation Vapour barrier ½” (13mm) gypsum wall board ½” (13mm) thin brick on adhesive mortar	Brick veneer 1” (25mm) air space 4” (100mm) XPS insulation Air and vapour barrier 5/8” (16mm) Densglass sheathing ½” (13mm) gypsum wall board on steel studs
Fenestration/ Doors	**Windows:** Double glazed IGU with low-E coating in thermally broken aluminum frame punched windows (Alternate: Keep existing single glazed aluminum frame windows) **Doors:** Insulated steel doors and frames	**Windows:** Double glazed IGU with low-E coating in thermally broken aluminum frame curtain wall **Doors:** Insulated steel doors and frames	**Windows:** Double glazed IGU with low-E coating in thermally broken aluminum frame punched windows and curtain wall **Doors:** Glazed doors part of aluminum frame
Roof	TPO membrane 4” (100mm) XPS insulation Vapour barrier Existing mass timber deck	**Main roof:** TPO membrane 4” (100mm) XPS insulation Vapour barrier Metal deck	2-ply SBS modified bitumen ¼” protection board 4” (100mm) XPS insulation ½” (13mm) Densglass sheathing Metal deck

		Roof terrace: Plastic decking on pedestals and supports Protection mat 2-ply SBS modified bitumen 5” (125mm) XPS insulation Vapour barrier 5/8” (16mm) gypsum sheathing Metal deck	
Soffit	N/A	Wood soffit board 6” (150mm) SPF insulation	Wood soffit board 6” (150mm) SPF insulation
Foundation Wall (Below Grade)	Existing drainage mat Existing bitumen waterproofing Existing foundation wall	N/A	Drainage mat 2” (50mm) XPS insulation Spray-applied dampproofing Concrete foundation wall
Slab on grade	Existing concrete slab on grade, uninsulated	N/A	2” (50mm) XPS insulation below concrete slab on grade

Montreal – Envelope

The table below shows the effective U- and R-Values for all 3 scenarios. Note, Scenario B only shows the addition portion (1-storey addition above existing). The remaining values are expected to be the same as Scenario A.

	Scenario A (Retrofit Factory to Office)			Scenario B (Retrofit Factory to Office + Addition)			Scenario C (Demolish Factory, Build Office)		
Air Leakage Rate at 75Pa	3.0 L/s/m^2			2.5 L/s/m^2			1.5 L/s/m^2		
	Area (m^2)	**U-Value**	**RSI-Value (R-Value)**	**Area (m^2)**	**U-Value**	**RSI-Value (R-Value)**	**Area (m^2)**	**U-Value**	**RSI-Value (R-Value)**
Overall	11742	3.0	0.3 (R1.9)	10502	3.2	0.3 (R1.9)	33314	0.6	1.6 (R9.0)
Walls	1693	1.1	0.9 (R5.0)	350	0.5	2.2 (R12.3)	3122	0.3	3.2 (R18.0)
Roofs	4841	0.4	2.8 (R15.8)	4888	0.3	3.4 (R19.2)	3618	0.3	3.5 (R20.0)
Fenestration	760	3.2	0.3 (R1.8)	730	2.5	0.4 (R2.2)	3230	2.1	0.5 (R2.7)
Opaque Doors	48	4.3	0.2 (R1.3)	N/A	N/A	N/A	N/A	N/A	N/A
Soffits	N/A	N/A	N/A	31	0.2	5.2 (R29.6)	226	0.2	5.2 (R29.6)
Skylight	55	2.0	0.5 (R2.8)	55	2.0	0.5 (R2.8)	N/A	N/A	N/A
Below grade walls	N/A	N/A	N/A	N/A	N/A	N/A	18918	0.5	1.9 (R11.0)
Slab on grade	4400	6.7	0.1 (R0.8)	N/A	N/A	N/A	4200	0.5	1.8 (R10.1)

Montreal – HVAC

Based on the as-built plans provided, we have assumed that for both Scenario A and Scenario B, the HVAC system will consist of multiple small RTUs located on the roof and ducted down to each floor of the new office space. The RTUs will be separate dedicated units for perimeter and interior zones. RTUs serving interior zones should be packaged DX units with either gas burner or electric resistance heater. RTUs serving perimeter zones should be ASHP units with a supplementary source of heating from either natural gas burner or electric resistance heater. For purposes of this study, we have assumed electric resistance heaters for all RTUs. Gas supplement should be provided only if there is limited peak electrical capacity in the building. The RTUs should be variable air flow connected to VAV boxes in the distribution ductwork to allow for individual space temperature control of areas with different occupancies (for example offices, meeting rooms, break rooms, etc.). For energy efficiency, each RTU should be provided with an economizer to allow for free cooling in winter and during shoulder seasons as well as CO_2 sensors to allow for modulation of the fresh air based on actual building occupancy. Electric baseboard heaters are assumed at the perimeter where there are windows.

For Scenario C, there are multiple different designs of HVAC systems that could be considered and analysis of different options was outside of the scope of this study. We decided to assume a hydronic system consisting of 2-pipe fan coil units in interior spaces and 4-pipe fan coil units in perimeter spaces with hydronic radiant ceiling panels above windows. This design option allows for flexibility as the hydronic fan coil units are relatively easily relocated and reconfigured to suit any interior layout of the office space. The hydronic fan coil units also allow for heat recovery between spaces in cooling and spaces in heating through the central hydronic plant.

The central hydronic heating and cooling plant was assumed to consist of air to water heat pumps located on the roof which can provide heating water, chilled water, or simultaneous heating and chilled water with heat recovery. This will allow for heat recovery from the interior spaces which require cooling year-round for use in heating for the perimeter spaces. The balance of heating not provided by the air to water heat pumps will be provided by electric or gas fired boilers. For purposes of this study, we have assumed electric boilers, but gas boilers could be used if there is a limitation on the building's peak electrical capacity.

We have assumed ventilation air will be supplied from a dedicated ERV located on the roof supplying fresh air ducted to the return of each fan coil unit. Fresh air ducts will be supplied with VAV boxes controlled by CO_2 sensor for demand controlled ventilation. Exhaust air from the core central washrooms on each floor will be ducted to the ERV for energy recovery.

Sizing of the cooling loads are based on typical office occupancy loads. We have not accounted for any special cooling loads which may be installed by tenants such as server rooms. Extra cooling for specialized cooling loads are assumed to be provided by the tenants using a dedicated system such as spit ductless AC units.

	Scenario A (Retrofit Factory to Office)	**Scenario B** (Retrofit Factory to Office + Addition)	**Scenario C** (Demolish Factory, Build Office)
Distribution	Ducted supply air with VAV boxes from individual RTUs on roof. RTUs separated into interior/perimeter zones. Electric baseboard heaters at perimeter windows.	Ducted supply air with VAV boxes from individual RTUs on roof. RTUs separated into interior/perimeter zones. Electric baseboard heaters at perimeter windows.	Distributed hydronic fan coil units, 2-pipe for interior zones, 4-pipe for perimeter zones and top floor. Hydronic radiant ceiling panels at perimeter. New hydronic heating water and chilled water piping from central plant to each floor, heating loop serving perimeter, chilled water loop serving interior.
Heating and Air Conditioning	Packaged DX RTUs with electric resistance heat serving interior zones.	Packaged DX RTUs with electric resistance heat serving interior zones.	Central 4-pipe ASHP on roof serving chilled water and heating water for fan coil units

	Packaged ASHP RTUs with electric resistance heat back-up serving perimeter zones.	Packaged ASHP RTUs with electric resistance heat back-up serving perimeter zones.	and hydronic radiant panels, with heat recovery.
Ventilation and Exhaust	Ventilation through RTUs, with economizer mode for free cooling. CO_2 sensors for modulation of fresh air for demand-controlled ventilation. ERV added to RTUs for pre-heating fresh air. New central sanitary exhaust duct riser in core serving core washrooms with capped connections on each floor for future tenant connections connected to exhaust fan on roof.	Ventilation through RTUs, with economizer mode for free cooling. CO_2 sensors for modulation of fresh air for demand-controlled ventilation. ERV added to RTUs for pre-heating fresh air. New central sanitary exhaust duct riser in core serving core washrooms with capped connections on each floor for future tenant connections connected to exhaust fan on roof.	Central ERV with minimum 75% thermal heat recovery efficiency connected to central washroom exhaust riser, general exhaust riser and supplying 100% outside air to fan coil units on each floor. Hydronic heating/cooling coil to heat/cool supply air to 13°C. Fresh air to be ducted to each fan coil unit with VAV boxes controlled by local CO_2 sensors for demand control ventilation. Provide capped sanitary exhaust duct connections on each floor for future tenant use.

Montreal – Plumbing

Based on typical office building layouts, we have assumed there will be one or two sets of core washrooms provided on each floor of the office building plus there may be some shower and change facilities provided for individuals who choose to bike to work. Each set of core washrooms and shower facilities will be provided with a dedicated point-of-use electric tank heater to provide DHW to the group of lavatories and showers.

Each floor of the office building should be provided with a capped DCW supply which can be connected to by tenants. Based on typical office building policies, we have assumed that all tenants will provide their own DHW heaters and consideration of tenant installed DHW heaters is excluded from our analysis in this report.

All plumbing fixtures are assumed to be low flow fixtures in compliance with local codes and standards. For added water conservation, a rainwater collection system could be installed to collect rainwater which can then be treated and used for flushing toilets. However, this is an added cost which would not be included in a typical building construction and has not been included in our analysis for this study.

	Scenario A (Retrofit Factory to Office)	**Scenario B** (Retrofit Factory to Office + Addition)	**Scenario C** (Demolish Factory, Build Office)
Domestic Cold Water (DCW)	Local point of use electric tank heaters serving each floor core washrooms, janitor's closets and other common area services.	Local point of use electric tank heaters serving each floor core washrooms, janitor's closets and other common area services.	Local point of use electric tank heaters serving each floor core washrooms, janitor's closets and other common area services.
Domestic Hot Water (DHW)	Review size and capacity of existing DCW service to ensure adequately sized and coordinate with local municipality for new service as required. New DCW riser in core of building serving core washrooms on each floor. Provide capped DCW branch on each floor for future tenant connection.	Size of existing DCW service to the building to be reviewed for capacity. Coordinate with local utility provider for new service as required. New DCW riser in core of building serving core washrooms on each floor. Provide capped DCW branch on each floor for future tenant connection.	Coordinate with local municipality to provide a new DCW service. New DCW riser in core of building serving core washrooms on each floor. Provide capped DCW branch on each floor for future tenant connection.
Sanitary and Storm Drainage	New sanitary drain and sanitary vent risers in core serving core washrooms, draining into existing sanitary main to municipal sewer. Size of main building sanitary to be reviewed for capacity, coordinate with local municipality for new sanitary drain connection as required. Existing storm drainage piping generally to remain and be re-used.	New sanitary drain and sanitary vent risers in core serving core washrooms, draining into existing sanitary main to municipal sewer. Size of main building sanitary to be reviewed for capacity, coordinate with local municipality for new sanitary drain connection as required. Existing storm drain risers to be extended up to serve new addition roof.	Coordinate with the local municipality to provide new sanitary drain connections to the new building. Provide complete new sanitary drain, vents and storm water drainage piping in new building to meet the building requirements and local codes. If no change in the overall building footprint, then most likely the existing storm sewer connection to the property can be re-used.
Plumbing Fixtures	New plumbing fixtures for men's, women's and universal washrooms on each floor as required to meet local code, accessibility and inclusivity requirements. Recommend providing change rooms with showers for employees who choose to bike to work.	Same as Scenario A.	Same as Scenario A.

Montreal – Fire Protection

Based on typical industrial and typical office buildings, we assume the existing building is already fully sprinklered and has a standpipe system. The existing sprinkler and standpipe system will need to be reviewed by the design team and/or a fire protection contractor and modified to suit the new occupancy and floor plan layouts and meet local code requirements.

For Scenarios B and C where the building height is increasing, a flow test is recommended to be completed to confirm that the city pressure is sufficient and new fire pumps and/or standpipe pumps may be necessary.

	Scenario A (Retrofit Factory to Office)	**Scenario B** (Retrofit Factory to Office + Addition)	**Scenario C** (Demolish Factory, Build Office)
Sprinkler System (if applicable)	Modify existing sprinkler coverage on all floors to meet local code requirements based on the revised occupancy classification. Review system flow and pressure and provide a fire pump as required.	Modify existing sprinkler coverage and extend coverage to additional floors to meet local code requirements based on the revised occupancy classification. Review system flow and pressure and provide a fire pump as required.	Provide complete new sprinkler system to meet local code requirements.
Standpipe System	Provide new fire hose cabinets as required to suit new building layout and egress routes. Review system flow and pressure and provide a standpipe pump as required.	Provide new fire hose cabinets on all floors as required to suit new building layout, and egress routes. Review system flow and pressure and provide a fire pump as required.	Provide complete new standpipe system to meet local code requirements.

Montreal – Electrical, Security, and IT

Converting a factory into an office building requires substantial revisions to electrical infrastructure. Factories are designed for heavy electrical loads, including process equipment, welding machines, and HVAC systems. Loads are often continuous and may involve high inrush currents. Power distribution is typically designed around high-capacity feeders, bus ducts, and motor control centers (MCCs) supplying equipment across the factory floors. Office loads are primarily lighting, receptacles, IT/server equipment, and HVAC systems. Loads are generally lower and more even throughout the space. For the new office building, load studies will be required to confirm required service size and proceed with required requests and coordination with utility providers. The internal distribution in the office building will typically include electrical distribution panels on each floor that will further distribute feeder to individual tenants as required with dedicated electrical panels. Industrial lighting typically includes fluorescent fixtures designed for large open factory spaces, high ceilings, and task lighting for production equipment. Lighting for the new commercial office buildings is typically energy-efficient LED lighting with layouts based on office standards, with emphasis on comfort, glare reduction, and aesthetics, including decorative fixtures in lobbies and meeting room. Exit lighting for factory/industrial buildings are focused on major egress routes, such as factory floor exits. Exit lighting for commercial/office buildings is more comprehensive to account for partitioned spaces such as meeting rooms, offices, lunchrooms and corridors.

Security systems in industrial buildings are perimeter focused, with the intent of protecting equipment in controlled areas. Commercial buildings require more intensive systems that require card access in entrances, elevators, tenant spaces, IT Rooms, etc. Security cameras are all required to cover both interior and exterior sections of the building. Systems typically terminate at a central security desk in the main lobby of the building.

IT requirements in industrial buildings are more centralized, providing connectivity to office and control rooms as required. Commercial buildings will often require high density cabling system, and coordination with local utility providers to provide required service to the building. Network risers will be developed to provide IT connections to all floor spaces. Network distribution to different tenant spaces and offices will be coordinated with respective clients.

	Scenario A (Retrofit Factory to Office)	**Scenario B** (Retrofit Factory to Office + Addition)	**Scenario C** (Demolish Factory, Build Office)
Electrical Service	Review capacity of existing electrical service to ensure suitable for new electrical loads and coordinate with local service provider to upgrade the electrical service as required.	Review capacity of existing electrical service to ensure suitable for new electrical loads and coordinate with local utility provider to upgrade the electrical service as required. Provide distribution to additional floor using bus duct or other raceways.	Coordinate with local service provider for new service sized for new building electrical loads.
Power Distribution	Modify existing main electrical room switch gear as required and provide new power distribution feeders and local panels on each floor complete with sub-meters for tenants. New feeder from main electrical room to feed new RTUs on roof.	Modify existing main electrical room switch gear as required and provide new power distribution feeders and local panels on each floor complete with sub-meters for tenants. New feeder from main electrical room to feed new RTUs on roof. Provide distribution to additional floor using bus duct or other raceways.	New switch gear and electrical distribution feeders and panels for each floor with sub-meters for tenants. New distribution panel in mechanical rooms to serve mechanical equipment. Distribution to include separate panels for lighting and power loads.
Lighting	Provide new LED light fixtures in leasable areas laid out in a general grid to meet minimum lighting requirements for an open office space, ready for	Provide new LED light fixtures in leasable areas laid out in a general grid to meet minimum lighting requirements for an open office space, ready for	Provide new LED light fixtures in leasable areas laid out in a general grid to meet minimum lighting requirements for an open office space, ready for

	future tenant improvement. Provide new LED light fixtures in entrance lobby, elevator lobbies, and other back-of-house areas as required to meet code and owner's requirements. Provide new exit signage as required to suite new building layout.	future tenant improvement. Provide new LED light fixtures in entrance lobby, elevator lobbies, and other back-of-house areas as required to meet code and owner's requirements. Provide new exit signage as required to suite new building layout.	future tenant improvement. Provide new LED light fixtures in entrance lobby, elevator lobbies, and other back-of-house areas as required to meet code and owner's requirements. Provide new exit signage as required to suite new building layout.
Security	Provide central security access card system with card readers at building entrances, elevators, and floors. Provide security cameras as required to cover exterior and interior of building. Terminate at central security desk in main entrance lobby.	Provide central security access card system with card readers at building entrances, elevators, and floors. Provide security cameras as required to cover exterior and interior of building. Terminate at central security desk in main entrance lobby.	Provide central security access card system with card readers at building entrances, elevators, and floors. Provide security cameras as required to cover exterior and interior of building. Terminate at central security desk in main entrance lobby.
IT	Coordinate with local utility providers to provide IT/Comms to IT/Comms rooms on each floor.	Coordinate with local utility providers to provide IT/Comms to IT/Comms rooms on each floor.	Coordinate with local utility providers to provide IT/Comms to IT/Comms rooms on each floor.

Vancouver – Structural

The as-built scenario for Vancouver was Scenario B, which presented the construction of a new additional building behind the existing, and the addition of a small lean-to onto the existing structure. The as-built construction of the addition was identified as being highly bespoke and not “typical” for the nature and quality of the structural framing that would generally be seen for extensions of existing residential construction. Therefore, a more “typical” structural form for the addition was developed, where it was assumed that the addition would be compliant with Part 9 of the British Columbia Building code. This included limiting the layouts and spans of the structure to be typical of small-scale light-frame housing and to minimize the depth of the beams (generally keeping the floor span below 4m) and having the floors supported on stud walls rather than introducing singular structural columns and beams. The small lean-to extension above ground and the respective basement extension to the as-built construction was maintained as the only intervention work to be undertaken to the existing building.

Similarly, for Scenario C, the design of the new buildings was developed with Giaimo to reflect more “typical” residential light-frame timber construction practices in Vancouver, and the Main Building geometry as well as the geometry of the “secondary building” or “shed” were developed in accordance with Part 9 of the British Columbia Building Code.

For Scenario A, it was assumed that generally, there would be no structural interventions.

The overarching assumptions for the design of Scenario B and C are below:

- Part 9 of the Vancouver Building Code used to determine the size and spacing of all light-framed wood members
- All construction consists of timber light-frame floor joists and wall systems in accordance with Part 9 of the British Columbia Building Code
- Steel connector element quantities are not included in the scope of the estimates
- Floor and wall joists assumed to be the same size and spacing for connection compatibility
- Interior walls have plywood sheathing on one face, exterior walls have sheathing on both faces
- Floor joist systems utilize strapping for the bracing system as per minimum code requirements
- Pitched roof assumes king-post truss system
- Material properties
    - Plywood density = 550 kg/m3
    - Timber stud density = 355 kg/m3
    - Concrete density = 2400 kg/m3
    - Shear wall steel reinforcement density = 65 kg/m3
    - Slab steel reinforcement density = 100 kg/m3
    - Foundation steel reinforcement density = 80 kg/m3

Vancouver – Structural

The detailed assumptions and overall structural geometry, notes and volumes are shown below:

	Scenario A (Retrofit Residential)	**Scenario B** (Retrofit Residential + Addition + Infill)	**Scenario C** (Demolish Residential, Build New Residential)
Main Geometry	Existing	Extension off the north face of existing building (1.75m) including basement and ground levels, with new porch at roof. New stairway at west face for basement entrance. Floor to floor height: 3.3m	Floor to floor height: 3m Foundation: Concrete spread footing
Gravity System	Existing	Light-framed timber walls and floors: **Exterior Walls above ground:** 38x184mm (2x8) joists @ 400mm o/c, double-sided sheathing (705 kg timber) **Floor and Roof:** 38x184mm (2x8) joists @ 400mm o/c, single- sided sheathing, strapping at joists (470 kg timber) **Stairs:** Concrete, average 280mm depth (1930kg concrete, 375kg steel reinforcement)	Light-framed timber walls and floors: **Interior Walls:** 38x89mm (2x4) joists @ 600mm o/c, single-sided sheathing (380 kg timber) **Exterior Walls:** 38x235mm (2x10) joists @ 400mm o/c, double-sided sheathing (1970 kg timber) **Floors:** 38x235mm (2x10) joists @ 400mm o/c, single- sided sheathing, strapping at joists (1130 kg timber)
Lateral System	Existing	Light-framed timber shear walls with plywood floor	Light-framed timber shear walls with plywood floor
Foundations	Existing	**Concrete basement foundation wall:** 300mm wall with 400mm wide by 300mm high footing extrusion at wall base (24,000 kg concrete, 650kg steel reinforcement) **Concrete slab:** 250mm slab at basement floor (12,100kg concrete, 500kg steel reinforcement)	**Exterior wall concrete footings:** 1.5m deep wall by 300mm thick with 450mm wide by 200mm high footing (48000 kg concrete, 1400kg steel reinforcement)
Additional And Demolition	No structural interventions required.	Excavation to form new foundation, underpinning of existing foundation	**Pitched roof with king-post truss system:** Truss composed of 38x235mm (2x10) elements for the chord and web elements, with the same sized joists spanning between, and a single sheathing layer (1500kg timber)

Vancouver – Structural

	Scenario A (Retrofit Residential)	**Scenario B** (Retrofit Residential + Addition + Infill)	**Scenario C** (Demolish Residential, Build New Residential)
Additional Assumptions	Assumption that no structural work is required	- Maximum floor spans are not exceeded on plan (3.71m); therefore, no adjustments are necessary for total interior wall length - Quantities for the main building addition are based on the IFC drawing set - New wall and floor assemblies for the main building addition are not informed by the existing building's construction	- Additional walls are assumed in spaces where the maximum allowable floor span of 4.16m (with 38x235 studs) is exceeded - 38.7m of additional interior wall length total, including all floor levels - Floor to floor height of the exterior garage is assumed to be 3m due to absence of information in the drawing set - King post truss system is also assumed for garage pitched roof

Vancouver – Envelope

All assemblies were selected to meet NECB minimum performance path, and air leakage rates were standardized across scenarios using NECB thresholds. Although green roofs, solar panels, overcladding, or recycled materials are common in some construction, these studies were excluded from scope due to their complexity and variability. The focus remained on baseline construction practices with heritage preservation in mind.

Scenario A wall assembly was based on the as-built drawings. Since there is no change in use and the buildings are maintained as residential, we assumed the scale of the buildings allow for more preservation of existing materials. Therefore, as per the as-built drawings, we have assumed that the horizontal wood lap sizing, sheathing, and main structural framing can be salvaged and re-used, while adding additional insulation interior and exterior of the sheathing layer. Window frames were also assumed to be re-used, with replacement of more efficient double-glazed units. However, in lieu of using SPF insulation used in the as-built condition, we have adjusted the insulation type to be a fibreglass batt insulation as more typical.

Scenario B descriptions describe the addition portion to the main building, as well as the infill building (new building on the same property). Similarly to the other case studies, the Scenario B descriptions show the addition portions only. The remaining retrofit of the main existing building is expected to have gone through the same retrofit as Scenario A.

In Scenario C, the as-built drawings chose typical construction materials and since there is also a new separate infill building in Scenario B, we maintained the same wall assembly for a better comparison. Therefore, in this case study, Scenarios B and C will be similar. Scenario C also includes garages in the back, which we have assumed will have the same construction as the main building, except without insulation.

	Scenario A (Retrofit Residential)	**Scenario B** (Retrofit Residential + Addition + Infill)	**Scenario C** (Demolish Residential, Build New Residential)
Walls	Existing horizontal wood lap siding 9.5mm cavity VP air and water resistive barrier Existing shiplap sheathing Existing 2x4 wood framing at 24” (610mm) o.c. 6” (150mm) batt insulation Polyethylene vapour retarder 13mm gypsum wall board	**Addition:** Fiber cement siding ½” (13mm) vertical strapping ½” (13mm) horizontal strapping VP air and water resistive barrier ½” (13mm) plywood sheathing 2x8 wood framing at 16” (400mm) o.c. 8.5” (215mm) batt insulation Polyethylene vapour barrier 5/8” (16mm) gypsum wall board **Infill:** Same as Addition	Same as Scenario B Infill
Fenestration/ Doors	**Windows:** Existing wood frame, double glazed IGU punched windows **Doors:** Vinyl frame sliding glass doors; Insulated fibreglass door with glazing lite; opaque insulated fiberglass door; skylights	**Addition:** **Windows:** Vinyl frame, double glazed IGU punched windows **Doors:** Insulated fibreglass door with glazing lite; opaque insulated fiberglass door **Infill:** Same as Addition	Same as Scenario B Infill
Roof	Asphalt shingles Underlayment ½” (13mm) plywood sheathing 63mm vented air cavity	**Addition:** **Main Roof:** Asphalt shingles	Same as Scenario B Infill

	Existing Strapping Existing 2x4 rafters 8.5” (215mm) batt insulation Vapour barrier 5/8” (16mm) gypsum wall board	½” (13mm) furring strips Underlayment ½” (13mm) plywood sheathing Engineered roof truss 8.5” (215mm) batt insulation Vapour barrier 5/8” (16mm) gypsum wallboard **Roof Terrace:** River rock ballast 2-ply modified bitumen 5/8” (16mm) TG plywood Floor joists 8.5” (215mm) batt insulation 2 layers of ½” (13mm) gypsum wallboard **Infill:** Asphalt shingles ½” (13mm) furring strips Underlayment ½” (13mm) plywood sheathing Engineered roof truss 8.5” (215mm) batt insulation Vapour barrier 5/8” (16mm) gypsum wallboard	
Soffit	N/A	**Addition:** N/A **Infill:** Cementitious board soffit panel 8.5” (215mm) batt insulation TJI at 24” (610mm) o.c. Vapour barrier 5/8” (16mm) plywood subfloor Finished floor	Same as Scenario B Infill
Foundation Wall (Below Grade)	Existing Drainage mat on dampproofing Existing concrete foundation wall Existing 2x6 wood framing 24” (610mm) o.c. 6” (150mm) batt insulation ½” (13mm) gypsum wall board	**Addition:** N/A **Infill:** Drainage mat on dampproofing Concrete foundation wall 2x6 wood framing 24” (610mm) o.c. 6” (150mm) batt insulation ½” (13mm) gypsum wall board	Same as Scenario B Infill
Slab on grade	Existing concrete slab on grade Existing vapour barrier Existing 2” (50mm) XPS rigid insulation Existing compact fill	**Addition:** N/A **Infill:** Concrete slab on grade Vapour barrier 4” (100mm) XPS rigid insulation Compact fill	Same as Scenario B Infill

Vancouver – Envelope

The table below shows the effective U- and R-Values for all 3 scenarios. Note, Scenario B only shows the addition portions (back addition and separate infill building). The remaining values are expected to be the same as Scenario A.

	Scenario A (Retrofit Residential)			**Scenario B** (Retrofit Residential + Addition + Infill) Addition			**Scenario B** (Retrofit Residential + Addition + Infill) Infill		
Air Leakage Rate at 75Pa	2.5 L/s/m²			1.5 L/s/m²			1.5 L/s/m²		
	Area (m²)	**U-Value**	**RSI-Value (R-Value)**	**Area (m²)**	**U-Value**	**RSI-Value (R-Value)**	**Area (m²)**	**U-Value**	**RSI-Value (R-Value)**
Overall	500	0.5	1.9 (R10.6)	137	0.4	2.4 (R13.8)	519	0.4	2.3 (R12.9)
Walls	190	0.4	2.5 (R14.0)	80	0.3	3.8 (R21.9)	104	0.3	3.5 (R19.9)
Roofs	160	0.3	3.2 (R18.3)	14	0.3	3.6 (R20.7)	137	0.3	3.7 (R21.0)
Fenestration	30	1.5	0.6 (R3.6)	2	2.0	0.5 (R2.9)	22	1.8	0.5 (R3.1)
Opaque Doors	15	1.7	0.6 (R3.3)	12	1.1	0.9 (R5.3)	30	1.1	0.9 (R3.1)
Soffits	N/A	N/A	2.8 (R7.0)	2	0.4	2.7 (R15.6)	3	0.3	3.2 (R18.3)
Below grade walls	34	0.8	1.9 (R15.9)	13	0.7	1.4 (R7.9)	91	0.5	2.0 (R11.3)
Slab on grade	500	0.4	1.9 (R15.9)	13	0.3	3.0 (R17.0)	133	0.3	3.2 (R17.9)

	Scenario C (Demolish Single Family Dwelling, Build Residential + Addition)		
Air Leakage Rate at 75Pa	1.5 L/s/m²		
	Area (m²)	**U-Value**	**RSI-Value (R-Value)**
Overall	875	0.4	2.4 (R13.4)
Walls	341	0.3	3.8 (R21.9)
Roofs	186	0.3	3.7 (R21.2)
Fenestration	51	1.8	0.5 (R3.1)
Opaque Doors	21	1.3	0.7 (R4.2)
Soffits	N/A	N/A	N/A
Below grade walls	132	0.5	2.1 (R11.8)
Slab on grade	143	0.3	3.2 (R17.9)

Vancouver – HVAC

The overall concept for all three Scenarios is construction of multiplex residential buildings which maximize available floor area as separate residential units. Based on the as-built drawings provided, our assumption is the existing structure is redeveloped into a triplex for both Scenario A and B, with the separate in-fill building constructed as a duplex in Scenario B. Based on concept drawings provided to us, we have assumed Scenario C consists of a triplex building. Although ducted supply systems are feasible in these scenarios, this would require more intrusion into the space for mechanical equipment, bulkheads and duct shafts. We opted for a simplified approach for HVAC to incorporate ductless split VRF systems, one for each individual residential unit, with the outdoor units mounted on the exterior wall and piped with refrigerant piping to individual ductless indoor units, generally one indoor unit for each principal living area and bedroom. These will provide heating and cooling to the suites and ensures each individual suite has control of their own heating and cooling. This also allows for each individual system to be fed from the respective sub-panel for each suite for metering electrical consumption. An added benefit over a ducted system is the individual ductless units allow for individual temperature control in each principal room of the suites for best thermal comfort. The split VRF units can provide cooling and heating even on the coldest winter days in Vancouver with no back-up source of heating required. However, if this concept is applied to other regions of Canada, the design team must check local peak winter conditions, and a back-up source of heat may be necessary if it is anticipated that outside temperatures may drop below the minimum ambient operating conditions for the VRF system.

Ventilation air for all three scenarios is provided by an ERV which can generally be located above the ceiling in the bathroom or in a closet. It will require small diameter supply air ducts to be run in small bulkheads or inside walls or ceiling joists into each principal room and exhaust air out from each bathroom and kitchen area.

Scenario C include garages at the back of the property which we have assumed will be unconditioned.

	Scenario A (Retrofit Residential)	**Scenario B** (Retrofit Residential + Addition + Infill)	**Scenario C** (Demolish Residential, Build New Residential)
HVAC - Delivery	Ductless split VRF heat pumps in each principal room. Outdoor unit mounted on the exterior wall of the building. Electric baseboard heaters as needed in non-principal rooms (such as bathrooms or mudrooms) with exterior wall or roof exposure.	Same as Scenario A for both additions.	Same as Scenario A for new residential building. Garages assumed to be unheated.
Ventilation	ERV in each individual suite, with supply ducts to each principal room and exhaust from each bathroom/powder room and kitchen area.	Same as Scenario A for both additions.	Same as Scenario A for new residential building. Garages assumed to be not ventilated.

Vancouver – Plumbing

For all Scenarios we assume there will be a single incoming water supply with a single water meter. The size of the existing water supply to the property must be reviewed to ensure it is adequate for the added loads and it may be necessary to coordinate with the local municipality to upgrade the water supply size and provide a new meter. Ideally the water meter should be located outside in a meter chamber to allow access without needing to enter individual resident suites. Alternatively, a small water meter room should be incorporated into the building plans with direct exterior access.

We have assumed individual DHW systems for each resident suite, consisting of an electric DHW storage tank heater which can be incorporated into a closet, mudroom or bathroom. This also allows for individual metering of electricity consumption for DHW. Alternatively, if a dedicated meter room is provided and it is not desirable to incorporate space for a tank heater inside each suite, a central DHW tank heater could be incorporated into the water meter room to serve DHW for all units. The analysis for this study is based on individual DHW tank heaters for each suite.

All plumbing fixtures should be low flow fixtures in compliance with local codes and authorities having jurisdiction.

For all Scenarios, the size of the existing sanitary sewer connection to the property must be reviewed to ensure it is adequately sized to accommodate the increased sanitary load.

We have assumed the garages included in Scenario C will not be provided with water or sanitary drainage connections.

	Scenario A (Retrofit Residential)	**Scenario B** (Retrofit Residential + Addition + Infill)	**Scenario C** (Demolish Residential, Build New Residential)
Domestic Cold Water (DCW)	Install Electric Domestic Hot Water Heater Tank, one per suite and connect to fixtures.	Same as Scenario A for both buildings.	Same as Scenario A for new residential building.
Domestic Hot Water (DHW)	Review size and capacity of existing DCW service to ensure adequately sized and coordinate with local municipality for additional new service as required.	Retrofit Residential Building: Same as Scenario A. Infill Building: Coordinate with local municipality to provide new DCW service.	Coordinate with local municipality to provide new DCW service. New garages assumed to be not serviced with water.
Storm Drainage	Provide roof drainage system to direct water away from building per BC Building Code.	Same as Scenario A for both buildings.	Same as Scenario A for all buildings.
Sanitary Drainage	Review size and capacity of existing sanitary service to ensure adequately sized. Coordinate with local municipality for additional new sanitary drain connection if required.	Retrofit Residential Building: Same as Scenario A. Infill Building: Coordinate with the local municipality to provide new sanitary drain connections to the new building. Provide complete new sanitary drain, vents and storm water drainage piping in new building to meet the building requirements and local codes.	Review size and capacity of existing sanitary connection to ensure adequately sized. Coordinate with local municipality for additional new sanitary drain connection if required. New garages assumed to be not serviced with sanitary drainage.

Vancouver – Electrical and Fire Safety

All three scenario involve retrofit residential. A load study followed by a review of the condition of the existing main electrical service is required prior to determination if a new service is required. New kitchens, laundry rooms, and bathrooms introduced in the extension require dedicated circuits for appliances (e.g., ovens, dishwashers, washers, dryers). Provision of dedicated panel and submeter for each dwelling unit to be coordinated with owner and designed accordingly. Additional receptacles and outlets to be installed in additional space per local codes at a minimum, and to meet client requirement as requested.

	Scenario A (Retrofit Residential)	**Scenario B** (Retrofit Residential + Addition + Infill)	**Scenario C** (Demolish Residential, Build New Residential)
Electrical Service and Distribution	Existing, confirm existing electrical panels are in suitable condition and sized appropriately. Provide sub-panels for each individual unit complete with sub-meters.	Coordinate new electrical service with BC Hydro for additional building. Provide distribution circuits and outlets as per BC building code. Provide sub-panels for each individual unit complete with sub-meters.	Coordinate new electrical service with BC Hydro for additional building. Provide distribution circuits and outlets as per BC building code. Provide individual sub-panels for each individual unit complete with sub-meters.
Fire Alarm System	Not required per prototype design. Requirements may vary depending on local codes.	Not required per prototype design. Requirements may vary depending on local codes.	Not required per prototype design. Requirements may vary depending on local codes.
Smoke Alarms	Provide and install smoke alarms as per Vancouver Building Bylaw and BC Building Code.	Provide and install smoke alarms as per Vancouver Building Bylaw and BC Building Code.	Provide and install smoke alarms as per Vancouver Building Bylaw and BC Building Code.

Limitations

- Documents provided for our assessment represent the as-built condition of each respective case study building.
- The scope of our work and related responsibilities related to our work are defined in our proposal dated January 9, 2025.
- Any user accepts that decisions made or actions taken based upon interpretation of our work are the responsibility of only the parties directly involved in the decisions or actions.
- No party other than the Client shall rely on the Consultant's work without the express written consent of the Consultant, and then only to the extent of the specific terms in that consent. Any use which a third party makes of this work, or any reliance on or decisions made based on it, are the responsibility of such third parties. Any third-party user of this report specifically denies any right to any claims, whether in contract, tort and/or any other cause of action in law, against the Consultant (including Sub-Consultants, their officers, agents and employees). The work reflects the Consultant's best judgement in light of the information reviewed by them at the time of preparation. It is not a certification of compliance with past or present regulations. Unless otherwise agreed in writing by the Consultant, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity; it is written to be read in its entirety.
- Only the specific information identified has been reviewed. No physical or destructive testing has been performed unless specifically recorded. Conditions existing but not recorded were not apparent given the level of study undertaken.
- The Consultant is not responsible for, or obligated to identify, mistakes or insufficiencies in the information obtained from the various sources, or to verify the accuracy of the information.
- No statements by the Consultant are given as or shall be interpreted as opinions for legal, environmental or health findings. The Consultant is not investigating or providing advice about pollutants, contaminants or hazardous materials.
- Applicable codes and design standards may have undergone revisions since the subject properties were reviewed. As an example, design loads (such as those for temperature, snow, wind, rain, seismic etc.) and the specific methods of calculating the capacity of the systems to resist these loads may have changed significantly. Unless specifically included in our scope, no calculations or evaluations have been completed to verify compliance with current building codes and design standards.
- Mechanical recommendations are based on the latest available equipment, refrigerants, and technologies at the time of completing this study.
- When applying recommendations from this study, it remains the design team's responsibility to be aware of and follow all applicable codes and regulations in place applicable to the building type, occupancy, and location for the project being undertaken.
- An in-depth analysis of the building's electrical service capacity and electrical distribution shall be the responsibility of the design team implementing any recommendations from this study.
- Local weather design conditions shall be considered when applying any recommendations from this study. All air source heat pump capacities, efficiencies and operating ranges are affected by the local weather conditions. Solutions utilizing air source heat pumps proposed in this study may not work or be suitable in all locations across Canada.
- WSP offers no guarantees beyond the standard of care typical in the industry for our services.
- The information provided in this report outlines preliminary work into the Case Studies only. These findings are not to be used for construction or represent an exhaustive or complete design for these scenarios and shall not be replicated for implementation on other projects.
- Design consultant team implementing any recommendations in this study shall be responsible for undertaking all design and analysis of the existing buildings for their respective projects, requirements, and use cases.

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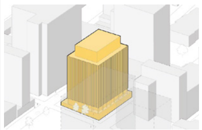
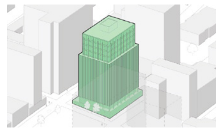
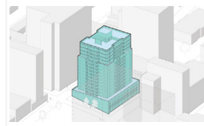
D - Energy Modeling Reports

HALIFAX | ENERGY MODELLING INPUTS

Location	Halifax
Weather File	CWEC 2020
Main Occupancy	Residential

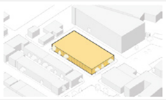
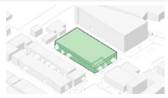
	Scenario A	Scenario B		Scenario C	Reference / Note
	Existing	Existing	New Construction	New Construction	
BUILDING INFORMATION					
					per WSP Engineering Report.
No. of Storeys Above Grade	12	15		16	
No of Levels Underground Parkade	1-1/2	1-1/2		3	
Gross Floor Area	16,075 m^2	19,915 m^2		16,370 m^2	
Dwelling Units	178	190		170	
Space Types	Residential Dwelling Units, Office, Corridors, Electrical and Mechanical, Storage, Parkade	Same as Scenario A		Same as Scenario A	per Architectural Drawing Set.
OPAQUE ENVELOPE THERMAL PERFORMANCE					
Foundation					
Effective R-Value	R_{SI} - 3.0 R_{IP} - 16.9	R_{SI} - 3.0 R_{IP} - 16.9	n/a	R_{SI} - 3.0 R_{IP} - 17.0	Assembly and effective R-value modelled per WSP Engineering Report.
Foundation Wall					
Effective R-Value	R_{SI} - 3.8 R_{IP} - 21.7	R_{SI} - 3.8 R_{IP} - 21.7	n/a	R_{SI} - 2.5 R_{IP} - 13.9	Assembly and effective R-value modelled per WSP Engineering Report.
Exterior Walls					
Effective R-Value	R_{SI} - 1.5 R_{IP} - 8.4	R_{SI} - 1.5 R_{IP} - 8.4	n/a	R_{SI} - 1.0 R_{IP} - 5.5	Assembly and effective R-value modelled per WSP Engineering Report.
Roof					
Effective R-Value	R_{SI} - 2.7 R_{IP} - 15.5	R_{SI} - 2.7 R_{IP} - 15.5	R_{SI} - 3.4 R_{IP} - 19.3	R_{SI} - 3.2 R_{IP} - 18.3	Assembly and effective R-value modelled per WSP Engineering Report.
Soffits					
Effective R-Value	R_{SI} - 0.7 R_{IP} - 4.2	R_{SI} - 0.7 R_{IP} - 4.2	n/a	n/a	Assembly and effective R-value modelled per WSP Engineering Report.
FENESTRATION & DOORS					
Window-to-wall Ratio	42%	48%		49%	per Architectural Drawing Sets.
Fenestration					
U-value	U_{SI} - 4.2 U_{IP} - 0.74	U_{SI} - 4.2 U_{IP} - 0.74	U_{SI} - 2.2 U_{IP} - 0.39	U_{SI} - 2.4 U_{IP} - 0.42	Window type and performance modelled per WSP Engineering Report.
SHGC	0.33	0.33	0.33	0.33	
Opaque Doors					
U-value	n/a	n/a	n/a	n/a	
AIRTIGHTNESS					
Air Leakage Rate @ 75 Pa	2.5 l/s/m^2 total envelope area	2.5 l/s/m^2 total envelope area		1.5 l/s/m^2 total envelope area	per WSP Engineering Report.

	Scenario A	Scenario B		Scenario C	Reference / Note
	Existing	Existing	New Construction	New Construction	
MECHANICAL & ELECTRICAL					
System Overview	Individual split hybrid VRF indoor units, one per suite, connected to central outdoor units located on the roof, using hydronic piping inside suites. Electric resistance heating coil as back-up. In-suite ERVs.	Water source heat pumps with built-in ERVs in suites connected to heat pump loop risers.		Same as Scenario B	per WSP Engineering Report.
HVAC Plant					
Description	Central ASHP outdoor units connected with refrigerant piping to hybrid system control boxes on each floor, hydronic piping distribution to indoor units.	Cooling tower and heating-only ASHPs, electric boiler connected to central heat pump loop for back-up heating.		Same as Scenario B	per WSP Engineering Report.
Heating Efficiency	COP-3.9 @ 8.3°C COP-3.0 @ -8.3°C Back-up: 100%	Same as Scenario A		Same as Scenario A	Assumption.
Cooling Efficiency	EER-11.2 IEER-12.9	Same as Scenario A		Same as Scenario A	Assumption.
CW Loop Temperature	7°C	Same as Scenario A		Same as Scenario A	Assumption.
HW Loop Temperature	82°C @ -16°C 60°C @ 0°C	Same as Scenario A		Same as Scenario A	Assumption.
Pump Type	Variable Speed	Same as Scenario A		Same as Scenario A	Assumption.
Pump Power	300 W/(l/s)	Same as Scenario A		Same as Scenario A	Assumption.
Zone Equipment					
Description	Ducted indoor units.	Water source heat pumps.		Same as Scenario B	per WSP Engineering Report.
Fan Type	Variable Air Volume	Same as Scenario A		Same as Scenario A	per WSP Engineering Report.
Fan Power	0.3 W/cfm	Same as Scenario A		Same as Scenario A	Assumption.
Ventilation System					
Description	In-suite ERVs	Same as Scenario A		Same as Scenario A	per WSP Engineering Report.
Outdoor Air Rate	Residential & Office: 5 cfm/person + 0.06 cfm/ft2 Corridor: 0.06 cfm/ft2	Same as Scenario A		Same as Scenario A	per ASHRAE 62.1-2019 Table 6-1.
Fan Power	1.0 W/cfm	1.0 W/cfm		Same as Scenario A	Assumption.
SRE	75%	Same as Scenario A		Same as Scenario A	Assumption.
Corridor Ventilation System					
Description	ASHP make-up air unit with electric back-up.	Water source make-up air unit on roof serving air riser for corridor ventilation.		Water source make-up air unit on roof service air riser for corridor ventilation.	per WSP Engineering Report.
Outdoor Air Rate	30 cfm / suite	30 cfm / suite		30 cfm / suite	per WSP Engineering Report.
Heating Efficiency	COP-3.9 @ 8.3°C COP-3.0 @ -8.3°C Back-up: 100%	n/a		n/a	Assumption.
Cooling Efficiency	EER-11.2 IEER-12.9	n/a		n/a	Assumption.
Supply Air Temperature	Outdoor Air Reset	Outdoor Air Reset		Outdoor Air Reset	Assumption.
Fan Power	1.3 W/cfm	1.3 W/cfm		1.3 W/cfm	Assumption.
Sensible Recovery Efficiency (SRE)	n/a	n/a		n/a	per WSP Engineering Report.
Exhaust					
Parkade	3.7 $l/s/m^2$	3.7 $l/s/m^2$		3.7 $l/s/m^2$	per ASHRAE 62.1-2019 Table 6-1.
Washrooms	Exhaust via ERV	Exhaust via ERV		Exhaust via ERV	
SERVICE HOT WATER SYSTEM					
Description	Individual electric tank heaters inside each suite.	Central DHW system connected to the heat pump loop for pre-heating. Electric tank heaters.		DHW pre-heat using heat exchanger connected to heat pump loop with gas fired boilers or electric boilers to supplement.	per WSP Engineering Report.
Peak Hot Water Load	Residential: 500 W/occupant Office: 90 W/occupant	Same as Scenario A		Same	per NECB 2020 Table A-8.4.3.2.(2)-B
Low Flow Fixtures	Yes	Same as Scenario A		Same as Scenario A	Assumption.
% Flow Reduction	30%	Same as Scenario A		Same as Scenario A	
Efficiency	100%	Pre-heat: HW loop Electric tank: 100%		Same as Scenario A	

OPERATION AND LOADS				
Indoor Temperature Setpoints				
Heating Setpoint / Setback	Setpoint: 22°C Setback: 18°C	Same as Scenario A	Same as Scenario A	per NECB 2020 Table A-8.4.3.2.(1)-G and NECB 2020 Table A-8.4.3.2.(1)-A
Cooling Setpoint / Setback	Setpoint: 24°C Setback: n/a			
Parkade	n/a		Unconditioned	per WSP Engineering Report.
Lighting & Loads				
No. of Elevators	1 Elevator	Same as Scenario A	2 Elevators	per WSP Engineering Report.
Elevator Load	14.6 kW/elevator		Same as Scenario A	per BC Hydro Energy Modelling Guidelines
Occupancy	Residential: Average of 2.5 people per unit. Office: 20 m^2/occ Corridor/Storage: 100 m^2/occ Elec/Mech: 200 m^2/occ			Modelled per NECB 2020 Space Type (Table A-8.4.3.2.(2)-B).
Plug Loads	Residential: 5.0 W/m^2 Office: 7.5 W/m^2 Elec/Mech: 1 W/m^2			
Lighting	Residential: 5 W/m^2 Office: 6.6 W/m^2 Corridor: 4.4 W/m^2 Elec/Mech: 4.6 W/m^2 Storage: 4.1 W/m^2			Modelled per NECB 2020 Space Type methodology (Table 4.2.1.5 + Section 8.4.3.4.(1)).
Schedules	Residential: NECB Schedule G Office: NECB Schedule A			per NECB 2020 Table A-8.4.3.2.(2)-B

MONTREAL - ENERGY MODELLING INPUTS

Location	Montreal
Weather File	CWEC 2020
Main Occupancy	Office

	Scenario A	**Scenario B**		**Scenario C**	**Reference / Note**
	Existing	Existing	New Construction	New Construction	
BUILDING INFORMATION					
					per WSP Engineering Report.
No. of Storeys Above Grade	2	3		6	
No of Levels Underground Parkade	n/a	n/a		1	
Gross Floor Area (m2)	8,800 m^2	12,930 m^2		17,330 m^2	
Space Types	Office, Corridor, Lobby, Stairwell, Change Room, WC, Reception, Storage, Recycling, Electrical / Mechanical, Parkade	Same as Scenario A		Same as Scenario A	per Architectural Drawing Set.
OPAQUE ENVELOPE THERMAL PERFORMANCE					
Foundation					
Effective R-Value	R_{SI} - 0.1 R_{IP} - 0.8	R_{SI} - 0.1 R_{IP} - 0.8	n/a	R_{SI} - 1.78 R_{IP} - 10.1	Assembly and effective R-value modelled per WSP Engineering Report.
Foundation Wall					
Effective R-Value	n/a	n/a	n/a	R_{SI} - 1.94 R_{IP} - 11.0	Assembly and effective R-value modelled per WSP Engineering Report.
Exterior Walls					
Effective R-Value	R_{SI} - 0.88 R_{IP} - 5.0	R_{SI} - 0.88 R_{IP} - 5.0	R_{SI} - 2.17 R_{IP} - 12.3	R_{SI} - 3.17 R_{IP} - 18.0	Assembly and effective R-value modelled per WSP Engineering Report.
Roof					
Effective R-Value	R_{SI} - 2.78 R_{IP} - 15.8	n/a	R_{SI} - 3.38 R_{IP} - 19.2	R_{SI} - 3.52 R_{IP} - 20.0	Assembly and effective R-value modelled per WSP Engineering Report.
Soffits					
Effective R-Value	n/a	n/a	R_{SI} - 5.21 R_{IP} - 29.6	R_{SI} - 5.21 R_{IP} - 29.6	Assembly and effective R-value modelled per WSP Engineering Report.
FENESTRATION & DOORS					
Window-to-wall Ratio	32%	35%		54%	per Architectural Drawing Sets.
Fenestration					
U-value	U_{SI} - 3.2 U_{IP} - 0.56	U_{SI} - 3.2 U_{IP} - 0.56	U_{SI} - 2.5 U_{IP} - 0.44	U_{SI} - 2.1 U_{IP} - 0.37	Window type and performance modelled per WSP Engineering Report.
SHGC	0.33	0.33	0.33	0.33	
Opaque Doors					
U-value	U_{SI} - 4.3 U_{IP} - 0.76	U_{SI} - 4.3 U_{IP} - 0.76	n/a	n/a	Door type and performance modelled per WSP Engineering Report.
AIRTIGHTNESS					
Air Leakage Rate @ 75 Pa	3.0 l/s/m^2 total envelope area	3.0 l/s/m^2 total envelope area	2.5 l/s/m^2 total envelope area	1.5 l/s/m^2 total envelope area	per WSP Engineering Report.

MECHANICAL & ELECTRICAL				
System Overview	Packaged ASHP RTUs with electric back-up heating and built-in ERV. RTUs ducted to VAV boxes. RTUs separated into interior/perimeter zones. Electric baseboard heaters at perimeter.	Same as Scenario A	Central 4-pipe ASHP connected to FCUs and hydronic radiant panels, with heat recovery. Central ERV.	per WSP Engineering Report.
HVAC Plant				
Description	Packaged ASHP RTUs with electric back-up heating and built in ERV.	Same as Scenario A	Central air-to-water heat pump.	per WSP Engineering Report.
Outdoor Air Rate	Office: 5 cfm/person + 0.06 cfm/ft2 Corridor: 0.06 cfm/ft2		n/a	per ASHRAE 62.1-2019 Table 6-1.
Outdoor Air Fraction	10-15%		n/a	per WSP Engineering Report.
Outdoor Air Control	CO_2 sensors		n/a	
Heating Efficiency	COP-3.9 @ 8.3°C COP-3.0 @ -8.3°C Back-up: 100%		COP-3.9 @ 8.3°C COP-3.0 @ -8.3°C	Assumption.
Cooling Efficiency	EER-11.2 IEER-12.9		EER-11.2 IEER-12.9	
Supply Air Temperature	Reset between 13-18°C based on heating / cooling demand.		n/a	per WSP Engineering Report.
Fan Type	Variable Air Volume		n/a	
Fan Power	1.3 W/cfm		n/a	Assumption.
Economizer	Yes		n/a	
Heat Recovery	Yes		Yes	per WSP Engineering Report.
Sensible Recovery Efficiency (SRE)	75%		n/a	
Pump Type	n/a		Variable Speed	Assumption.
Pump Power	n/a		300 W/(l/s)	
Zone Equipment				
Description	Electric baseboard heaters at perimeter.	Same as Scenario A	Hydronic FCUs, 2-pipe for interior zones, 4-pipe for perimeter zones and top floor. Hydronic radiant ceiling panels at perimeter.	per WSP Engineering Report.
Fan Type	n/a		Variable Air Volume	
Fan Power	n/a		0.3 W/cfm	Assumption.
Ventilation System				
Description	Ventilation provided via RTU	Same as Scenario A	Central ERV ducted to FCUs	per WSP Engineering Report.
Outdoor Air Rate	n/a		Office: 5 cfm/person + 0.06 cfm/ft2 Corridor: 0.06 cfm/ft2	per ASHRAE 62.1-2019 Table 6-1.
Outdoor Air Control	n/a		CO_2 sensors	per WSP Engineering Report.
Sensible Recovery Efficiency (SRE)	n/a		75%	
Exhaust				
Parkade	n/a	Same as Scenario A	3.7 l/s/m^2	per ASHRAE 62.1-2019 Table 6-1.
Washrooms	Direct exhaust		Exhaust via ERV	per WSP Engineering Report.
SERVICE HOT WATER SYSTEM				
Description	Electric hot water heaters	Same as Scenario A	Same as Scenario A	per WSP Engineering Report.
Peak Hot Water Load	90 W/occupant			per NECB 2020 Table A-8.4.3.2.(2)-B
Efficiency	100%			
LOADS & OPERATION				
Indoor Temperature Setpoints				
Heating Setpoint / Setback	Setpoint: 22 Setback: 18	Same as Scenario A	Same as Scenario A	per NECB 2020 Table A-8.4.3.2.(1)-A
Cooling Setpoint / Setback	Setpoint: 24 Setback: n/a			
Parkade	n/a		Unconditioned	per WSP Engineering Report.
Lighting & Loads				
No. of Elevators	3 Elevators	Same as Scenario A	Same as Scenario A	per WSP Engineering Report.
Elevator Load	14.6 kW/elevator			per BC Hydro Energy Modelling Guidelines
Occupancy	Building average: 21.2 m^2/occ			Modelled per NECB 2020 Space Type (Table A-8.4.3.2.(2)-B).
Plug Loads	Building average: 6.8 W/m^2			
Lighting	Building average: 6.4 W/m2			Modelled per NECB 2020 Space Type methodology (Table 4.2.1.5 + Section 8.4.3.4.(1)).
Schedules	NECB Schedule A			per NECB 2020 Table A-8.4.3.2.(2)-B

VANCOUVER | ENERGY MODELLING INPUTS

Location Vancouver
Weather File CWEC 2020
Main Occupancy Residential

	Scenario A	Scenario B			Scenario C	Reference / Note
	Existing	Existing	New Construction Addition	New Construction Infill	New Construction	
BUILDING INFORMATION						
						per WSP Engineering Report.
No. of Storeys Above Grade	3	3			3	
Underground Parkade	n/a	n/a			n/a	
Gross Floor Area	205 m^2	536 m^2			425 m^2	
Dwelling Units	2	2+2			3+garage	
Space Types	Residential	Residential			Residential	per Architectural Drawing Sets.
OPAQUE ENVELOPE THERMAL PERFORMANCE						
Foundation						
Effective R-Value	R_{SI} - 1.9 R_{IP} - 15.9	R_{SI} - 1.9 R_{IP} - 15.9	R_{SI} - 3.0 R_{IP} - 17.0	R_{SI} - 3.2 R_{IP} - 17.9	R_{SI} - 3.2 R_{IP} - 17.9	Assembly and effective R-value modelled per WSP Engineering Report.
Foundation Wall						
Effective R-Value	R_{SI} - 2.8 R_{IP} - 7.0	R_{SI} - 2.8 R_{IP} - 7.0	R_{SI} - 1.4 R_{IP} - 7.9	R_{SI} - 2.0 R_{IP} - 11.3	R_{SI} - 2.1 R_{IP} - 11.8	Assembly and effective R-value modelled per WSP Engineering Report.
Exterior Walls						
Effective R-Value	R_{SI} - 2.5 R_{IP} - 14.0	R_{SI} - 2.5 R_{IP} - 14.0	R_{SI} - 3.8 R_{IP} - 21.9	R_{SI} - 3.5 R_{IP} - 19.9	R_{SI} - 3.8 R_{IP} - 21.9	Assembly and effective R-value modelled per WSP Engineering Report.
Roof						
Effective R-Value	R_{SI} - 3.2 R_{IP} - 18.3	R_{SI} - 3.2 R_{IP} - 18.3	R_{SI} - 3.6 R_{IP} - 20.7	R_{SI} - 3.7 R_{IP} - 21.0	R_{SI} - 3.7 R_{IP} - 21.2	Assembly and effective R-value modelled per WSP Engineering Report.
Soffits						
Effective R-Value	n/a	n/a	R_{SI} - 2.7 R_{IP} - 15.6	R_{SI} - 3.2 R_{IP} - 18.3	n/a	Assembly and effective R-value modelled per WSP Engineering Report.
FENESTRATION & DOORS						
Window-to-wall Ratio	17%	14%			15%	per Architectural Drawing Sets.
Fenestration						
U-value	U_{SI} - 1.5 U_{IP} - 0.26	U_{SI} - 1.5 U_{IP} - 0.26	U_{SI} - 2.0 U_{IP} - 0.35	U_{SI} - 1.8 U_{IP} - 0.32	U_{SI} - 1.8 U_{IP} - 0.32	Window type and performance modelled per WSP Engineering Report.
SHGC	0.33	0.33	0.33	0.33	0.33	
Skylights						
U-value	n/a	n/a	n/a	n/a	n/a	
SHGC	n/a	n/a	n/a	n/a	n/a	
Opaque Doors						
U-value	U_{SI} - 1.7 U_{IP} - 0.30	U_{SI} - 1.7 U_{IP} - 0.30	U_{SI} - 1.1 U_{IP} - 0.19	U_{SI} - 1.1 U_{IP} - 0.19	U_{SI} - 1.3 U_{IP} - 0.23	Door type and performance modelled per WSP Engineering Report.
AIRTIGHTNESS						
Air Leakage Rate @ 75 Pa	2.5 l/s/m^2 total envelope area	2.5 l/s/m^2 total envelope area	1.5 l/s/m^2 total envelope area	1.5 l/s/m^2 total envelope area	1.5 l/s/m^2 total envelope area	Infiltration rate modelled per WSP Engineering Report.

	Scenario A	Scenario B			Scenario C	Reference / Note
	Existing	Existing	New Construction Addition	New Construction Infill	New Construction	
MECHANICAL & ELECTRICAL						
System Overview	Ductless split VRF heat pumps in each principal room to provide heating and cooling. Electric baseboard heaters in building perimeter areas not directly served by the heat pumps.	Same as Scenario A			Same as Scenario A. Garage assumed to be unheated.	per WSP Engineering Report.
HVAC Plant						
Description	ASHP	Same as Scenario A			Same as Scenario A. Garage assumed to be unconditioned.	per WSP Engineering Report.
Heating Efficiency	COP-3.3 @ 8.3°C COP-2.2 @ -8.3°C					Assumption.
Cooling Efficiency	EER-11.2 IEER-12.9					
Zone Equipment						
Description	Electric Baseboard Heaters	Same as Scenario A			Same as Scenario A. Garage assumed to be unconditioned.	per WSP Engineering Report.
Efficiency	100%					
Suite Ventilation System						
Description	In-suite ERV. Washrooms exhausted via ERV.	Same as Scenario A			Same as Scenario A. Garage assumed to be unheated.	per WSP Engineering Report.
Outdoor Air Rate	5 cfm/person 0.06 cfm/ft^2					per ASHRAE 62.1-2019 Table 6-1.
Fan Power	1.0 W/cfm					Assumption.
Sensible Recovery Efficiency (SRE)	75%					Assumption.
SERVICE HOT WATER SYSTEM						
Description	In-suite electric hot water heaters.	Same as Scenario A			Same as Scenario A	per WSP Engineering Report.
Peak Hot Water Load	500 W/occupant					per NECB 2020 Table A-8.4.3.2.(2)-B
Low Flow Fixtures	Yes					Assumption.
% Flow Reduction	30%					
Efficiency	100%					
OPERATION AND LOADS						
Indoor Temperature Setpoints						
Heating Setpoint / Setback	Setpoint: 22°C Setback: 18°C	Same as Scenario A			Same as Scenario A	per NECB 2020 Table A-8.4.3.2.(1)-G
Cooling Setpoint / Setback	Setpoint: 24°C Setback: n/a					
Lighting & Loads						
Occupancy	Average of 3 people per unit.	Same as Scenario A				Assumption.
Plug Loads	5 W/m^2				Same as Scenario A	per NECB 2020 Table A-8.4.3.2.(2)-A
Lighting	5.0 W/m^2					per NECB 2020 8.4.3.4.(1)
Schedules	NECB Schedule G					per NECB 2020 Table A-8.4.3.2.(2)-A