Image: Footprint

725 Granville

Embodied Carbon Assessment Report

2023-06-22

BOMA BRITISH COLUMBIA

CF Cadillac Fairview

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Executive Summary

Authorization

This report was prepared at the request of BOMA BC for the 725 Granville redevelopment.

Footprint has been retained as the life cycle assessment consultant for 725 Granville Street in Vancouver, British Columbia. Our scope of work consists of performing a cradle-to-grave lifecycle assessment of the building's redevelopment against an alternative scenario in which the existing building was demolished and a functionally equivalent building constructed in place and identify the saved emissions.

Methodology

A life cycle assessment (LCA) analyzes the environmental impacts of a building associated with all the stages of a building's life, from materials extraction, through materials processing, manufacturing, construction, operations and end of life. Life cycle assessment scopes can vary depending on the project needs and goals, but must always include the complete enclosure and structure. The specific metric used to measure the environmental impact is global warming potential (GWP), also referred to as embodied carbon, and is presented as kilograms of carbon dioxide equivalent ($kgCO_2e$).

The life cycle assessment was completed as follows:

- A materials quantity take-off was performed using Revit building information modelling (BIM) exports and hand calculations on existing architectural and structural drawings
- A life cycle assessment was calculated for both scenarios (Redevelopment vs. Demolition & New Construction) using One Click LCA for a 60-year service life and follows a cradle-to-grave scope.

The results of this study are summarized in Table 1 with the materials assumed for this assessment as listed in Appendix A: Design Inputs of this report.

Key Findings

The report identifies and compares the carbon emissions of the redevelopment and an alternative scenario in which a functionally equivalent building was constructed in place. The results are as follows:

Table 1: Embodied Carbon Results

Stage	Redevelopment Scenario ($kgCO_2e$)	Demolition and New Construction Scenario ($kgCO_2e$)
C1-C4 End-of-Life (existing building)	N/A	540,775
A1-A3 Product	7,010,847	23,471,517
A4-A5 Construction	489,450	3,543,536
B1-B4 Use	173,612	173,612
C1-C4 End-of-Life	185,918	437,780
Total Embodied Emissions	7,859,827	28,167,221

The embodied carbon saved from the redevelopment scenario is 20,307,394 $kgCO_2e$, or a **72.1% reduction**, compared against the demolition and new construction scenario.

Introduction

Purpose of This Report

This report presents the findings of the embodied carbon analysis conducted for 725 Granville Street in Vancouver, British Columbia. The analysis compares the building's retrofit development carbon emissions against a scenario in which the existing building is demolished and a functionally equivalent building constructed in place.

Life cycle assessment (LCA) is the method of measuring a project's environmental impact through the entire life of the building and includes the manufacturing of products, construction, and end use of the resources required for the delivery of the building function. Life cycle assessment scopes can vary depending on the project needs and goals, but must always include the complete enclosure and structure and report on the global warming potential (GWP), also known as embodied carbon, as kilograms of carbon dioxide equivalent ($kgCO_2e$).

Background

Canada has made the commitment to reduce carbon emissions as a signatory to the Paris Agreement, aiming to limit global warming and mitigate climate change.

As part of this effort, there is a growing focus on examining the embodied carbon associated with buildings, recognizing its significance in strategies to decrease emissions.

For more information, refer to Appendix B: Climate Change Background.

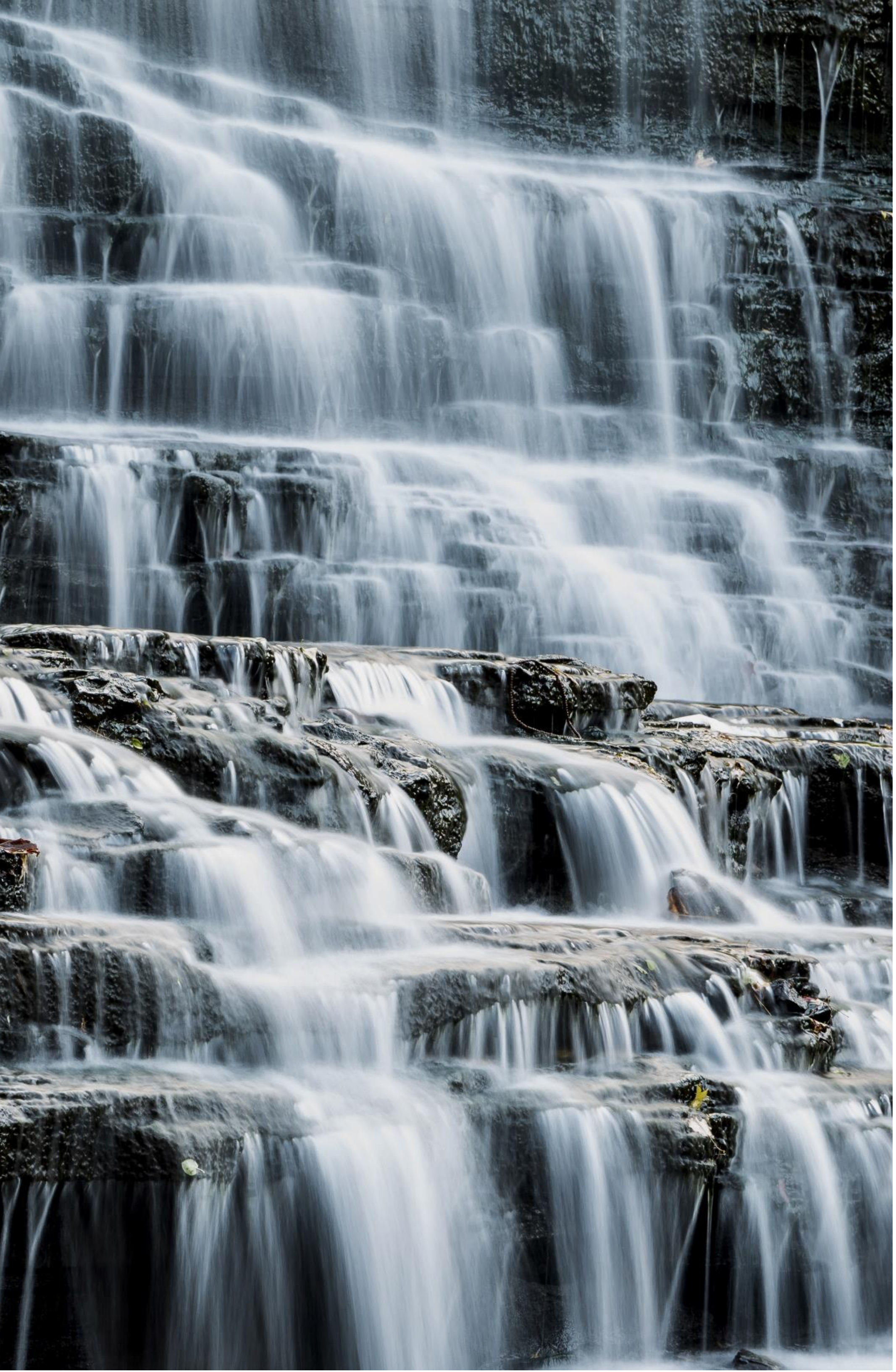
Project Description

The existing building at 725 Granville Street was constructed in 1973, as the home of the department store Eaton's, which included seven-stores above grade two levels of underground parking.

The concrete structure provided an opportunity to transform the former single tenant department store into a 58,960 square meter multi-tenant space that includes small retail, a large anchor retail tenant, and converting four floors into office space and was constructed by Cadillac Fairview in 2014.

The redevelopment included the re-use of materials, including the exterior concrete panel cladding, which were used at the Langley Airport to create additional roadway.

This redevelopment includes the addition of 233 square metres of gross floor area, two atrium spaces, seismic upgrades, and the relocation of elevators. The office spaces are currently home to Microsoft and Sony Pictures Imageworks.



Glossary

The following is a list of key terms and definitions that will be found through-out this report.

Embodied carbon: A common name referring to the results of global warming potential. Refer to global warming potential.

Environmental product declaration (EPD): A standardized document which outlines the environmental impacts of a product. These documents can be product specific to a manufacturer or represent industry wide data for a product type. An included environmental impact category would be global warming potential.

Global warming potential (GWP): An environmental impact category developed to compare the global warming impacts of different green house gas emissions converted into a carbon dioxide equivalent (CO_2e). In the building industry this relates to the greenhouse gas emissions from manufacturing, transportation, installation, maintenance, and disposal of building materials and does not include emissions from energy consumption during occupancy. Also referred to as embodied carbon.

kgCO_2e: The metric used to represent global warming potential provided in kilograms of carbon dioxide equivalent.

Life cycle stages: Specific periods within the life of a product (building) that include early material stages, construction, and end-of-life. Included stages within life cycle assessments may vary.

Life cycle assessment: A tool used to assess environmental impacts of building's life cycle.

Methodology

The analysis of the building's life cycle impact and subsequent report was completed using One Click LCA. The program uses US/Canadian data and supports TRACI 2.1 and is a commonly used assessment tool for whole building life cycle assessments. All of the datasets in the tool follow ISO 14044 standard. One Click LCA has been third party verified by ITB for compliancy with EN 15978, ISO 21931–1 and ISO 21929, and data requirements of ISO 14040 and EN 15804. Official letters of compliancy can be found here https://www.oneclicklca.com/wp-content/uploads/2016/11/360optimi-verification-ITB-Certificate-scanned-1.pdf

Service Life and Scope

The life cycle assessment scenarios created for this assume a building lifetime of 60 years and include the following :

- building envelope and roof assemblies
- foundations and footings
- structural wall assemblies, floors and ceilings
- stair construction

The following items are excluded from the scope:

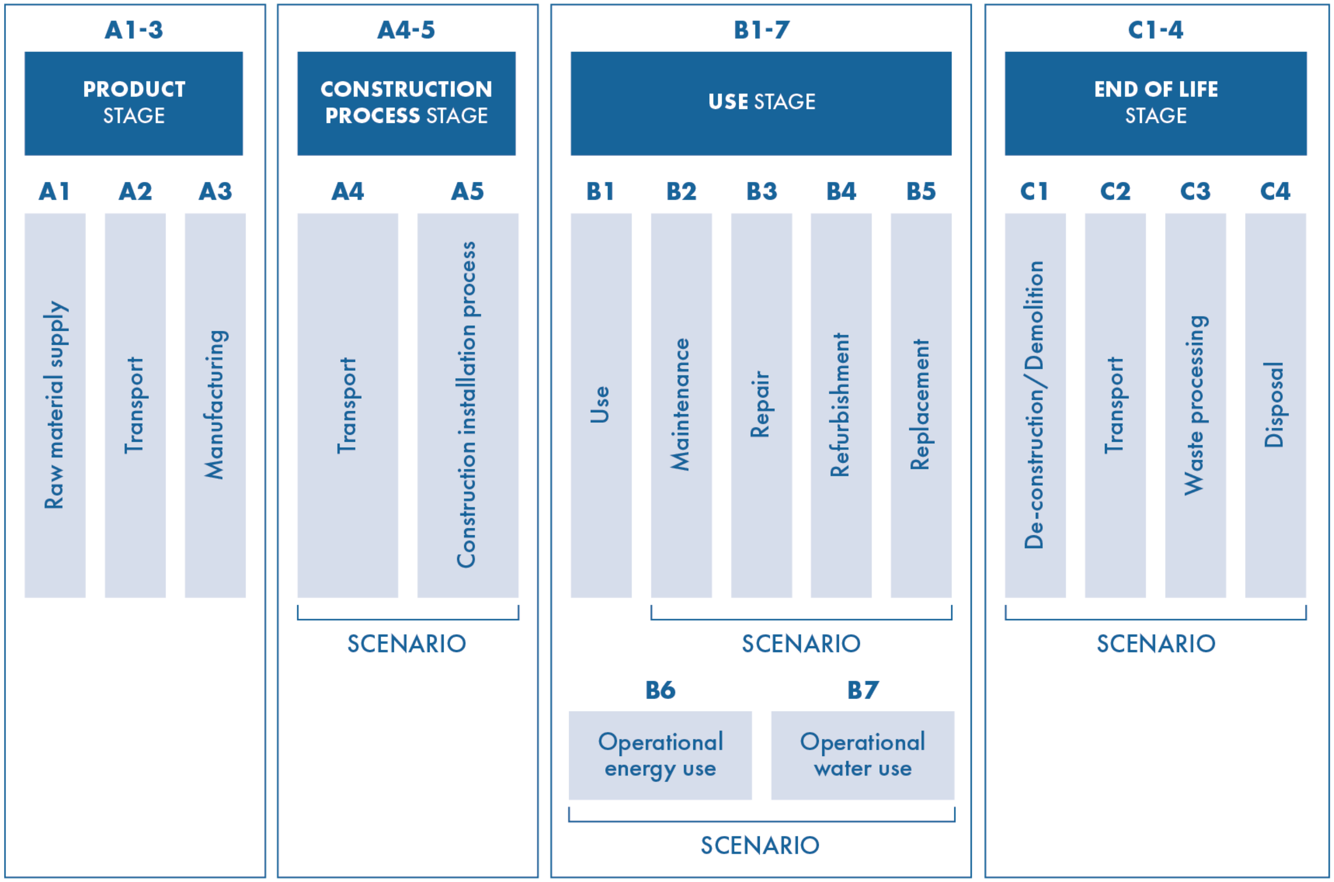
- excavation and site development
- interior finishes or tenant development
- electrical, mechanical, plumbing, fire detection, alarm systems, elevators, etc. building services
- operating energy and water consumption

Using ISO21930 and EN 15804, the assessment includes the following life-cycle stages, allowing each stage to be compared in isolation:

- A1-A3 Extraction and Manufacturing
- A4 Transportation to site
- A5 Construction Installation
- B1-B5 Maintenance and material replacements
- C1-C4 End of life

The following image illustrates the life-cycle stages. A1-A3 Product Stage is always represented as a combined value for building-level assessments. C1-C4 End of Life Stage is also typically represented as a combined value for building-level assessments. Other stages may be included, omitted, or replaced with other scenarios depending the purpose of the assessment.

BUILDING LIFE CYCLE INFORMATION



Design Scenarios

The LCA considered two design scenarios in this analysis to compare the potential emissions that were not emitted by redeveloping the property rather than demolishing.

Redevelopment Design

The redevelopment design preserves the concrete frame structure with minimal demolition, primarily for relocating the elevators and incorporating 4th floor atriums. Structural upgrades were implemented as necessary. The new wall facade features a combination of metal panels, stone, and curtain wall sections.

The benefits of the re-use of materials from the redevelopment, such as the concrete panels, could not be quantified for this assessment and have been excluded.

Demolition and New Construction Scenario

This alternative scenario considers the end-of-life stages (demolition) and the construction of a new concrete frame building with the same gross floor area. Structural elements were modelled with equivalent load-bearing capacity and strengths. The size and locations of the envelope components was maintained in both models.

Data Sources

To gather the necessary information for the life cycle assessment, inputs were derived from the architectural and structural drawings, Revit files, specifications, and supplementary data from One Click LCA.

A summary of the specific building information data sources, materials, and assumptions are provided in Appendix A: Design Inputs.

Environmental Product Declarations

The selection for each building material or product was selected to best represent common materials and products from the currently available data. Wherever required, industry wide environmental product declarations or data sets were selected. Where industry wide data may not be available, product specific declarations may have been selected as a representation.

For concrete, the industry wide environmental product declarations from Concrete BC have been selected with One Click LCA data for reinforcement at 80% recycled content.

Results

The embodied carbon results for the redevelopment and demolition and new construction scenarios are summarized in the following tables. The results are presented in $kgCO_2e$.

Redevelopment Results

The embodied carbon for each life cycle stage is shown within Table 2. The results show that A1-A3, the product stage, is the highest contributor to the total embodied carbon emissions.

Table 2: Redevelopment Scenario

Life-Cycle Stage	Embodied Carbon ($kg\ CO_2e$)
A1-A3 Product	7,010,847
A4-A5 Construction	489,450
B1-B4 Use	173,612
C1-C4 End-of-Life	185,918
Total Embodied Emissions	**7,859,827**

Demolition and New Construction Scenario Results

The embodied carbon for each life cycle stage is shown within Table 3. The results include the total demolition of the building prior to redevelopment. The emissions for this scenario are higher as it includes the demolition of an existing building and in addition to the new construction.

Table 3: Demolition and New Construction Scenario

Life-Cycle Stage	Embodied Carbon (kg CO_2e)
C1-C4 End-of-Life (existing building)	540,775
A1-A3 Product	23,471,517
A4-A5 Construction	3,543,536
B1-B4 Use	173,612
C1-C4 End-of-Life	437,780
Total Embodied Emissions	**28,167,221**

Comparison of Scenarios

The majority of emissions for both scenarios are associated with the A1-A3: Product life-cycle stage as detailed within the Methodology section. Since the Demolition and New Construction requires the construction of a full building, including structure and envelope, the amount of new materials utilized produces higher embodied carbon emissions. The emissions for the Redevelopment Scenario are decreased by 70% compared against the Demolition and New Construction scenario.

The second highest contributor of emissions for both scenarios is the A4-A5: Construction stage. When comparison the Redevelopment Scenario against the Demolition and New Construction scenario, the emissions are reduced by 86%.

The B1-B4: Use stage remains consistent through-out all scenarios, as it is based on the repair and replacement of materials. This includes repairs to the building including replacement of gypsum board and roofing membranes.

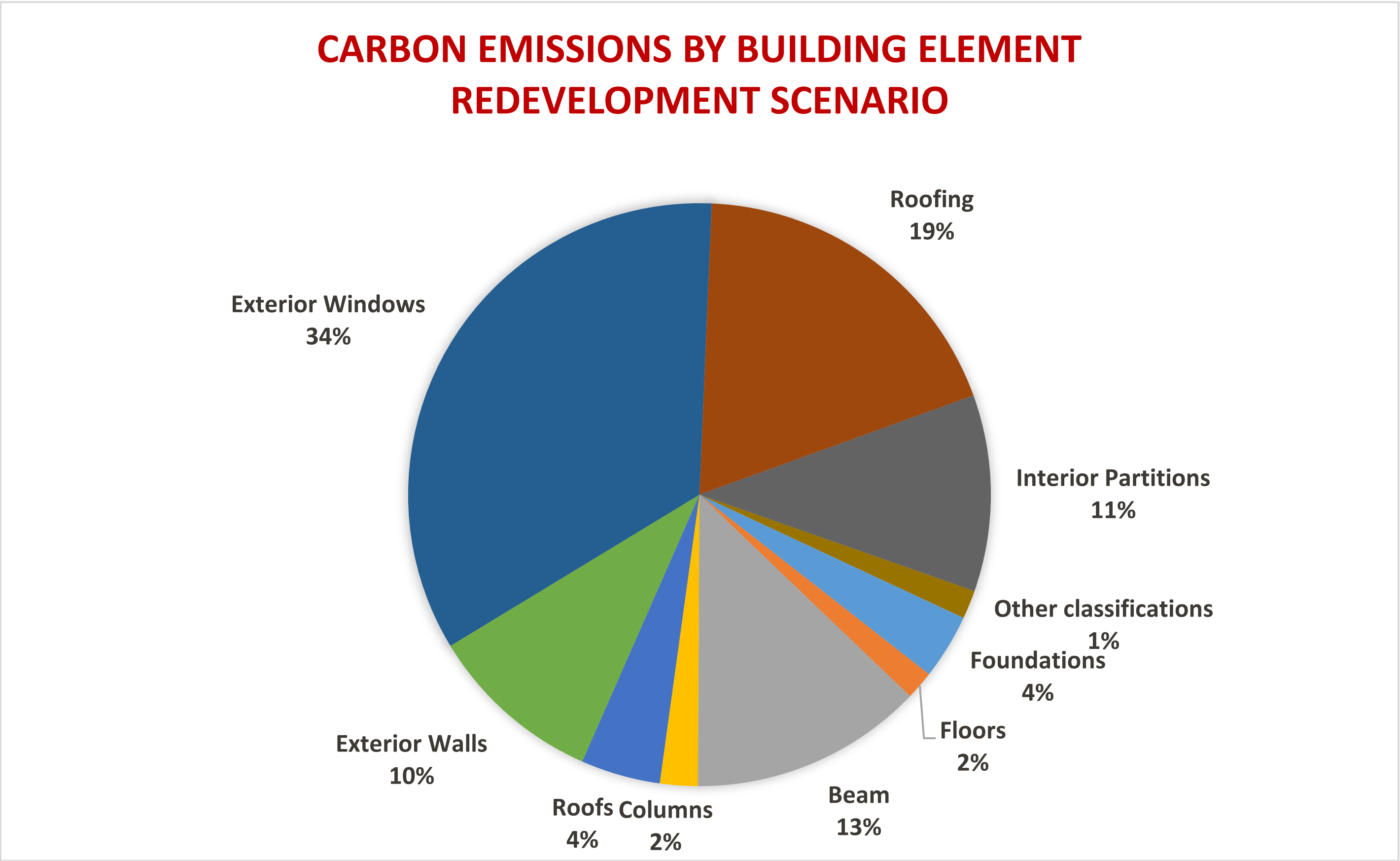
The C1-C4: End of Life stage quantifies products at the end of their life span. It includes the demolition of the building elements, and waste transportation, processing, and disposal. Due to less overall materials, the Redevelopment Scenario provides a 58% decrease in emissions compared to the Demolition and New Construction Scenario. It should be noted that the alternative scenario must also account for the demolition of the previous structure which is an additional 540,775 kgCO_2e.

Overall, the embodied carbon emissions for the Redevelopment Scenario, is 72.1% less than the Demolition and New Construction scenario. This is direct result of demolition the existing building coupled with the total materials required for a new building structure and envelope.

Results Breakdown by Building Elements

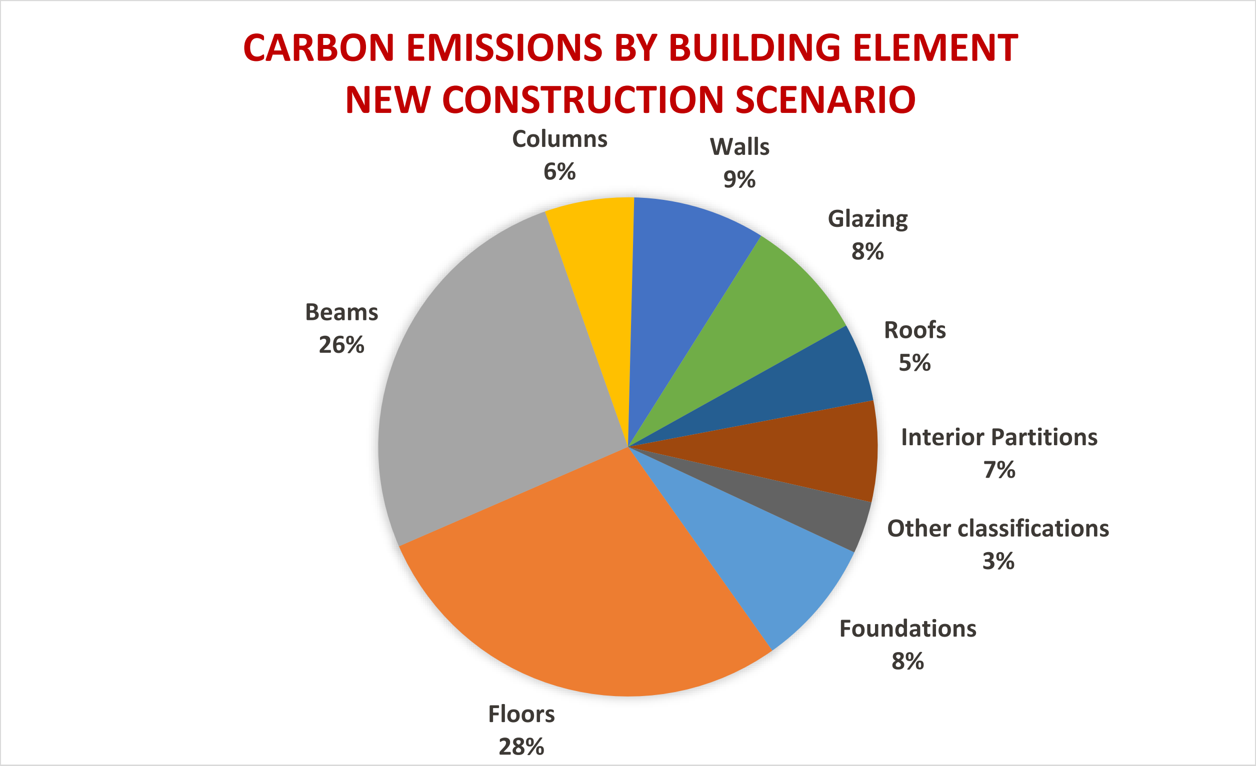
Figure 1: Upfront Carbon Emissionsby Building Element for Redevelopment

The breakdown of the embodied carbon over assembly categories are shown in Figure 3. The information will show that the exterior windows and roof construction are the highest contributors to the overall emissions of the project, contributing 34% and 19% respectively.



The breakdown of the embodied carbon emissions over assembly categories are shown in Figure 4. The information will show that the floors and beams are the highest contributors to the overall emissions of the project, contributing 28% and 26% respectively.

Figure 4: Upfront Carbon Emissionsby Building Element for New Construction Design



Challenges

Life cycle assessment is increasing in popularity as a valuable tool for assessing the environmental impacts of building design and construction as it enables informed decision-making and aids in identifying areas of opportunity for improvements.

However, one of the major challenges is obtaining data on materials through third-party verified environmental product declarations. In the current market, environmental product declarations may not be available for some product types or in specific regions. The demand for environmental product declarations is increasing due to requests from projects following green building rating systems or evaluating embodied carbon contributions, and the market is responding. With the declarations we hope to enhance transparency and provide valuable insights into the environmental impacts of the products utilized in the built environment. This effort is essential in overcoming data-related challenges and further advancing the effectiveness of life cycle assessments.

It should also be acknowledged that results may vary due to the different datasets that life cycle assessment programs use. Some programs may allow for product specific environmental product declarations to be selected or utilize their own datasets.

Additionally, relying on inputs based on building information modelling (BIM) software can present its own set of challenges. While BIM offers valuable insights, it requires careful consideration and validation of the data used for the assessment.

Even with these barriers and challenges, assessing a building’s embodied carbon emissions is a practical analysis and should be considered as a regular part of the building design process.

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Conclusions & Key Takeaways

As the analysis results show, the chosen redevelopment scenario contributes fewer overall carbon emissions than the alternative scenario. demolition and new construction. The redevelopment scenario results in over 20 million $kgCO_2e$ fewer carbon emissions as compared to the demolition and new construction scenario, or a reduction of 72.1%.

The reduction of emissions in the redevelopment scenario is largely attributed to the adaptive design approach, which emphasizes the reuse of the existing structure and minimizes the use of carbon-intensive materials like concrete and steel. By reducing the quantity of these materials, which are significant contributors to embodied carbon, the overall emissions in the redevelopment project are significantly reduced.

Appendix A: Design Inputs

The design scenarios have been assessed with information as noted in the report above. In the event information was not available, reasonable assumptions have been made based on similar project types and past project experience.

TABLE 3: DATA SOURCES FOR LIFE CYCLE ASSESSMENT

Data Type	Data Source
A1-A3: Product Stage	Drawings and design information from architectural and structural as-built Revit models. Additional assumptions may be required due to unavailable information and will be defined within this report.
A4: Material Transport	Regionally applicable transportation scenarios from One Click LCA. Those represent regionally typical transportation distances and methods for product types, which are relevant when no decisions on suppliers are made.
A5: Construction and Installation	Impacts are based on conservative default values from One Click LCA.
B1-B5: Use	Material service lives are based on the typical values for the materials in question, which have been reviewed for relevance for the project. The values have been adjusted where necessary. Material maintenance and repair activities have not been included in the scope, materials have been assumed to be replaced in their entirety at the end of their service life.
B6-B7: Use Phase Consumption	Impacts are omitted from this analysis.
C1-C4: End of Life	End of life impacts are based on One Click LCA's scenarios which represent the typical end of life processing for material types in compliance with the requirements of the EN 15804+A1.

TABLE 4: DESIGN SCENARIO DETAILS AND ASSUMPTIONS

Assembly	Details and Assumptions	
	New Construction	Redevelopment
Exterior Walls	**Envelope**	
	Stud wall assembly: Cladding, vertical z-girt, 4" semi-rigid insulation, self adhesive membrane, ½" DensGlass Gold sheathing, 6" steel studs, ½" gypsum wallboard **Cladding:** Aluminum composite panels, reinforced stone cladding, prefinished metal louver, or metal wall cladding **Parapets:** At curtain wall, 4" semi-rigid insulation (mineral wool), steel studs, ½" DensDeck sheathing, self adhesive membrane, 1" semi-rigid insulation, horizontal z-girts, flashing At cladding, 4" semi-rigid insulation (mineral wool), steel studs, ½" DensDeck sheathing, batt insulation (where required), SBS roofing membrane, 1" semi-rigid insulation (mineral wool), z-girts, flashing	
Glazing Systems	**Curtain Wall**	
	AluQuebec curtain wall system with spandrels, including extruded polystyrene back-pan insulation and back-up wall with steel studs and gypsum board.	
Foundation	**Footings**	
	Concrete at 35 MPa with 100 kg/m3 of reinforcement	Additions of concrete at 35 MPa with 100 kg/m3 of reinforcement

Assembly	Details and Assumptions	
	New Construction	**Redevelopment**
	Slab on Grade	
	4”, 5”, or 6” concrete slab at 35 MPa with 100 kg/m3 of reinforcement	Minor additions of concrete at 35 MPa with 100 kg/m3 of reinforcement
	Foundation Walls	
	12”, 15”, or 18” concrete wall (per existing structure) at 35 MPa with 100 kg/m3 of reinforcement	-
Floors	**Structure**	
	6” concrete slabs at 35 MPa with 100 kg/m3 of reinforcement	Concrete topping over steel deck (18 gauge) where required for repair or additions 3” concrete topping (20 MPa or 40 MPa) 5.5” concrete topping (35 MPa)
Roof	**Envelope**	
	Pre-cast pavers (on portion), SBS roofing membrane, 2 layers of 3/16” overlay board, minimum 2” rigid insulation (polyisocyanurate) with tapering, vapour barrier, ½” DensDeck sheathing (where required)	
	Structure	
	1 ½” steel deck, 22 gauge	New additions of 1 ½” steel deck, 20 and 22 gauge
Columns and Beams	**Columns:** Concrete at 35 MPa with 100 kg/m3 of reinforcement, hollow structural sections and various structural steel shapes **Beams:** Concrete at 35 MPa with 100 kg/m3 of reinforcement, hollow structural sections and various structural steel shapes	

ENVIRONMENTAL PRODUCT DECLARATIONS

The selection for each building material or product was selected to best represent the associated materials and products. Wherever possible, product specific EPDs are selected as based on the specifications. In the event that a product specific EPD is not available, industry wide EPD or data sets as available by One Click LCA will be used in place. EPDs include Concrete BC for ready-mix concrete (baseline mixes), the Canadian Institute of Steel Construction for structural steel and hollow structural steel sections, generic dataset for reinforcement with recycled content, and North American insulation Manufacturers Association for semi-rigid insulation. In the event that a product type cannot be represented or industry wide EPDs, an alternative product may be used in place.

Appendix B: Climate Action Background

Commitment to Net Zero by 2050

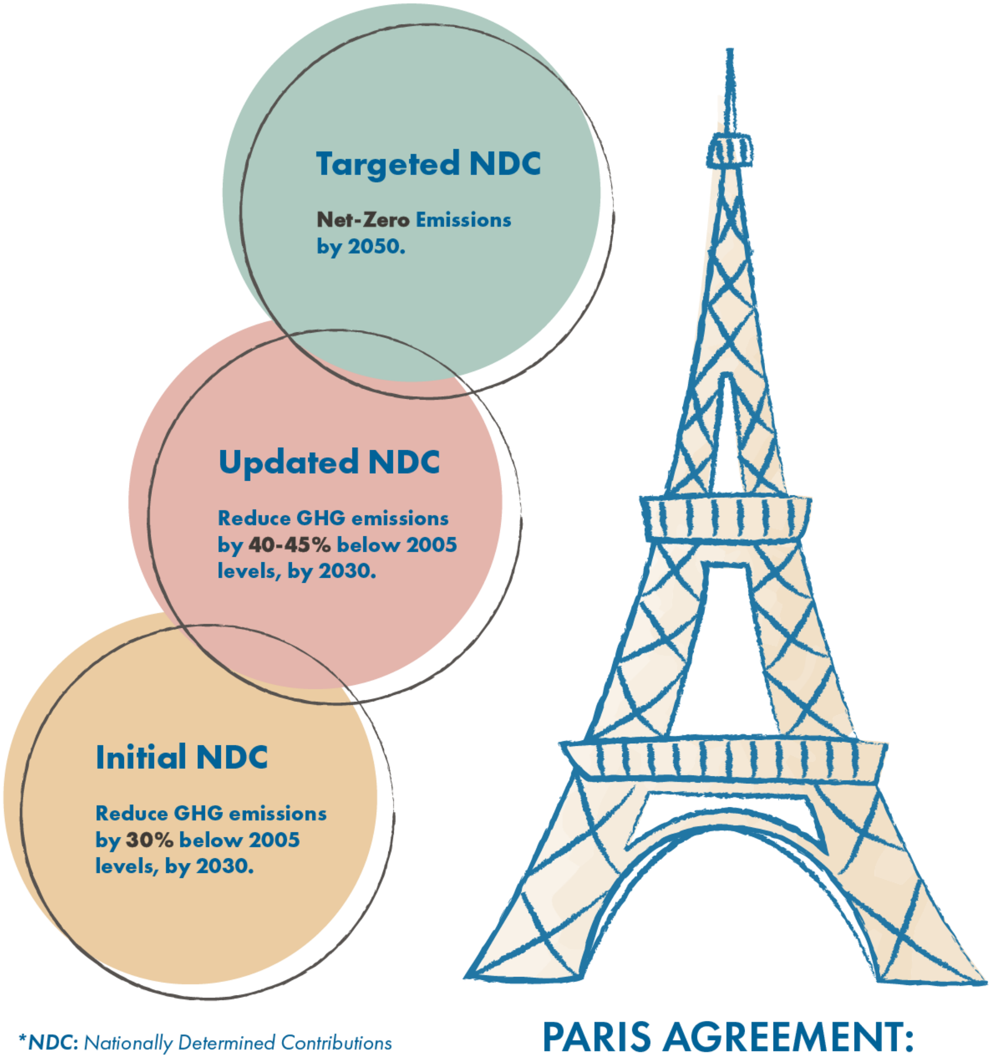
In 2016, Canada was one of 195 signatories on the Paris Agreement. This agreement was created within the UN Framework Convention of Climate Change (UNFCCC) and represented during the 21st UN Climate Change Conference of Parties (COP21) in 2015. One of the main goals of the agreement is to limit global warming to 1.5 degrees Celsius above pre-industrial levels.

The Government of Canada developed the 2016 Pan-Canadian Framework on Clean Growth and Climate Change with provinces and territories and in consultation with Indigenous peoples. The framework addresses the goals of the Paris Agreement and outlines greenhouse gas reduction targets to achieve a 30% reduction in greenhouse gas emissions by 2030.

Changes Identified and Projected for Canada

To move forward with a framework towards a 30% reduction and eventual net-zero carbon emissions, several measures have been implemented (or are underway) nationally to assist in achieving these targets. In addition to each province and territory requiring a carbon pricing system, other items such as phasing out coal by 2030, phasing down hydrofluorocarbons, and implementing methane regulations are part of these strategies.

As the targets towards a 30% reduction and net-zero emissions draw closer, more stringent reduction measures and updated standards, such as the National Building Code, can be expected.



PARIS AGREEMENT:
CANADA'S COMMITMENT

Climate Change Impacts and Risks

Many people think of global warming and climate change as synonyms, but scientists prefer to use "climate change" when describing the complex shifts now affecting our planet's weather and climate systems. Climate change encompasses not only rising average temperatures but also extreme weather events, rising seas and a range of other impacts.

At the current level of global policy implementation, the average global temperature will likely increase over 3ºC above pre-industrial levels by 2100, passing 1.5ºC between 2030 and 2052. An increase of 2ºC is considered the limit or tipping-point, beyond which changes to climate systems and co6rresponding impacts are irreversible.

Some of the direct impacts of climate change include:

- Rising maximum temperatures
- Rising sea levels
- An increase in heavy precipitation (heavy rain and hail)
- An increase in extreme weather events

Things that we depend upon and value — water, energy, transportation, wildlife, agriculture, ecosystems, and human health — are experiencing the effects of a changing climate. These can have significant implications for both people and infrastructure.

Carbon Reduction Measures

According to the Canada Green Building Council, Zero Carbon Building Design Standard Version 3, The Intergovernmental Panel on Climate Change (IPCC) has fixed the world's available carbon budget, the maximum amount of greenhouse gases (GHG) that can be realized into the atmosphere, as 400 gigatons (Gt) of carbon dioxide equivalent (CO_2e). Building operations account for 17% of the Canada's carbon emissions. In order to avoid exceeding the carbon budget identified and mitigate the effects of climate change, the building industry needs to create energy efficient buildings that rely on carbon-free energy sources.

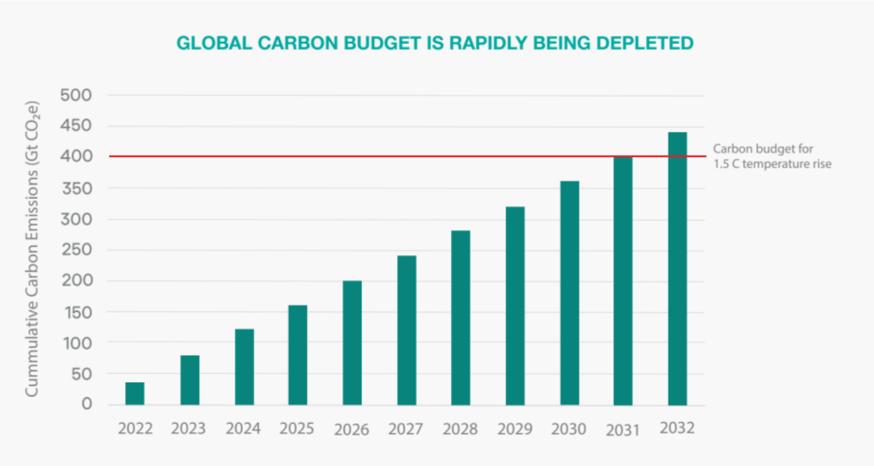


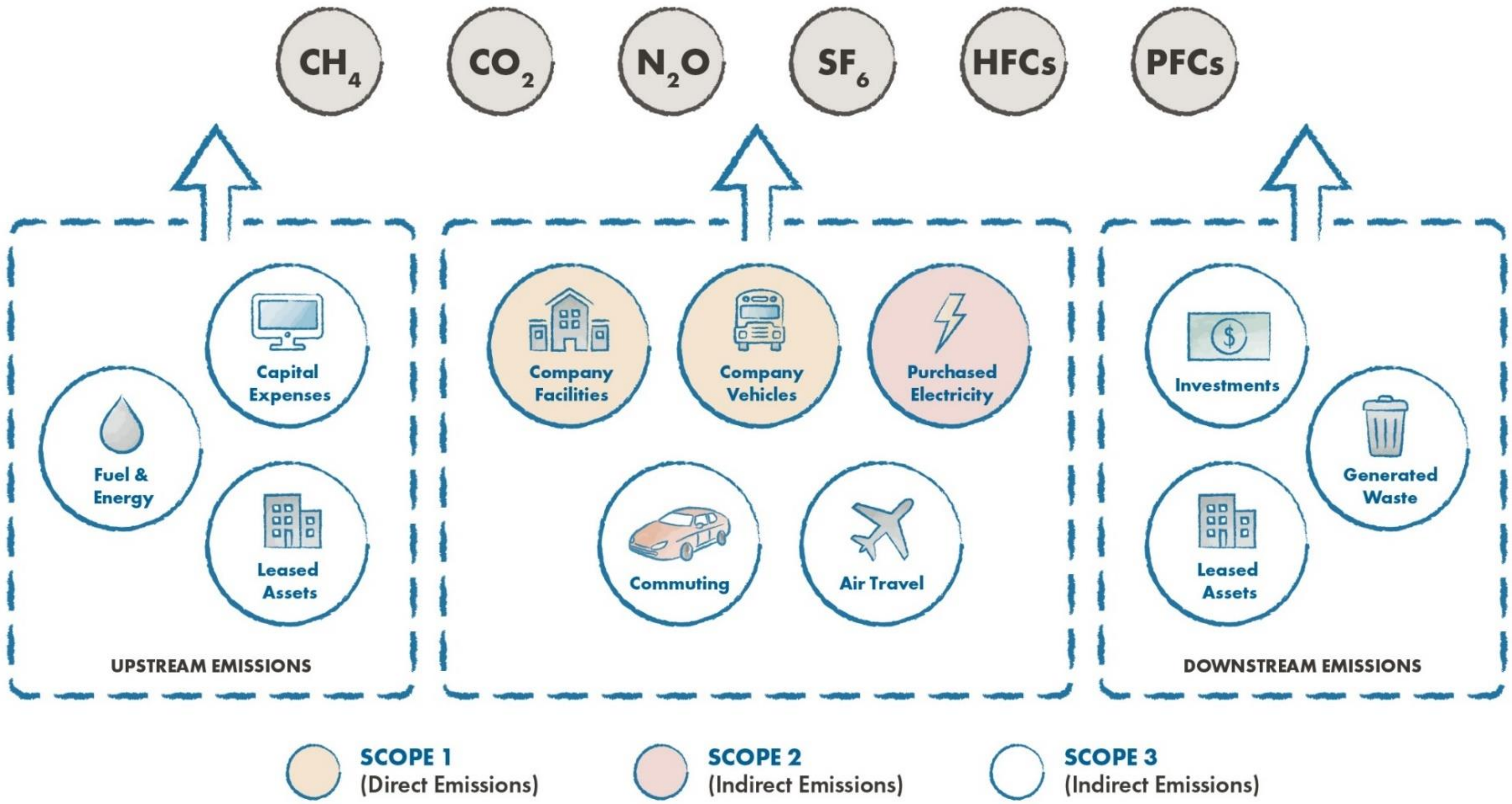
Image: Canada Green Building Council, Zero Carbon Building Design Standard Version 3

Greenhouse gas emissions are divided into three scopes:

Scope 1: emissions occurring from sources that are controlled or owned by an organization, including facilities and company vehicles.

Scope 2: indirect emissions associated with the purchasing of utilities as a result of the organizations energy use, including electricity, steam, and natural gas.

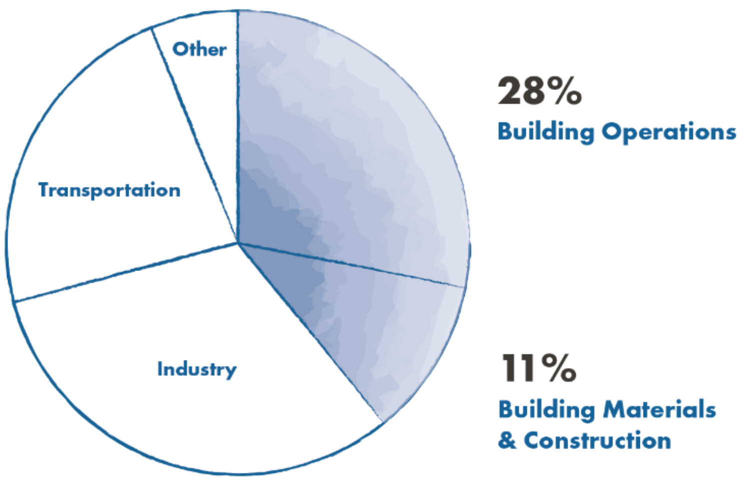
Scope 3: emissions as a result of the activities from assets not owned or controlled by the reporting organization, but that the organization indirectly impacts in its value chain.[3] This includes both upstream, downstream emissions, commuting, and business associated air travel.



[3] https://www.epa.gov/climateleadership/scope-3-inventory-guidance

Embodied Carbon Emissions

Embodied carbon has historically been neglected, although it's annual contribution to carbon emissions is close to half of all operational carbon. Carbon emissions can be classified into two categories, embodied and operational carbon. Embodied carbon addresses greenhouse gas emissions prior to occupancy, including harvest, extraction, manufacturing, transportation, construction, operation, demolition, and disposal. It is a static contribution where as operational carbon varies due to energy use. Operational carbon is the carbon released during the occupancy and management stages of the building, including process loads, heating and cooling, ventilation, and lighting.



A life-cycle assessment analyses the environmental impacts of a building associated with all the stages of a building's life, from materials extraction, through materials processing, manufacturing, construction, operations and end of life. The six metrics used to measure the environmental impact are:

- Global warming potential
- Depletion of the stratospheric ozone layer
- Acidification of land and water sources
- Eutrophication, in kg nitrogen or kg phosphate
- Formation of tropospheric ozone
- Depletion of nonrenewable energy resources