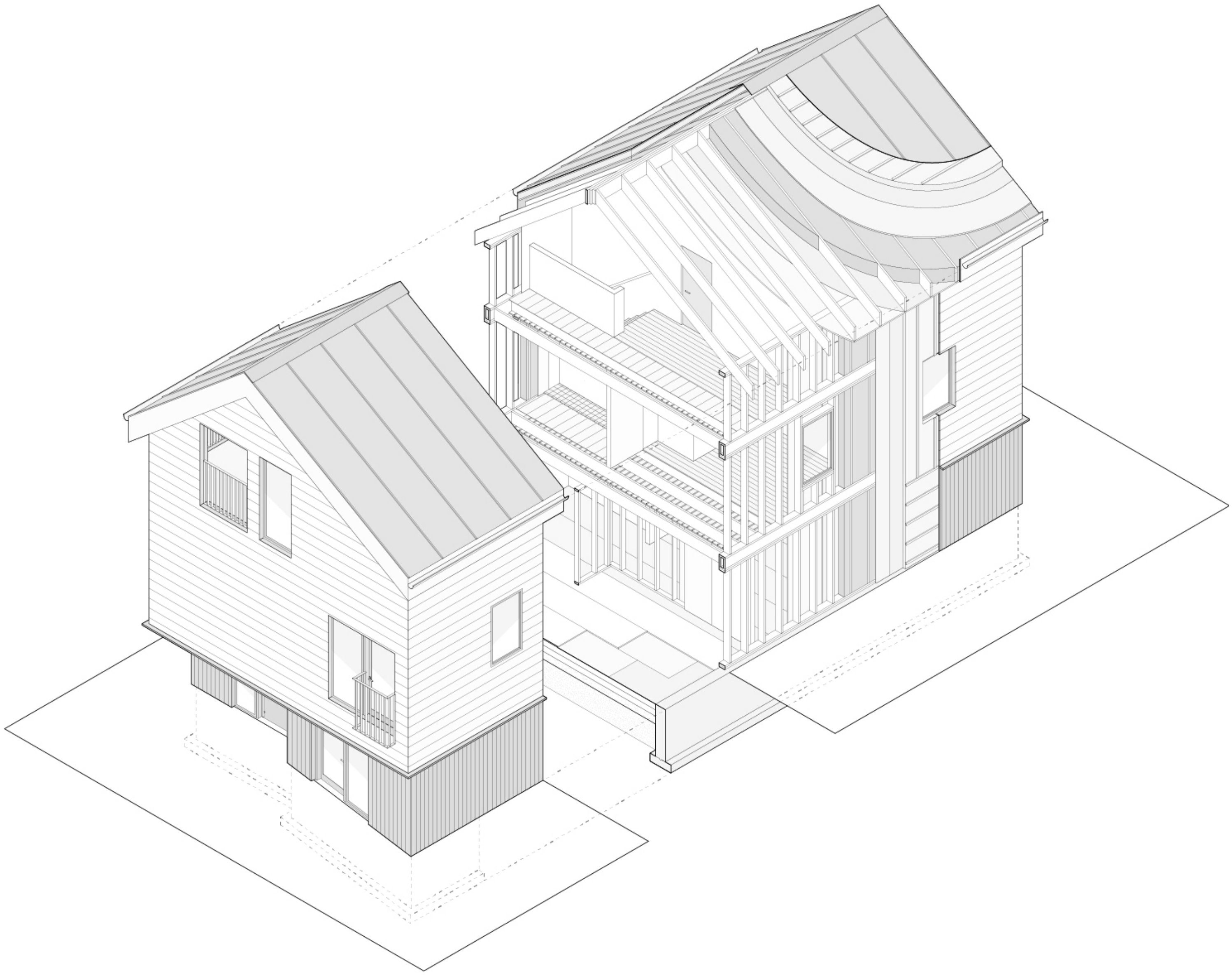

Materials Guide

Housing Design Catalogue
August 2025

Ha/f Climate Design

Ha/f Climate Design was founded to halve the emissions of the built environment this decade. We partner with designers, builders and policy makers on capacity building, research, industry education, and policies to address the whole life cost and carbon impacts of buildings, landscapes, and infrastructure.

Report Authors:

Juliette Cook
Kelly Alvarez Doran, OAA
Ryan Bruer, OAA
Rashmi Sirkar
Likhitha Varikuti
Miriam Palmer

With support from Vermeulens Cost Consultants.

This Materials Guide was developed by Ha/f Climate Design and received funding from the Government of Canada. The views expressed in this document are those of the author(s) and do not necessarily reflect the views of CMHC or the Government of Canada, nor do they constitute an endorsement of its contents.

Contents

1.0 / Introduction

Housing Design Catalogue

The Housing Design Catalogue features over 50 prototypical housing designs, including detached accessory dwelling units, townhouses, rowhouses, and multiplexes, for seven distinct regions of Canada. The designs were developed by regional architecture and engineering firms to comply with applicable building codes, planning, and zoning requirements while prioritizing energy efficiency, accessibility, livability, and climate resilience. Housing Design Catalogue drawings are intended to be near permit-ready but do require the user to make decisions to finalize their design. Design decisions include selecting elements left as placeholders in the drawing packages such as cladding and roofing materials, selecting manufacturers/products to be used during construction, and specifying elements not typically included within a building permit drawing set such as interior finishes and millwork. This guide is intended to support users through the process of finalizing a design.

Why a Materials Guide?

As described above, a user must make selections for cladding, roofing, insulation, interior finishes, and other materials, which will be used to adapt and finalize a design from the Housing Design Catalogue, and ultimately construct their project.

Working within the prototypical catalogue designs, there are a wide variety of options of building materials on the market today. This guide aims to help catalogue users select appropriate, available, durable, cost-effective, and environmentally conscious materials for every layer of construction. Choosing the right materials for a project requires balancing several factors, including cost and availability, carbon footprint, thermal performance, climate resilience, durability, and aesthetic preference.

This guide provides objective carbon intensity data, expected life span, and comparative cost information for a variety of materials and products applicable to Catalogue prototypical designs. This information can support users making material selections for their adapted design. Users should read this guide alongside other Catalogue resources including the design drawings, Climate Resilience Guide, Building Performance Reports, and Construction Cost Estimates to make material decisions that align with project goals for sustainability, durability, resilience, and cost.

How to Read this Guide

This guide is organized by material categories, each with a list of material options typical of construction across Canada. Five data points provide users insight into the relative carbon footprint, costs, and life span of each material option. Embodied carbon and cost figures are indicative averages based on multiple suppliers across Canada. Costing may vary significantly for projects in remote or hard-to-access locations, and some degree of variability should be expected even in urban or southern regions depending on market conditions and supplier availability. Expected life span is also highly dependent on factors such as exposure conditions and the level of maintenance conducted over the product's service life, and may therefore vary considerably.

Material Category & Product Name	Thickness	Embodied Carbon Intensity (A-C)	Biogenic Carbon Intensity	Relative Upfront Cost	Expected Life Span	Relative Life Cycle Cost
Specific Material Name	mm	$kgCO_2e/m^2$	$kgCO_2e/m^2$	$-$$$$	Years	$-$$$$
		1	2	3	4	5

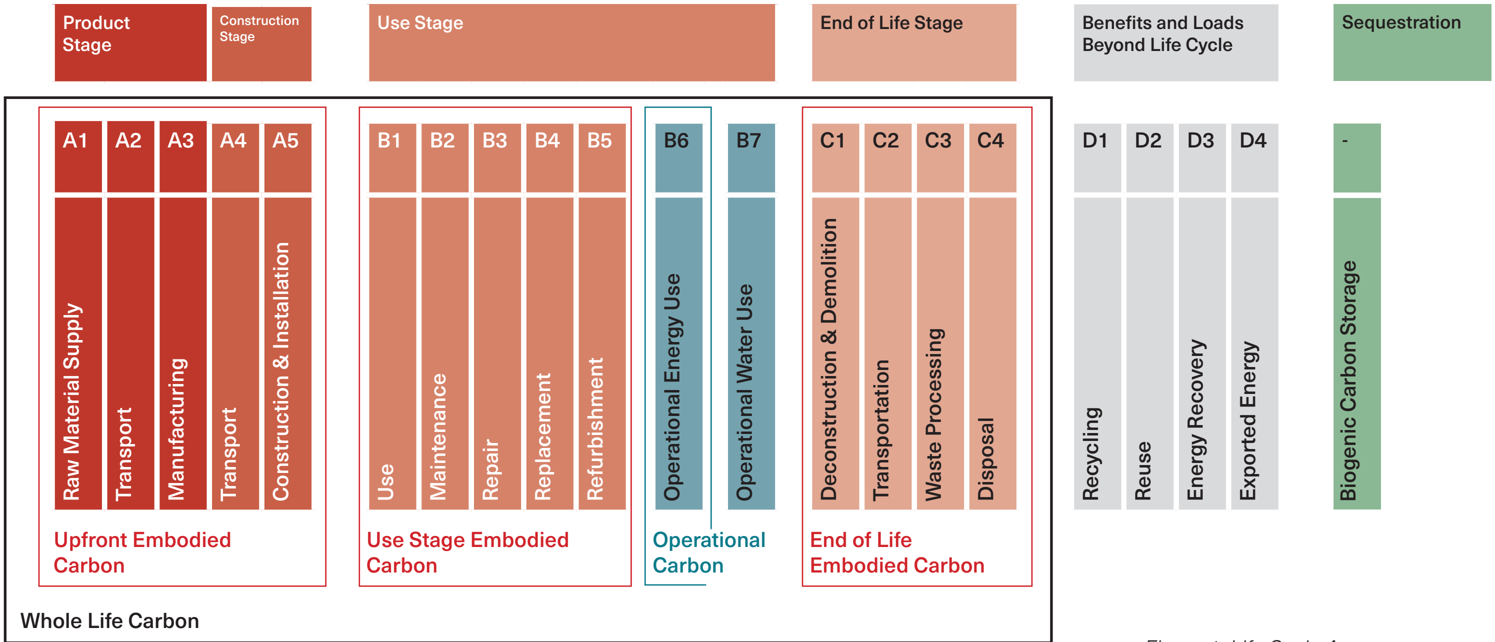

Figure 1. Life Cycle Assessment (LCA) system boundaries as defined by EN 15978 and ISO 21930, including biogenic carbon storage.

1/ Embodied Carbon Intensity

This guide presents both A-C Global Warming Potential (GWP) and biogenic carbon. A-C Embodied carbon refers to the material emissions associated with all stages of the carbon life cycle, from raw extraction, manufacturing, and construction, through the use stage including repair and replacement, and to the assumed end-of-life scenario. These boundaries are illustrated in Figure 1 and align with international standards EN 15978 and ISO 21930, as well as Canadian guidance such as the *National Guidelines for Whole-building Life Cycle Assessment* published by the National Research Council of Canada (NRC).

Upfront embodied carbon refers to the emissions created during the extraction, processing, manufacture, transport to site, and installation of a product. With each replacement cycle, the upfront carbon of a material is re-emitted and added again to its whole life impact, increasing the total carbon intensity of that material in proportion to its durability.

Figures shown represent one square metre (m²) of the material at the thickness indicated, and are averages from suppliers across Canada. Refer to specific manufacturer documents for the most accurate data.

2/ Biogenic Carbon Intensity

This guide also presents biogenic carbon, which refers to the carbon stored in biological materials such as wood, plant fibres, or soil-derived materials. Biogenic carbon becomes sequestered when the biological material is harvested and remains stored as long as the material is maintained in use. Figures shown represent sequestration in the product stage (A1-A3), per EN 15978 and ISO 21930.

3/ Relative Upfront Costs

The upfront costs in this guide are a relative measure of the product's supply and installed cost within the range of values for each material category. Dollar symbols ($) indicate the relative cost in four quartiles for each category, with $ representing the lowest-cost quartile and $$$$ the highest. See Appendix A (p. 15) for more details.

Construction costs can vary by market, and labour costs for installation will vary based on project specifics and local labour rates. Users should consult local suppliers and contractors for accurate estimates.

4/ Expected Life Span

Due to material properties, levels of exposure, and operability, the materials in this guide have a wide range of expected life spans. Over the life of a building, the use, maintenance, repair, replacement, and refurbishment of these materials result in use-stage costs and embodied carbon impacts. Users should consult with a Qualified Professional to select materials and consider rates of replacement and required maintenance.

Figures shown are averages from suppliers across Canada. Refer to specific manufacturer documents for specific life spans and maintenance requirements.

5/ Relative Life Cycle Cost

The life cycle costs presented in this guide are a relative measure of a product's supply and installed cost over a sixty-year period. This approach accounts not only for initial construction costs, but also for the frequency of replacement based on typical service life.

For example, consider a 140 m^2 residential roof:

- Asphalt shingles cost approximately $75/$m^2$, resulting in an initial cost of around $10,500. With a typical service life of 20 years, the roof would require two full replacements over a 60-year period. This brings the total life cycle cost to approximately $31,500.

- In contrast, 38mm prefinished metal standing seam roofing costs about $120/$m^2$, or $16,800 in initial construction costs. With a longer typical service life of 40 years, it would only require one replacement over the same 60-year period, for a total life cycle cost of around $33,600.

This comparison illustrates how materials with higher durability and lower replacement frequency can have comparable life cycle costs, even if their initial cost appears significantly higher. The same logic applies to embodied carbon: each time a material is replaced, the emissions associated with its extraction, manufacturing, and installation are emitted again, making durability a key factor in reducing whole life carbon.

Material Health Considerations

While this guide focuses primarily on carbon, it is important to recognize that material choices also carry implications for human and environmental health. These impacts can occur at various stages of the material life cycle, including extraction, manufacturing, installation, use, and end-of-life. Health risks may affect not only building occupants, but also workers involved in producing or installing materials, as well as communities near manufacturing or disposal sites.

Material health can refer to a range of factors: from off-gassing or emissions that affect indoor air quality, to the presence of substances that are hazardous during handling, or persistent in the environment after disposal. For this reason, many practitioners are moving toward using third-party tools and declarations to screen materials for health-related concerns. Product documentation such as Health Product Declarations (HPDs), Environmental Product Declarations (EPDs), Safety Data Sheets (SDS or MSDS), and manufacturer specification sheets can all help identify potential health risks or certifications related to material safety and transparency.

Selecting materials with lower health impacts can improve indoor air quality, reduce risk during construction, and minimise harm throughout the supply chain, supporting not just occupant wellbeing but broader environmental and social goals. This is particularly important when selecting interior finishes, which directly affect indoor air quality and are in close, prolonged contact with building occupants.

2.0 / Material Selection

Building Envelope
1. Cladding
2. Roofing
3. Insulation - Rigid
4. Insulation - Cavity
5. Membranes
6. Sheathing
7. Windows
8. Exterior Doors

Interiors
9. Flooring
10. Wall Board
11. Paints and Finishes
12. Interior Doors

Structural Elements
13. Strapping
14. Stud
15. Joist
16. Bottom Plate
17. Top Plate
18. Beam
19. Footing
20. Grade Beam
21. Slab on Grade
22. Subfloor

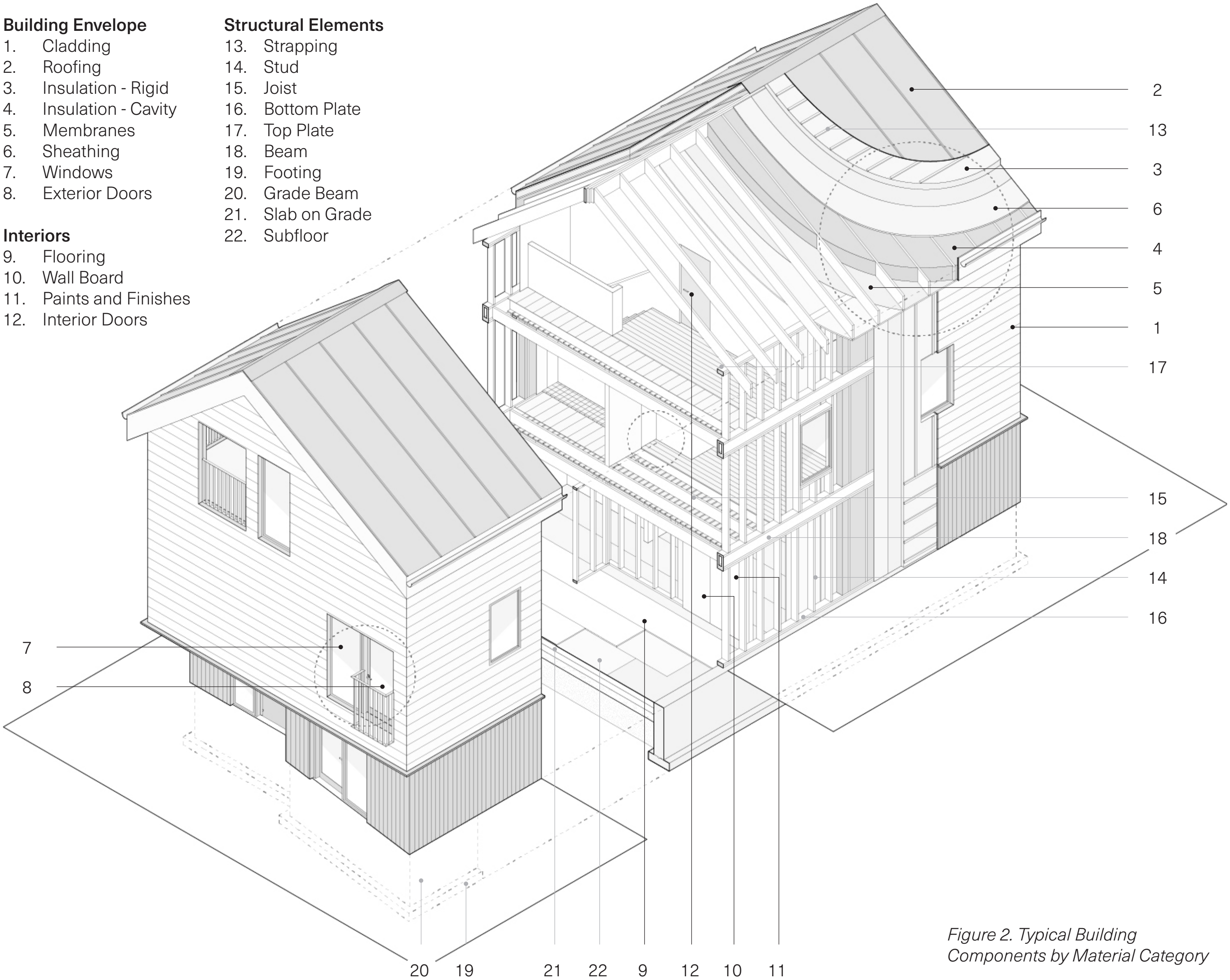

Figure 2. Typical Building Components by Material Category

Typical Building Components

This diagram illustrates an example of typical building components found in a Housing Design Catalogue design. Actual components may vary based on the specific design, regional requirements, and choices made by the end user. Fixtures, fittings, and mechanical systems are not pictured in this diagram, but general information on these components is provided in later sections of this guide.

All thicknesses, carbon intensities, and cost values referenced in the following tables are based on representative assemblies and average market research. These values are indicative only and may not reflect (a) the actual materials available to users or (b) the specific requirements of their project. Users must verify EPDs, material performance, code compliance, and pricing based on their own project context.

Material substitutions should be carefully considered, as they may not be compatible with the prototypical assemblies described in the Housing Design Catalogue design drawings. In particular, insulation values can vary significantly across material types and may require different thicknesses to meet equivalent performance and code requirements. Users are advised to consult a Qualified Professional before making modifications.

Material Category & Product Name	Thickness (mm)	Embodied Carbon Intensity ($kgCO_2e/m^2$)	Biogenic Carbon Intensity ($kgCO_2e/m^2$)	Relative Upfront Cost ($ - $$$$)	Expected Life Span (years)	Relative Life Cycle Cost ($ - $$$$)

1/ Cladding

Includes only the exposed exterior cladding material and typical method of attachment; does not include underlying components such as insulation, air barrier, or sheathing. The EIFS system includes a finish layer, stucco, drain screen, sealants, and EPS insulation.

Treated Pine	19mm	**4.2**	17.9	$	60	**$**
Thermally Modified Wood	19mm	**6.2**	15.7	$$$ - $$$$	60	**$$$**
Fibre Cement Plank or Panel	19mm	**13.7**	-	$	60	**$**
Prefinished Steel	1-5mm	**15.1**	-	$-$$	60	**$**
Natural Stone Panels	32mm	**18.0**	-	$$$$	60	**$$$ - $$$$**
Painted Cedar	13mm	**22.0**	6.1	$	60	**$**
Vinyl Siding	1-5mm	**25.6**	-	$	25	**$ - $$**
Aluminium	1-5mm	**53.2**	-	$	60	**$**
Brick (including mortar)	90mm	**59.9**	-	$$$	60	**$$ - $$$**
EIFS	150mm	**82.5**	-	$$	25	**$$$$**
Terracotta Tile	40mm	**133.6**	-	$$$$	60	**$$$$**

2/ Roofing

Includes only the outermost roofing material (e.g. membrane, shingle, or metal roofing); does not include underlying insulation, sheathing, or structural layers.

Sloped Roofing

Galvanized Corrugated Steel	1mm	**6.3**	-	$	40	**$$**
Fibre Cement Board Slates	4mm	**8.4**	-	$$$	60	**$$**
Natural Slate	6-10mm	**8.9**	-	$$$$	60	**$$$$**
Prefinished Metal Standing Seam (22mm)	<1mm	**12.8**	-	$	60	**$**
Cedar Shingles	10-12mm	**16.2**	25.0	$$	20	**$**
Asphalt Shingles	3mm	**16.5**	-	$	20	**$$$$**
Zinc Standing Seam (22mm)	<1mm	**21.5**	-	$$$	60	**$$$**
Prefinished Metal Standing Seam (38mm)	<1mm	**21.7**	-	$$	60	**$ - $$**

Flat Roofing

4-Ply Built-up Roofing (BUR)	6-10mm	**10.3**	-	$$	20	**$$$$**
Asphaltic Roof Board	3mm	**10.8**	-	$	20	**$**
2-Ply SBS Modified Bitumen	6mm	**15.2**	-	$$	30	**$**
Single Ply TPO	1-2mm	**15.6**	-	$$$$	30	**$$ - $$$**
Single Ply EPDM	1-2mm	**21.0**	-	$$$$	30	**$$**

Material Category & Product Name	Thickness (mm)	Embodied Carbon Intensity ($kgCO_2e/m^2$)	Biogenic Carbon Intensity ($kgCO_2e/m^2$)	Relative Upfront Cost ($ - $$$$)	Expected Life Span (years)	Relative Life Cycle Cost ($ - $$$$)

3-4/ Insulation

Includes only the insulation material itself, whether installed in cavities or as continuous rigid insulation; does not include supporting layers or fasteners.

Rigid Insulation

Cellular Glass Foam Board	R5 46mm	**1.4**	-	$$$$	60	**$$$$**
Halogen-free Polyiso Board	R5 22mm	**3.3**	-	$$ - $$$	60	**$$ - $$$**
Mineral Wool Board (Formaldehyde Binder)	R5 30mm	**3.4**	-	$	60	**$**
Mineral Wool Board (Formaldehyde Free)	R5 30mm	**3.7**	-	$	60	**$**
EPS Board	R5 35mm	**3.8**	-	$	60	**$**
Standard Polyiso Board	R5 25mm	**5.1**	-	$	60	**$**
Standard Fibreglass Board	R5 40mm	**5.5**	-	$	60	**$**
FSK-Faced Fibreglass Board	R5 40mm	**6.0**	-	$	60	**$**
Wood Fibreboard	R5 38mm	**7.7**	12.3	$	60	**$**
XPS Board	R5 22mm	**25.2**	-	$	60	**$**

Cavity Insulation

Blown-In Cellulose	R20 140mm	**0.4**	2.8	$	60	**$**
Blown Fibreglass	R21 140mm	**0.6**	-	$	60	**$**
Unfaced Fibreglass Batt	R21 140mm	**1.0**	-	$$	60	**$$**
FSK-Face Fibreglass Batt	R17 140mm	**1.1**	-	$$	60	**$$**
Kraft-faced Fibreglass Batt	R23 140mm	**1.1**	-	$$	60	**$$**
Mineral Wool Batt	R21 140mm	**1.2**	-	$$$$	60	**$$$$**
Hemp Fibre Batt	R20 140mm	**1.6**	2.2	$$$$	60	**$$$$**
Sheep Wool Batt	R20 140mm	**3.2**	-	$$$ - $$$$	60	**$$$ - $$$$**
Wood Fibre Batt	R22 140mm	**7.7**	12.3	$$	60	**$$**
Closed Cell Sprayfoam	R39 140mm	**22.2**	-	$$	60	**$$**

5/ Membranes

Includes only the primary membrane layer (e.g. air/vapour barrier or waterproofing membrane); does not include substrate or protective layers.

Sugarcane Vapour Barrier	0.22mm	**0.4**	-	$$	30	**$$**
Smart Vapour Retarder	0.40mm	**1.3**	-	$$	30	**$$**
Polyethylene Vapour Barrier (6 mil)	0.15mm	**1.4**	-	$	30	**$**
Building Wrap / Paper	0.22mm	**1.5**	-	$	30	**$**
Self-Adhered Air Vapour Barrier	1.00mm	**8.8**	-	$ - $$	30	**$ - $$**
Liquid Applied Membrane	0.50mm	**24.2**	-	$$$$	30	**$$$$**

Material Category & Product Name	Thickness (mm)	Embodied Carbon Intensity ($kgCO_2e/m^2$)	Biogenic Carbon Intensity ($kgCO_2e/m^2$)	Relative Upfront Cost ($ - $$$$)	Expected Life Span (years)	Relative Life Cycle Cost ($ - $$$$)

6/ Sheathing

Includes only the sheathing material (e.g. plywood, OSB, fibreboard) used in wall, roof, or floor assemblies; does not include framing, insulation, or membranes.

Material Category & Product Name	Thickness (mm)	Embodied Carbon Intensity ($kgCO_2e/m^2$)	Biogenic Carbon Intensity ($kgCO_2e/m^2$)	Relative Upfront Cost ($ - $$$$)	Expected Life Span (years)	Relative Life Cycle Cost ($ - $$$$)
Plywood	13mm	**3.1**	10.2	$$	60	**$$**
Plywood	16mm	**3.8**	12.6	$$$	60	**$$$**
Plywood	19mm	**4.5**	14.9	$$$$	60	**$$$$**
Oriented Strand Board (OSB)	19mm	**5.5**	20.8	$	60	**$**
Glass Mat Gysum Board	12mm	**6.9**	-	$$	60	**$$**
Glass Mat Gysum Board	16mm	**8.4**	-	$$	60	**$$**
Strawboard	30mm	**11.2**	12.4	$$$$	60	**$$$$**

7/ Windows

Includes the full window unit, comprising frame, glazing, hardware, sealants, and gaskets.

Material Category & Product Name	Thickness (mm)	Embodied Carbon Intensity ($kgCO_2e/m^2$)	Biogenic Carbon Intensity ($kgCO_2e/m^2$)	Relative Upfront Cost ($ - $$$$)	Expected Life Span (years)	Relative Life Cycle Cost ($ - $$$$)
Wood Frame	varies	**76.2**	13.7	$	30	**$**
Aluminium Clad Wood Frame	varies	**91.9**	9.6	$$	30	**$$**
Wood-Plastic Composite Frame	varies	**200.0**	-	$$$	30	**$$$**
Insulated Fibreglass Frame	varies	**215.8**	-	$ - $$	30	**$ - $$**
Insulated Vinyl Frame	varies	**248.8**	-	$	20	**$$ - $$$**
Anodized Aluminium Frame	varies	**277.2**	-	$$$$	30	**$$$$**

8/ Exterior Doors

Includes the door leaf, threshold, and corresponding fittings as defined in the product EPD; vision glass is not included unless explicitly stated in the product name.

Material Category & Product Name	Thickness (mm)	Embodied Carbon Intensity ($kgCO_2e/m^2$)	Biogenic Carbon Intensity ($kgCO_2e/m^2$)	Relative Upfront Cost ($ - $$$$)	Expected Life Span (years)	Relative Life Cycle Cost ($ - $$$$)
Exterior Wood w/ Mineral Wool Core	varies	**71.2**	41.1	$$	40	**$$**
Aluminium-clad Wood Patio Door (Triple-pane)	varies	**173.1**	22.7	$$$$	40	**$$$$**
Exterior Metal w/ Mineral Wool Core	varies	**493.4**	-	$	40	**$**
Exterior Coated Aluminium	varies	**745.5**	-	$$$$	40	**$$$$**

Material Category & Product Name	Thickness (mm)	Embodied Carbon Intensity ($kgCO_2e/m^2$)	Biogenic Carbon Intensity ($kgCO_2e/m^2$)	Relative Upfront Cost ($ - $$$$)	Expected Life Span (years)	Relative Life Cycle Cost ($ - $$$$)
9/ Flooring	Includes only the flooring finish layer (e.g. tile, wood, resilient flooring); subfloor, underlayment, or acoustic membranes are not included unless required for installation and noted.					
Hardwood	19mm	**4.0**	31.0	$$	60	**$**
Linoleum	3mm	**11.1**	4.2	$	20	**$**
Hempwood	19mm	**11.9**	12.7	$$	25	**$$$**
Engineered Wood	19mm	**23.8**	19.8	$$ - $$$	30	**$$ - $$$**
Cork Tile	6mm	**24.0**	14.0	$ - $$	15	**$$ - $$$**
Ceramic Tile	8mm	**28.9**	-	$$$ - $$$$	30	**$$$ - $$$$**
Vinyl Tile	2-8mm	**75.7**	-	$	25	**$**
10/ Wall Board	Includes only the board product used as a finish layer (e.g. drywall, wood panel); does not include paint, fasteners, or additional treatments.					
Hempboard	13mm	**2.7**	4.2	$$$	60	**$**
Finished Plywood	13mm	**3.1**	10.2	$$$	60	**$**
Lime Render	9-12mm	**4.0**	-	$$$$	10	**$$$$**
Gypsum Wall Board (including Mold Resistant Types)	12.5mm	**5.9**	-	$	40	**$**
Type C Gypsum Wall Board	12.5mm	**6.0**	-	$	40	**$**
Type X Gypsum Wall Board	12.5mm	**12.1**	-	$	40	**$**
11/ Paints and Finishes	Includes only the applied finish layer (e.g. paint, stain, or coating) as typically used on interior surfaces.					
Lime-based Paint	<1mm	**0.3**	0.1	$ - $$	10	**$ - $$**
Graphene-based Paint	<1mm	**1.4**	-	$$	10	**$$**
Acrylic/Latex Paint	<1mm	**1.6**	-	$	10	**$**
Clay-based Paint	2mm	**2.0**	-	$ - $$$$	10	**$ - $$$$**
Mineral Silicate Paint	1-5mm	**8.4**	-	$	10	**$**
12/ Interior Doors	Includes the door leaf only, typically flush doors; does not include frames, or hardware.					
Solid Wood	varies	**27.8**	27.4	$$$$	40	**$$$$**
Hollowcore Wood	varies	**29.1**	18.5	$	40	**$**
Formaldehyde-Free Particleboard / MDF	varies	**35.1**	10.1	$$	40	**$$**
Standard Particleboard / MDF	varies	**39.3**	28.8	$$	40	**$$**
Formaldehyde-Free Plywood	varies	**56.3**	54.3	$$	40	**$$**
Standard Plywood	varies	**56.3**	54.3	$$	40	**$$**
Hollow Metal	varies	**120.9**	0	$$$$	40	**$$$$**

3.0 / Structural Materials

While this Guide does not cover structural materials in depth, there are important differences within each of the following standard categories that can significantly affect both the carbon intensity of the whole building. Given the designs in the Catalogue (with select exceptions in the Yukon, Northwest Territories, and Nunavut) will primarily employ wood framing for above grade, and concrete block or cast-in-place concrete for below grade, this Guide focuses on considerations for these materials.

Wood Products

All of the Catalogue designs mainly use wood-framed structures employing dimensional lumber and engineered wood products. All of these elements will have roughly similar carbon intensity for a given volume, which is declared by the Canadian Wood Council for all softwood lumber products.

The overall environmental impacts of wood products can be improved by selecting products with sustainable harvesting practices. There are several regulatory bodies operating across Canada to ensure responsible forestry management. Forest Stewardship Council (FSC) certified lumber is harvested from forests operating with zero-deforestation, fair labour practices, community consultation, and animal protection. The Sustainable Forestry Initiative (SFI) and the Canadian Standards Association (CSA) also certify managed forests and have similarly high ethical and environmental harvesting standards.

Steel Reinforcement

Steel reinforcement bar (rebar) is an essential component in cast-in-place concrete and reinforced concrete masonry units (CMUs), providing the tensile strength needed for structural performance. While it is present in relatively small quantities, the relative carbon intensity of steel results in significant impact. Steel products are produced across Canada. Canadian steel is typically lower carbon than American or internationally sourced steel, and by selecting Canadian steel products will ensure it has a known carbon impact. Steel is an infinitely recyclable metal, and much easier to source than other recycled materials. Rebar is available with up to 99% recycled content, which performs the same as virgin steel with significantly lower environmental impacts from mining and production.

Concrete

Concrete, along with the steel reinforcement used to stabilize it, is one of the most carbon intensive materials in a building's construction. There is significant variation in environmental impacts within the standard strengths and mixes available on the market, and there are specific additives and qualities that can help reduce these impacts. Most carbon-reduction strategies rely on additives and mix ratios with longer curing times. This stresses the importance of "strength at age design," which specifies the strength of the concrete once it has cured for a given number of days. The standard length of this curing time is 28 days, but if the construction process will take longer or there is flexibility in timing, lower carbon mixes that take longer to cure should be considered. Cure times can be specified up to 56 or even 91 days long.

Concrete mixes are composed of cement, aggregates, and water in varying proportions. Cement is the component of concrete with the highest carbon intensity, which accounts for the majority of concrete's environmental impact. Supplementary cementitious materials (SCMs) help to lower this intensity by replacing some (30% or more) of the cement in a concrete mix. Many contractors and concrete installers already add SCMs to improve the workability and consistency of their concrete mix, and will be open to sourcing appropriate SCMs to lower the carbon impact of the mix. While SCMs can entirely replace a proportion of the cement in a concrete mix, lower carbon products are available for the remaining necessary amount of cement. General Use (GU) cement is the typical higher-carbon product, whereas General Use Limestone (GUL) cement has a lower carbon intensity with the same strength performance.

4.0 / Fixtures, Fittings, and Millwork

Fixtures and fittings represent an important category of materials with implications for both embodied carbon and indoor environmental quality. These components, such as plumbing fixtures, hardware, lighting, appliances, and built-in millwork like cabinetry and shelving, are often replaced or upgraded multiple times over a building's service life and can contribute disproportionately to a home's cumulative carbon impact over 60 years.

Life Span & Replacement Cycles

Fixtures and fittings are generally small in volume but can have shorter service lives than primary building materials. Items like faucets, showerheads, cabinet hardware, and light fixtures may be replaced every 10 to 20 years, while larger appliances or mechanical fixtures, like water heaters or range hoods, typically last between 10 and 25 years. Built-in millwork, such as kitchen cabinets, may last 20 to 40 years depending on material quality, usage, and trends in design. Each replacement cycle adds new embodied carbon and cost, which can be minimized by selecting durable, repairable products with available parts and manufacturer support.

Embodied Carbon Impacts

In terms of environmental impact, carbon intensity varies widely depending on the material (such as brass, stainless steel, plastic, wood, or ceramic) and finish (such as chrome plating, powder coating, or laminates). For built-in millwork, impacts also vary significantly based on core material (such as solid wood, MDF, or particleboard) and surface finish (such as laminates or veneers). The manufacturing process further influences overall carbon footprint. While third-party EPDs are less common for small-scale fixtures than for structural materials, they are becoming increasingly available, particularly for plumbing products, cabinetry, and commercial-grade hardware. In the absence of EPDs, specifiers should consider product life span, material composition, and manufacturer transparency as proxies for environmental performance.

Material Health Considerations

Fixtures and fittings also have a direct impact on indoor air quality and occupant health. Products that come into regular contact with water or air, such as faucets, water heaters, and ventilation fans, can introduce contaminants if not properly certified. Millwork and cabinetry can also off-gas volatile organic compounds (VOCs) from composite wood cores, adhesives, or finishes. Look for materials and finishes that are low in VOCs, heavy metals, and other harmful substances. Product safety and health information is typically available through Safety Data Sheets (SDS), manufacturer technical documentation, or transparency labels such as Declare, Cradle to Cradle, or GreenScreen assessments.

Installation Methods and End-of-life Considerations

Installation methods play an important role in supporting reuse and recyclability. Wherever possible, fixtures, fittings, and millwork should be installed using mechanical fasteners like screws or brackets rather than adhesives or foams. Mechanically fastened components are easier to remove without damage, increasing the potential for reuse or material separation during renovation or deconstruction. In contrast, materials bonded with adhesives are often difficult or impossible to separate without contamination or breakage, limiting recyclability and increasing landfill waste. Selecting reversible installation techniques also supports future adaptability of spaces, which can reduce unnecessary material replacement over time.

By choosing durable, low-toxicity fixtures, fittings, and millwork, users can reduce replacement frequency and minimise environmental and health impacts over time.

5.0 / Mechanical Systems

Current Canadian standards for embodied carbon reporting do not include mechanical systems (heating and cooling) and the embodied carbon emissions associated with these systems have not been considered in the carbon reporting for these designs. According to the *RICS Whole Life Carbon Assessment for the Built Environment* (2023), mechanical, electrical, and plumbing (MEP) systems can contribute up to one-third of a building's embodied carbon over a 60-year life span. This significant impact is due to several factors. Mechanical systems predominantly use high embodied carbon metals such as aluminium motors and heat exchangers, copper and cast iron pipework, rare earth metal electric batteries and solar panels, and steel ductwork. Given the limited recyclability of these components, new equipment often requires mining, treatment, and processing of virgin metals, which is highly energy-intensive.

As our electrical grids decarbonize, the use of heat pumps is becoming more widespread. These systems can deliver significant reductions in operational energy demand, however these carbon savings may be negated due to the high embodied carbon impacts of refrigerant leakage. Refrigerants are gases used in building systems, like compressors, that are integral to heating and cooling mechanisms, and not a fuel that helps power it; hence refrigerant leakage during the building's use phase is added to embodied carbon impact and not operational carbon impact.

Commercial refrigerants commonly used across North America are synthetic chemicals, like HFCs, that have very high global warming potential. Replacing these refrigerants with natural refrigerants like CO2, ammonia, and propane, has the potential to dramatically reduce the embodied carbon impacts of refrigerant leakage. Right-sizing equipment will help to reduce overall refrigerant charge, and specifying factory-sealed equipment where possible will help to minimize leakage during transportation and installation.

For further detail on MEP-related impacts, refer to additional guidance from LETI (*Climate Emergency Design Guide*, 2020), UKGBC (*Whole Life Carbon Roadmap*, 2021), and CIBSE (*TM65: Embodied Carbon in Building Services*, 2021).

Appendix A

Methodology

The material life cycle assessments were completed using A–C embodied carbon stages, in alignment with EN 15978, ISO 21930, and the *National Guidelines for Whole-building Life Cycle Assessment* (NRC, Canada). Where relevant, biogenic carbon sequestration has been reported separately and not deducted from total emissions, in accordance with best practices for transparent reporting established by these standards.

Study Period
60 years

Reference Unit
1m^2 of a given material.

- Rigid insulation values are based on 1m^2 of material at a thickness sufficient to achieve RSI-0.88 (R-5).
- Cavity insulation values are based on 1m^2 of material with a standard 140mm (5.5–6”) thickness, representing typical stud cavity depth. Relative RSI and R-values are provided for comparison across materials.
- For windows and doors, carbon values represent an average per square metre, regardless of specific dimensions or configurations. To estimate total embodied or biogenic carbon for a given product, users can multiply the values by the surface area of the unit. For reference, a typical exterior door is approximately 1.95m^2, and a typical interior flush door is approximately 1.7m^2. For windows, the total glazing area in a design can be used to calculate cumulative carbon impacts.

Key Metrics

- Thicknesses are provided in millimetres (mm), where applicable.
- Embodied carbon and biogenic carbon data is presented in units of kilograms of carbon dioxide equivalent per square metre of gross floor area (kgCO2e/m^2).
- Expected life span is listed in years and reflects typical service life under normal conditions of use and maintenance.
- Relative upfront and life cycle costs are shown on a scale from $ to $$$$, using a percentile method within each material category. Quartiles are determined by the full cost range, from the lowest-cost product (0%) to the highest-cost product (100%), with each quartile representing 25% of that range. Mid-range quartile ratings ($$ and $$$) may not appear in every category.

Material Acronyms

BUR Built-Up Roofing, composed of layers of liquid bitumen and felt

EIFS Exterior Insulation and Finish System, a stucco wall panel cladding

EPDM Ethylene Propylene Diene Monomer, a synthetic rubber roofing membrane

EPS Expanded Polystyrene, a type of foam used as a board insulation

FSK Foil Scrim Kraft, a flame retardant facing used in building materials

MDF Medium Density Fibreboard, a wood-based board materials

Polyiso Short for Polyisocyanurate, a type of foam used as a board insulation

SBS Styrene-Butadiene-Styrene, a type of rubber used to modify bitumen roofing

TPO Thermoplastic Polyolefin, a single-ply roofing membrane

XPS Extruded polystyrene, a type of foam used as a board insulation

Appendix B

Sources

Life Spans

As declared in EPDs, or sourced from:

Fannie Mae. (2018, November). Useful life charts: Multi-family properties. Reserve Data Analyst. https://www.reservedataanalyst.com/mt-content/uploads/2018/11/fannie-mae-useful-life-charts-multi-family-properties.pdf

Material and EPD Databases

2050 Materials. (n.d.). Home. 2050 Materials. Retrieved January 30, 2025, from https://app.2050-materials.com/

Healthy Materials Lab. (n.d.). Material collections. Healthy Materials Lab. Retrieved January 30, 2025, from https://healthymaterialslab.org/material-collections

Kornerup, J. U., Foltinger, S. W., & Lewis, M. (2024). Climate impact of indoor paint. Henning Larsen Architects. https://brandcentral.ramboll.com/share/mPyia7qmVPP4AGSYeYXv

One Click LCA. (n.d.). Home. One Click LCA. Retrieved January 30, 2025, from http://www.oneclicklcaapp.com/

Transparency Catalog. (n.d.). Home. Transparency Catalog. Retrieved January 30, 2025, from https://transparencycatalog.com/

Waldman, B., Hyatt, A., Carlisle, S., Palmeri, J., & Simonen, K. (2023, August). North American material baselines. Carbon Leadership Forum.

Costing Information

Relative upfront and life cycle cost information was developed in collaboration with Vermeulens Cost Consultants, whose expertise helped align cost comparisons with industry benchmarks and current market conditions.