



2023 Carbon Leadership Forum

# **North American Material Baselines**

BASELINE REPORT | APRIL 2023



## About the Carbon Leadership Forum

The Carbon Leadership Forum, hosted at the University of Washington, accelerates the transformation of the building sector to radically reduce the greenhouse gas emissions attributed to materials, also known as embodied carbon, used in buildings and infrastructure. We research, educate, and foster cross-collaboration to bring the embodied carbon of buildings and infrastructure down to zero.

## Authors

The research team from the Carbon Leadership Forum at the University of Washington College of Built Environments:

- Brook Waldman, Researcher
- Allison Hyatt, Researcher
- Stephanie Carlisle, Senior Researcher
- Jordan Palmeri, Senior Researcher
- Kathrina Simonen, Executive Director

Author contributions: B.W., S.C., A.H & K.S. Conceptualization; B.W., A.H., and J.P. Formal analysis; J.P., S.C., B.W., A.H., and K.S. Writing-review & editing; J.P. Writing-original draft of report; B.W. & A.H. Writing-original draft of appendices; A.H. & B.W. Data visualization in appendices; K.S. Funding acquisition.

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## INTRODUCTION

The building industry has an essential role to play in tackling the greenhouse gas (GHG) emissions associated with materials manufacturing, use, and disposal, also known as **embodied carbon**. Our present understanding of the importance of embodied carbon has been enabled by rigorous quantitative modeling that tracks carbon emissions across the full life cycle of materials and products, using **life cycle assessment (LCA)**.<sup>1</sup> LCA reports embodied carbon impacts using a metric called global warming potential (GWP). GWP is quantified in kilograms of CO<sub>2</sub> equivalent (kg CO<sub>2</sub>e) and is used in this report to communicate the embodied carbon of materials and products.

The Carbon Leadership Forum (CLF) is part of a broad movement working to drive down the embodied carbon of building materials and products by encouraging the disclosure of high-quality embodied carbon data by manufacturers. LCA data and results are essential for guiding science-based efforts to decarbonize buildings and infrastructure.

Designers, owners, and policymakers need access to verified, third party-reviewed, and published data on building materials and products to facilitate procurement decisions, set decarbonization targets, and inform design. One tool for achieving this goal has been the collection and use of **environmental product declarations (EPDs)** to inform decision-making. EPDs are third party-verified documents based on LCA models, written in conformance with international standards, that report the environmental impacts of a product. These declarations can be used to track supply chain-specific product data and compare products if the products are functionally equivalent and have aligned LCA scopes. EPDs report many impacts, including but not limited to embodied carbon.

The development of Material Baselines by CLF originated in support of the Embodied Carbon in Construction Calculator (EC3) tool, which aims to collect all third party-reviewed EPDs for published categories. The Material Baselines were originally published in 2019 and again in 2021. This document supersedes all previous versions and makes many changes to the methodology and reporting to adapt to the changing uses of material baselines in policy, procurement, research, analysis tools, and reporting. **The baseline values published in this report are not comparable to past reports due to changes in methodology.** A more detailed explanation of changes to the Material Baselines can be found in Appendix A2.

### Embodied Carbon

the greenhouse gas (GHG) emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of construction materials.

### Life Cycle Assessment (LCA)

a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy, and the associated environmental impacts directly attributable to a product or process throughout its life cycle

### Environmental Product Declaration (EPD)

EPDs are third party-verified documents written in conformance with international standards that report the environmental impacts of a product, including its global warming potential, based on life cycle assessment models.

1. World Green Building Council (WGBC). (2019). Bringing Embodied Carbon Upfront. <https://www.worldgbc.org/news-media/bringing-embodied-carbon-upfront>

## PURPOSE OF THE REPORT

The purpose of the CLF North American Material Baselines Report is to provide a snapshot of the state of EPDs. This report includes:

- **Background methodology:** this report narrative;
- **CLF Baselines:** industry-average embodied carbon values against which product level comparisons can be made; and
- **Appendices:** detailed Appendix for each product category that includes a description of the embodied carbon impacts, the available EPDs, and summary statistics.

The **CLF Baselines** represent an estimate of industry-average GHG emissions for construction materials manufactured in North America. Globally, the availability of embodied carbon data for materials and products is growing as more and more manufacturers make the environmental impacts of their supply chains known by publishing EPDs. Still, the publication of EPDs and other carbon disclosure is voluntary and its adoption has been uneven. While not all products or manufacturers are currently represented in public databases such as EC3, the number of available EPDs has grown over the last few years. Due to the dynamic nature of these datasets, evolving **Product Category Rules (PCRs)**, and the additional uncertainty factors being placed on EPD results in the EC3 tool, users have identified the need for a static baseline against which product-level comparisons can be made and measurable targets can be established. This report issues a snapshot of all available North American EPDs, providing a fixed reference point for comparisons of A1-A3 (cradle-to-gate) embodied carbon impacts for building materials.

The snapshot of available EPDs summarized in each Appendix was assembled using the EC3 database in Fall 2022. This report uses the term “product EPD” to refer to any EPD that represents products from a single manufacturer, as opposed to an industry-wide EPD that represents products from many manufacturers.

## USE OF CLF BASELINES

This report summarizes available EPD data on North American building materials from 2022. This publication is part of an ongoing project to track the growth of EPD data and will be updated on an annual basis. The information in this report can be used by a diverse audience, including but not limited to:

- policymakers
- architects, engineers, and contractors
- material manufacturers
- LCA and building material researchers
- tool developers
- building sector rating systems

### What is a baseline?

A baseline is a basis for comparison; a reference point against which other things can be evaluated.

### Product Category Rule (PCR)

a set of specific rules, requirements, and guidelines for developing Type III environmental declarations for one or more product categories. Product category rules are reviewed and improved periodically over time.

2. International EPD System, “Sector or Industry Average EPD,” <https://epdweb3.azurewebsites.net/all-about-epds/what-is-an-epd>

An overwhelming majority of the CLF Baselines published in this report are based on a North American industry-wide EPD if one was available at the time of publication. The Baseline values represent an estimate of industry-average GHG emissions for construction materials manufactured in North America. As such, it is appropriate to use this number as a rough estimate of a product type's embodied carbon before a specific product has been selected, or as a default value for broad product comparisons.

Industry-wide EPDs are developed by industry associations representing multiple manufacturers and locations and declare the environmental impacts associated with an “average product” in a clearly defined sector or geographic area.<sup>2</sup> Products covered in an industry-wide EPD follow the same Product Category Rule (PCR) and have the same declared unit. All industry-wide EPDs are published, peer-reviewed documents based on rigorous LCA models.

Additionally, the Appendices in this report allow users to better understand the availability of existing industry-wide and product EPDs, and the variability of product types across a category. Where there is sufficient data within a material category, the corresponding Appendix provides:

- number of product EPDs per product type
- percentile values and average GWP results of product EPDs per product type
- general location of manufacturing facilities publishing EPDs
- the relative contribution of different life cycle stages to the embodied carbon of different products

## SCOPE

Baseline figures are representative of North American manufacturing, acknowledging global trade for upstream supply chain materials. The CLF Baselines represent Product Stage (A1-A3) carbon impacts — that is, the cradle-to-gate impacts from raw material extraction to manufacturing. This cradle-to-gate scope comprises the majority of embodied carbon impacts for the majority of materials and is consistent with the scope of most product EPDs.<sup>3</sup> Additional impacts from transportation and installation (A4-A5) can also be considered in upfront embodied carbon and can be significant for some material categories, but are not included in these figures, as they are not currently required by many PCRs for publication in EPDs. As this data becomes available, it will be important for A4 and A5 impacts to be integrated into procurement decisions.

Some EPDs are beginning to report additional life cycle stages including stage B (use), stage C (end-of-life), and module D (benefits and loads beyond the system boundary). When this information is reported in EPDs, the CLF makes note of its presence in the main Baselines table and includes the detailed impacts in the Appendix to help users make more informed choices when evaluating and comparing materials in the context of a building or infrastructure project's lifecycle. It is important to utilize these additional

3. Carbon Leadership Forum. (2018). *Life Cycle Assessment of Buildings: A Practice Guide*. <https://doi.org/http://hdl.handle.net/1773/41885>.

life cycle stage results to make functionally equivalent comparisons between materials and products.

One notable exception to the A1-A3 scope boundary presented in the main table of this report has been made for foam insulation materials, where blowing agent emissions during installation and over the product's lifespan can be a significant contributor to the product's overall embodied carbon. Disclosing these impacts has been essential for the movement to replace hydrofluorocarbon (HFC) blowing agents with lower-GWP alternatives. Since insulation EPDs are required to report these impacts where applicable, the CLF Baselines for board and foamed-in-place insulations do account for additional life cycle stages. See the Appendices for more information.

## BASELINE METHODOLOGY

### Background Data

The CLF Baselines and associated Appendices draw upon a range of available data including:

- industry-wide EPDs, representing production-weighted averages for product types
- all known product EPDs for a product type, at the time of publication, were pulled from the EC3 tool with EC3 uncertainty factors and non-North American EPDs removed<sup>4</sup>
- other data as referenced

### Calculation Methods

The CLF estimated baseline values using one of two methods, depending on the availability and quality of data for a material category. In some cases, the availability and quality of data were not adequate to estimate a sufficiently representative Baseline for North American production. In these cases, CLF did not publish a Baseline but did provide a detailed Appendix reporting published EPD values (including distribution and summary statistics). The methods below are listed in order of hierarchical preference, which means CLF first utilized the Industry method (when available) and then the Product method.

1. **Industry:** The "Industry" method was used if an industry-wide EPD (IW-EPD) or industry-wide background LCA report was available in a given product category. In many cases, the CLF Baseline was equal to the industry-wide EPD's published value. In some cases, additional regional averages were reported by industries in their EPDs or background LCA report and then utilized as CLF Baselines. Any alterations to the industry-average EPD values were noted directly in the table of published Baseline values. CLF did not adjust any reported IW-EPD values to account for uncertainty.

4. CLF received custom batch downloads from the Building Transparency EC3 tool in September and October of 2022 for this report. This report evaluates the declared values within the EPDs. EC3's uncertainty factors were not included in the data presented.

For this project, CLF generally assumed—barring evidence to the contrary—that an IW-EPD was adequately representative of the industry.<sup>5</sup> While the background data used to develop an IW-EPD may not have covered every North American manufacturer or product, they typically covered a large proportion of the market. They are also production-weighted, and they must meet representativeness criteria for average EPDs per ISO 21930:2017, Section 5.3 EPDs per ISO 21930:2017, Section 5.3.

#### **ISO 21930:2017 Section 5.3 Representativeness Criteria:**

To ensure an average EPD is representative, the information provided in the average EPD and the LCA report shall include, but not be limited to:

- a technical description of the average product group (see EXAMPLES 1 to 3);
- the number of manufacturing plants included in the EPD;
- the names of manufacturing companies or brands or associations;
- a description of the relative production representativeness covered by the EPD;
- the geographical coverage;
- the range of products for which the EPD is relevant;

In addition, the following information shall be provided in the project report to be transparent:

- description of how the selection of the sites/products was done and how the average was determined;
- information on parameters in the LCA having the most influence.

2. **Product:** The “Product” method was used if the product category did not have an industry-wide EPD but did have product EPDs. CLF evaluated the available product EPDs to determine whether the data could be considered adequately representative of all North American production and appropriate for use as a CLF Baseline. CLF utilized ISO 21930:2017 (Section 5.3) as a framework to help evaluate the degree to which a collection of product EPDs adequately represented North American production for a given product type. If CLF determined that the collection of EPDs sufficiently represented the industry, a Baseline was established. Additionally, a detailed description of how the selection of product EPDs meets the ISO criteria and how the Baseline was calculated was included in the Appendix for that product type.

CLF did not adjust any reported product EPD values to account for uncertainty.

## **COMPARABILITY**

CLF Baselines can be used as a basis for comparison when the conditions of Section 5.5 of ISO 21930:2017 are met. To make comparisons using LCA data, it is incumbent upon a user to assure that the products, materials, or assemblies are functionally

5. Although IW-EPDs were available for wood I-joists and insulated metal panels, the IW-EPD was not used to establish a Baseline. These IW-EPDs cover a range of products with associated ranges in performance and GWP, so one cannot make useful comparisons based on the declared unit alone.

equivalent— they serve the same purpose and meet the same performance standards within the building or infrastructure design.

**ISO 21930:2017 Section 5.5 Comparability Requirements:**

The following key aspects must be addressed to enable comparability:

**Function**

- the product/systems shall have the same functional performance
- the comparison is based on the same functional unit
- the environmental performance of excluded elements is the same
- the influence of the product systems on the use stage of the building (including operational energy) are taken into account or are the same

**Amount**

- the type and amount of any materials excluded are exactly the same

**LCA**

- any excluded processes and life cycle stages are the same
- equivalent scenarios are used
- biogenic carbon and carbonation are considered completely and consistently within the scope of comparison
- module D cannot be aggregated with A1-C4 and used in comparisons since it is outside the system boundary but it can be taken into account as optional supplemental environmental information using equivalent scenarios

The CLF Baselines represent an estimate of industry-average GHG emissions for construction materials manufactured in North America and are organized by “Category” and “Product type” to help facilitate appropriate comparisons. A “Product type” is a level at which functionally equivalent comparisons can be more easily made since many, but not all, products within a single product type can be functionally equivalent in an application. A “Category” is a level at which functionally similar product types are grouped. Comparing products at the category level requires more professional judgment since different product types have varying performance characteristics that may or may not make them comparable.

Functional equivalence is heavily dependent on the application in which the product type is being used. For example, within the category of “blanket insulation” can be found the product types of mineral wool and fiberglass blanket insulation. These products are functionally similar and may be comparable if the user is only seeking the function of filling a wall cavity with insulation to a specified R-value. However, these products have different acoustic properties, density, fire properties, and exposure applications that may not allow for functional similarity and comparability if specified for any of these performance characteristics. Therefore, the specified function matters when making decisions on functional equivalence and comparability.

## LIMITATIONS AND OPPORTUNITIES FOR IMPROVEMENT

This section describes the limitations of this work and opportunities for improvement in future versions of this report. The limitations and opportunities for improvement are categorized into the following topics:

### Industry-wide EPDs

Across the available IW-EPDs, the quality and quantity of representative data varies widely. Limitations also exist in the reporting of variability and production volumes represented in IW-EPDs. Interpretation of IW-EPDs could be improved through the publication of the background LCA report along with the industry-wide LCA that includes variability indicators such as ranges and standard deviation. Including the total production volumes represented in the IW-EPD relative to total industry production volumes would be helpful information. Additionally, including manufacturers that contributed data by name can also improve IW-EPDs. Finally, PCRs could more explicitly reference ISO 21930:2017 Section 5.3 representativeness criteria which may help improve the verification of IW-EPDs relative to that criteria.

### Criteria for establishing a Baseline category

CLF does not have consistent criteria for establishing a Baseline category. The Baselines were initially developed to support the EC3 tool and therefore had categories that were closely aligned with the EC3 tool. These categories were mainly driven by the availability of EPD data and whether a category was made “public” in EC3. As the Baselines evolved, there were relics of past categories and newer categories that did not fit a clear set of criteria. To improve this work, CLF could create a clear set of criteria for the inclusion/exclusion of materials and products in the Baseline categories. Public input is welcome to help inform useful categories. CLF was interested in adding an asphalt category but did not have the time and resources to include it in this year’s report.

### Establishing baselines using the Product method

In all but one case, CLF was not confident that the collection of available product EPDs represented the entire industry. Due to the current scarcity of information on industry production quantities and the unequal representation of high- and low-carbon products in the current selection of available EPDs, it was challenging to evaluate the collection of product EPDs against Section 5.3 of ISO 21930:2017. To improve this report, CLF could allocate more time and resources to conduct a more detailed evaluation of representativeness for the collection of product EPDs. This work could involve collaboration with industry associations and/or groups of manufacturers to help characterize existing EPD data relative to the rest of the industry. Additionally, there may be opportunities to develop Baselines that represent a subset of IW products or manufacturers in material categories that currently lack comprehensive IW-EPDs.

## Comparability

Uncertainty is typically not included in LCA results nor incorporated into EPD values. Additionally, in each of the broad categories and many of the narrower product types, there are EPDs for multiple unique products with unique performance characteristics that are not always possible to identify from the data currently included in EPDs. To improve this report, PCRs could include methods for calculating uncertainty and be more prescriptive of upstream data choices when supply chain-specific data is not being used. Additionally, the inclusion of better descriptions of product performance characteristics and the creation of a digital EPD system could help overcome these limits through more efficient sorting and grouping of product types that have equivalent performance characteristics.

## ENGAGING AND HELPING REFINE THIS WORK

We are actively looking for help in refining these methods, and look forward to helping accelerate the standardization of calculating and reporting uncertainty and variability in EPDs to improve the quality, quantity, accessibility, and comparability of embodied carbon data. If you have questions or are interested in engaging and helping to refine this work, please email [clinfo@uw.edu](mailto:clinfo@uw.edu).

# 2023 BASELINES VALUES

## General Notes

- Baseline GWP values represent life cycle stages A1-A3 unless stated otherwise.
- Baseline GWP values are representative of North American manufacturing, acknowledging global trade for upstream supply chain materials.
- Generally, the Baseline GWP values use the same number of significant digits used in the original data source. Where CLF performs a calculation to establish a baseline GWP value (e.g., averaging multiple values or converting between fabricated and unfabricated steel product GWP), these values are rounded to two or three significant digits.
- Category appendices include full citations for the data sources listed here.

**Table 1: USA Ready-Mixed Concrete Regional and National Baselines**

	2500 psi (17.2 MPa)	3000 psi (20.7 MPa)	4000 psi (27.6 MPa)	5000 psi (34.5 MPa)	6000 psi (41.4 MPa)	8000 psi (55.1 MPa)	LW 3000 psi (20.7 MPa)	LW 4000 psi (27.6 MPa)	LW 5000 psi (34.5 MPa)
<b>Pacific Southwest</b>	257	279	323	378	401	456	500	546	594
<b>Pacific Northwest</b>	235	261	316	386	408	487	518	575	632
<b>Rocky Mountains</b>	232	255	301	358	379	440	484	532	580
<b>South Central</b>	226	245	286	336	356	409	468	510	555
<b>North Central</b>	241	264	312	372	394	460	487	537	591
<b>Southeastern</b>	247	268	309	360	382	435	478	521	562
<b>Great Lakes</b>	232	255	303	363	383	452	499	551	603
<b>Eastern</b>	240	264	314	378	399	472	517	573	628
<b>National</b>	240	262	308	365	385	446	492	540	588

**Notes:** All values are Baseline GWP (kg CO<sub>2</sub>e / m<sup>3</sup>).

**Data Source:** NRMCA. (2022). *National and regional LCA benchmark (industry average) report - v3.2*

**Table 2: Canadian Ready-Mixed Concrete Regional Baselines**

	15 MPa	20 MPa	25 MPa	30 MPa	32 MPa	35 MPa	40 MPa	45 MPa	50 MPa	55 MPa	60 MPa	70 MPa	80 MPa	
<b>British Columbia</b>	with AEs	--	193.86	230.52	269.83	285.31	310.51	344.04	355.65	345.16	402.11	421.88	--	--
	without AEs	179.42	194.73	219.7	258.92	272.44	293.75	329	335.06	359.49	376.56	400.43	--	--
<b>Alberta</b>	with AEs	--	273.04	318.42	368.87	396.85	409.82	426.88	464.66	488.29	466.27	--	--	--
	without AEs	--	260.95	306.32	334.47	313.61	328.02	418.44	--	447.4	--	--	--	--
<b>Saskatchewan</b>	with AEs	--	--	312.83	346.17	379.55	417.21	441.57	473.78	--	--	--	--	--
	without AEs	--	--	296.06	317.39	338.27	358.43	414.04	458.41	--	--	--	--	--
<b>Manitoba</b>	with AEs	--	203.52	229.86	252.54	277.07	297.58	308.87	361.69	395.93	--	--	--	--
	without AEs	--	202.25	223.41	245.92	--	268.42	289.75	333.45	367.01	--	--	--	--
<b>Ontario</b>	with AEs	--	227.16	260.64	292.72	326.46	334.49	361.65	379.45	456.93	--	--	--	--
	without AEs	--	220.29	254.05	264.38	264.38	295.46	326.25	349.88	335.76	354.67	361.25	354.42	--
<b>Quebec</b>	with AEs	--	278.1	298.87	342.52	362.8	393.24	396.62	413.72	410.8	--	444.71	--	--
	without AEs	--	263.8	287.42	307.09	--	345.4	364.24	381.16	404.38	--	424.74	--	485.72
<b>Atlantic</b>	with AEs	--	343.96	360.99	394.38	438.78	447.25	474.19	528.55	551.01	--	--	--	--
	without AEs	--	336.63	354.02	379.12	--	422.25	449.16	501.86	536.01	--	580.21	--	--

**Notes:** All values are Baseline GWP (kg CO<sub>2</sub>e / m<sup>3</sup>). Canadian ready-mixed concrete industry EPDs provide multiple baseline mixes per strength value in some cases. Where available, CLF included baseline values for one mix with air-entraining admixtures (AEAs), and one without.

**Data Source:** Concrete BC. (2022). *Concrete BC member industry-wide EPD for ready-mixed concrete*; Concrete Alberta (2022). *Concrete Alberta member industry-wide EPD for ready-mixed concrete*; Concrete Saskatchewan. (2022). *Member industry-wide EPD for ready-mixed concrete*; Concrete Manitoba. (2022). *Member industry-wide EPD for ready-mixed concrete*; Concrete Ontario. (2022). *Member industry-wide EPD for ready-mixed concrete*; Association Béton Québec. (2022). *Member industry-wide EPD for ready-mixed concrete*; Atlantic Concrete Association. (2022). *Member industry-wide EPD for ready-mixed concrete*.

**Table 3: North American Material Baselines (ready-mixed concrete in Table 1+2)**

Category	Product Type	Description	CLF Baseline GWP (kg CO2e per declared unit)	Declared Unit	Method	Additional Life Cycle Stages Reported in Appendix?	Data Source and Notes
<b>Concrete</b>							
Flowable fill Appendix B-3	Flowable fill	Normal weight mixes for compressive strengths: 100 psi, 150 psi, 200 psi, 500 psi, and 1000 psi	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.
Shotcrete Appendix B-4	Shotcrete	Normal weight mixes for compressive strengths: 3000 psi, 4000 psi, 5000 psi, 6000 psi, and 8000 psi	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.
Cement grout Appendix B-5	Cement grout	Normal weight mixes for compressive strengths: 2500 psi, 3000 psi, 4000 psi, 5000 psi, and 6000 psi	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.
Cement Appendix B-6	Portland cement	Portland cement that conforms to ASTM C150 (USA) and/or CSA A3001 (Canada); includes a range of subtypes	922	1 metric ton	Industry	<input type="checkbox"/>	PCA. (2021). Environmental product declaration - Portland cement.
Cement Appendix B-6	Blended hydraulic cement	Per ASTM C219 and specified in ASTM C595, ASTM C1157, AASHTO M 240, or CSA A3001; includes a range of blended cement subtypes	742	1 metric ton	Industry	<input type="checkbox"/>	PCA. (2021). Environmental product declaration - Blended hydraulic cement.
Cement Appendix B-6	Portland-limestone cement	Conforms to ASTM C595 Type 1L (USA) or Type GUL (Canada); limestone content is >5% and ≤15% by mass	846	1 metric ton	Industry	<input type="checkbox"/>	PCA. (2021). Environmental product declaration - Portland-limestone cement.
Cement Appendix B-6	Masonry Cement	Per ASTM C219 and specified in ASTM C91 or CSA A3002; includes multiple subtypes	589	1 metric ton	Industry	<input type="checkbox"/>	PCA. (2021). Environmental product declaration - Masonry cement .
<b>Masonry</b>							
<b>North America</b>							
Concrete masonry units Appendix C-1	CMU - North America	CMU, including normal-, medium-, and light-weight products	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.
<b>Canada, East</b>							
Concrete masonry units Appendix C-1	CMU - Eastern Canada, lightweight	Lightweight CMU produced in Eastern Canada	170	1 m3	Industry	<input type="checkbox"/>	CCMPA. (2022). Environmental product declaration - Normal weight and lightweight concrete block masonry units. Average of Canada East, Lightweight CMU: 176.54 kg CO2e. GU SCM 164.16 kg CO2e. GUL SCM
Concrete masonry units Appendix C-1	CMU - Eastern Canada, normal weight	Normal weight CMU produced in Eastern Canada	200	1 m3	Industry	<input type="checkbox"/>	CCMPA. (2022). Environmental product declaration - Normal weight and lightweight concrete block masonry units. Average of Canada East, Normal weight CMU: 205.38 kg CO2e. GU SCM 190.58 kg CO2e. GUL SCM
<b>Canada, West</b>							
Concrete masonry units Appendix C-1	CMU - Western Canada, lightweight	Lightweight CMU produced in Western Canada	210	1 m3	Industry	<input type="checkbox"/>	CCMPA. (2022). Environmental product declaration - Normal weight and lightweight concrete block masonry units. Average of Canada West, Lightweight CMU: 213.94 kg CO2e. GU SCM 197.93 kg CO2e. GUL SCM
Concrete masonry units Appendix C-1	CMU - Western Canada, normal weight	Normal weight CMU produced in Western Canada	240	1 m3	Industry	<input type="checkbox"/>	CCMPA. (2022). Environmental product declaration - Normal weight and lightweight concrete block masonry units. Average of Canada West, Normal weight CMU: 251.64 kg CO2e. GU SCM 232.28 kg CO2e. GUL SCM
<b>Steel</b>							
Rebar Appendix D-2	Rebar - unfabricated	Unfabricated steel reinforcement bar, including plain carbon steel and low-alloy steel bars of multiple grades and sizes	753	1 metric ton	Industry	<input type="checkbox"/>	CRSI. (2022). Environmental product declaration - Steel reinforcement bar. Converted to unfabricated product GWP. See appendix for details.
Rebar Appendix D-2	Rebar - fabricated	Fabricated steel reinforcement bar, including plain carbon steel and low-alloy steel bars of multiple grades and sizes	854	1 metric ton	Industry	<input type="checkbox"/>	CRSI. (2022). Environmental product declaration - Steel reinforcement bar.

**Table 3: North American Material Baselines (ready-mixed concrete in Table 1+2) (cont.)**

Category	Product Type	Description	CLF Baseline GWP (kg CO2e per declared unit)	Declared Unit	Method	Additional Life Cycle Stages Reported in Appendix?	Data Source and Notes
Steel wire and mesh Appendix D-3	Steel wire and mesh	Steel wire and mesh for concrete reinforcement	None	1 metric ton	--	<input type="checkbox"/>	No adequately representative data source.
Structural steel Appendix D-4	Hot-rolled sections - unfabricated	Unfabricated hot-rolled steel shapes for structural applications, including: wide flange and other beams, channels, angles, and tees	1,000	1 metric ton	Industry	<input type="checkbox"/>	AISC. (2021). Environmental product declaration - Fabricated hot-rolled sections. Converted to unfabricated product GWP. See appendix for details.
Structural steel Appendix D-4	Hot-rolled sections - fabricated	Fabricated hot-rolled steel shapes for structural applications, including: wide flange and other beams, channels, angles, and tees	1,220	1 metric ton	Industry	<input type="checkbox"/>	AISC. (2021). Environmental product declaration - Fabricated hot-rolled sections.
Structural steel Appendix D-4	Plate steel - unfabricated	Unfabricated flat steel products (generally thicker than 6 mm or ¼") for structural applications	1,480	1 metric ton	Industry	<input type="checkbox"/>	AISC. (2021). Environmental product declaration - Fabricated steel plate. Converted to unfabricated product GWP. See appendix for details.
Structural steel Appendix D-4	Plate steel - fabricated	Fabricated flat steel products (generally thicker than 6 mm or ¼") for structural applications	1,730	1 metric ton	Industry	<input type="checkbox"/>	AISC. (2021). Environmental product declaration - Fabricated steel plate.
Structural steel Appendix D-4	Hollow structural sections (HSS) - unfabricated	Unfabricated hollow steel sections (square, rectangle, circle) for structural applications	1,710	1 metric ton	Industry	<input type="checkbox"/>	STI. (2021). Environmental product declaration - Hollow structural sections.
Structural steel Appendix D-4	Hollow structural sections (HSS) - fabricated	Fabricated hollow steel sections (square, rectangle, circle) for structural applications	1,990	1 metric ton	Industry	<input type="checkbox"/>	AISC. (2021). Environmental product declaration - Fabricated hollow structural sections.
Cold-formed steel framing Appendix D-5	Cold-formed steel framing	Galvanized cold-formed steel shapes for light framing, such as studs and track	2,440	1 metric ton	Industry	<input type="checkbox"/>	SFIA. (2021). Cold-formed steel framing.
Open-web steel joists Appendix D-6	Open-web steel joists	Prefabricated steel joists and girders with open middle web and top and bottom chords	1,430	1 metric ton	Industry	<input type="checkbox"/>	SJI. (2022). Environmental product declaration - Open web steel joists and joist girders.
Steel decking Appendix D-7	Steel decking	Includes range of surface treatments (galvanized or uncoated steel to which paint may be applied) and thickness/gauge.	2,320	1 metric ton	Industry	<input type="checkbox"/>	SDI. (2022). Environmental product declaration - Steel roof and floor deck.
<b>Aluminum</b>							
Aluminum extrusions Appendix E-1	Aluminum extrusions - mill finish	Standard (non-thermally-improved) extrusions with mill finish (no additional surface treatment)	10,250	1 metric ton	Industry	<input checked="" type="checkbox"/>	AEC. (2022). Environmental product declaration - Aluminum extrusions - mill finished, painted, and anodized.
Aluminum extrusions Appendix E-1	Aluminum extrusions - painted	Standard (non-thermally-improved) extrusions with paint finish	11,670	1 metric ton	Industry	<input checked="" type="checkbox"/>	AEC. (2022). Environmental product declaration - Aluminum extrusions - mill finished, painted, and anodized.
Aluminum extrusions Appendix E-1	Aluminum extrusions - anodized	Standard (non-thermally-improved) extrusions with anodized finish	10,760	1 metric ton	Industry	<input checked="" type="checkbox"/>	AEC. (2022). Environmental product declaration - Aluminum extrusions - mill finished, painted, and anodized.
Aluminum extrusions Appendix E-1	Thermally-improved aluminum extrusions - painted	Thermally-improved extrusions for exterior envelope assemblies (e.g., curtain wall, storefront, etc.) with paint finish	12,700	1 metric ton	Industry	<input checked="" type="checkbox"/>	AEC. (2022). Environmental product declaration - Thermally improved aluminum extrusions - painted and anodized.
Aluminum extrusions Appendix E-1	Thermally-improved aluminum extrusions - anodized	Thermally-improved extrusions for exterior envelope assemblies (e.g., curtain wall, storefront, etc.) with anodized finish	11,800	1 metric ton	Industry	<input checked="" type="checkbox"/>	AEC. (2022). Environmental product declaration - Thermally improved aluminum extrusions - painted and anodized.
<b>Wood and Composites</b>							
Wood framing Appendix F-1	Wood framing	Dimensional softwood framing lumber; generally excludes decking lumber (e.g., redwood)	63.12	1 m3	Industry	<input type="checkbox"/>	AWC. (2020). Environmental product declaration - North American softwood lumber.
Structural composite lumber Appendix F-2	Laminated Veneer Lumber (LVL)	Includes LVL of different sizes, structural capacity, and structural applications	361.45	1 m3	Industry	<input type="checkbox"/>	AWC. (2020). Environmental product declaration - North American laminated veneer lumber.
Structural composite lumber Appendix F-2	Laminated Strand Lumber (LSL)	Includes LSL of different sizes, structural capacity, and structural applications	274.9	1 m3	Industry	<input type="checkbox"/>	AWC. (2021). Environmental product declaration - North American laminated strand lumber.
Structural composite lumber Appendix F-2	Oriented Strand Lumber (OSL)	Includes OSL of different sizes, structural capacity, and structural applications	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.

**Table 3: North American Material Baselines (ready-mixed concrete in Table 1+2) (cont.)**

Category	Product Type	Description	CLF Baseline GWP (kg CO2e per declared unit)	Declared Unit	Method	Additional Life Cycle Stages Reported in Appendix?	Data Source and Notes
Structural composite lumber Appendix F-2	Parallel Strand Lumber (PSL)	Includes PSL of different sizes, structural capacity, and structural applications	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.
Mass timber panels Appendix F-3	Cross Laminated Timber (CLT)	Structural panels composed of dimensional lumber and adhesives	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.
Mass timber panels Appendix F-3	Nail Laminated Timber (NLT)	Structural panels composed of dimensional lumber and nails	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.
Mass timber panels Appendix F-3	Dowel Laminated Timber (DLT)	Structural panels composed of dimensional lumber and dowels	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.
Mass timber panels Appendix F-3	Mass ply panel (MPP)	Structural panels composed of multiple thin wood veneers bonded with resin adhesives	none	1 m3	--	<input type="checkbox"/>	No adequately representative data source.
Glue laminated timber Appendix F-4	Glue laminated timber (GLT)	Includes GLT products of different shapes, sizes, and configurations	137.19	1 m3	Industry	<input type="checkbox"/>	AWC. (2020). Environmental product declaration - North American glue laminated timber.
Wood sheathing Appendix F-5	Softwood plywood	Includes all thicknesses of softwood plywood	219.32	1 m3	Industry	<input type="checkbox"/>	AWC. (2020). Environmental product declaration - North American softwood plywood.
Wood sheathing Appendix F-5	Oriented Strand Board (OSB)	Includes all thicknesses of oriented strand board	242.58	1 m3	Industry	<input type="checkbox"/>	AWC. (2020). Environmental product declaration - North American oriented strand board.
Glass-mat gypsum board Appendix F-6	Glass-mat gypsum board: 1/2" (12.7 mm)	Non-combustible gypsum core with glass-mat surface on each side, 1/2" regular board	437.4	1000 ft2	Industry	<input type="checkbox"/>	GA. (2021). An industry-wide cradle-to-gate EPD for 1/2" and 5/8" glass-mat gypsum boards.
Glass-mat gypsum board Appendix F-6	Glass-mat gypsum board: 5/8" (15.9 mm)	Non-combustible, water-resistant gypsum core with glass-mat surface on each side, 5/8" type X board	503.9	1000 ft2	Industry	<input type="checkbox"/>	GA. (2021). An industry-wide cradle-to-gate EPD for 1/2" and 5/8" glass-mat gypsum boards.
Wood I-joists Appendix F-7	Wood I-joists	Includes wood I-joists of different sizes, materials (softwood or LVL for the chords and plywood or OSB for the web), and structural capacity	none	1 m	--	<input type="checkbox"/>	No adequately representative data source.
<b>Insulation</b>							
Board insulation Appendix G-1	Expanded polystyrene (EPS)	EPS Type I closed-cell rigid foam board insulation	2.67	1 m2 @ RSI-1	Industry	<input checked="" type="checkbox"/>	EPS-IA. (2017). Environmental product declaration - Expanded polystyrene insulation. Scope includes A1-A3, B1, & C4. See appendix for details.
Board insulation Appendix G-1	Polyiso - wall	Polyisocyanurate closed-cell rigid foam board for wall applications with glass-reinforced aluminum foil facers	4.19	1 m2 @ RSI-1	Industry	<input checked="" type="checkbox"/>	PIMA. (2020). Environmental product declaration - Polyiso wall insulation boards. Scope includes A1-A3, B1, & C4. See appendix for details.
Board insulation Appendix G-1	Polyiso - roof - GRF facer	Polyisocyanurate closed-cell rigid foam board for roof applications with glass-fiber-reinforced cellulosic facers	2.20	1 m2 @ RSI-1	Industry	<input checked="" type="checkbox"/>	PIMA. (2020). Environmental product declaration - Polyiso roof insulation boards. Scope includes A1-A3, B1, & C4. See appendix for details.
Board insulation Appendix G-1	Polyiso - roof - CFG facer	Polyisocyanurate closed-cell rigid foam board for roof applications with polymer-bonded coated glass facers	3.04	1 m2 @ RSI-1	Industry	<input checked="" type="checkbox"/>	PIMA. (2020). Environmental product declaration - Polyiso roof insulation boards. Scope includes A1-A3, B1, & C4. See appendix for details.
Board insulation Appendix G-1	Extruded polystyrene (XPS)	Extruded polystyrene closed-cell foam board insulation; conventional HFC- and/or lower-GWP blowing agent	41	1 m2 @ RSI-1	Product	<input checked="" type="checkbox"/>	Average calculated from collection of 6 product EPDs. Scope includes A1-A3, B1, & C4. See appendix for details and citations.
Board insulation Appendix G-1	Heavy density mineral wool board	Semi-rigid mineral wool (natural rock and/or slag fibers) board insulation, 70 - 128 kg/m3 (4.4 - 8 lbs/ft3)	8.35	1 m2 @ RSI-1	Industry	<input checked="" type="checkbox"/>	NAIMA. (2018). Environmental product declaration - Mineral wool board. Scope includes A1-A3, B1, & C4. See appendix for details.
Blanket insulation Appendix G-2	Mineral wool blanket	Flexible insulating mineral wool (natural rock and/or slag fibers) batts, rolls, or light-density boards, 40 - 69 kg / m3 (2.5 - 4.3 lbs / ft3).	3.33	1 m2 @ RSI-1	Industry	<input checked="" type="checkbox"/>	NAIMA. (2018). Environmental product declaration - Mineral wool board.
Blanket insulation Appendix G-2	Fiberglass blanket	Flexible insulating fiberglass batts or rolls.	None	1 m2 @ RSI-1	--	<input type="checkbox"/>	No adequately representative data source.

**Table 3: North American Material Baselines (ready-mixed concrete in Table 1+2) (cont.)**

Category	Product Type	Description	CLF Baseline GWP (kg CO2e per declared unit)	Declared Unit	Method	Additional Life Cycle Stages Reported in Appendix?	Data Source and Notes
Foamed-in-place insulation Appendix G-3	Closed-cell spray polyurethane foam - medium density	Medium density closed-cell SPF, typ 1.5-2.5 pcf (24-40 kg/m <sup>3</sup> ), HFC or HFO blowing agent	12.1	1 m <sup>2</sup> @ RSI-1	Industry	<input checked="" type="checkbox"/>	Average of closed-cell SPF IW-EPDs: SPFA. (2018). Environmental product declaration - spray polyurethane foam insulation (HFC) and (HFO). Scope includes A1-3, A5, B1, & C4. 20.1 kg CO2e. (HFC) 4.04 kg CO2e. (HFO)
Foamed-in-place insulation Appendix G-3	Closed-cell spray polyurethane foam - roofing	High density closed-cell SPF, typ 2.5-4.0 pcf (40-64 kg/m <sup>3</sup> ), HFC or HFO blowing agent	15.5	1 m <sup>2</sup> @ RSI-1	Industry	<input checked="" type="checkbox"/>	Average of roofing SPF IW-EPDs: SPFA. (2018). Environmental product declaration - spray polyurethane foam insulation (HFC) and (HFO). Scope includes A1-3, A5, B1, & C4. 26.3 kg CO2e. SPFA. (HFC). 4.8 kg CO2e. SPFA. (2018). (HFO).
Foamed-in-place insulation Appendix G-3	Closed-cell spray polyurethane foam - 2K-LP	Two component, low pressure foam, typ 1.8-2.0 pcf (29-32 kg/m <sup>3</sup> ), HFC or HFO blowing agent	19.7	1 m <sup>2</sup> @ RSI-1	Industry	<input checked="" type="checkbox"/>	Average of 2k_LP SPF IW-EPDs: SPFA. (2018). Environmental product declaration - spray polyurethane foam insulation (HFC) and (HFO). Scope includes A1-3, A5, B1, & C4. 35.7 kg CO2e. (HFC). 3.7 kg CO2e. (HFO).
Foamed-in-place insulation Appendix G-3	Open-cell spray polyurethane foam	Open-cell SPF using reactive blowing agent (water)	1.6	1 m <sup>2</sup> @ RSI-1	Industry	<input checked="" type="checkbox"/>	SPFA. (2018). Environmental product declaration - spray polyurethane foam insulation (HFC) and (HFO). Scope includes A1-A3, A5, B1, & C4.
Loose-fill insulation Appendix G-4	Loose-fill cellulose	Cellulose unbonded loose-fill insulation	0.487	1 m <sup>2</sup> @ RSI-1	Industry	<input checked="" type="checkbox"/>	CIMA. (2019). Industry-wide type III EPD - Conventional loose-fill cellulose insulation.
Loose-fill insulation Appendix G-4	Loose-fill mineral wool	Mineral wool (natural rock and/or slag fibers) unbonded loose-fill insulation	1.56	1 m <sup>2</sup> @ RSI-1	Industry	<input checked="" type="checkbox"/>	NAIMA. (2018). Environmental product declaration - Mineral wool loose-fill.
Loose-fill insulation Appendix G-4	Loose-fill fiberglass	Fiberglass unbonded loose-fill insulation	None	1 m <sup>2</sup> @ RSI-1	--	<input type="checkbox"/>	No adequately representative data source.
<b>Cladding &amp; Roofing</b>							
Metal panel cladding Appendix H-1	Roll-formed metal panel - steel	Roll-formed steel cladding panel such as standing seam or box rib; includes products of various thickness and coating options	1,530	100 m <sup>2</sup>	Industry	<input type="checkbox"/>	MCA. (2020). Environmental product declaration - Roll formed cladding.
Metal panel cladding Appendix H-1	Roll-formed metal panel - aluminum	Roll-formed aluminum cladding panel such as standing seam or box rib; includes products of various thickness and coating options	1,860	100 m <sup>2</sup>	Industry	<input type="checkbox"/>	MCA. (2020). Environmental product declaration - Roll formed cladding.
Metal panel cladding Appendix H-1	Metal composite material (MCM) panel	Sandwich panel composed of metal skins and thin polyethylene or fire-resistant core	2,800	100 m <sup>2</sup>	Industry	<input type="checkbox"/>	MCA. (2020). Environmental product declaration - Metal composite material wall and roof panel systems.
Insulated metal panel cladding Appendix H-2	Insulated metal panel (IMP)	Sandwich panel composed of metal skins and insulation core for exterior cladding; includes a range of metal types, metal gauge, and insulation thickness/R-value	none	100 m <sup>2</sup>	--	<input type="checkbox"/>	No adequately representative data source.
Membrane roofing Appendix H-3	Single ply membrane roofing - PVC (40 mils)	Single ply PVC membrane roofing at 40 mil thickness	4.2	1 m <sup>2</sup>	Industry	<input checked="" type="checkbox"/>	CFFA. (2020). Industry average EPD of CFFA SPPR PVC roofing membranes.
Membrane roofing Appendix H-3	Single ply membrane roofing - PVC (48 mils)	Single ply PVC membrane roofing at 48 mil thickness	5.2	1 m <sup>2</sup>	Industry	<input checked="" type="checkbox"/>	CFFA. (2020). Industry average EPD of CFFA SPPR PVC roofing membranes.
Membrane roofing Appendix H-3	Single ply membrane roofing - PVC (60 mils)	Single ply PVC membrane roofing at 60 mil thickness	6.3	1 m <sup>2</sup>	Industry	<input checked="" type="checkbox"/>	CFFA. (2020). Industry average EPD of CFFA SPPR PVC roofing membranes.
Membrane roofing Appendix H-3	Single ply membrane roofing - PVC (80 mils)	Single ply PVC membrane roofing at 80 mil thickness	8.3	1 m <sup>2</sup>	Industry	<input checked="" type="checkbox"/>	CFFA. (2020). Industry average EPD of CFFA SPPR PVC roofing membranes.
<b>Openings</b>							
Flat glass Appendix J-1	Flat glass panes	Clear, low-iron, and tinted glass products that have been manufactured in an unprocessed annealed state.	1,430	1 metric ton	Industry	<input type="checkbox"/>	NGA. (2019). Environmental product declaration - Flat glass.
Processed glass Appendix J-2	Processed glass panes	Flat glass that has undergone one or more of the following processing techniques: coating, laminating, heat treatment, or mechanical or chemical processing.	none	1 m <sup>2</sup>	--	<input type="checkbox"/>	No adequately representative data source.

**Table 3: North American Material Baselines (ready-mixed concrete in Table 1+2) (cont.)**

Category	Product Type	Description	CLF Baseline GWP (kg CO2e per declared unit)	Declared Unit	Method	Additional Life Cycle Stages Reported in Appendix?	Data Source and Notes
Insulated glass units Appendix J-3	Insulated Glass Units (IGUs)	Includes multiple glass panes, spacer(s), desiccant, sealants, and any interlayer materials. Window Frames are excluded.	none	1 m2	--	<input type="checkbox"/>	No adequately representative data source.
<b>Finishes</b>							
Gypsum board Appendix K-1	Gypsum board: 1/2" Lightweight	1/2" thick gypsum board, excluding mold and moisture resistant (MMR), fiberglass-reinforced, or glass-mat products	207	1000 ft2	Industry	<input type="checkbox"/>	ASMI. (2020). An industry average cradle-to-gate life cycle assessment of 1/2" lightweight and 5/8" type X conventional gypsum board for the USA and Canadian markets.
Gypsum board Appendix K-1	Gypsum board: 5/8" Type X	5/8" thick Type X gypsum board, excluding mold and moisture resistant (MMR), fiberglass-reinforced, or glass-mat products	277	1000 ft2	Industry	<input type="checkbox"/>	GA. (2020). Industry average EPD for 5/8" type X conventional gypsum board.
Acoustical ceiling tiles Appendix K-2	Acoustical ceiling tiles	Includes ACT products with a range of core materials, NRC and CAC ratings, and panel thicknesses.	none	1 ft2	--	<input checked="" type="checkbox"/>	No adequately representative data source.
Resilient flooring Appendix K-3	Homogeneous Vinyl Flooring	Vinyl flooring with uniform structure and composition from top to bottom	8.84	1 m2	Industry	<input checked="" type="checkbox"/>	RFCI. (2019). Environmental product declaration - Homogeneous vinyl flooring.
Resilient flooring Appendix K-3	Heterogeneous Vinyl Flooring	Vinyl flooring with separate layers for wear, decor/pattern, reinforcement, and/or backing	7.04	1 m2	Industry	<input checked="" type="checkbox"/>	RFCI. (2019). Environmental product declaration - Heterogeneous vinyl flooring.
Resilient flooring Appendix K-3	Rubber Flooring	Homogeneous (uniform) or heterogeneous (layered) flooring made from synthetic and/or natural rubber.	15.6	1 m2	Industry	<input checked="" type="checkbox"/>	RFCI. (2019). Environmental product declaration - Rubber flooring.
Resilient flooring Appendix K-3	Vinyl Composition Tile (VCT)	Homogeneous (uniform) flooring product made from calcium carbonate (limestone), with smaller amounts of PVC, plasticizers, and additives.	4.96	1 m2	Industry	<input checked="" type="checkbox"/>	RFCI. (2019). Environmental product declaration - Vinyl composition tile.
Resilient flooring Appendix K-3	Vinyl Tile	Resilient flooring made from calcium carbonate (limestone), with smaller amounts of PVC, plasticizers, additives, and in some cases fiberglass; includes products described as "vinyl tile," "solid vinyl tile," and "luxury vinyl tile"	11.9	1 m2	Industry	<input checked="" type="checkbox"/>	RFCI. (2019). Environmental product declaration - Vinyl tile.
Resilient flooring Appendix K-3	Rigid Core Flooring	Layered vinyl flooring with rigid core made from calcium carbonate (limestone), with smaller amounts of PVC, plasticizers, and additives	20.5	1 m2	Industry	<input checked="" type="checkbox"/>	RFCI. (2019). Environmental product declaration - Rigid core flooring.
Carpet Appendix K-4	Carpet	Carpet tile for commercial applications	none	1 m2	--	<input checked="" type="checkbox"/>	No adequately representative data source.
<b>Communications</b>							
Data cabling Appendix L-1	Fiber data cabling	Optical fiber cable with voice, data, and power over ethernet (PoE) applications	none	1 m	--	<input type="checkbox"/>	No adequately representative data source.
Data cabling Appendix L-1	Twisted pair data cabling	Twisted copper cable (Category 3-7)	none	1 m	--	<input type="checkbox"/>	No adequately representative data source.