2021 Carbon Leadership Forum

Material Baselines

BASELINE REPORT v2 | July 2021

Carbon Leadership Forum

ABOUT THE CARBON LEADERSHIP FORUM

The Carbon Leadership Forum is a non-profit industry-academic collaborative at the University of Washington. We are architects, engineers, contractors, material suppliers, building owners, and policymakers who work collaboratively, pioneering research, creating resources, and incubating member-led initiatives for greatest collective impact. Our goal is to accelerate transformation of the building sector to radically reduce and ultimately eliminate the embodied carbon in building materials and construction.

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ACKNOWLEDGMENTS

The research team would like to thank Building Transparency and the Pankow Foundation for supporting this research. This document supersedes the EC3 Beta Baseline documents published in 2019 and updated in 2020. We would like to thank Stacy Smedly, Phil Northcott, Vaclav Hasik, and Mikaela DeRousseau from Building Transparency for their review and work on the EC3 tool, and Vaclav Hasik and Mikaela DeRousseau for their LCA and EPD data analysis that informed these findings.

CITATION

Carlisle, S., Waldman, B., Lewis, M., and Simonen, K. (2021). 2021 Carbon Leadership Forum Material Baseline Report. (version 2). Carbon Leadership Forum, University of Washington. Seattle, WA. July 2021. http://hdl.handle.net/1773/47141

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INTRODUCTION

The building industry has an essential role to play in tackling climate change associated with building construction and materials manufacturing. Our present understanding of the importance of embodied carbon has been enabled by rigorous quantitative modeling that tracks carbon emissions across the full life of materials and products, using **life cycle assessment (LCA)**.[1] In recent years, the building industry has adopted LCA as the globally accepted method for evaluating and communicating environmental impacts, and applied these methods to the study of materials, products, and assemblies. LCA data and results are essential for guiding science-based efforts to decarbonize buildings and infrastructure.

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. It is essential that designers, owners, and policymakers have access to verified, third-party reviewed and published data on building materials and products in order 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 scopes.

The development of material baselines originated in support of the Embodied Carbon in Construction Calculator (EC3) tool, which aims to collect all third-part-reviewed EPDs for published categories. The EC3 Baselines were originally published in 2019. This document supersedes those and the 2021 CLF Material Baseline Report version 1. (See the *Updates* section for a list of changes since the previous version.) The EC3 tool and its open-access database of digital EPDs is one source for accessing and evaluating available EPDs and the relative carbon impacts that they report. Such databases support designers, owners, and policymakers in selecting low-carbon products during procurement and design. These databases are dynamic, updated constantly as new products are added and upstream data on key processes, such as carbon intensity of regional electricity grids, are revised.

In order to set achievable targets, it is necessary to have a baseline from which to compare products within a material or product category. This document provides an overview of the 2021 CLF Material Baselines published by the CLF. This report constitutes an update to 2019 Beta Baselines and 2021 CLF Material Baselines Report version 1 with improved data sourcing, citation, and categories.

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

Life Cycle assessment (LCA)

LCA is a systematic methodology for compiling and examining the inputs and outputs of materials and energy, and the associated environmental impacts directly attributable to a building, infrastructure, product or material throughout its lifecycle (ISO 14040: 2006).

Environmental Product Declaration (EPD)

EPDs are third party-verified documents based on LCA models, written in conformance with international standards, that report the environmental impacts of a product.

BASELINE DEFINITION AND USE

Globally, the availability of embodied carbon data for materials and products is growing as more and more manufacturers produce EPDs and make the environmental impacts of their supply chains known. Still, the publication of EPDs and other carbon disclosure is voluntary and its adoption has been uneven. Because not all products or manufacturers are currently represented in public databases such as EC3, the ranges reported will very likely continue to be low estimates of the full material supply chain's carbon impacts, representing manufacturers that have voluntarily chosen to disclose the carbon footprint of their products. Due to the dynamic nature of these datasets, users have identified the need for a static baseline to compare results against, and against which they can set measurable targets.

Presently, the CLF publishes three figures in order to provide a picture of variability within a product category, according to the best publicly available data: High, Median, and Low. **The baselines are intended to give a rough order of magnitude of embodied carbon impacts per category reflecting the significant variability of product manufacturing and uncertainty of LCA data available.** Collectively, these values represent the expected range of embodied carbon impacts for most products in their category, taking variability and uncertainty into account.

The **CLF Baseline** represents a conservative, or "high" estimate for embodied carbon in a product category. This value is intended to give a rough order of magnitude of embodied carbon impacts and represents a high estimate of the embodied carbon footprint of a product if no effort is made to choose a low-carbon alternative. Most products in the category will fall below this threshold. This CLF Baseline number can be considered a good starting point from which to develop carbon caps or reductions. For categories in which there are sufficient product-specific EPDs, the CLF Baseline is tied to the 80th percentile value of the category, (i.e., the point where 80% of the results have values below this number), as represented in the EC3 database of published, peer-reviewed EPD results. The CLF Baseline is shown within the EC3 tool for all public categories.

The CLF "Typical" Estimate represents the median performance of products contained within a category. This value is tied to an industry-average EPD, if one is available and valid at the time of publication. This number can be seen as a typical estimate for the category, representing standard manufacturing practice. As such, it is appropriate to use this number as a rough estimate before products have been selected, or as a default value for broad product comparisons. Industry-average 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.[2] Products covered in an industry-average EPD follow the same Product Category Rule (PCR) and have the same declared unit. All industry-average EPDs

What is a baseline?

A baseline is a static reference against which to compare progress towards a goal. Baseline data enables the tracking of changes or improvements over time and across projects.

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

referenced by the EC3 database are published, peer-reviewed documents based on rigorous LCA models.

The **CLF "Achievable" Estimate** represents an achievable target, or a low value for the category, whereby at least 20% of products meeting the specification are better than this value. For categories in which more than 20 product-specific EPDs are available and where these products represent the range of materials and production expected within the category, this value has been based on 20th percentile figures in the EC3 tool and noted in the data citation. Products that meet this threshold could credibly be considered very low-carbon materials compared to those of similar performance and function. Where there is not yet sufficient data to support a confident estimate of the low value for the category, "TBD" ("to be determined") appears in the table below.

DATA SOURCES

These estimates are created based upon a range of available data including:

- Industry-average EPDs, representing production-weighted averages for a material category.
- Distribution of impacts from all known product-specific EPDs for a product category, at the time of publication.
- Peer-reviewed, published reports on carbon impacts and variability within a material category.
- The Inventory of Carbon and Energy[3] which includes embodied carbon ranges of key materials.

Given that most material product categories currently lack industry-wide embodied carbon data that disclose variability across supply chains and manufacturers, the CLF is estimating these baselines using one of four methods, depending on the quality of available data for a material product category:

Method 1: If industry-specific data exist regarding the range of the emissions in this product category, the ranges used will be extracted from that data and the source will be listed as a primary citation. For example, the CLF Ready Mixed Concrete figures draw from an Industry-Average EPD and also a recently published National and Regional Industry-Average Benchmark Report which discloses variability across regions and mixes per strength class. Both sources of data are published by the National Ready Mixed Concrete Association (NRMCA, 2019 and 2020).[4]

Method 2: If a product category has many EPDs (more than 20 product-specific EPDs are present in the EC3 database), and the products included are assessed to represent the current market, the results of the EC3 tool will be directly used to estimate the baselines. In this case, "High" and "Low" figures are extracted from the EC3 tool. These

3. Circular Ecology, Embodied energy and carbon - The ICE database V3.0 Beta, 2019. http://www.circularecology.com/embodied-energy-and-carbon-footprint-database.html#.XdDAHVdKjD4

4. National Ready Mixed Concrete Association (NRMCA). (2020). Appendix D: NRMCA Member National and Regional LCA Benchmark (Industry Average) Report - Version 3. Athena Sustainable Materials Institute. Retrieved from https://www.nrmca.org/wp-content/uploads/2020/10/NRMCA_REGIONAL_BENCHMARK_April2020.pdf

   National Ready Mixed Concrete Association (NRMCA). (2019). NRMCA Member Industry-Average EPD for Ready Mixed Concrete. NSF. Retrieved from https://www.nrmca.org/wp-content/uploads/2020/02/EPD10080.pdf

represent the 80th and 20th percentiles, respectively, of the distribution of the EPD data in the EC3 tool (including uncertainty factors) at the time of publication. Note that this is an approximation of the 80th percentile due to the lack of data on industry production volumes, which would be needed to make a production-weighted calculation. This method is more appropriate for material categories such as carpet or gypsum board, for which there are hundreds of EPDs representing multiple suppliers and a broad range of product types. When Method 2 is used, the number of EPDs on which the value is based is noted in the "Data Source".

Method 3: If a product category has very few EPDs (less than 20) in the EC3 database or if the available EPDs are understood to not represent the full breadth of the market, then the CLF will estimate the baseline to be either: the industry-average value plus an uncertainty factor to account for variation across the industry, or the midpoint between an industry-average value and an industry-high value for the material category or product sub-type. The industry-average or industry-high values will be obtained from industry-wide EPDs or the Inventory of Carbon and Energy (ICE). This method is used for categories such as wood products in which very few EPDs have been published and in which variability has not been disclosed in industry-wide EPDs or other public reports.

Method 4: If a product category has no industry EPD and very few product EPDs, and there is another CLF Baseline product category with very similar material characteristics (in terms of raw materials, transport, and manufacturing processes), then the CLF will use the second category as a proxy and match its values for the category until better data is available.

None of these methods are statistically exact. 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, these methods are approximations that may be used until better data exists. Ideally this data would be provided directly from LCA studies that have access to the industry-specific production and emissions data. The CLF has made every effort to be fully transparent about the source and quality of data used to establish these baselines on a category-by-category basis.

SCOPE

Baseline figures are representative of North American manufacturing, acknowledging global trade. 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-specific EPDs.[5] Additional impacts from transportation and installation (A4-5) can also be considered in upfront embodied carbon and can be significant for some material categories, but are not includ-

5. Carbon Leadership Forum, "Life Cycle Assessment of Buildings: A Practice Guide," 2018, https://doi.org/http://hdl.handle.net/1773/41885.

ed in these figures, as they are not currently required by many Product Category Rules for publication in Environmental Product Declarations (EPDs). As this data becomes available, it will be important for A4 and A5 impacts to be integrated into procurement decisions.

One notable exception to the A1-3 scope boundary 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 GWP. Disclosing these impacts has been essential for the movement to replace hydrofluorocarbon (HFC) blowing agents with lower global warming potential (GWP) alternatives. Since insulation EPDs are required to include these impacts where applicable, the CLF Baselines for board and foamed-in-place insulations do account for additional lifecycle stages.

COMPARABILITY

Life Cycle Assessment is a comparative practice, and it is important for users to follow best practice in making appropriate comparisons between products and materials. The CLF Baselines represent a rough estimate of a product category's carbon footprint. However, in order to make material comparisons, it is incumbent upon a user to assure that the products, materials, or assemblies are functionally equivalent — i.e., that they serve the same purpose and meet the same performance standards within the building design. Please refer to the Embodied Carbon in the EC3 Tool: Methodology Report for future guidance on making appropriate comparisons.

Additionally, the EPDs in each of the broad categories include many unique products with unique performance characteristics that are not always possible to identify from the data currently included in EPDs. Better descriptions of the performance characteristics and creation of a digital EPD system could help overcome these limits.

The CLF Baseline figures do not represent the impacts associated with the full life cycle of a building assembly. Only the Product Stage (A1-A3) is included, as this represents the scope of most EPDs in the EC3 database. Baseline figures, therefore, do not include Transportation to site (A4), Installation (A5), Use (B1-B3) or End-of-Life (C1-C4) stages. (See note above for exception for insulation materials.) Care should be taken when comparing materials or products with different use or end-of-life scenarios. In order to make cross-category comparisons or to assess a whole building over its full life span, more rigorous modeling must be conducted using a whole building LCA (WBLCA) tool with a full cradle-to-grave scope.

UPDATES

The Carbon Leadership Forum is publishing these baseline figures in support of the EC3 tool and other embodied carbon reduction initiatives, and will endeavor to update them annually. New baseline categories will be added as more EPDs are published and data availability improves in both scope and resolution. These baselines will also be used to test and improve the methods used to assess embodied carbon of materials and products. If you have suggestions or feedback on how we might improve these baselines, please contact clfinfo@uw.edu.

Since the last version of this report (*2021 CLF Material Baselines, version 1.0*), the following changes and improvements have been made, including:

New categories

- Concrete masonry units (CMU)
- Steel wire and mesh
- Steel decking
- Aluminum extrusions
- Thermally improved aluminum extrusions
- Insulated metal panels (IMP)
- Metal roof and wall panels

Updates to previous categories

- Data cabling: reorganized to have three subtypes, based on industry and user input.
- Glass mat gypsum sheathing: updated values to reflect a new industry-wide EPD, split to two subtypes based on thickness, and changed declared unit (1 m2 rather than 1000 m2).
- Gypsum board: changed declared unit (1 m2 rather than 1000 m2).
- Resilient flooring: updated the "typical" value to better reflect the range of products, and to correct previous over-weighting of one industry-wide EPD.

Methodology and documentation updates

- Method 3 includes an additional path for establishing the high baseline value based on the industry average value and an uncertainty factor to account for variation.
- The new Method 4 establishes values for a product type with limited data by using another very similar product type as proxy.
- The Scope section notes an exception (for some foam insulations) to the general rule that the values here apply to A1-A3 impacts only.

ENGAGE AND HELP REFINE

We are actively looking for help in refining these methods, and look forward to helping accelerate the standardization of calculation and reporting of uncertainty and variability in EPDs in order to improve the quality, quantity, and accessibility of embodied carbon data. If you are interested in engaging in the technical committees supporting methodology and data development, please email clfinfo@uw.edu for updates and forums for discussion, feedback, and continued research.

2021 BASELINE FIGURES

Version 2.0, July 2021

		2021 CLF BASELINES v2 kg CO2e per declared unit					
Category	**Subtype**	**Achievable (Low)**	**Typical (Median)**	**Baseline (High)**	**Declared unit**	**Method**	**Data Source & Notes**
CONCRETE							
Ready Mixed Concrete	0-2500 psi (0-17.2 Mpa)	190	266	**340**	m3	1	Typical = NRMCA USA benchmark value per strength class (NRMCA, 2020, Table E1); Low = IW-EPD Ready Mixed Concrete (NRMCA, 2019) minimum value per strength class; High = IW-EPD Ready Mixed Concrete (NRMCA, 2019) maximum value per strength class + uncertainty factor to account for cement variation (Building Transparency analysis, citation forthcoming). Note that the NRMCA Industry Average EPD (NRMCA, 2019) provides data for strength ranges (e.g., 3001 - 4000 psi), while the NRMCA Benchmark Report (NRMCA, 2020) provides data for specific strength values (e.g., 4000 psi).
	2501-3000 psi (17.2-20.7 MPa)	210	291	**380**	m3	1	
	3001-4000 psi (20.7-27.6 MPa)	260	343	**470**	m3	1	
	4001-5000 psi (27.6-34.5 MPa)	320	406	**580**	m3	1	
	5001-6000 psi (34.5-41.4 MPa)	330	429	**610**	m3	1	
	6001-8000 psi (41.3-55.1 MPa)	380	498	**710**	m3	1	
	>8001 psi (>55.1 MPa)	411	535	**710**	m3	1	NRMCA does not publish data for concrete mixes over 8000 psi in their IW-EPD or benchmark report. Low = EC3 20th percentile, Feb 2021, drawn from 120 product-specific EPDs. Typical = EC3 average, Feb 2021, drawn from 120 product-specific EPDs. High = default to CLF High Baseline for next-highest strength class value (6001-8000 psi) until more data is available.
Slurry	Flowable Fill	90	170	**230**	m3	2	Flowable fill is not represented in a separate IW-EPD. Low/Typical/High based on EC3-calculated 20th percentile / average / 80th percentile Dec 2020, drawn from 998 product EPDs for slurry mixes of ≤1200 psi. NRMCA IW-EPD numbers for lightweight concrete across strengths represented in dataset.
	Structural Grout	270	458	**620**	m3	2	Structural grout is not represented in a separate IW-EPD. Low/Typical/High based on EC3-calculated 20th percentile / average / 80th percentile Dec 2020, drawn from 409 product EPDs for slurry mixes of ≥1200 psi. NRMCA IW-EPD numbers for lightweight concrete across strengths represented in dataset.
Shotcrete		Match ready mixed concrete values per strength			m3	4	Due to limited data and product type similarity, ready mixed concrete values may be used as a reasonable proxy for shotcrete until more specific data is available.
MASONRY							
Concrete Masonry Unit		TBD	370	**545**	m3	2	Typical = median reported value of all North American EPDs in EC3 database July 2021, where IW-EPDs (CCMPA, 2016) are weighted at 20x. High = EC3-calculated 80th percentile July 2021, drawn from North American data: 2 IW-EPD values and 107 product-specific EPDs.
STEEL							
Rebar		0.8	0.98	**1.7**	kg	2	Typical = IW-EPD Fabricated Steel Reinforcement (CSRI, 2017); Low = EC3-calculated 20th percentile Jan 2021; High = EC3-calculated 80th percentile Jan 2021 drawn from IW-EPD and 64 product-specific EPDs.
Steel Wire and Mesh		Match rebar values			kg	4	Due to limited data and product type similarity, rebar values may be used as a reasonable proxy for steel wire and mesh concrete reinforcement until more specific data is available.
Plate Steel		1.0	1.47	**3.0**	kg	3	Typical = IW-EPD Fabricated Steel Plate (AISC, 2016c); Due to low number of EPDs, Low = point between IW-EPD value and estimated global low based on ICE database (Circular Ecology, 2019); High = point between IW-EPD value and estimated global high based on ICE database (Circular Ecology, 2019).
Structural Steel	Hollow Sections	1.5	2.39	**3.0**	kg	3	Typical = IW-EPD Fabricated Hollow Structural Sections (AISC, 2016a); Due to low number of EPDs, Low = point between IW-EPD value and estimated global low based on ICE database (Circular Ecology, 2019); High adjusted to reflect similar ranges as other steel products on this list due to shortage of available data. This aligns with the average value of 2 IW-EPDs (AISC, 2016 and STI, 2016) including EC3-assessed uncertainty factor July 2021.
Structural Steel	Hot-Rolled Sections	0.8	1.16	**1.7**	kg	2	Typical = IW-EPD Fabricated Hot Rolled Structural Sections (AISC, 2016b); Low = EC3-calculated 20th percentile Jan 2021; High = EC3-calculated 80th percentile Jan 2021 drawn from IW-EPD and 34 product-specific EPDs.
Steel decking		1.5	2.37	**3.1**	kg	3	Typical = steel deck IW-EPD (SDI, 2015). Low = IW-EPD minus uncertainty factor to account for variability in e.g., production methods, grid mix, coating types, and changes over time (IW-EPD based on year 2012 primary data). High = IW-EPD plus EC3-assessed uncertainty factor to account for variability. (This also aligns with the midpoint between IW-EPD and highest product EPD value, including uncertainty factor, in EC3 database June 2021.)

		2021 CLF BASELINES v2 kg CO2e per declared unit					
Category	**Subtype**	**Achievable (Low)**	**Typical (Median)**	**Baseline (High)**	**Declared unit**	**Method**	**Data Source & Notes**
Cold Formed Steel	Framing	1.5	2.28	**3.0**	kg	3	Typical = IW-EPD Cold-Formed Steel Studs and Track Manufactured in U.S. and Canada (SRI, 2016); Due to low number of EPDs, Low = point between IW-EPD value and estimated global low based on ICE database (Circular Ecology, 2019); High = point between IW-EPD value and estimated global high based on ICE database (Circular Ecology, 2019).These numbers match the 20% and 80% figures in EC3 as of Jan 2021, drawn from IW-EPD and 4 product-specific EPDs.
Open-web steel joists	Open-web steel joists	0.7	1.38	**2.5**	kg	3	Typical = IW-EPD Open-web steel joists (SJI, 2015); Due to low number of EPDs, Low = CLF 2019 beta value = IW-EPD value minus estimated uncertainty factor; High = CLF 2019 beta high value = IW-EPD value plus estimated uncertainty factor.
ALUMINUM							
Aluminum Extrusions		TBD	8.91	**12.4**	kg	3	Typical = IW-EPD Aluminum Extrusions (AEC 2016a), based on a painted extrusion reference product. High = typical value + estimated uncertainty factor based on: industry EPDs and their background report (AEC 2016a, b, & c); the Carbon Trust's global report on aluminum carbon flows (Carbon Trust, 2011); International Aluminum Institute (IAI 2021); product EPDs in the EC3 database; coatings LCA study (DSM, 2011). Note: this category includes a range of finish options including mill finish, painted, and anodized.
Thermally Improved Aluminum Extrusions		TBD	9.78	**13.6**	kg	3	Typical = IW-EPD Thermally Improved Aluminum Extrusions (AEC 2016b), based on a thermally improved painted extrusion reference product. High = typical value + estimated uncertainty based on: industry EPDs and their background report (AEC 2016a, b, & c); the Carbon Trust's global report on aluminum carbon flows (Carbon Trust, 2011); International Aluminum Institute (IAI 2021); product EPDs in the EC3 database; coatings LCA study (DSM, 2011). Note: this category includes a range of finish options including mill finish, painted, and anodized.
WOOD & COMPOSITES							
Dimension Lumber	Wood framing	50	63	**100**	m3	3	Typical = IW-EPD Softwood lumber (AWC/CWC, 2020); Due to low number of EPDs, Low = CLF 2019 beta value = IW-EPD value minus estimated uncertainty factor; High = CLF 2019 beta high value = IW-EPD value plus estimated uncertainty factor.
Plywood & OSB Sheathing		200	230	**400**	m3	2	Typical = IW-EPDs NA Softwood Plywood (AWC/CWC, 2020) and NA Oriented Strand Board (AWC/CWC, 2020) (unweighted average of the two); Low = EC3-calculated 20th percentile Jan 2021; High = EC3-calculated 80th percentile Jan 2021 drawn from 24 product-specific EPDs and 2 IW-EPDs .
Glass Mat Gypsum Sheathing	1/2" (12.7 mm)	TBD	4.71	**6.3**	m2	3	Typical = IW-EPD Glass Mat Gypsum Boards 1/2" (GA, 2021); High = IW-EPD plus EC3-assessed uncertainty factor (33%) to account for industry variation, July 2021.
Glass Mat Gypsum Sheathing	5/8" (15.9 mm)	TBD	5.42	**7.2**	m2	3	Typical = IW-EPD Glass Mat Gypsum Boards 5/8" (GA, 2021); High = IW-EPD plus EC3-assessed uncertainty factor (33%) to account for industry variation, July 2021.
Prefabricated Wood Products	Wood I-joists	1.0	1.97	**6.0**	m	3	Category includes wood I-joists of different sizes, materials (softwood or LVL for the chords and plywood or OSB for the web), and structural capacity, which significantly affects EC variability. Typical = IW-EPD NA Wood I-Joist (AWC/CWC, 2020); Low = CLF 2019 beta low value; High = CLF 2019 beta high value.
Composite Lumber	LSL/LVL/PSL	230	361	**400**	m3	3	Category includes multiple product types created by combining wood veneers, strands, or flakes with adhesive. Types differ by manufacturing process and performance qualities. Typical = IW-EPD Laminated Veneer Lumber (AWC/CWC, 2020); Due to low number of EPDs, Low = CLF 2019 beta value = IW-EPD value minus estimated uncertainty factor; High = CLF 2019 beta high value = IW-EPD value plus estimated uncertainty factor.
Mass Timber	GLT/CLT/DLT/NLT	104	137	**200**	m3	3	Category includes multiple product types created by combining individual wood laminations (dimension lumber) with adhesive or fasteners into panels and/or larger-dimension beams and columns. Types differ by manufacturing process and performance qualities. Typical = IW-EPD NA Glue Laminated Timber (AWC/CWC, 2020); Low = EC3-calculated 20th percentile Jan 2021; High = EC3-calculated 80th percentile Jan 2021 drawn from IW-EPD and 7 product-specific EPDs, plus additional 5% factor to approximate manufacturing variability between product types and manufacturers.

		2021 CLF BASELINES v2 kg CO2e per declared unit					
Category	**Subtype**	**Achievable (Low)**	**Typical (Median)**	**Baseline (High)**	**Declared unit**	**Method**	**Data Source & Notes**
INSULATION							
Insulation by form	Board	**2**	10	**20**	m2-Rsi	2	This category includes several material options, including a variety of foam and fiber insulation products. Therefore, no single IW-EPD is available that covers this range of products. Low = EC3-calculated 20th percentile Jan 2021; Typical based on EC-calculated average January 2021 (Note that the term "typical" is less relevant for a category that includes such a range of material types); High = EC3-calculated 80th percentile Jan 2021 drawn from 271 product-specific EPDs and six IW-EPDs in the EC3 database. IW-EPDs include: Mineral Wool Insulation Board (NAIMA, 2018a&b), EPS Foam Insulation (EPS-IA, 2017), and Polyiso insulation boards (PIMA 2020a,b,&c). Note these values account for embodied GWP after A1-A3 due to blowing agent emissions for HFC-containing foam insulations.
	Blanket	0.5	3	**4**	m2-Rsi	2	This category includes several material options, including cellulose, fiberglass, light mineral wool, and others. No single industry-wide EPD is presently available that covers this range of products. Low = EC3-calculated 20th percentile Jan 2021; Typical / High = EC3-calculated average / 80th percentile Jan 2021 drawn from 56 product-specific EPDs, plus additional uncertainty factor (25%) to account for variability between product types and manufacturers.
	Foamed-in-Place	2.33	9	**20**	m2-Rsi	3	Typical = IW-EPD Spray Polyurethane Foam Insulation (HFC) and Spray Polyurethane Foam Insulation (HF0) (SPFA, 2018). Note: this value covers both oc and cc spray foam products. Low = EC3-calculated 20th percentile Jan 2021; High = EC3-calculated 80th percentile Jan 2021, plus additional uncertainty factor (25%) to account for estimated market share and variability between product types. Note these values account for embodied GWP after A1-A3 due to blowing agent emissions for HFC-containing foam insulations.
	Blown	1	2	**3**	m2-Rsi	3	This category includes several material options, including loose blown cellulose, mineral wool, and fiberglass. No single industry-wide EPD is presently available that covers this range of products. Low/Typical/High values based on 2 IW-EPDs - Conventional Loose-Fill Cellulose Insulation (CIMA/CIMAC, 2019) and Mineral Wool Loose Fill (NAIMA, 2018c), and 8 product-specific EPDs in EC3 database plus uncertainty factor to account for variability between product types and manufacturers.
CLADDING							
Insulated Metal Panel (IMP)		62	107	**145**	m2	3	Typical = IW-EPD Insulated Metal Panel (MCA, 2020a), based on 2" IMP with 24 gauge steel coil reference product. Low = EC3 20th percentile Jan 2021; High = IW-EPD + EC3-generated uncertainty factor (approx 35.5%) Note that many insulated metal panels use polyurethane-based foam insulation, which typically contains high-GWP HFC blowing agents that emit to the atmosphere during A3 manufacturing (accounted for here) and during B1 building use and C4 end-of-life (not accounted for here).
Metal Panel		12	15.3	**26**	m2	2	Category includes roll-formed metal panel for exterior cladding, such as standing seam or box rib profile. Typical = IW-EPD Roll Formed Steel Cladding (MCA, 2020b) based on a 0.028 inch thick (24 gauge) steel panel reference product. High = 80th percentile of manually filtered EC3 search results June 2021, drawn from 16 product EPDs (5 of which from North America) and 2 IW-EPD values (MCA, 2020b). Low = value of lowest GWP reported in EPD for metal cladding panels in EC3 database June 2021. Note that products of different thickness, material (steel and aluminum), and coating options are included in these results.
FINISHES							
Gypsum Board		2.5	2.98	**4.5**	m2	2	Typical = IW-EPD Type X Conventional Gypsum Board (Gypsum Association, 2020), based on a 5/8" gypsum board product; Low = EC3 20th percentile Jan 2021; High = EC3 calculated 80th percentile Jan 2021 drawn from IW-EPD and 85 product-specific EPDs.
Acoustical Ceiling Tiles		6	11	**14**	m2	2	No industry-wide EPD is presently available for this product. Low = EC3-calculated 20th percentile, Typical = EC3-calculated average, High = EC3-calculated 80th percentile Jan 2021 drawn from 157 product-specific EPDs.
Resilient Flooring		6	11.5	**20**	m2	2	Typical = unweighted average of 6 available North American IW-EPDs (RFCI, 2019a-f); Low/High = EC3-calculated 20th/80th percentiles Jan 2021, drawn from IW-EPDs and 167 product-specific EPDs.
Carpet		6	11	**20**	m2	2	No industry-wide EPD is presently available for this product. Low = EC3-calculated 20th percentile, Typical = EC3-calculated average, High = EC3-calculated 80th percentile Jan 2021 drawn from 274 product-specific EPDs plus additional uncertainty factor (25%) to account for variability between product types and manufacturers.

		2021 CLF BASELINES v2 kg CO2e per declared unit					
Category	**Subtype**	**Achievable (Low)**	**Typical (Median)**	**Baseline (High)**	**Declared unit**	**Method**	**Data Source & Notes**
COMMUNICATIONS							
Data Cabling	Fiber Data Cabling	2.64	7.75	**14.60**	m	2	Category includes: optical fiber premises cable with voice, data and PoE applications with various OFNR or OFNP ratings for plenum or riser environments. No industry-wide EPD is presently available for this product. Low = EC3 20th percentile, Typical = EC3 average, High = EC3 calculated 80th percentile May 2021 drawn from 32 product-specific EPDs.
	Twisted Pair Data Cabling	0.23	0.37	**0.46**	m	2	Category includes: premises copper cable (Category 3-7) voice, data and PoE applications with various CMR or CMP ratings for plenum or riser environments. No industry-wide EPD is presently available for this product. Low = EC3 20th percentile, Typical = EC3 average, High = EC3 calculated 80th percentile May 2021 drawn from 149 product-specific EPDs.
	Other Data Cabling	0.20	0.46	**0.75**	m	2	Category includes: premises composite cables (Coax), patch cords, and other cabling typologies. No industry-wide EPD is presently available for this product. Low = EC3 20th percentile, Typical = EC3 data median (instead of EC3 average, to reduce effect of a few significant outlier data points), High = EC3 calculated 80th percentile May 2021 drawn from 100 product-specific EPDs.
BULK MATERIALS							
Flat Glass		1.2	1.4	**2.3**	kg	2	Typical = IW-EPD Flat Glass (NGA 2019); Low = CLF beta low = IW-EPD minus estimated uncertainty factor; High = EC3-calculated 80th percentile Jan 2021.

Note: for a full list of EPDs referenced above see following page.

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