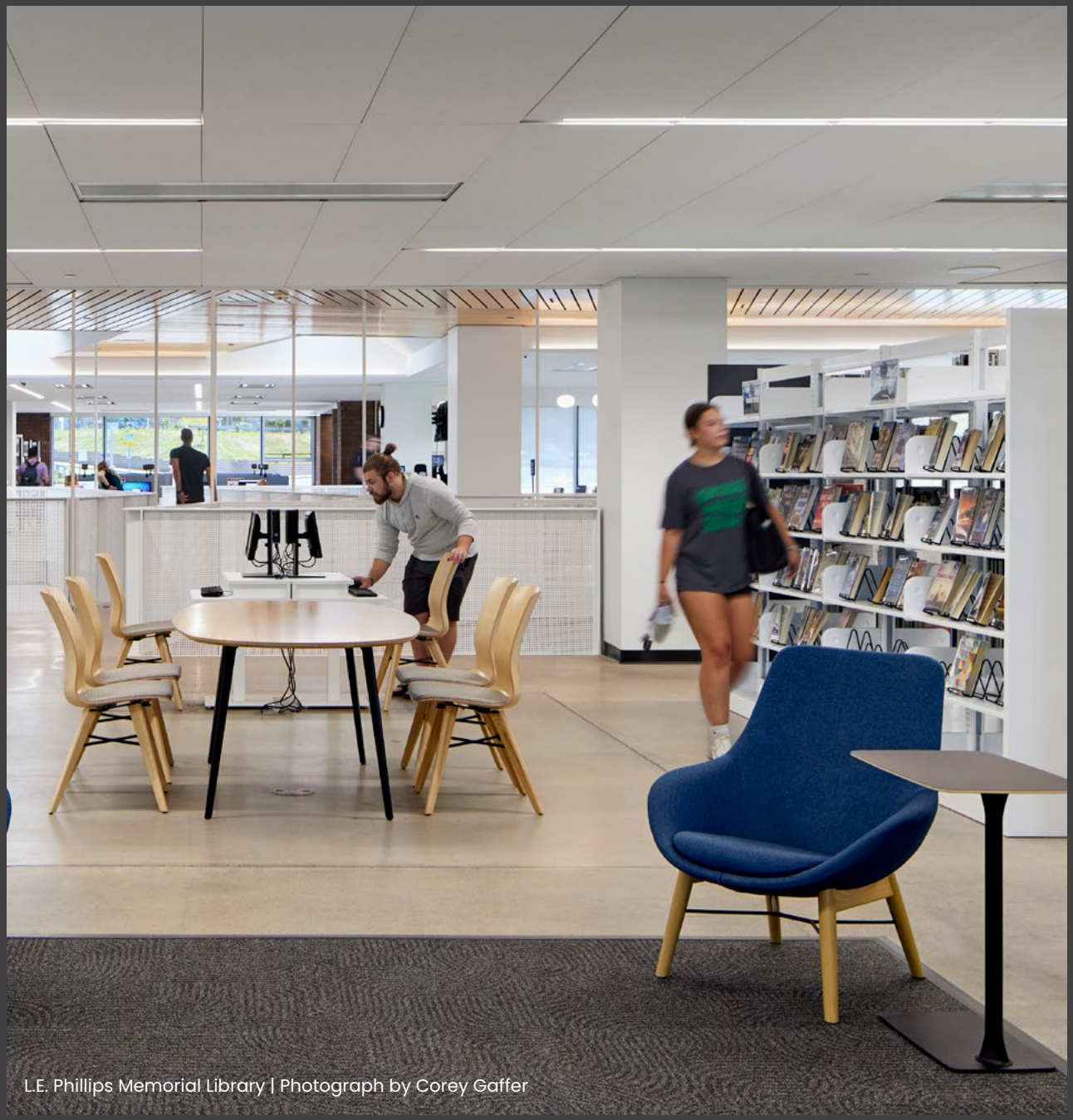

L.E. Phillips Memorial Library | Photograph by Corey Gaffer

Embodied Carbon in Commercial Furniture

Introducing a calculator, a case study, and a new set of baselines

Simona Fischer, Lauren Gardner, Emily Gross, Veronica Karr, and Java Nyamjav

MSRDesign

MSR Design 510 Marquette Office | Photograph by Lara Swimmer

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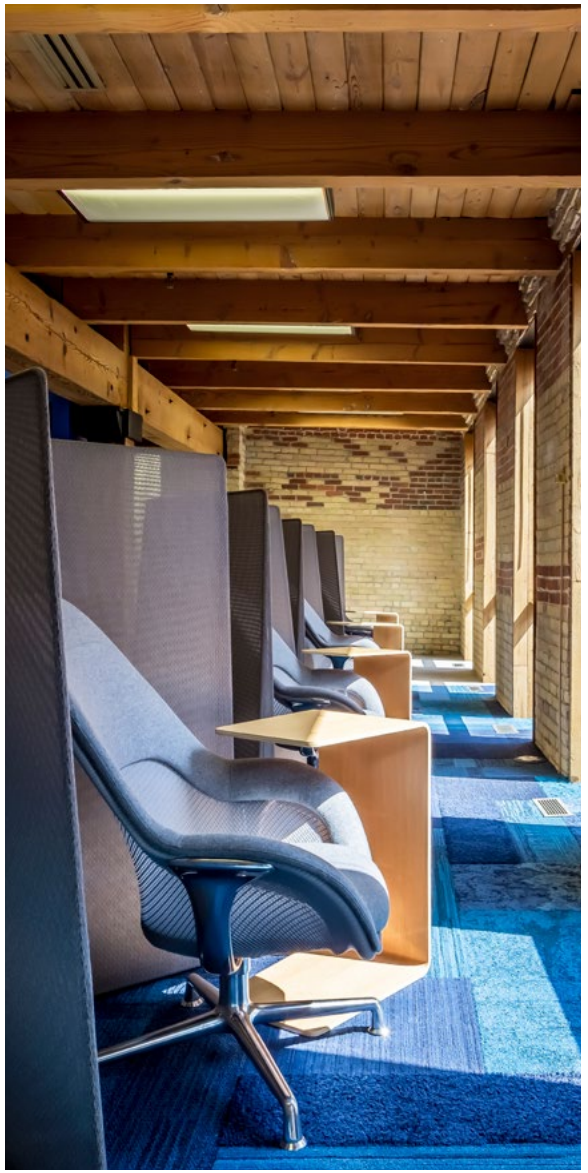
Introduction

In current architectural practice, whole-building life cycle assessment (LCA) focuses largely on modeling the footprint of structural and architectural design features to estimate the total embodied carbon (EC) footprint of a building. Many interior finishes and fixtures are available in BIM-based LCA tools, such as the Tally plugin for Revit, but the carbon footprint of elements such as furniture and casework cannot be calculated because these Revit families are not supported in Tally or other LCA modeling tools and calculators.

While based on limited data sets and only a limited number of furniture pieces, previously published research reports on embodied carbon in commercial furniture do demonstrate that furniture does significantly contribute to EC estimates. A review of these studies raises the following questions: How much data is missing on the impact of commercial furniture, and how might an accurate accounting change the perception of furniture and carbon in new and renovation construction projects?

As a result, this study was conducted in order to increase industry understanding of the carbon impact of commercial furniture and provide guidance to designers in selecting lower-carbon furniture options. This report includes the following:

- Process and results of data collection with the goal of establishing average baseline EC values for an expanded number of furniture categories, including various types of seating, tables, lounge furniture, shelving, and workstations. Baselines are based on a larger set of environmental product declaration (EPD) data compared to previous precedent reports.
- A new furniture EC calculator developed for use in design. The furniture calculator is available for public download as part of the MSR Design Sustainability Tracker document.
- A case study of an interior renovation project using the furniture EC calculator.



Aimia US Headquarters | Photograph by Brandon Stengel

Summary of Previous Research

A critical driver of the carbon footprint in tenant improvement projects is churn, where materials are replaced and every subsequent renovation adds to the total lifetime EC footprint. Two Carbon Leadership Forum reports discuss the impact of embodied carbon in commercial buildings. As illustrated in Figure 1, the global warming potential (GWP) impact of interior renovations in a 60-year-old building may add up to a lifetime footprint of 130–810 kg CO2e/m2 (12–75 kg CO2e/sf) (Huang, Simonen, Ditto, 2019). In a 2017 study, the impact of new construction ranged from 50 to 1,300 kg CO2e/m2 (4–120 kg CO2e/sf) (Simonen, Rodriguez, Barrera, Huang, McDade, Strain, 2017). Placing these numbers in context shows that the lifetime impact of interior GWP can be equal to or more than the carbon footprint of initial construction.

The Carbon Leadership Forum study "Life Cycle Assessment of Tenant Improvement in Commercial Office Buildings" (Huang, Simonen, and Ditto, 2019) presents five case studies focused on estimating the EC of TI updates, including furniture. Results reveal that the greatest carbon contributors, in four of the five projects, were cubicles, chairs, tables, and sofas. (One project was a medical office without furniture information.) To calculate EC, they used an average of three EPDs for chairs, one EPD for workstations, sofas, and tables, and an industry average EPD for laminate casework (Simonen, Ditto, Huang, 2019). The study's LCA calculator served as an inspiration for this research.

A study conducted on an office building in Seattle, Washington, published by LMN Architects shows that the accumulated carbon impact over 60 years due to interior renovations can exceed the initial structure and envelope EC. The interiors included carpet, resilient flooring, partition assemblies, furniture, custom display tables, ceilings, paint, acoustic wall panels, interior glazing, and doors. For the furniture component, this study references product-specific chair EPDs and an industry average GWP of medium-density fiberboard (MDF) material for cubicles (Chen, Anderson, 2019).

These previous studies only reference a few furniture typologies, most of which have only one EPD. This research study increases the number of furniture types and EPDs per type to establish more reliable averages based on a wider range of GWP data.

Background on Embodied Carbon in Furniture

With a wide range of materials, small components, and manufacturing processes, furniture can be complex, making it onerous and costly to conduct an accurate LCA. However, to better understand holistic project embodied carbon, it is imperative to include furniture for several reasons. The first reason is furniture's relatively short life cycle, and the frequency of replacement. Commercial furniture often has a life span of less than 15 years, and is replaced multiple times throughout a building's life cycle, incurring a new embodied carbon cost each time. Second, in projects such as interior renovations or tenant improvements, furniture can constitute a large portion of the new design that goes into a space. If furniture is not accounted for, an interiors project may appear to have a low carbon footprint when in fact the unaccounted-for EC of furniture could more than double the impact.

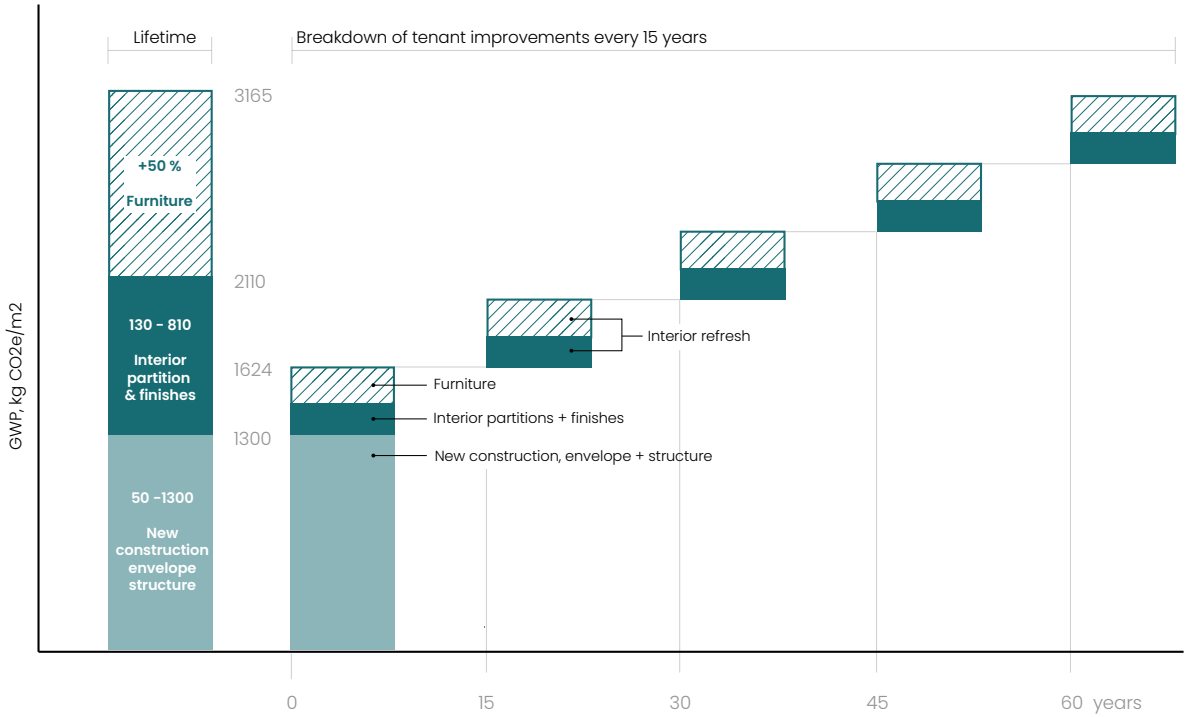


Figure 1. Illustration of lifetime embodied carbon accumulation for tenant improvement over 60 years comparing the impact of new construction and interiors from a previous report (Simonen, Huang, Ditto, 2019) to new furniture data obtained in this study. Furniture increased the total lifetime carbon footprint of a tenant improvement project by more than 50%.

Third, due to its complexity, furniture can be a significantly carbon-intensive portion of a project. The task chair shown in Figure 2 includes an EC assessment of five primary materials, each with its own extraction, manufacturing, and transportation processes. In this case, 60% of the EC is in material extractions, 20% in assembly, and the remainder distributed through use to end of life. Each time the chair is replaced, the entire carbon emission of that chair is repeated, creating a large carbon accumulation over time.

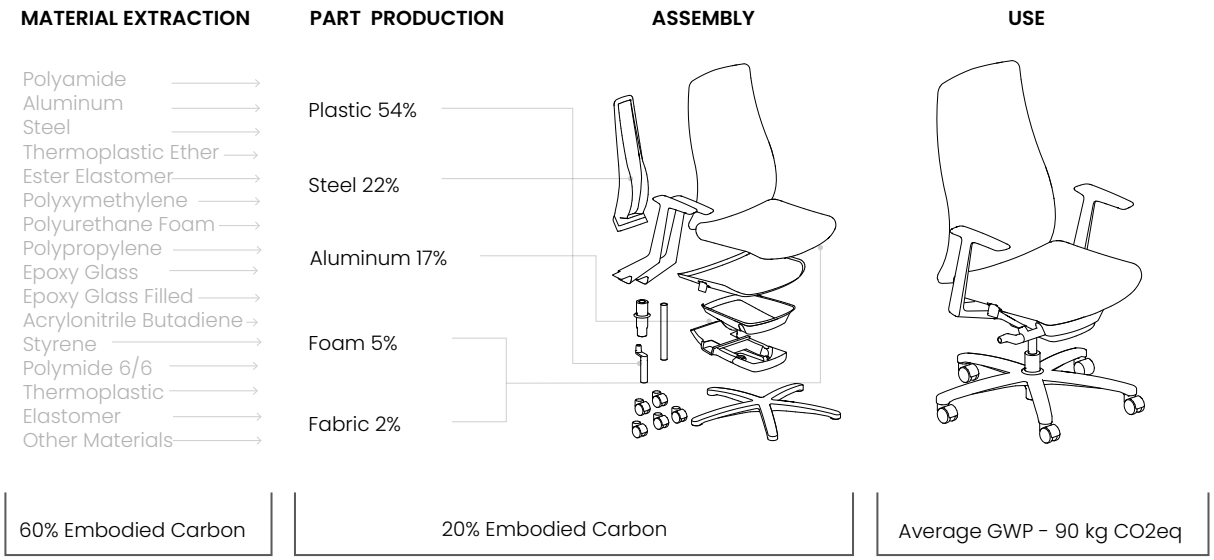


Figure 2. Breakdown of typical office task chair.

Many commercial furniture manufacturers in the United States have committed to sustainable practices by obtaining ingredient transparency labels and/or adhering to industry-created sustainable manufacturing standards, such as ANSI/ BIFMA. These standards are focused on criteria such as human health impacts of materials and reducing waste and water use in manufacturing. Important criteria to consider in any building or consumer product, they should also beconsidered in the context of carbon footprint. However, calculating embodied carbon is still new in the furniture industry, and the relatively limited number of EPDs available for furniture products presents a difficulty in systematically calculating the carbon impact.

Furniture Types & Data Collection Methodology

Furniture Types

This study focuses on a representative list of office furniture (Figure 3) within five categories, including seating (upholstered and non-upholstered), tables, workstations, lounges, and shelving, for a total of 22 different furniture types. The furniture types reflect contract-grade furniture.

Custom furniture pieces, those with built-in lighting or electric and data ports, and categories for which no EC data could be found were excluded from this study.

Upholstery finishes that are user-specified were not considered and would represent an additional carbon impact (along with other potential health impacts).

Data Collection

A total of 48 documents were used to obtain GWP data, including both industry-average and product-specific EPDs, and product environmental data sheets. In general, three EPDs were sought for each type of furniture to generate an average GWP number. Due to limited availability, stools and laptop tables each have fewer than 3 EPDs. EPDs were acquired

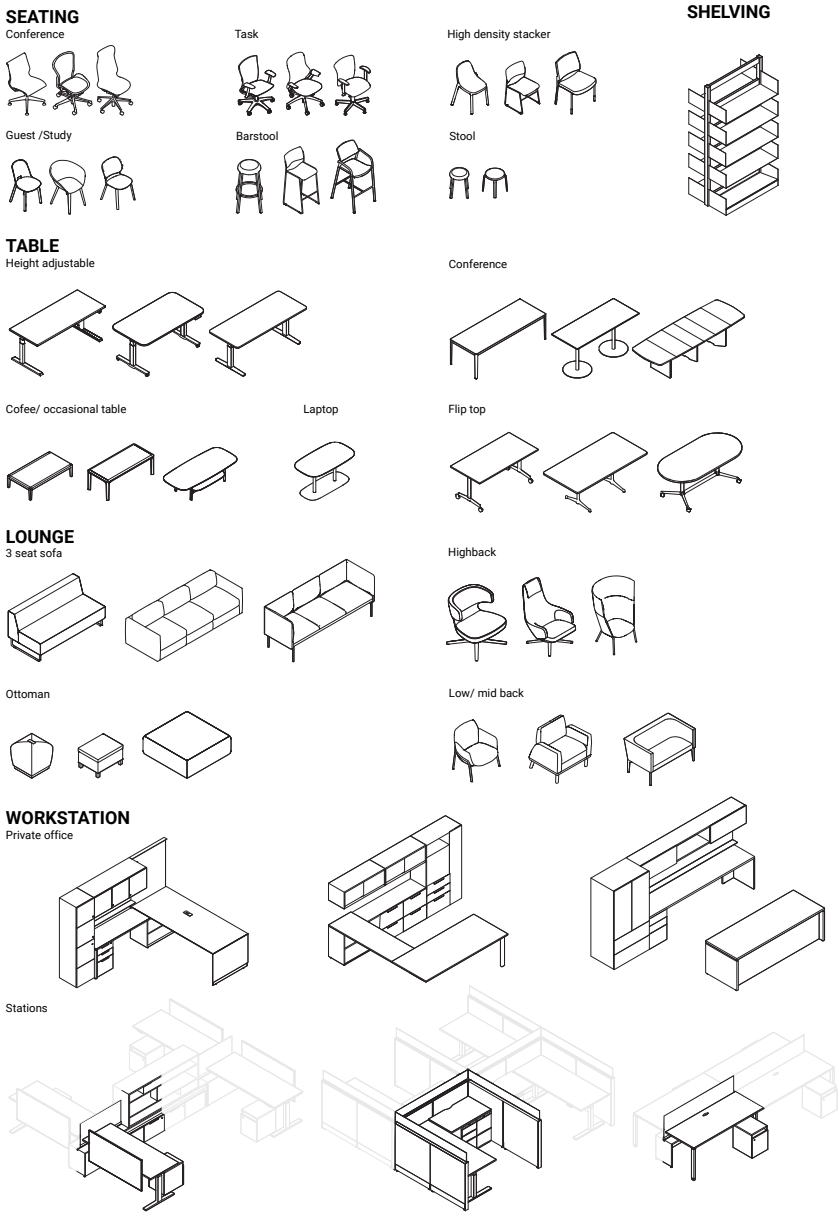


Figure 3. Illustration of furniture included in study and calculator.

from national and international EPD-specific databases, third-party certifiers, general broad-category sustainability documentation databases, and furniture manufacturers' websites.

The simplest way to access a large number of EPDs was through EPD-specific databases and third-party certifiers (Figure 4). The EPD databases ranged from international (The International EPD System) to regional (The EPD Registry with products from Europe, South America, and Australia, or EPD Norge from Norway). These databases provided the widest variety of products since manufacturers get certified through the companies that maintain the databases. Third-party certifiers (SCS Global Services and NSF International) also provide a number of EPDs from different manufacturers on their websites, but the selection of data is limited to their respective clients.

General sustainability documentation databases (such as Mindful Materials and UL Spot) were also used to find a number of EPDs. These databases enable filtered searches based on different certifications and standards, but even in these databases, not all EPDs were included. Many databases are incomplete and do not represent the full list of available products with EPDs, which may be in part because of fees charged by some database companies to feature a manufacturer's documentation.

Finally, some manufacturers provide product-specific EPDs on their product websites. Since each manufacturer has its own organizational structure for locating documents, finding EPDs on manufacturer websites is time-consuming. Contacting manufacturers' representatives directly was the quickest way to get access to specific EPDs.

Where full EPDs were not available, the team used product environmental data sheets, a simplified report containing material ingredients, recycled content, certifications, and condensed LCA information. Eight EPDs came from outside of North America. Since the calculation includes only LCA scopes A1-A3, it does not include A4 (transportation to site), which could add a significant contribution to the GWP of products manufactured outside of North America.

Data Standardization

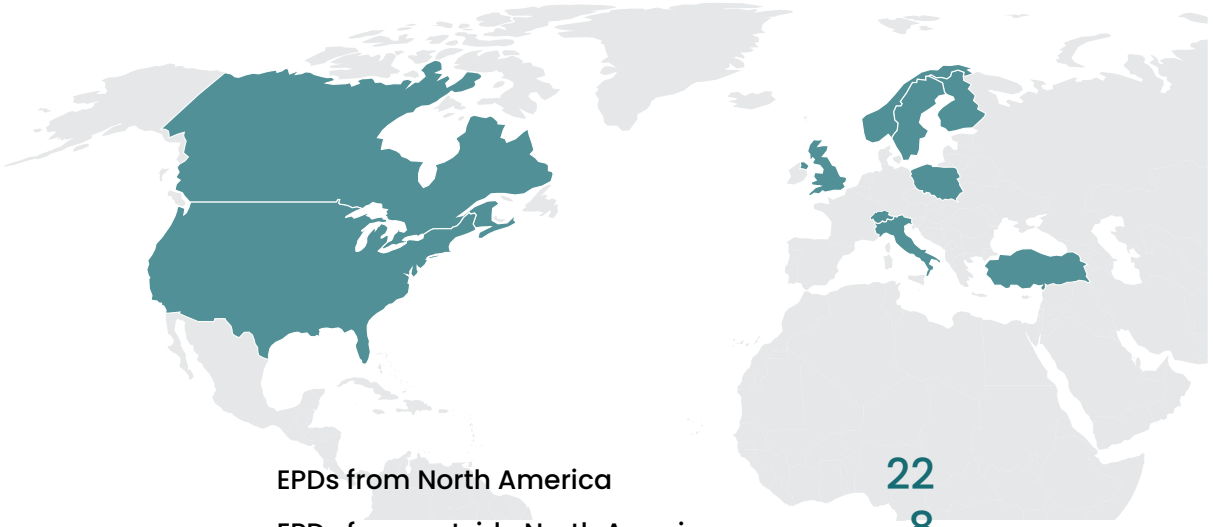
Since different greenhouse gases (GHG) emitted during the life cycle of a product have a different rate of absorption and length of stay in the atmosphere, to normalize the data GHG are compared to carbon dioxide and measured in kg or lbs of carbon dioxide equivalent (CO2eq or CO2e). GHG, and by extension product life cycles, are compared in terms of GWP, a comparison of how much solar energy the emissions of 1 ton of a GHG will absorb over a standard period of time (EPA, 2021). Carbon footprint is often referred to in terms of kg CO2e per meter squared, or GWP per square meter, with a higher number being a greater footprint. Most EPDs globally use kgCO2eq. To make our result comparable to American Institute of Architects' (AIA) embodied carbon benchmarks in the U.S. (COTE Super Spreadsheet), results are shown in kgCO2eq/sf.

Comments and Limitations

To qualify as an EPD, a report must adhere to the International Standards Organization (ISO) 14025 standard as a Type III label. Despite the standard, EPDs can differ significantly due to several factors:

- Data collected to create an EPD is governed by the product category rules (PCR) of a particular product category. Governing data collected for that product type can vary where certain types of furnishings are categorized as different product types from others.
- EPDs and LCAs are conducted and prepared by variety of third-party certifiers around the world.
- Some EPDs focus on A1-A3 (extraction, transport, and manufacturing) life cycle stages, while others show the entire life cycle, including stages A4 (transport), B (usage), C (end-of-life), and even D (beyond the systems boundary). For this study, the researchers standardized the data by using scope A1-A3 wherever possible. In some cases, a simplified LCA did not indicate the breakdown of scope, so the entire LCA total was used. These differences are color-coded in the Excel calculator.

Epd Databases & Third-Party Certifiers	Manufacturer-Provided Epds North America	Manufacturer-Provided EPDs International
▪ EPD Library International	▪ Allsteel	▪ Arper | Italy
▪ EPD Registry	▪ Emeco	▪ Benchmark Furniture | UK
▪ LCA Database	▪ Gunlocke	▪ Fora Form | Norway
▪ Mindful Materials	▪ Haworth	▪ Framery Acoustics | Finland
▪ Norwegian EPD database	▪ Herman Miller	▪ Koleksiyon | Turkey
▪ NSF International	▪ KI	▪ Magis Design | Italy
▪ SCS Global Services	▪ Knoll	▪ Mark Products | UK
▪ Spot	▪ Steelcase	▪ Mattiazzi | Sweden
	▪ Teknion | Canada	▪ Nowy Styl | Poland
		▪ Vitra | Switzerland



EPDs from North America	22
EPDs from outside North America	8
Product environmental data sheets with Life cycle information	15
In process of recertifying	3
Total documents used for calculator	48

GWP Results By Furniture Type

The chart in Figure 5 illustrates the average GWP of 22 furniture types including seating, tables, workstations, lounge furniture, and shelving. Seating and tables had the most EPDs available, from a greater variety of products. The narrowest GWP range was found in seating, indicating that chair and table manufacturers are more experienced at the EPD process and have more mature LCA data, or that commercial seating and tables are made from a narrower range of materials, leading to more uniformity in the data. In contrast, workstation and lounge furniture data had such a broad range, it raised potential concerns about the quality of the LCA data. However, the variety of styles and materials may account for a broader range of GWP impacts in these categories.

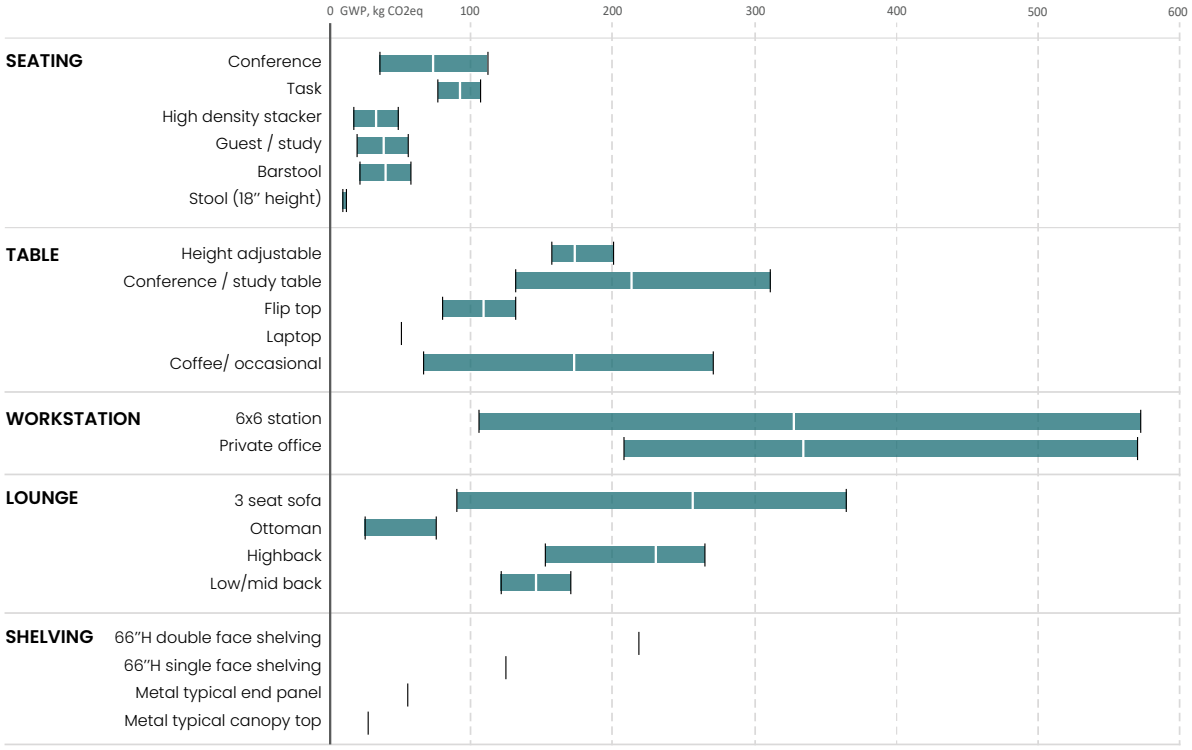


Figure 5. Global warming potential (GWP) range and median measured in kgCO2eq per unit of furniture.

Shelving data is shown as a point instead of a range because it was obtained by modeling in Revit using modified floor and wall families with adjusted thicknesses and material layers, and calculating GWP using the Tally plug-in. Resarch findings include:

- Overall, the process of conducting this study revealed that tvery few EPDs are available for commercial furniture.
- Seating and table data was complete enough to estimate a reasonable average baseline.
- More data is needed to establish stronger baselines within workstation and lounge furniture categories.
- Eight EPDs came from outside of North America. Since the calculation includes only scopes A1-A3, it does not include A4 (transportation to site), which could add a significant contribution to the products outside of North America. However, most of these manufacturers also have North American locations.
- More recent data may be available since the summer of 2021 when data collection for the study occurred.

Furniture Embodied Carbon Calculator

GWP Summary | Furniture		
GWP per square foot		
New furniture	#DIV/0!	lbs CO2e/sf
Salvaged furniture	#DIV/0!	lbs CO2e/sf
New + Salvaged furniture	#DIV/0!	lbs CO2e/sf

Total GWP with GFO, lb CO2e		
New furniture	[illegible]	lb CO2e
Salvaged furniture	[illegible]	lb CO2e
New + Salvaged furniture	[illegible]	lb CO2e

Furniture		Quantity of Material		Furniture EPD Data Ranges (see notes below)						CLF baseline GWP
				EPD 1		EPD 2		EPD 3		
Description	Notes	New	Salvaged	Manufacturer	kg CO2e	Manufacturer	kg CO2e	Manufacturer	kg CO2e	kg CO2e
Chair - Conference	with casters	45	30	Herman Miller	34.40	Herman Miller	73.00	Knoll	110.00	
Chair - Task	with casters and adjustabiliy	5	60	Herman Miller	75.70	Knoll	88.30	Steelcase	106.40	77.80
Chair - High Density Stacker	typically 40+ chairs stacking on dolly		2	Emeco	16.30	Howe	30.60	KI	48.30	
Chair - Guest/Study	poly seat, wood legs		2	Emeco	19.00	Knoll	51.90	Haworth	67.00	
Chair - Barstool	painted metal base with poly seat	25		Emeco	21.00	Howe	38.50	KI	57.17	
Chair - Stool (18" seat height)	18"seat height	9		Emeco	8.46	Mark Products	11.00			
Table - Height Adjustable	24"x36" typ size	37	19	Teknion	156.00	Steelcase	160.00	Haworth	200.00	
Table - Conference/Study Table	36"x72" typ size	3	46	Haworth	130.00	Steelcase	190.00	Gunlocke	310.00	134.00
Table - Flip Top	flip top with casters			Howe	79.30	KI	110.00	KI	130.00	
Table - Laptop	wood or metal base with lam or quartz top	6		Arper	50.00					
Table - Coffee/Occasional Table	wood or metal base with lam or quartz top		3	Koleksiyon	66.00	Haworth	180.00	Haworth	270.00	
Workstation - 6x6 Station	6' x 6' floor plate desk configuration (L shaped)			Teknion	105.00	Haworth	300.00	Knoll	572.00	435.00
Workstation - Private Office	L shaped with wall mounted elements			Knoll	208.00	Gunlocke	220.00	Haworth	570.00	489.00
Lounge - 3-seat Sofa	3 seat upholstered sofa	6		Haworth	89.00	Koleksiyon	309.00	ForaForm	364.00	98.20
Lounge - Ottoman	small ottoman/pouf	7		ForaForm	24.00	Koleksiyon	40.00	Haworth	75.00	
Lounge - Highback	wood or metal base with upholstered seat and back	2		Haworth	120.00	Vitra	270.00	Haworth	430.00	
Lounge - Low/Mid Back	wood or metal base with upholstered seat and back	11	2	Haworth	120.00	Vitra	152.00	KI	170.00	
Shelving - 66"H Double Face Shelving	welded frame unit		10		0.00	MSR Design STUDY VIA TALLY - modeled after Estey product			217.50	
Shelving - 66"H Single Face Shelving	welded frame unit		12		0.00	MSR Design STUDY VIA TALLY - modeled after Estey product			124.29	
Shelving - Metal Typical End Panel	66"H End panel				0.00	MSR Design STUDY VIA TALLY - modeled after Estey product			54.22	
Shelving - Metal Typical Canopy Top					0.00	MSR Design STUDY VIA TALLY - modeled after Estey product			26.30	
add additional furniture as needed					0.00					

Description	GWP Calculator | Furniture: GWP Averages, kg CO2e	GWP Averages, lb CO2e	GWP with GFO, lb CO2e: New	GWP with GFO, lb CO2e: Salvaged
Chair - Conference	72.467	159.768	7,189.570	4,792.840
Chair - Task	90.138	198.710	993.550	11,922.600
Chair - High Density Stacker	31.733	69.960	0.000	139.920
Chair - Guest/Study	45.967	101.339	0.000	202.678
Chair - Barstool	38.890	85.738	2,143.450	0.000
Chair - Stool (18" seat height)	9.730	21.451	193.059	0.000
Table - Height Adjustable	172.000	379.190	[illegible]	7,204.700
Table - Conference/Study Table	[illegible]	[illegible]	[illegible]	[illegible]
Table - Flip Top	106.433	234.645	0.000	0.000
Table - Laptop	50.000	110.231	661.386	0.000
Table - Coffee/Occasional Table	172.000	379.190	0.000	[illegible]
Workstation - 6x6 Station	[illegible]	717.978	0.000	0.000
Workstation - Private Office	[illegible]	[illegible]	0.000	0.000
Lounge - 3-seat Sofa	[illegible]	[illegible]	[illegible]	0.000
Lounge - Ottoman	[illegible]	102.145	[illegible]	0.000
Lounge - Highback	[illegible]	[illegible]	[illegible]	0.000
Lounge - Low/Mid Back	[illegible]	[illegible]	[illegible]	[illegible]
Shelving - 66"H Double Face Shelving	[illegible]	[illegible]	0.000	[illegible]
Shelving - 66"H Single Face Shelving	[illegible]	[illegible]	0.000	[illegible]
Shelving - Metal Typical End Panel	[illegible]	[illegible]	0.000	0.000
Shelving - Metal Typical Canopy Top	[illegible]	[illegible]	0.000	0.000
add additional furniture as needed	0.000	0.000	0.000	0.000

Figure 6. Furniture Embodied Carbon Calculator, available for download as part of the MSR Design Sustainability Tracker.

The embodied carbon calculator developed for this study is derived from the series of EPDs and other EC documentation collected for furniture products. The total embodied carbon of furniture on a project is calculated by multiplying the average GWP of a furniture type by a quantity takeoff for a given material or product. A user inputs the quantity of each type of furniture, with the option to enter quantities in either the new furniture or salvaged furniture columns (Figure 6).

The calculator does not account for the different life spans of individual products, but most are estimated to range from 12 to 15 years, the same as the refresh cycle for interior finishes. Using the spreadsheet calculator, the user can change the frequency of interior renovations, which is used to calculate a lifetime EC number for furniture used in a building, for comparison against the lifetime EC of structure, envelope, and interior finishes.

Case Study Using Furniture Embodied Carbon Calculator

MSR Design 510 Marquette Studio

To test the calculator, MSR Design's 510 Marquette studio TI project was used as a case study. The studio renovation was partly a driver for creating the calculator, since the project team recognized in a furniture-intensive space with relatively few partition walls, any life cycle calculation that did not include furniture would likely be omitting a significant source of carbon impact.

In fact, the furniture impact was not only significant, but the case study also revealed that 56% of embodied carbon was not accounted for in the standard Revit-to-Tally workflow modeling of the interior architecture (Figure 7). Including interior partitions and finishes, architecture modeling revealed that carpet and gypsum walls were the largest EC contributors. The calculation was set for a 50-year life span, with automatic Tally refreshment cycles every 12 years. Salvaged finish materials were calculated separately, as shown in dashed outline in the chart (Figure 7).

As part of the process of seeking Living Building Challenge Materials Petal certification, the 510 Marquette Studio utilized significant quantities of salvaged furniture. To show the impact, an original iteration of the calculator was revised to include separate columns for quantifying new versus salvaged furniture.

Results indicate that the design reduced the combined EC of the finished studio (including architecture, finishes and furniture) by 33% simply through the use of salvaged furniture.

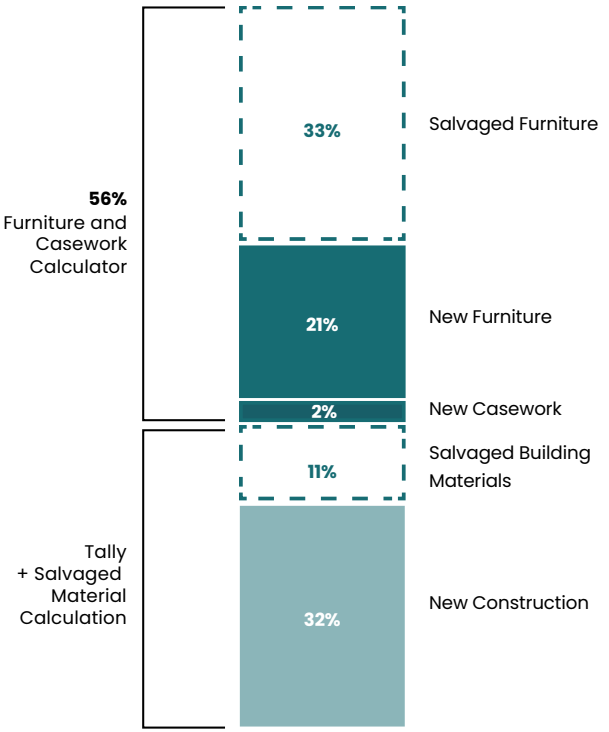


Figure 7. Furniture embodied carbon calculator results from MSR Design's Living Building Challenge Materials Petal-Certified studio tenant improvement project.

Discussion & Recommendations

Carbon Impact of Commercial Furniture, Recommendations for Designers & the Need for More Data

This study reinforces previous findings that the embodied carbon impact of furniture can be enormous in commercial spaces. Calculating the EC of furniture and including furniture in whole building life cycle assessment is critical to helping designers make informed decisions. However, the study also reveals that EPDs for furniture are scarce in the industry at this time, limiting the ability to act upon the study's findings. Well-known certifications such as LEED and The Living Building Challenge do not include furniture in their whole-building LCA requirements, leaving a potentially large gap in the EC estimations.

Some manufacturers have expressed that the expense of obtaining an EPD is a hardship. According to informal estimates, the price of acquiring an EPD can range widely, from $5,000 to $50,000 or more, depending on the complexity of the product and availability of LCA data. Therefore, it can rapidly become a significant expense, particularly for small businesses. However, a number of emerging online tools and resources are available to product manufacturers to conduct a basic LCA of materials used in their products and generate preliminary EC numbers in the form of a product environmental data sheet, prior to obtaining a full third-party EPD.

An EPD does remain the highest standard of LCA data communication at this time. As the building industry begins to lower the embodied carbon in products competitively, designers and manufacturers will need to be critical of how carbon reduction is actually accomplished. Standardized data will be crucial in the process. Carbon offsets must be counted separately from the footprint of LCA scope processes, so that a product is not shown misleadingly to be carbon-negative, when it is in fact the result of purchased offsets. The calculator tool demonstrates that to drastically reduce the carbon impact of furniture, more furniture must be diverted from landfills. According to 2018 estimates from the United States Environmental Protection Agency (EPA), up to 8.5 million tons (17 billion pounds) of office assets end up in US landfills annually. As a result, it is critical to normalize salvaging, reusing, and refurbishing in the design process to reduce furniture embodied carbon.

Recommendations for Designers

- Include furniture in EC calculations since those EC amounts can build up over time, potentially exceeding the envelope and structural EC amounts.
- Ask for EPDs from manufacturers, or other equivalent certifications that include GWP or carbon footprint. If they are lacking an EPD, direct manufacturers to Carbon Leadership Forum, for more guidance on obtaining an EPD.
- Encourage clients who purchase their own furniture to choose manufacturers with EPDs.
- Choose low carbon, durable, reusable, recyclable materials. Choose materials that have potential in the circular economy

One 10 Office | Photograph by Brandon Stengel

- Link a version of this calculator to the budget for furniture so that it automatically fills in carbon information when the project is in its early stages.
- Prioritize reusing or refurbishing a client's existing furniture during renovations.
- Select furniture remanufacturing companies that take back systems furniture for reuse, including:
  - Reseat
  - Herman Miller Renew Take-Back Program
  - Davies Office Remanufactured Office Furniture

Recommendations for Furniture Manufacturers & EPD Provider

- All manufacturers should provide EPDs for their products to increase transparency. If a full EPD is not yet possible, EC data can be calculated using online carbon calculator tools for product designers.
- Redesign furniture with EC in mind and streamline the design. Complexity is no longer an excuse for not knowing the data.
- Reuse, recycle, and refurbish materials to reduce EC.
- Create a closed loop system and develop take back programs for previously used products for reuse, recycling, or refurbishing.
- Performance and transparency are both priorities. Avoid greenwashing.
- Keep EC in mind in balance with other aspects of healthy materials. References include:
  - AIA Materials Pledge
  - Living Product Challenge
  - *Metropolis* Climate Action Toolkit

Recommendations for LCA and EPD Creators & Database Providers

- Better data management and information sharing across data platforms are urgently needed.
- Continue to develop consistency across EPDs regarding scope, period, and units so that they can be easily compared.

References

American Institute of Architects. 2023. "AIA COTE Super Spreadsheet, Current Version." https://www.aia.org/awards/7301-cote-top-ten-awards

Chenn, Jenn, and Anderson, Kjell. 2019. "Tenant Improvement Embodied Carbon Study." LMN Architects. https://lmnarchitects.com/lmn-research/tenant-improvements-embodied-carbon-study

EPA. 2021. "Facts and Figures about Materials, Waste and Recycling," United States Environmental Protection Agency. https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/durable-goods-product-specific-data

Huang, M., Simonen, K., Ditto, J. Carbon Leadership Forum. 2019. "Life Cycle Assessment of Tenant Improvement in Buildings." https://carbonleadershipforum.org/lca-of-mep-systems-and-tenant-improvements/ Select "TI LCA Report: Full Report on TI Study."

Simonen, K., Rodriguez, B., Barrera, S., Huang, M., McDade, E,. Strain, L. Carbon Leadership Forum. 2017. "Embodied Carbon Benchmark Study: LCA for Low Carbon Construction Part One." https://digital.lib.washington.edu/researchworks/bitstream/handle/1773/38017/CLF%20Embodied%20Carbon%20Benchmark%20Study.pdf

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The furniture calculator is available as part of the "MSR Design Sustainability Tracker," which can be downloaded from the MSR Design **website.** Tally reports and Excel tables are available upon request.


WORKSHOP | Photograph by Brandon Stengel
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