Life Cycle Assessment

of a Commercial Tenant Improvement Project

Summary Document by the Carbon Leadership Forum

October 2019

wework

CLF Carbon Leadership Forum

Acknowledgments

The research team would like to thank Meghan Lewis of WeWork for her role in initiating this study and providing the needed material data for this work.

The research team would also like to recognize the Oregon Department of Environmental Quality, who sponsored an earlier preliminary study exploring the LCA impacts of MEP and TI. This earlier study provided the foundational work for this WeWork study.

Citations

Huang, M., Rodriguez, B.X., Simonen, K. (2019) *Life Cycle Assessment of a Commercial Tenant Improvement Project: Summary Document*.

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Introduction

WeWork provides office spaces around the world and wants to understand the environmental impacts of a typical WeWork office. The Carbon Leadership Forum (CLF) was asked to estimate these impacts by performing a life cycle assessment (LCA) of a sample WeWork commercial office tenant improvement project. The CLF identified critical items in the project to help WeWork understand the environmental impacts of its supply chain.

This summary document is an abridged version of the full internal report presented to WeWork. It summarizes the goal and scope, methodology, results, and discussion of this study.

Goal and scope

The goal and scope of the LCA are described in this section.

Goal

The goal of this study is to help WeWork understand the environmental impacts of a typical WeWork office and identify areas for reducing embodied carbon across their construction supply chain. Additional information about the goal and background of the study is presented in Table 1, which is formatted according to a framework or "taxonomy" developed as a part of ongoing efforts to standardize building LCA reporting.

Scope

The scope of the assessment refers to 1) the physical scope of the project, which describes which parts of the building or project are included or excluded from the analysis, and 2) the life cycle scope of the project, which describes which parts of life cycle (cradle, use, end-of-life) are assessed.

This LCA was performed on a case study project provided by WeWork. The case study building is not identified in this summary document due to confidentiality reasons, but basic information about the project is listed below:

- Total floor area: 72,160 USF / about 79,000 GSF (7343 m2)
- Number of floors: 4
- Average floor plate area: about 19,750 GSF
- Number of desks: 1370

A screening-level LCA was initially performed on the project cost estimate in order to determine which items should be included in the detailed LCA. The detailed LCA required a limited scope because 1) there were limits on the effort and time available to complete the project within the desired timeline and 2) there was not always LCA data available for certain items. This screening-level LCA and justification for the scope designation are described more in the section **LCA methodology > Method 1: EIOLCA.**

The scope is also supplemented with additional background information per the LCA taxonomy, presented in Table 2.

Table 1. Goal description.

LCA taxonomy	Project information
Assessment goal	
• Intended application	To inform WeWork's supply chain sustainability program and establish priorities for reducing embodied carbon across their construction supply chain.
• Reasons for carrying out the study	To support WeWork in reducing the carbon impact of its supply chain
• Intended audience	• Internal WeWork team • Other stakeholders, such as relevant product manufacturers
• Whether results are intended to be used in comparative assertions	No comparative assertions will be made
Background information on assessment	
General information on LCA	
• Date of LCA assessment	February - May 2019
• Assessment stage: Project phase at time of LCA assessment	Construction and move-in complete as of February 2019
• Client for assessment	WeWork
• Name and qualification of LCA assessor	• Kate Simonen, AIA, LEED, PE, SE • Monica Huang, EIT, MSCE • Barbara X. Rodriguez, PhD Candidate
• Organization of assessor	Carbon Leadership Forum
Verification	Verification not performed
LCA data and methods	
• Source, type and quality of LCA data	• EPDs • Quartz database (2015) • Athena 5.2 (2016)
• LCA impacts and assessment method including version number and reference	• Characterization method: TRACI 2.1 • LCA impacts assessed: o Global warming potential (kg CO2e) o Acidification potential (kg SO2e) o Eutrophication (kg Ne) o Ozone depletion potential (kg CFC11e) o Smog formation potential (kg O3e) o Primary energy (MJ) o Mass (kg)
Assumptions and scenarios	
• HVAC, natural ventilation and daylight simulation performed	Unknown
• Source, type and quality of building data	The cost estimates and quantity take-offs were generated by the WeWork construction and building openings teams. This information is considered to be highly accurate.
• BIM model available (Y/N)	Yes

Table 2. Scope description.

LCA taxonomy	Project information
Project information	
• Project name	Not disclosed
• Project type	Office, Building Class A
• Project architect, engineer, and/or contractor	WeWork, IA (Interior Architects) – Architect of Record
• Project owner, developer, and/or manager	WeWork
• Project construction cost	Not disclosed
• Rating scheme	LEED (Core & Shell), CALGreen Building Code
• Rating achieved	Gold (Core & Shell)
• Year of building construction completion	2019 (C&S Completed 1987)
• Year of building commissioning	Systems commissioned in 2018
• Year of occupancy	2019
• Year of refurbishment	Not applicable
Functional unit	
Building scale and performance	
Area characteristics	
• Building footprint area	12,900 USF / 18,706 GSF
• Total gross floor area (GFA)	72,160 USF / 79,000 GSF
• Parking lot size	Not applicable
Height characteristics	
• Average ceiling height	8’6” – 9’0”
• Building total height	Project is limited to 4 floors of building
• Number of stories above grade	16 (project is limited to 4 floors)
• Number of stories below grade	Project does not include parking
Relevant technical and functional requirements	
• Building use type(s)	Office
• Building occupancy type	(B) Business
• Design number of building occupants	1,370 desks
• Design life expectancy in years	Unknown
• Structural type (per IBC)	Project does not include structural design
Geographic and site characteristics	
• Climate zone (per IECC)	IECC climate zone 4
• Landscaping description	Not applicable
Location - address	
• Location - Street address	Not disclosed
• Location - city	Not disclosed
• Location - state/province	Not disclosed
• Location - country	United States
Life cycle scope	
Reference study period (RSP)	N/A
Life cycle stages	A (A1-A3 at minimum, A4-A5 where possible) C where possible
System boundary	
Building scope per Omniclass or RICS Professional Statement	See Table 3.

LCA methodology

Two LCA methods were performed on this project:

1) Method 1 is a preliminary screening analysis that applied Economic Input-Output LCA (EIOLCA) to the project cost estimate. This method is coarse and conservative, but is quickly performed.
2) Method 2 is a more detailed analysis that applies material-specific LCA data to quantity take-offs (QTOs) of the project plans. This method is more precise but requires more effort to perform.

Both methods are approximate and do not perfectly reflect actual conditions. The precision of the results are limited by the scope of the study and the lack of product-specific LCA data, so generic substitutions had to be made.

Method 1: EIOLCA

The economic input-output (EIO) LCA (EIOL CA) method was utilized as a screening analysis to help determine which items should be prioritized in the detailed LCA (method 2). This method translates dollars spent in a specific industrial sector (e.g. flat glass manufacturing) into environmental impacts. The most recently-published source of EIOLCA data is the United States Environmentally-Extended Input Output (USEEIO) database v1.1. This is a national input-output life cycle model developed by the US Environmental Protection Agency (EPA).[1] This dataset was published in 2017 and presents LCA data for 388 industrial sectors per $1 USD spent in the reference year 2013. This dataset is publicly available at https://catalog.data.gov/dataset/useeio-v1-1-matrices and was downloaded in September 2018. The USEEIO dataset was published in the form of the Producer Price Model, thus the LCA impacts for this EIOLCA analysis represent a cradle-to-gate scope, i.e. life cycle modules A1-A3.

The EIO LCA calculation method can be described as follows:

1. **Obtain cost estimate.** The cost estimate was performed and provided by WeWork. Each line item in the cost estimate represented a category of products, e.g. “Art,” “Audio-Visual Equipment,” “Beer & Coffee Equipment (Appliances).” There were 50 items in the cost estimate.
2. **Adjust costs to exclude labor.** It was assumed that the values in the cost estimate included the cost of labor. These costs were adjusted to exclude the estimated percentage cost of labor. The labor percentages were estimated using RSMeans.[2] Adjusting the costs for labor reduced the overall project cost to 71% of the original cost, meaning that material costs were approximately 71% of the overall project cost.
3. **Assign industrial sectors from the EIO LCA database to each group in the cost estimate.** There were 388 industrial sectors in the USEEIO database. Not all sectors in the database were applicable to the building industry, but multiple sectors could be relevant to each item in the cost estimate. For example, the cost estimate category “Aluminum-Framed Storefronts” could be attributed to the sectors “332320/metal windows, doors, and architectural products/us” as

[1] Y. Yang, W. W. Ingwersen, T. R. Hawkins, M. Srocka, and D. E. Meyer, “USEEIO: A new and transparent United States environmentally-extended input-output model,” *J. Clean. Prod.*, vol. 158, pp. 308–318, Aug. 2017.
[2] Gordian RSMeans Data, *Interior Costs with RSMeans data*, 35th ed. Rockland, MA, 2018.

well as "327200/glass and glass products/us." In cases where multiple sectors were applied, the costs were assumed to be evenly divided between the sectors.

4. **Adjust for inflation.** The USEEIO data reference year was 2013, meaning that the LCA impacts were expressed in 2013 dollars. To adjust for inflation, the basic Consumer Price Index from the U.S. Bureau of Labor Statistics was used to obtain an inflation factor of 1.09 to convert between 2013 and 2019 dollars.[3]
5. **Multiply costs with EIO LCA sector impacts. Sum and normalize per unit floor area.** The adjusted costs for each item were multiplied with the assigned sector impacts, summed, and then normalized per unit floor area.

Method 2: Detailed LCA

The methodology of the detailed LCA are described in this section. The steps for performing the detailed LCA are:

1. **Identify categories of interest**. The EIO LCA results were useful for identifying which categories in the cost estimate were critical to include and which could be omitted from the detailed LCA. The high-impact "priority" items were selected from the EIO LCA results by ranking the cost estimate categories according to the GWP results, and calculating the cumulative percentiles of the top *n* sectors to determine which sectors would be needed to capture the top 90 - 95% of impacts. The final list of items describing the scope of the study is shown in Table 3.
2. **Gather material quantity data**. In gathering the material quantity data, most of the material quantities were provided by WeWork. However, for Electrical and Plumbing items, the original QTO items were not assessed due insufficient quantity and LCA data for these items. Instead, the MEP assessment was adapted largely from a previous similar study, referred to as the ODEQ-CLF study (initiated and funded by the Oregon Department of Environmental Quality (ODEQ)).[4] HVAC items were taken from the project mechanical schedules.
3. **Simplify and combine similar QTO items**. To simplify the analysis to a level of work that could be completed within the desired timeline, similar items were combined into a generic item type, e.g. ten types of partitions were combined into a single type of partition.
4. **Collect LCA data for QTO items.** The research team searched for best-fit LCA data from building-specific LCA databases and EPDs, prioritizing North American sources then European sources where no other alternatives were available. Generally, database data (Quartz or Athena for North America) were preferred over EPD data because they were more generic and representative of the industry. Quartz was prioritized over Athena because Quartz was open-access while Athena was somewhat proprietary (though Athena can be downloaded for free).
5. **Apply LCA data to QTO items**. Certain assumptions had to be made about the LCA data and QTO data in order to perform the calculations, such as density or thickness assumptions in order to make the conversions between LCA units and QTO units.

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[3] U.S. Bureau of Labor Statistics, "CPI Inflation Calculator." [Online]. Available: https://data.bls.gov/cgi-bin/cpicalc.pl. [Accessed: 28-Feb-2019].

[4] ODEQ-CLF study: Carbon Leadership Forum (CLF), *LCA of MEP and TI* (2019). http://carbonleadershipforum.org/2019/05/07/lca-of-mep-and-ti/

Table 3. Categories evaluated in detailed LCA, organized by cost estimate categories, CSI categories, and source of material quantity data.

Cost estimate category	CSI category	Source of material quantity data
Aluminum-Framed Storefronts	08 81 00 - Glass Glazing	WeWork Revit file
	08 41 00 - Entrances and Storefronts	
Carpeting, Rugs	09 68 00 - Carpeting	WeWork QTO
Interior Partitions	09 21 00 - Plaster and Gypsum Board Assemblies	
	09 22 00 - Supports for Plaster and Gypsum Board	
	09 81 00 - Acoustic Insulation	
Metal Doors and Frames	08 10 00 - Doors and Frames/Furnish	
	08 70 00 - Hardware	
Millwork, including Phone Booths, Printer Nook	06 22 00 - Millwork	
	12 36 00 - Countertops	
Painting and Coating	09 72 00 - Wall Coverings/Furnish	
	09 91 00 - Painting	
Sliding Glass Doors	08 32 00 - Sliding Glass Doors Furnish	
Tiling	09 30 00 - Tiling/Furnish	
	09 34 00 - Waterproofing-Membrane Tiling	
	09 65 19 - Resilient Tile Flooring/Furnish	
Wood Flooring	06 16 00 - Sheathing	
	09 64 00 - Wood Flooring	
HVAC	23 21 00 - HVAC Hydronic Piping and Pumps	WeWork mechanical schedules
	23 31 00 - HVAC Casing and Distribution	
	23 31 13 - Metal Ducts	
	23 31 16 - Nonmetal Ducts	
	23 36 00 - HVAC Terminal Units	
Furniture	12 52 00 - Seating	WeWork Master Schedule (Google Sheets)
	12 51 00 - Office Furniture	
	12 48 00 - Rugs and Mats	
Communications Backbone Cabling	26 05 00 - Common Work Results for Electrical	ODEQ-CLF study
Electronic Safety and Security	28 00 00 - Electronic Safety and Security	
Interior Lighting	26 51 00 - Interior Lighting	
Light Fixtures	Included with Interior Lighting above	
Plumbing	22 20 00 - Plumbing Piping	

Results

The results for the EIOLCA analysis and the detailed LCA are presented in this section.

EIOLCA

The results for the EIOLCA analysis are shown in Table 4. The GWP value, 783 kg CO2e/m2, is higher than the median value of the Embodied Carbon Benchmark Study,[5] which captured most structure and enclosure impacts to be around 300-500 kg CO2e/m2, though the embodied carbon impacts ranged as high as 1000 kg CO2e/m2. Generally, EIOLCA produces conservative (high) values, so this high number is not unexpected, but it is within a reasonable order of magnitude.

Table 4. Total EIOLCA results (life cycle stage A1-A3).

GWP (kg CO2e/m2)	AP (kg SO2e/m2)	EP (kg Ne/m2)	ODP (kg CFC11e/m2)	SFP (kg O3e/m2)	Energy (MJ/m2)
783	2.1	0.9	8.4E-04	43	11898

Figure 1 presents a breakdown of the cost estimate category contributions to each impact measure in the EIOLCA. For simplicity in color-coding, only the top 15 categories were color-coded, and the rest were grouped into an 'Other' category. This figure shows that the highest-impact product categories across all impact measures generally are:

- Plaster and Gypsum Board (a.k.a. Interior Partitions)
- HVAC
- Aluminum-Framed Storefronts
- Fire suppression items (which is included in the 'Other' category)
- In the ODP measure, Millwork and Furniture

[5] Carbon Leadership Forum, *Embodied Carbon Benchmark Study* (2016). http://carbonleadershipforum.org/2016/12/30/embodied-carbon-benchmarks/

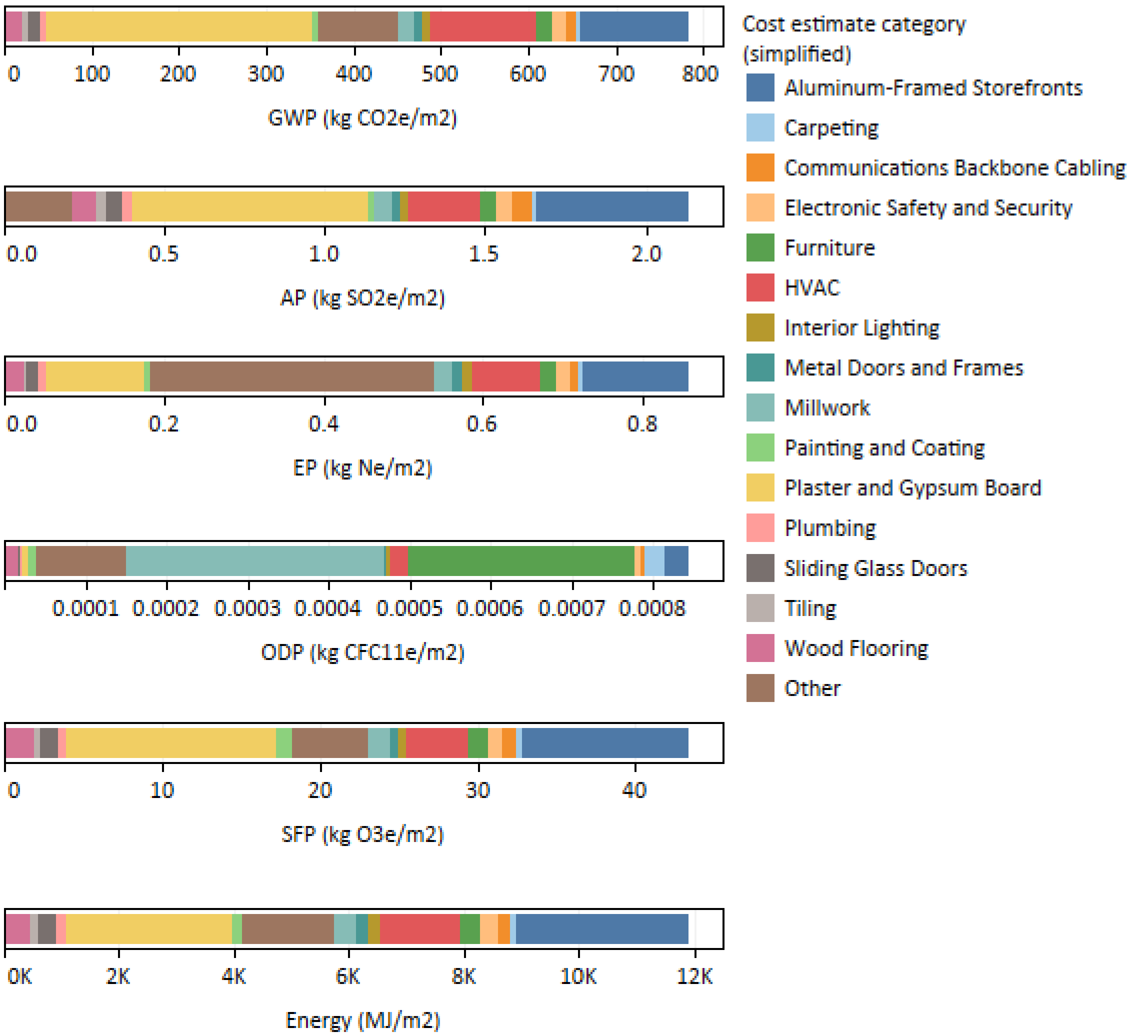

Figure 1. Overview of EIOLCA results (life cycle stages A1-A3).

Detailed LCA

This subsection presents the detailed LCA results.

About the data

The majority of the LCA results is based on generic North American database data. This is shown in Table 5, which presents the percentage allocation of data by data type and geographic region based on mass. This table shows that:

- By mass estimations, approximately 60% of the LCA results are based on LCA databases (87% of which is from Quartz) and 40% were based on EPDs.
- By mass estimations, approximately 80% LCA results are based on North American data sources, and 20% were based on European sources.

- Note that the 'Database + EPD' and 'North America + Europe' categories refers to millwork, which used a combination of North American database data and European EPD data.

Table 5. Percentage allocation of data by data type and geographic region based on mass.

	Geographic region			
Data type	**North America**	**North America + Europe**	**Europe**	**Grand Total**
Database: Quartz	50.3%	0.0%	0.0%	**50.3%**
Database: Oekobaudat	0.0%	0.0%	7.4%	**7.4%**
EPD	29.2%	0.1%	11.3%	**40.6%**
Database + EPD	1.8%	0.0%	0.0%	**1.8%**
Grand Total	**81%**	**0.1%**	**19%**	**100%**

Overall results

The overall results of the detailed LCA for life cycle stages A and C are shown in Table 6.

Table 6. Total detailed LCA results, life cycle stages A and C.

Life cycle stage	GWP (kg CO2e/ m2)	AP (kg SO2e/ m2)	EP (kg Ne/m2)	ODP (kg CFC11e/ m2)	SFP (kg O3e/ m2)	Primary energy (MJ/ m2)
A	194	1.2	0.10	5.4E-06	9.4	11454
C	-14	-0.1	2.08E-03	2.0E-07	-0.8	2

The total mass of the project was estimated to be 86 kg/m^2.

Figure 2 presents an overview of all impact categories for life cycle stages A and C. Note that stage C impacts tended to be negative due to recycling credits, which is typical for metals in the Quartz database. This figure shows that different material categories dominated different impact categories. This distribution of category allocations differs significantly from the EIOLCA distribution for several possible reasons:

- The Detailed LCA is more representative and specific than the EIOLCA
- The Detailed LCA omitted certain items from the EIOLCA. These were items that either had low predicted impact or lacked appropriate LCA data. Such items included demolition, fire control/suppression, certain electrical items, and certain TI items.
- The background EIOLCA data is very coarse, so there is a fair amount of uncertainty due to the assignment of industrial sectors and adjustments for cost of labor.

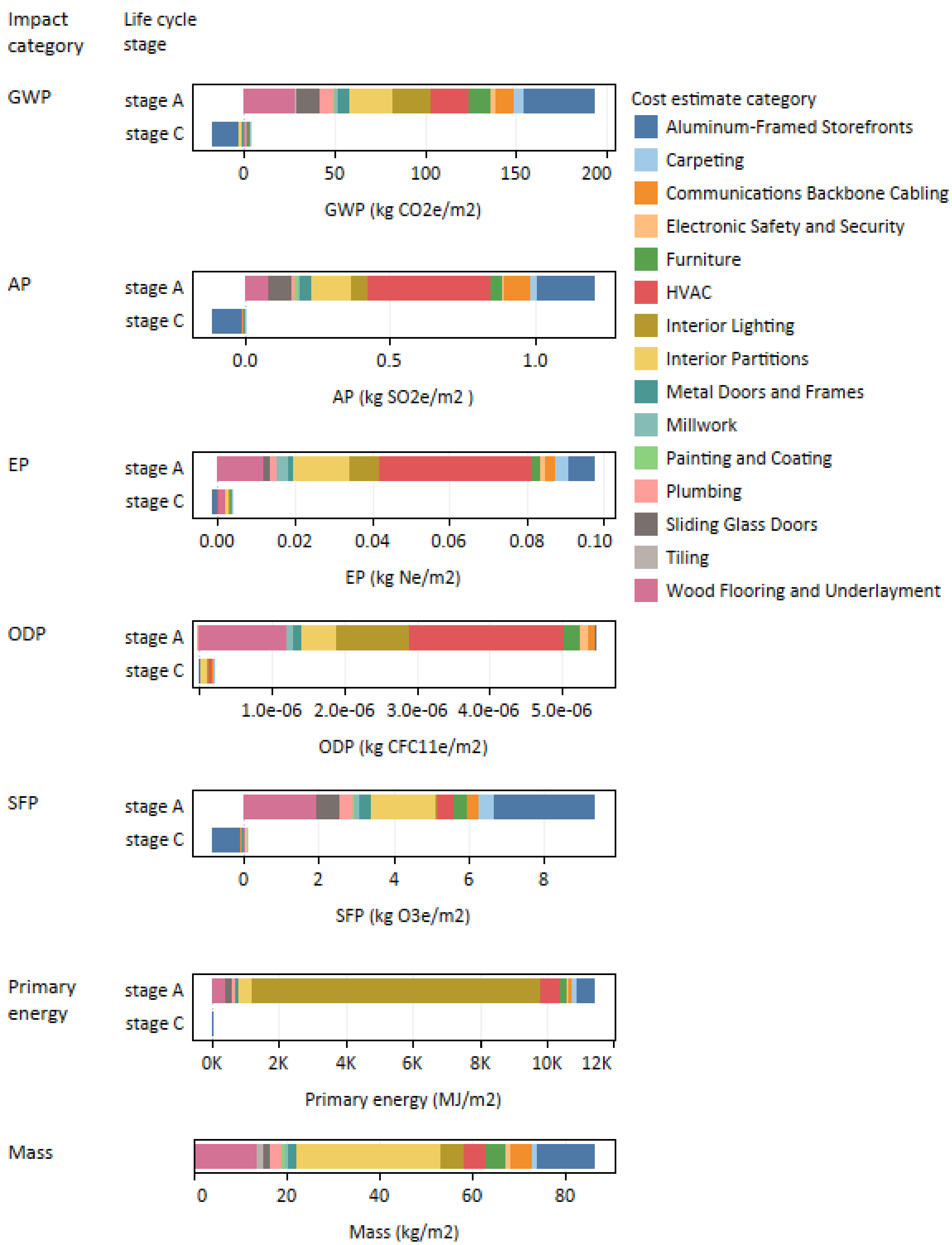

Figure 2. Contribution of cost estimate categories to overall results of the detailed LCA.

For GWP, the high-impact categories were:

- Aluminum-Framed Storefronts
- HVAC
- Interior Partitions
- Interior Lighting
- Wood Flooring and Underlayment

Three of these categories, Aluminum-Framed Storefronts, HVAC, and Interior Partitions, were also identified as high-impact categories observed in the EIOLCA results.

By mass, Interior Partitions, Wood Flooring & Underlayment, and Aluminum-Framed Storefronts made the greatest contributions.

Most environmental impact categories had a different distribution pattern of cost estimate category impacts. HVAC had a bigger impact in AP, EP, ODP, and primary energy than in GWP and mass. This means that HVAC is more significant in other impact categories than GWP or mass would suggest.

GWP detailed contribution analysis

GWP is explored in more detail in this section because it is a primary impact category of interest in the building industry.

Figure 3 ranks the cost estimate categories by GWP impact. As noted previously, Aluminum-Framed Storefronts, Wood Flooring, and Interior Partitions are the top contributors for TI. HVAC and Interior Lighting are top contributors for MEP.

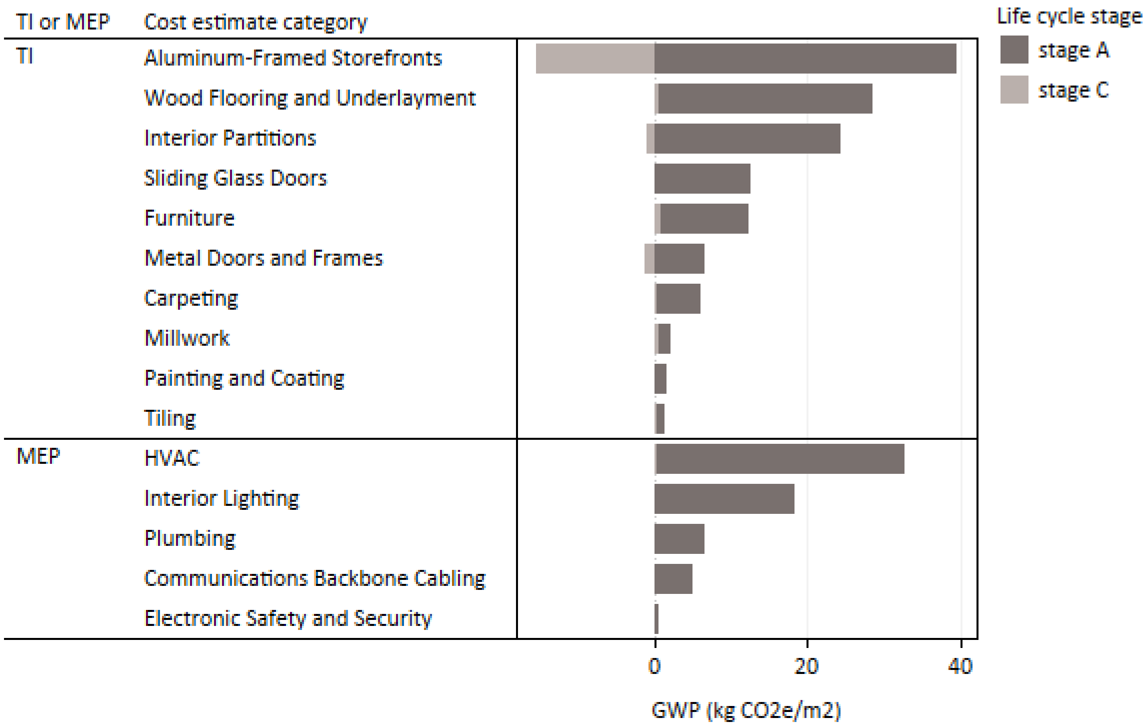

Figure 3. GWP contribution analysis by cost estimate category.

Figure 4 presents the top 20 high-impact items by GWP stage A impacts. A "surprise" high-impact item is rubber underlayment for wood flooring. However, the LCA data for rubber underlayment is uncertain, as discussed in the **Data Needs** section.

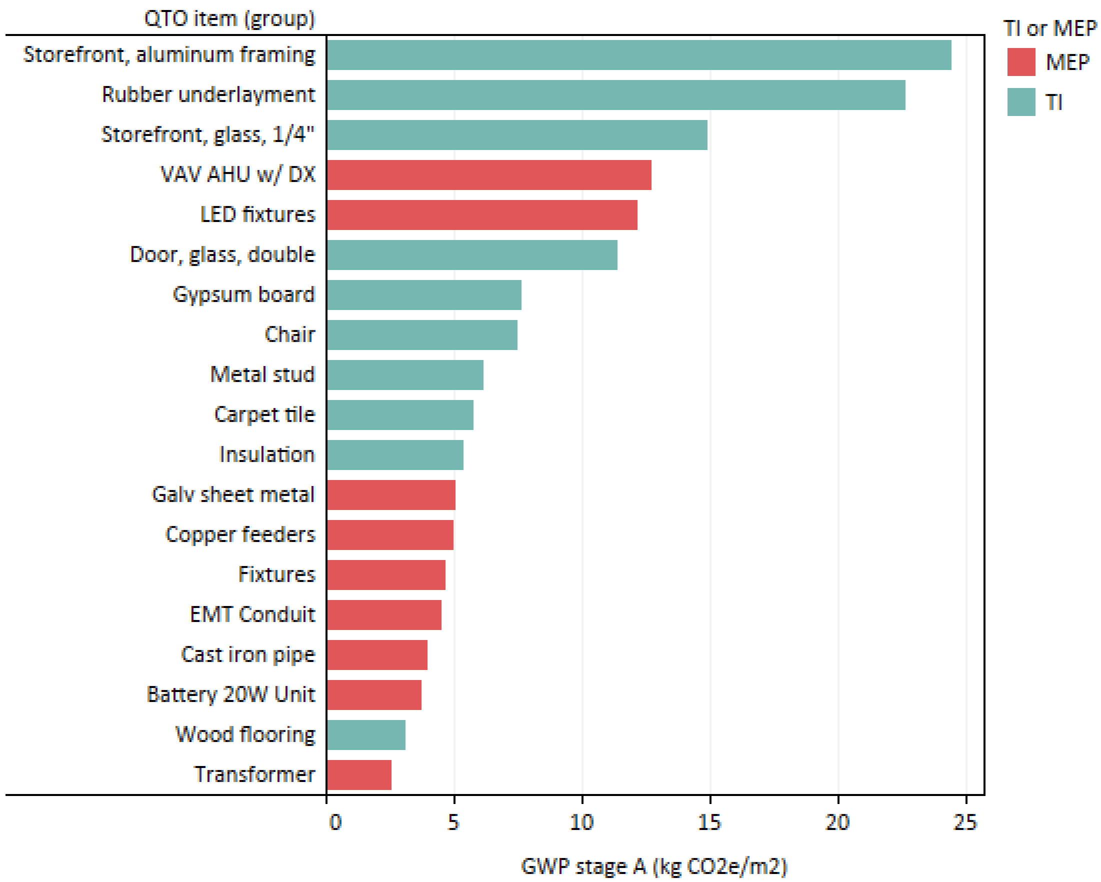

Figure 4. Top 20 QTO items for GWP, life cycle stage A.

Discussion

This section discusses critical items, data needs, comparisons, and limitations of this study.

Critical items

Based on the results of the detailed LCA, the high-GWP items are those shown in Figure 4. Some recommendations for reducing the environmental impacts of the highest-impact items are:

- **Storefront aluminum** and **glass**: The best way to reduce the impacts of storefront aluminum and glass is to reduce the amount of storefront in the project or to avoid storefront altogether. If storefronts cannot be eliminated from the project, their material quantities may be reduced by reducing the profile of the aluminum pieces and/or the thickness of the glass. Biogenic alternatives to aluminum storefront framing are also available and may have a lower global warming potential. If wood is used for storefront framing, then the wood should be sourced from sustainably managed forests.
- **Rubber underlayment** (for wood flooring). This LCA data for this item was substituted using a proxy (rubber floor tiles), so it is not certain if rubber underlayment is truly as high-impact as it appears in these results. If rubber underlayment is truly as high-impact as it appears, then the

research team would recommend the WeWork design team to try to avoid the use of rubber underlayment on future projects or to source recycled rubber products.

- **LED fixtures.** LEDs are constantly evolving and getting better (i.e. with better lighting performances, but also with increased functionalities), and their extended lifetimes are an important marketing asset. This means that the LEDs purchased today will be outdated by new products long before they fail, meaning that their actual lifetimes will be much shorter than anticipated because they will be eventually be replaced by better LEDs.
- **Air handling units (VAV AHU w/ DX).** With air handling units (AHUs), there is not much that can be done to reduce their embodied impacts because they generally require specific materials in their designed configurations. However, in terms of minimizing embodied carbon, it is more efficient to have fewer large AHUs than many small AHUs.
- **Sliding glass doors.** Glass doors are similar to storefronts in that they are both made of aluminum and glass, which are energy-intensive high-impact materials. Similar to the recommendations for storefront, the research team would recommend avoiding the use of sliding glass doors.

The impacts of other items, such as carpet tile and insulation, can be reduced by sourcing products that contain biogenic or recycled content.

Data needs

A number of items were identified as critically lacking appropriate LCA data. These items were identified as critical because they were fairly high-impact but had no satisfactory LCA data options. These items are:

- Rubber floor underlayment
- Wood flooring
- Sliding glass doors
- Most MEP items
- Refrigerants

Other items that are in need of suitable LCA data, but are less critical, are:

- Aluminum door frame
- Furniture
- Sisal carpet

Comparison

The CLF research team recently finished a study on the LCA impacts of MEP and TI.[6] This study was initiated and funded by the Oregon Department of Quality, and thus will be referred to as the ODEQ-CLF study. The results of the WeWork study are on the same order of magnitude as the ODEQ-CLF study, suggesting that the results of this WeWork study are reasonable and comparable to other projects. A

[6] Carbon Leadership Forum (CLF), *LCA of MEP and TI* (2019). http://carbonleadershipforum.org/projects/lca-of-mep-and-ti/

comparison the results between the ODEQ-CLF and this project is shown in Table 7. The ODEQ-CLF study evaluated five projects; the minimum and maximum values from the results are shown as a range in the table. Note that the MEP portion of the ODEQ-CLF study only evaluated GWP and mass.

Table 7. Comparison between the results of this study and the CLF LCA study, stage A impacts.

Project	Comp-onent	GWP (kg CO2e/ m2)	AP (kg SO2e/ m2)	EP (kg Ne/m2)	ODP (kg CFC11e/ m2)	SFP (kg O3e/ m2)	Primary energy (MJ/ m2)	Mass (kg/m2)
This study	TI	132	0.62	0.05	2.12E-06	8.24	1978	69
	MEP	63	0.74	0.15	4.07E-06	1.23	6976	20
ODEQ-CLF Study	TI	45 - 135	0.2 - 0.6	0.02 - 0.30	7.6E-07 - 5.4E-06	2.2 - 7.4	820 - 2750	17 - 43
	MEP	41.2 - 74.8	-	-	-	-	-	14.6 - 22.7

Neither of these studies are 3rd-party verified, therefore no attempts are comparison are being made.

Limitations

For TI, the limitations of this work are:

- **Material quantities**: Some of the material quantity estimates in this project are considered highly accurate because they were quantity take-offs performed by WeWork, while other estimates had a higher level of uncertainty, but these were usually for low-impact items (e.g. millwork, door hardware).
- **Quality of match between actual QTO item and LCA data**: LCA data was rarely available for the exact products used on the project. Sometimes, material substitutions had to be made in cases where there were no satisfactory LCA data available for the correct product (i.e. glulam was substituted for hardwood flooring).
- **Excluded items**: Some items were excluded because either a) LCA data could not be found (e.g. fire suppression items), or b) they were determined in the EIOLCA to be outside the scope of the study. The EIOLCA analysis suggested that fire suppression items may be high-impact, but these items could not be evaluated in the detailed LCA due to lack of LCA data for these types of items.

For MEP, the limitations of this work are:

- The electrical and plumbing portions of this study were not entirely based on actual quantities, since the subcontractors did not provide project-specific data. Instead, estimates per unit floor area from a previous study were applied to this study.
- The dearth of EPDs / LCA data for mechanical and electrical equipment – especially in the North American context – makes the mechanical components of these results very uncertain.

Conclusion

An LCA of a WeWork commercial office tenant improvement project was performed using two methods: 1) EIOLCA, which roughly estimated the impacts based on costs, and 2) a detailed LCA, which estimated the impacts based on detailed material quantity take-offs. The EIOLCA method assessed life cycle stage A only (cradle-to-gate; A1-A3) while the detailed method assessed life cycle stages A (A1 through A3 or A5, depending on the data sources) and C. The results of both methods are summarized in Table 8.

Table 8. Summary of LCA results.

Method	Life cycle stage	GWP (kg CO2e/ m2)	AP (kg SO2e/ m2)	EP (kg Ne/m2)	ODP (kg CFC11e/ m2)	SFP (kg O3e/ m2)	Primary energy (MJ/ m2)	Mass (kg/ m2)
EIOLCA	A1-A3	783	2.1	0.9	8.4E-04	43	11898	-
Detailed LCA	A	194	1.2	0.10	5.4E-06	9.4	11454	86
	C	-14	-0.1	2.08E-03	2.0E-07	-0.8	2	-

The results of the detailed LCA were compared to a similar earlier study, the ODEQ-CLF study on the LCA of MEP and TI. These results were on the same order of magnitude or within range of the results of the ODEQ-CLF study.

Based on an analysis of the detailed LCA results, the top ten high-impact items by GWP are:

1) Storefront – aluminum and glass
2) Rubber underlayment
3) Air-handling units
4) LED fixtures
5) Sliding glass doors
6) Partitions (gypsum board, insulation, and metal studs)
7) Chairs
8) Carpet tile
9) Ductwork sheet metal
10) Copper feeders

Refrigerants are also important to consider.

The research team recommends reducing the impacts of these high-impact items by avoiding or reducing the quantities used, and/or sourcing low-impact options for these products.