# Whole Building Life Cycle Assessment of a mass timber parking garage structure

## including & excluding biogenic carbon

Net ZED Case Study Lab

TALLWOOD DESIGN INSTITUTE

rendering courtesy of SRG Partnership

### Whole Building Life Cycle Assessment

Several whole building life cycle assessments (WBLCA) were carried out for the BC Passive House Factory using two different WBLCA softwares: Tally software (from KT Innovations), and the Athena Impact Estimator for Buildings (from Athena Sustainable Materials Institute). This poster details the results calculated using KT Innovation's Tally® software, with a result including and excluding biogenic carbon.

### Glenwood CLT Parking Garage

**Location:** Springfield, Oregon
**Architect:** SRG Partnership
**Structural Engineer:** KPFF
**Gross Area:** 194,999 ft² (18,116 m²)
**Use:** Parking Garage
**Reference Service Life for WBLCA:** 75 years

**Scope is limited to the building's structure and foundations:**

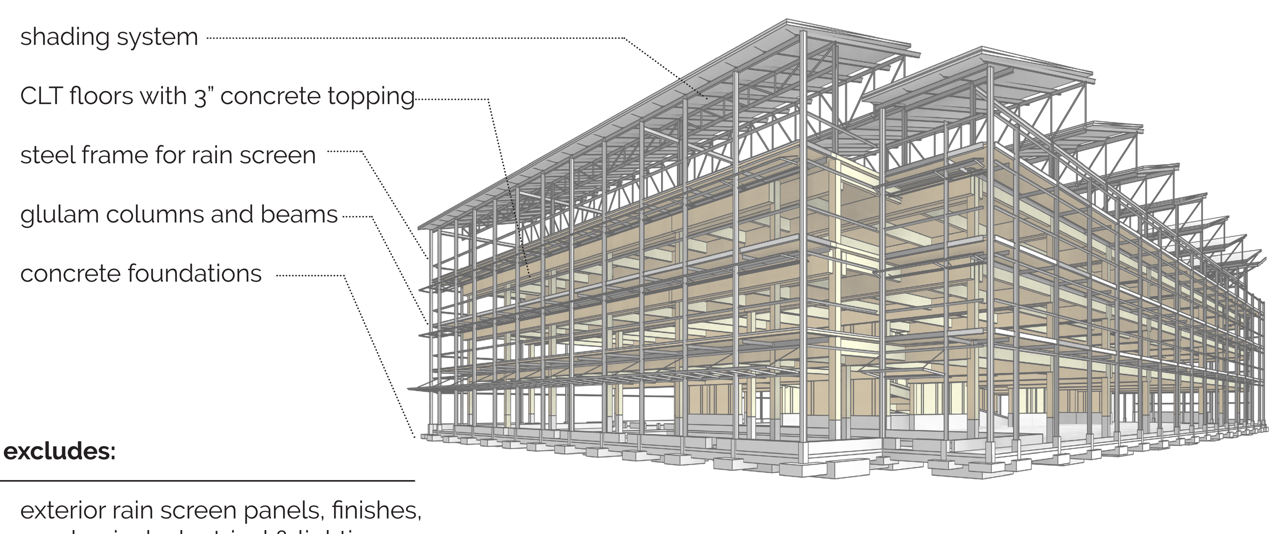
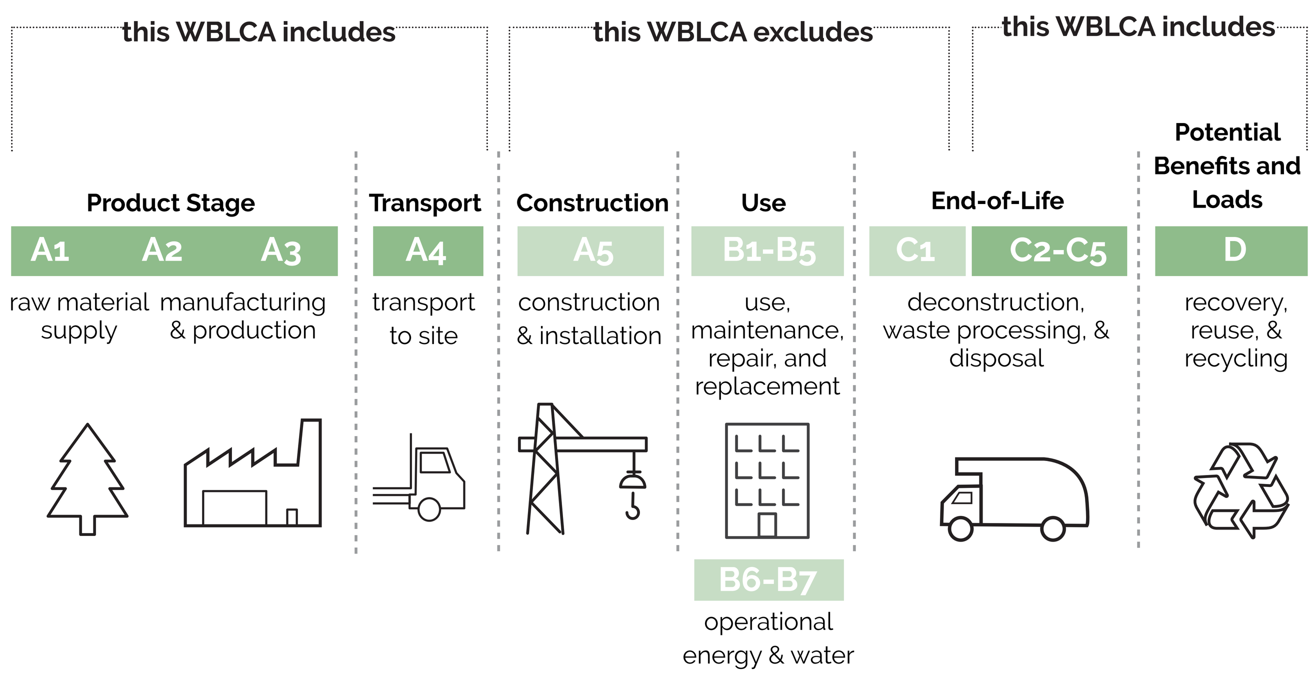



image courtesy of SRG Partnership

**Scope excludes:**

exterior rain screen panels, finishes, mechanical, electrical & lighting, plumbing, connections, fasteners, and sitework




## excluding biogenic carbon

### Embodied Carbon

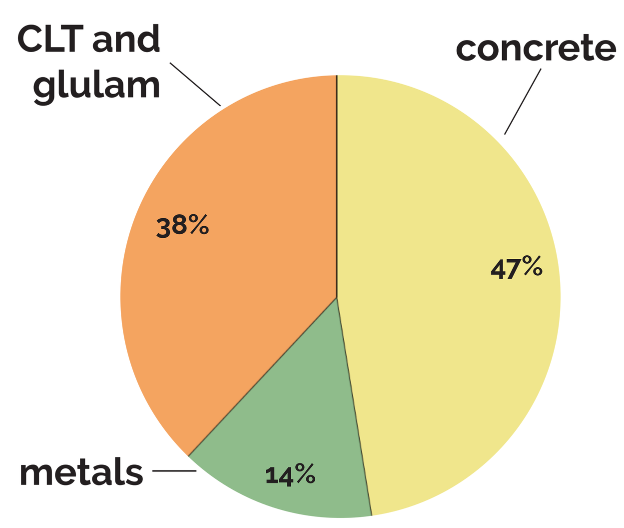
building size 18,116 m² (194,999 ft²)

global warming potential $kg\ CO_2eq$ per m²

| | |
|---|---|
| initial GWP | 77 |
| total GWP | 104 |

**GWP per material**

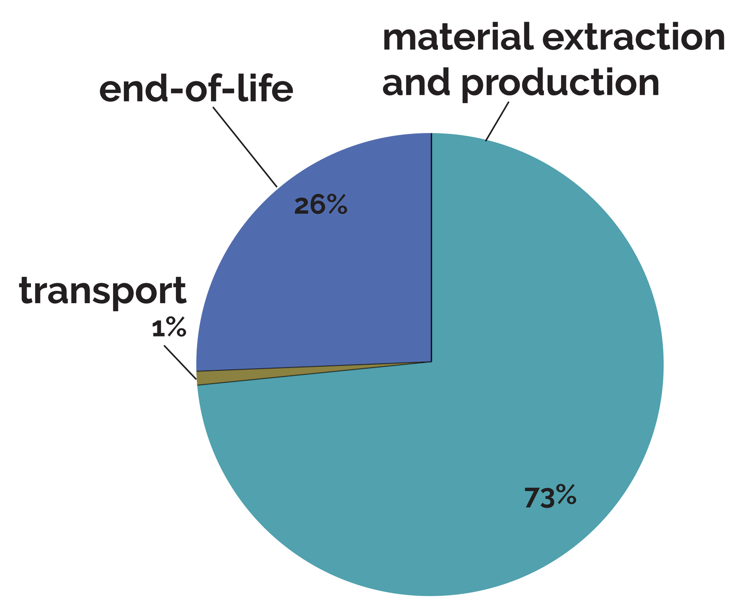
| | |
|---|---|
| CLT, Glulam, and Wood | 38% |
| Concrete | 47% |
| Metals | 14% |




**GWP** per material

**GWP per life stage**

| | | |
|---|---|---|
| A1-A3 | 76.02 kg/m² | 73% |
| A4 | 0.977 kg/m² | 1% |
| B | | not included |
| C2-C4 | 26.56 kg/m² | 26% |
| D | -16.3 kg/m² | |




**GWP** per life stage module

## including biogenic carbon

### Embodied Carbon

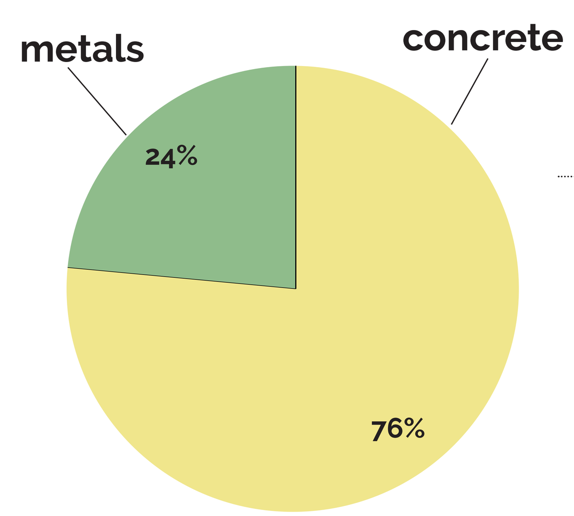
building size 18,116 m² (194,999 ft²)

global warming potential $kg\ CO_2eq$ per m²

| | |
|---|---|
| initial GWP | -9 |
| total GWP | 49 |

**GWP per material**

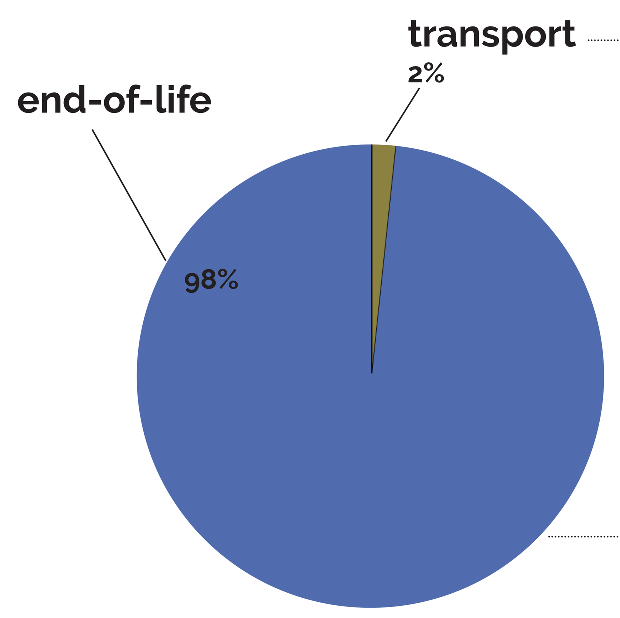
| | |
|---|---|
| CLT, Glulam, and Wood | -16% |
| Concrete | 76% |
| Metals | 24% |




**GWP** per material

**GWP per life stage**

| | | |
|---|---|---|
| A1-A3 | -10.0 kg/m² | -17% |
| A4 | 0.982 kg/m² | 2% |
| B | | not included |
| C2-C4 | 57.78 kg/m² | 98% |
| D | -3.89 kg/m² | |



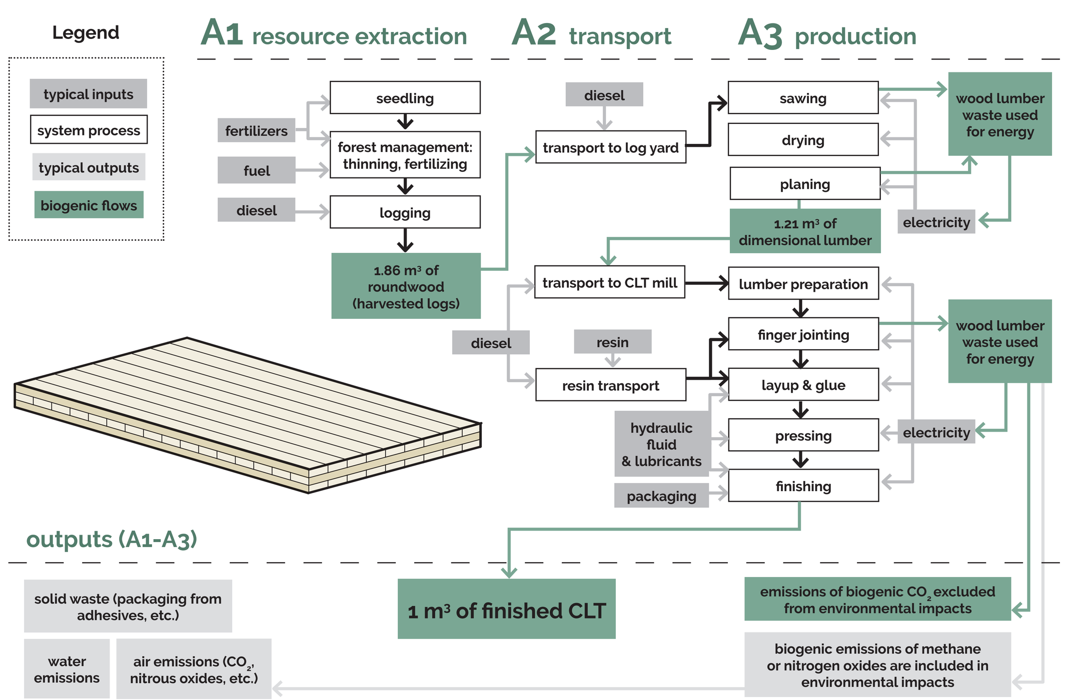

**GWP** per life stage module

- Tally, a software for WBLCA, can include or exclude biogenic carbon in an assessment. For mass timber buildings, this can have a large impact on the global warming potential. When biogenic carbon is included, the biogenic stored carbon in the wood materials is initially counted as a credit that reduces GWP. At the end-of-life, biogenic carbon leaves the system (expressed as emissions) through incineration, landfill, or recycling. Some biogenic carbon is assumed to be permanently sequestered in a landfill; that amount of carbon remains in the total GWP reduction.
- Global warming potential (GWP) is a climate change indicator of the sum of greenhouse gas emissions over a period of time, typically expressed as kg $CO_2$ eq. Including biogenic carbon results in a lower global warming potential.
- Initial GWP is the net $CO_2$ eq emissions associated with material extraction, material manufacturing, and transport to the construction site.
- Total GWP is the net $CO_2$ eq emissions associated with material extraction, material manufacturing, transport to the construction site, future deconstruction, and disposal of building materials.
- When including biogenic carbon, glulam and CLT reduce the GWP.
- CLT and glulam are not shown because they contribute to a net reduction in the GWP when including biogenic carbon.
- A1-A3 includes $CO_2$eq emissions from extraction of raw materials and manufacturing of building products.
- A4 is the $CO_2$eq emissions from transport of materials from manufacturing to construction site.
- B encompasses the $CO_2$eq emissions from maintenance and replacement of materials during the building's use. Because this WBLCA was purely structure, it was assumed that the structure would not be replaced during the building's life.
- C2 shows the $CO_2$eq emissions from transportation to disposal site, C3 shows emissions from waste processing, and C4 shows emissions from final disposal. Tally averages multiple end-of-life scenarios for glulam and CLT. In this WBLCA, it is assumed that 14.5% of glulam and CLT is recycled, 22% is incinerated with energy recovery, and 63.5% is landfilled.
- D indicates benefits beyond the system boundary. For wood, it shows potential credit for utilizing waste products for energy; it is expressed by the equivalent avoided emissions of US average grid electricity. The incinerated energy from wood products (or any landfill gas that is captured for energy) results in avoided production of energy from fossil fuels. Because avoided energy product cannot be directly attributed to the material use, it is expressed as a separate module "D," which is considered beyond the system boundary.
- Key Transport Distances:
  CLT & Glulam: 146 km
  Concrete: 24 km
  Steel: 431 km


- Including biogenic carbon results in the impacts being more heavily weighted towards end-of-life, when the biogenic carbon leaves the system.

## Embodied Carbon of Cross-Laminated Timber: Production and End of Life

### 1 What is the CLT production process?




### 2 What is the global warming potential associated with CLT production?

Example CLT Manufacturing $CO_2$eq Impacts for 1 m³ of CLT in North American facilities

**A1 Logging, Nursery, Site Preparation, Planting, & Forest Management**

Includes energy for harvesting (diesel, gasoline etc.) and ancillary materials (e.g., lubricants, motor oil).

**A2 Transportation to Manufacturing**

Transportation via truck consumes diesel fuel, emitting $CO_2$. Distance of harvesting site to factory determines the magnitude of impacts. Transportation includes secondary materials.

**A3 Sawmilling, Drying, Adhesives, CLT Production, & Packaging**

18% (manufacturer 1) to 39% (manufacturer 2) of energy for CLT manufacturing comes from waste wood, and these biogenic emissions are excluded from the GWP numbers.

| | A1: Impacts per 1 m³ of CLT | A2: Impacts per 1 m³ of CLT | A3: Impacts per 1 m³ of CLT |
|---|---|---|---|
| manufacturer 1 | GWP: 37.88 $kgCO_2eq$ | GWP: 51.97 $kgCO_2eq$ | GWP: 32.04 $kgCO_2eq$ |
| manufacturer 2 | GWP: 11.38 $kgCO_2eq$ | GWP: 27.12 $kgCO_2eq$ | GWP: 51.29 $kgCO_2eq$ |
| manufacturer 3 | GWP: 32.25 $kgCO_2eq$ | GWP: 20.65 $kgCO_2eq$ | GWP: 153 $kgCO_2eq$ |


1 FPInnovations Canada. (2018). *Nordic X-Lam (CLT) environmental product declaration.*
2 FPInnovations. (2013). *Environmental product declaration CrossLam by Structurlam.*
3 Puettmann, M., Sinha, A., & Ganguly, I. (2018). *CORRIM Report - Life cycle assessment of cross laminated timber produced in Oregon.*


### 3 What end-of-life scenarios exist for CLT panels at the end of their lives?

When a building is eventually demolished, the following end-of-life scenarios are possible:

**Disposal in Landfill**

CLT panels could be sent to landfills, where they will decompose and emit landfill gas, composed of methane and $CO_2$. In the United States, landfills of a certain size are required to capture landfill gas (EPA, 2019).

+ some carbon stored indefinitely; landfill gas can be used to produce energy
− landfill gas contains methane,which has greater global warming potential than an equivalent quantity of $CO_2$

**Incineration in Power Plant**

CLT panels could be incinerated in a bioenergy power plant to produce electricity, heat energy, or combined heat and power (CHP), emitting $CO_2$.

+ power produced from bioenergy (burning wood like CLT) potentially avoids fossil fuel use.
− carbon from CLT is released as $CO_2$, and the bioenergy power plant might not result in actual in reduction in fossil fuel use

**Recycling & Panel Reuse**

recycle: wood chips, MDF, etc. **or** full panel reuse

The reuse of full CLT panels is a preferable end-of-life option, although it would likely be difficult to achieve. Recycling CLT panels in other wood products such as wood chips or wood panel products is more likely.

+ reprocessing of material potentially avoids the growth and harvest of virgin wood
− recycling the material may not actually lead to a reduction in the harvest of virgin wood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