Whole Building Life Cycle Assessment of a mass timber multifamily residential structure

including & excluding biogenic carbon

Net ZED Case Study Lab

TALLWOOD DESIGN INSTITUTE

exterior photo of Carbon12
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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.

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

- CLT roof structure
- steel framed core
- glulam columns and beams
- CLT floors
- concrete foundations & one level of underground parking

Scope excludes:

building envelope, finishes, mechanical, electrical & lighting, plumbing, connections, fasteners, concrete formwork, and sitework

Carbon12

Location: Portland, OR
Architect: Path Architecture
Structural Engineer: Munzing Structural Engineering
General Contractor: Kaiser Group
Gross Area: 32,499 ft² (3,019 m²)
Height: 85 ft (26 m)
Use: condominium, retail, and underground parking
Reference Service Life for WBLCA: 75 years

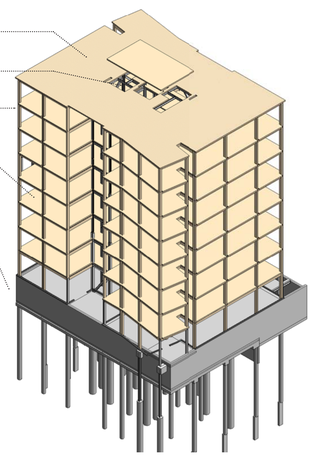
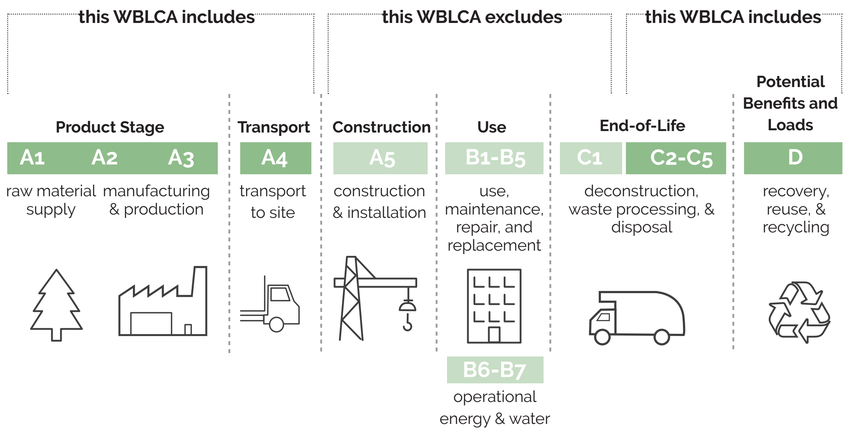


image courtesy of Path Architecture



excluding biogenic carbon

Embodied Carbon

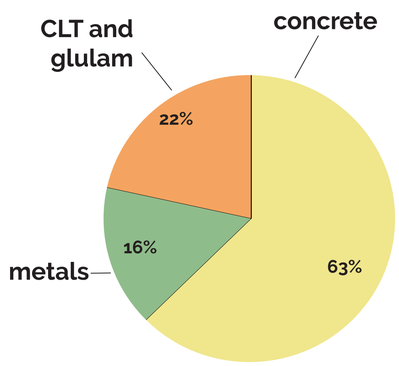
building size 9,837 gsm (105,890 gsf)

global warming potential kg CO_2eq per m²

initial GWP	**271**
total GWP	**322**

GWP per material

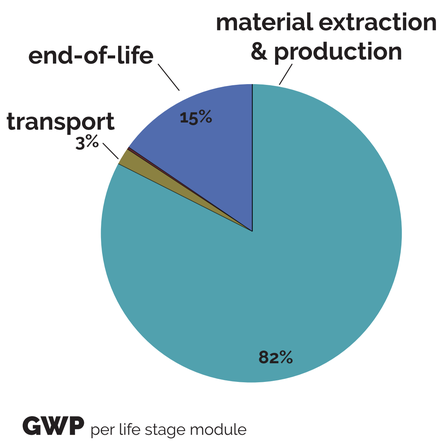
Glulam and CLT	**22%**
Concrete	**63%**
Metals	**16%**



GWP per material

GWP per life stage

A1-A3	265.4 kg/m²	**82%**
A4	5.85 kg/m²	**3%**
B		**not included**
C2-C4	49.67 kg/m²	**15%**
D	-46.2 kg/m²	



GWP per life stage module

including biogenic carbon

Embodied Carbon

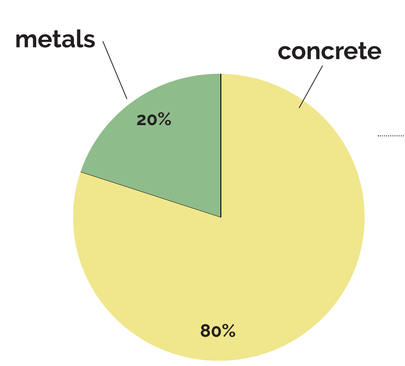
building size 9,837 gsm (105,890 gsf)

global warming potential kg CO_2eq per m²

initial GWP	**125**
total GWP	**227**

GWP per material

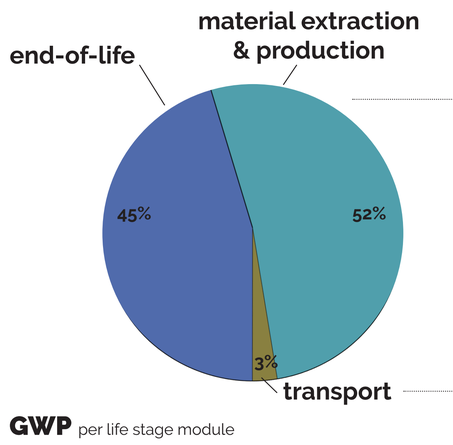
Glulam and CLT	**- 6%**
Concrete	**80%**
Metals	**20%**



GWP per material

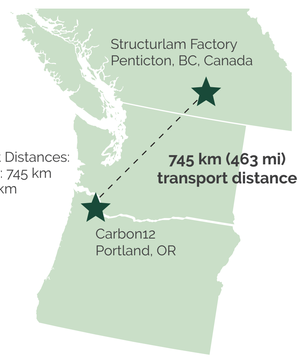
GWP per life stage

A1-A3	118.8 kg/m²	**52%**
A4	5.89 kg/m²	**3%**
B		**not included**
C2-C4	102.4 kg/m²	**45%**
D	-25.3 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_2eq emissions from extraction of raw materials and manufacturing of building products.
- A4 is the CO_2eq emissions from transport of materials from manufacturing to construction site.
- B encompasses the CO_2eq 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_2eq 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.
- Including biogenic carbon results in the impacts being more heavily weighted towards end-of-life, when the biogenic carbon leaves the system.

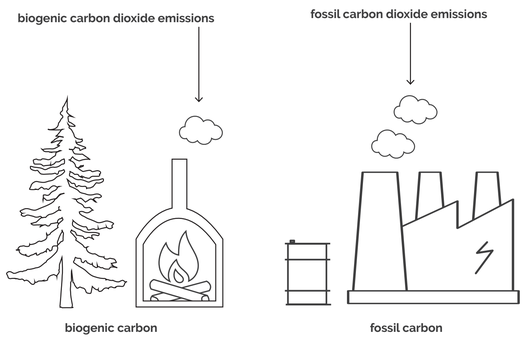


Key Transport Distances:
CLT & Glulam: 745 km
Concrete: 24 km
Steel: 431 km

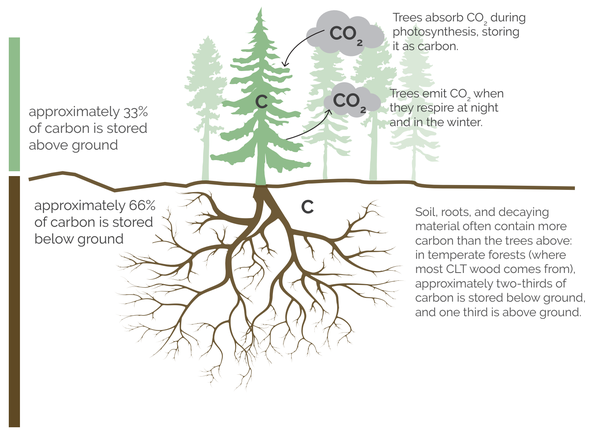
Biogenic Carbon and CLT

1 What is biogenic carbon?

Biogenic carbon is carbon derived from or contained in biological matter such as trees or plants. Fossil, or geologic, carbon refers to carbon contained in sources like coal, oil, or natural gas. Both sources emit carbon dioxide into the air when burned.



2 How do temperate forests store carbon?



3 What are the carbon flows in 1 m³ of CLT manufactured in North America?

During tree growth, harvest, manufacturing, construction, and disposal of CLT, various CO_2eq emissions occur. These flows are accounted for or omitted based on the standards and purpose of different types and scopes of environmental assessment. The carbon storage of wood may be represented by a negative, deductive value to the CO_2eq emissions of a CLT under certain assumptions of sustainable forestry.

carbon stored in the wood of CLT	emissions from harvest & manufacturing		unaccounted biogenic CO_2 emissions during harvest & manufacturing*	emissions from transportation to construction site		emissions from construction	emissions at end-of-life	
-741 kg CO_2 eq	80 kg CO_2 eq	206 kg CO_2 eq	28.5 kg CO_2 eq	0.67 kg CO_2 eq	34.1 kg CO_2 eq	5.76 kg CO_2 eq	17.4 kg CO_2 eq	568+ kg CO_2 eq
approximate[1]	low[2]	high[3]	estimate[1]*	low[4]	high[5]	estimate[6]	low[6]	high[7]

*usually not formally accounted for in life cycle assessments or environmental product declarations on the assumption that the emissions will be reabsorbed through new wood growth

1 FPInnovations Canada. (2018). *Nordic X-Lam (CLT) environmental product declaration.*
2 Athena Sustainable Materials Institute; (2013). *A Life cycle assessment of cross-laminated timber produced in Canada.*
3 Puettmann, M., Sinha, A., & Ganguly, I. (2018). *CORRIM Report - Life cycle assessment of cross laminated timber produced in Oregon.*
4 calculated with the software program Tally, based on travel distance of 25 km via diesel truck
5 calculated with the software program Athena, based on construction location of Portland, OR
6 calculated with the software program Athena, carbon storage capacity of CLT not included
7 calculated with the software program Tally, carbon storage of CLT considered to be re-emitted. End-of-life scenario mix: 14.5% of CLT is recycled, 22% is incinerated with energy recovery, and 63.5% is landfilled.

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