Whole Building Life Cycle Assessment of a mass timber industrial building

including & excluding biogenic carbon

Net ZED Case Study Lab

TALLWOOD DESIGN INSTITUTE

exterior photo of BC Passive House Factory © Ema Peter

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.

BC Passive House Factory

Location: Pemberton, British Columbia, Canada
Architect: Hemsworth Architecture
Structural Engineer: Equilibrium Consulting, Inc
General Contractor: Dürfield Constructors
Gross Area: 16,146 ft² (1,500 m²)
Height: 32 ft (9.7 m)
Use: industrial
Reference Service Life for WBLCA: 75 years

Scope includes structure, foundation, roof, exterior and interior assemblies.

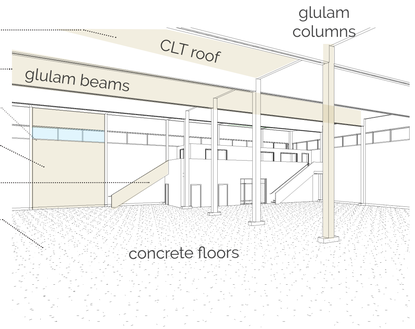
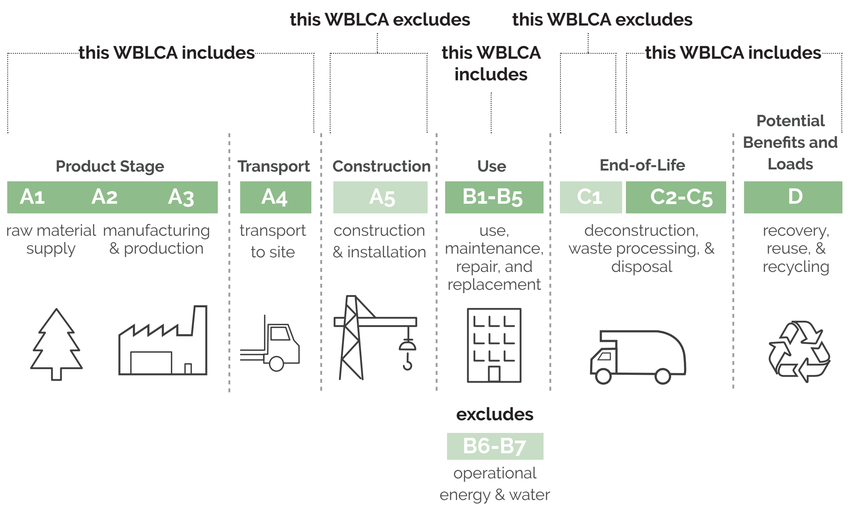


image courtesy of Hemsworth Architecture

Scope excludes:

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



excluding biogenic carbon

Embodied Carbon

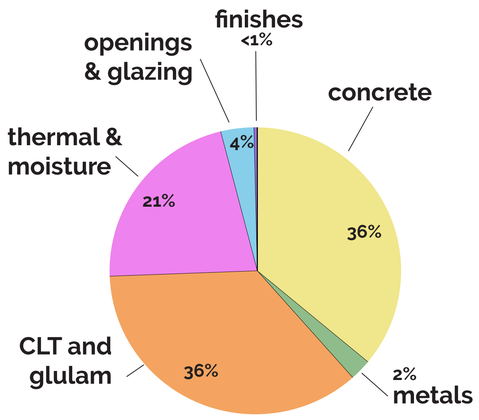
building size 1,500 m² (16,146 ft²)

global warming potential kg CO_2eq per m²

initial GWP	**195**
total GWP	**260**

GWP per material

CLT, Glulam, and Wood	**36%**
Concrete	**36%**
Metals	**2%**
Thermal & Moisture Protection	**21%**
Openings and Glazing	**4%**
Finishes	**<1%**



GWP per material

GWP per life stage

A1-A3	190.0 kg/m²	**64%**
A4	4.911 kg/m²	**1%**
B2-B5	16.41 kg/m²	**6%**
C2-C4	84.72 kg/m²	**29%**
D	-36.0 kg/m²	

GWP per life stage module

including biogenic carbon

Embodied Carbon

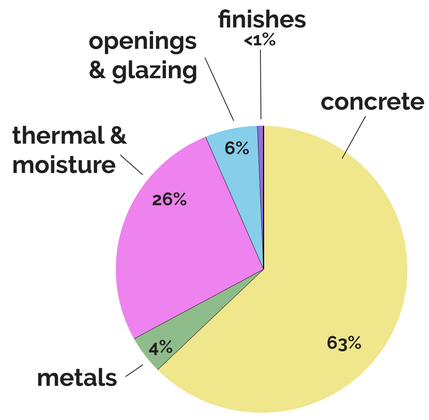
building size 1,500 m² (16,146 ft²)

global warming potential kg CO_2eq per m²

initial GWP	**-80**
total GWP	**114**

GWP per material

CLT, Glulam, and Wood	**-19%**
Concrete	**63%**
Metals	**4%**
Thermal & Moisture Protection	**26%**
Openings and Glazing	**6%**
Finishes	**<1%**



GWP per material

GWP per life stage

A1-A3	-85.2 kg/m²	**-42%**
A4	4.938 kg/m²	**2%**
B2-B5	15.83 kg/m²	**8%**
C2-C4	178.7 kg/m²	**88%**
D	4.321 kg/m²	**2%**

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.
- B2-B5 encompasses the CO_2eq emissions from maintenance and replacement of materials during the building's use. Module B1 is excluded.
- 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.

Transport distance assumptions
CLT & Glulam: 411 km
Concrete: 24 km
Steel: 434 km

CLT & Concrete: Environmental Impacts of 1 m³ of Material

About

The following comparisons of environmental impacts were carried out for CLT panels and a standard concrete in two different WBLCA softwares, in order to better understand the variations between the softwares, as well as whether or not the addition of module D altered the environmental impacts. The quantity of each material was defined as one square meter. The CLT in each software was the "generic" option, without any finishes or connections. Tally's results include biogenic carbon. The concrete in each software was to be 4000 psi, with 0-19% fly ash content. Steel rebar was not included.

Tally CLT density: 490 kg/m³
Athena CLT density: 458 kg/m³

Acidification Potential

Eutrophication Potential

Global Warming Potential

Smog Formation Potential

Primary Energy Demand

Conducted under a research grant from the TallWood Design Institute, funded by the USDA Agricultural Research Service under award # USDA-ARS #58-0204-6-002

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